COLLA 2012

The Second International Conference on Advanced Collaborative Networks, Systems and Applications

ISBN: 978-1-61208-206-6

June 24-29, 2012

Venice, Italy

COLLA 2012 Editors

Lasse Berntzen, Vestfold University College - Tønsberg, Norway

Katya Toneva, MirandaNet Academy, UK

Abdulrahman Yarali, Murray State University, USA

COLLA 2012

Foreword

The Second International Conference on Advanced Collaborative Networks, Systems and Applications [COLLA 2012], held between June 24-29, 2012 - Venice, Italy, continued a series of events dedicated to advanced collaborative networks, systems and applications, focusing on new mechanisms, infrastructures, services, tools and benchmarks.

Collaborative systems became a norm due to the globalization of services and infrastructures and to multinational corporation branches. While organizations and individuals relied on collaboration for decades, the advent of new technologies (Web services, Cloud computing, Service-oriented architecture, Semantics and Ontology, etc.) for inter- and intra-organization collaboration created an enabling environment for advanced collaboration.

As a consequence, new developments are expected from current networking and interacting technologies (protocols, interfaces, services, tools) to support the design and deployment of a scalable collaborative environments. Innovative systems and applications design, including collaborative robots, autonomous systems, and consideration for dynamic user behavior is the trend.

We take here the opportunity to warmly thank all the members of the COLLA 2012 Technical Program Committee, as well as the numerous reviewers. The creation of such a high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to COLLA 2012. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the COLLA 2012 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that COLLA 2012 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of collaborative networks, systems and applications.

We are convinced that the participants found the event useful and communications very open. We also hope the attendees enjoyed the charm of Venice, Italy.

COLLA 2012 Chairs:

Lasse Berntzen, Vestfold University College - Tønsberg, Norway
Mohamed Eltoweissy, Pacific Northwest National Laboratory / Virginia Tech, USA
Jaime Lloret Mauri, Universidad Politécnica de Valencia, Spain
Abdulrahman Yarali, Murray State University, USA

COLLA 2012

Committee

COLLA Advisory Committee

Lasse Berntzen, Vestfold University College - Tønsberg, Norway
Mohamed Eltoweissy, Pacific Northwest National Laboratory / Virginia Tech, USA
Jaime Lloret Mauri, Universidad Politécnica de Valencia, Spain
Abdulrahman Yarali, Murray State University, USA

COLLA 2012 Technical Program Committee

Imad Abugessaisa, Karolinska Institutet - Stockholm, Sweden
Leila Alem, CSIRO, Australia
Yasmine Arafa, University of East London, UK
Khalid Benali, LORIA - Nancy Université, France
Lasse Berntzen, Vestfold University College - Tønsberg, Norway
Cornelia Boldyreff, University of East London, UK
Stainam Brandao, COPPE/Federal University of Rio de Janeiro, Brazil
Patrick Brezillon, LIP6, University Pierre and Marie Curie (UPMC) - Paris, France
Shu-Ching Chen, Florida International University - Miami, USA
Shiping Chen, CSIRO, Australia
Xueqi Cheng, Institute of Computing Technology / Chinese Academy of Sciences, China
Jin-Hee Cho, U.S. Army Research Laboratory (USARL) - Adelphi, USA
Kevin Curran, University of Ulster - Derry, Northern Ireland, UK
Claudia d'Amato, University of Bari, Italy
Fulvio D'Antonio, Polytechnic University of Marche, Italy
Antonio De Nicola, ENEA, Italy
Jerome Dinet, Univeristé Paul Verlaine - Metz, France
Anna Divoli, Pingar. Italy
Mohamed Eltoweissy, Pacific Northwest National Laboratory / Virginia Tech, USA
Viviana Gaballo, University of Macerata, Italy
Carlos Granell, European Commission - Joint research Centre, Italy
Lei Guo, Ohio State University - Columbus, USA
Celso M. Hirata, Instituto Tecnologico de Aeronautica, Brazil
Chi Hung, Tsinghua University, China
Xin Jin, University of Texas at San Antonio, USA
Rajkumar Kannan, Bishop Heber College (Autonomous) - Tiruchirappalli, India
Holger Kett, Fraunhofer IAO - Stuttgart, Germany
Byoung Uk Kim, Ridgetop Group Inc. - Tucson, USA
Roland Kübert, High Performance Computing Center Stuttgart / Universität Stuttgart, Germany
Xiaoqing (Frank) Liu, Missouri University of Science and Technology, USA
Ying Liu, KAIST, Republic of Korea
Raymond A Liuzzi, Raymond Technologies - Whitesboro, USA

Wendy Lucas, Bentley University - Waltham, USA
Robert Matzinger, University of Applied Science Burgenland, Austria
Dennis McLeod, University of Southern California - Los Angeles, USA
Christoph Meinel, Hasso-Plattner-Institut GmbH - Potsdam, Germany
Klaus Moessner, University of Surrey, UK
Surya Nepal, CSIRO, Australia
Mourad Chabane Oussalah, LINA - CNRS Faculté des Sciences de Nantes, France
Philippe Palanque, IRIT, France
Willy Picard, Poznan University of Economics, Poland
Agostino Poggi, University of Parma, Italy
Stuart Rubin, SSC-PAC, USA
Francesc Saiqi Rubió, Open University of Catalonia (UOC), Spain
Abdel-Badeeh M. Salem, Ain Shams University - Cairo, Egypt
Pascal Salembier, University of Technology of Troyes, France
Corrado Santoro, University of Catania, Italy
Clemens Schefels, Goethe University Frankfurt, Germany
Kewei Sha, Oklahoma City University, USA
Dongwan Shin, New Mexico Tech, USA
Mohamed Shehab, University of North Carolina at Charlotte, USA
Mei-Ling Shyu, University of Miami - Coral Gables, USA
Alexander Smirnov, St. Petersburg Institute for Informatics & Automation of the Russian Academy of Sciences (SPIIRAS), Russia
Yehia Taher, ERISS / Tilburg University, The Netherlands
Christophe Thovex, LINA / University of Nantes, France
Katya Toneva, Middlesex University - London, UK
Zhengping Wu, University of Bridgeport, USA
Kevin X. Yang, Wolfson College / University of Cambridge, UK
Yi Yang, The Catholic University of America - Washington DC, USA
Xiaokun Zhang, Athabasca University, Canada

Copyright Information

For your reference, this is the text governing the copyright release for material published by IARIA.

The copyright release is a transfer of publication rights, which allows IARIA and its partners to drive the dissemination of the published material. This allows IARIA to give articles increased visibility via distribution, inclusion in libraries, and arrangements for submission to indexes.

I, the undersigned, declare that the article is original, and that I represent the authors of this article in the copyright release matters. If this work has been done as work-for-hire, I have obtained all necessary clearances to execute a copyright release. I hereby irrevocably transfer exclusive copyright for this material to IARIA. I give IARIA permission or reproduce the work in any media format such as, but not limited to, print, digital, or electronic. I give IARIA permission to distribute the materials without restriction to any institutions or individuals. I give IARIA permission to submit the work for inclusion in article repositories as IARIA sees fit.

I, the undersigned, declare that to the best of my knowledge, the article is does not contain libelous or otherwise unlawful contents or invading the right of privacy or infringing on a proprietary right.

Following the copyright release, any circulated version of the article must bear the copyright notice and any header and footer information that IARIA applies to the published article.

IARIA grants royalty-free permission to the authors to disseminate the work, under the above provisions, for any academic, commercial, or industrial use. IARIA grants royalty-free permission to any individuals or institutions to make the article available electronically, online, or in print.

IARIA acknowledges that rights to any algorithm, process, procedure, apparatus, or articles of manufacture remain with the authors and their employers.

I, the undersigned, understand that IARIA will not be liable, in contract, tort (including, without limitation, negligence), pre-contract or other representations (other than fraudulent misrepresentations) or otherwise in connection with the publication of my work.

Exception to the above is made for work-for-hire performed while employed by the government. In that case, copyright to the material remains with the said government. The rightful owners (authors and government entity) grant unlimited and unrestricted permission to IARIA, IARIA's contractors, and IARIA's partners to further distribute the work.

Table of Contents

Wireless Communication for Smart Grids

Abdulrahman Yarali
Murray State University
Email: ayarali@murraystate.edu

Saifur Rahman
Virginia Polytechnic & State University
Email: srahman@vt.edu

***Abstract*— Integration of information and communication technologies with the traditional of electric power infrastructures and creation of an interoperable, scalable, and flexible smart grid will require numerous technological innovations and advancements. The purpose of this paper is to take a detailed look at the various technologies which may be utilized in the data transmission for the smart grid and the problems or difficulties that must be overcome to effectively use them. A variety of wireless systems are analyzed and we discuss the security of these mediums as privacy remains a major obstacle for implementing smart grid technology.**

Keywords-component; smart grid, wireless systems, security, information and communication, SCADA

I. INTRODUCTION

The U.S. electricity generating and distribution infrastructure is undergoing dramatic changes. Historically, the industry has been driven from the production and supplier side where very large base load plants (mainly coal and nuclear) have maintained enough supply to handle the normal requirements with excess capacity available on demand. Recently, interest in renewable energy has greatly increased leading to more wind farms and solar plants. While these comprise only a very small fraction of the total electrical generation capability of the nation, their contribution is expected to grow in the coming decades. However, if these energy solutions are ever to have a major impact, several technological challenges must be met and solved. Among these are efficient, large scale energy storage solutions and the establishment of an extensive, responsive communications network to control the entire power grid.

The buzz phrase for this updated and improved electrical system is "the Smart Grid." The smart grid is intended to more efficiently operate this network of generators and distributors of power with automatic control and operation of the various systems in response to user needs and power availability. The reality is that there is no defined standard or picture of what the smart grid is. It is an emerging technology whose full purposes and requirements will only become clearer as the marketplace drives it. Presently, there are projects in place or ongoing throughout the U.S. to install smart meters on customer premises which take the place of the old electric usage meters which simply recorded the total usage for a given time period (typically one month.) At a minimum, these smart meters will allow the utility to obtain readings automatically through any of several possible communication channels. However, this is simply the first step in the smart grid process. Eventually, these meters are expected to provide constant, real time data back to the utility in order to constantly monitor usage rates, detect problems, and adjust the grid accordingly [1].

This change is itself simply an intermediate step as the true power of a smart grid lies in two way communication between the utility and the customer. Ideally, the customer will be sent information through the smart meter providing items such as power rate pricing which fluctuates based on the time of day and usage rates. The smart meter may communicate directly with appliances such as a washer and dryer, the stove and refrigerator, the heating and air unit, and the charging station for an electric car.

Communication in the smart grid can be divided into two primary sections - short range communication such as a home area network (HAN) which connects the varied devices of the home to its smart meter and the longer range transmission necessary to span the distance from the utility to the customer. In fact, a smart grid requires further communication between the interconnected utility generators and suppliers but that is beyond the scope of this paper. Ensuring security in each of these networks (which may each have different media) will be required as all of them must work together for the smart grid to function properly.

Many of the communication and security components are common between these energy subsystems. Supervisory Control and Data Acquisition (SCADA) is the core subsystem of smart grid. A second and a key component to smart grid is a number of secure, highly available wireless networks. These wireless technologies include WiMAX, WLAN, WAN, all generations of cellular technologies and wireless sensor protocols. Comprehensive security solution is a third key component as privacy remains a major obstacle for implementing smart grid technology [2].

This paper is presenting challenges, benefits and how, where, and what type of wireless communication systems are suitable for deployment in the electric power system. Various wireless technologies are discussed and analyzed for implementation. A concise summary of the technical underpinnings of each wireless technology with its strength and weakness is provided.

 ISBN: 978-1-61208-206-6

II. COMMUNICATION SECURITY

Placing a smart grid into operation is intended to produce a more reliable and resilient electrical system. However, the introduction of two way communication between the millions of devices on the grid may in fact greatly increase the problems associated with securing it. Therefore, placing the control of this grid onto computers and other smart devices which can affect its reliability means that extreme diligence must be used to protect the integrity of both the data and the infrastructure that collects and transmits it. In fact, it has been reported that cyber spies from Russia and China have already gained access to the U.S. electrical grid and may have even planted software into the system to cause future disruptions [3]. A recent report from the security firm McAfee details a wide ranging network hacking scheme that affected dozens of companies and government agencies around the world [4].

Looking at an individual household that is on the smart grid, there are privacy concerns as well. With the proper resources and ineffective security, a hacker with a malicious intent could even gain control of portions of the grid by compromising the communication system causing a widespread blackout. Since the grid is interconnected, this could in turn lead to power disruptions and control problems through a large region of the country [3]. Although not directly affecting the electrical grid, in November 2011, an attacker was able to gain access to the control system of an Illinois municipal water supplier and remotely disable operating equipment, highlighting the very real danger posed by these types of attacks [5].

In order to achieve comprehensive energy management and utility control, smart meters will also be applied to gas and water meters. This expansion of the smart grid infrastructure brings further complexity to the system. Like any computer network, the smart grid must meet several requirements. High reliability and availability are essential for proper control and operation of the grid so the system must be robust and include levels of redundancy for critical applications. The communication architecture must be able to span the large distances of the grid and effectively handle the large number of nodes (all of the individual smart meters) and the data they produce without excessive delays. The network should also be maintainable – i.e. updates and improvements should be simple to perform and not require physical modifications at each node. Lastly and perhaps most importantly, the network should contain these foundational supports in regards to security management [6]. First is the issue of trust. To work effectively, one must have assurance that the devices on the network are legal, that their messages are valid and that the data has not been manipulated. There must be a means of controlling who can access the network and send messages on it [7]. This is normally managed by some type of key protocol and an authentication mechanism. Privacy is also a paramount concern in order to prevent unauthorized users from being able to capture and read the data on the network [8].

While these security factors are software related, smart grid security must also rely heavily on physical protection. Whereas a typical network's infrastructure is located inside locked communication cabinets or rooms, many of the devices on the smart grid are in accessible locations where anyone can gain access. Smart meters are normally located on the outside of houses and incorporating elaborate security mechanisms for them is either impractical or too expensive. Electrical substations and power lines are located in remote locations in many instances, making oversight and protection problematic. These concerns mean that it is likely that a component of the smart grid will be compromised [6]. Having protocols in place to detect and bypass or eliminate these effected components is another essential aspect of smart grid security. NIST released its smart grid security guidelines, NISTIR 7628, in 2010. While this document provides a broad overview of the security concerns and generic instructions on what should be done to protect the system, details have yet to be published [9].

Generally, securing a wired network is easier, as the attacker must force access to the system. With firewalls, proper password protocols, and a strong understanding by the people involved of what vulnerabilities exist, good security can be accomplished. This will be vitality important for the wired portions of the smart grid as well but wireless networks can be more problematic.

As wireless communication becomes more and more widespread, however, this comes with a price as radio waves are free to be intercepted by anyone who chooses to listen. The architecture for most smart grid applications involves at least some element of wireless communication meaning that the data and control information of the electrical grid is exposed to those with the proper equipment and knowledge. The followings are various types of attacks to which a wireless system may be vulnerable [10]:

- Passive attacks are those in which the attacker simply listens to the network transmissions.
- Active attacks can take the following forms. Masquerading is when an attacker impersonates a valid user to gain access to the network. A replay attack occurs when an attacker captures valid transmissions (by eavesdropping) and then retransmits the messages to appear as a legitimate user. Message modification or tampering occurs when a valid message is altered in some way.
- A Denial of Service (DoS) attack is intended to completely halt network traffic.
- A Man in the Middle (MITM) attack can occur when an attacker gains access to the network between two valid nodes.

Wireless mesh networks are vulnerable to some special attacks which affect their routing mechanism. A blackhole attack occurs when a malicious node in the mesh claims to have a link to the destination when in fact it does not. The message is then dropped and never retransmitted. A wormhole attack relies on the attacker

 ISBN: 978-1-61208-206-6

capturing or installing two malicious nodes into the mesh. Messages that are sent through the wormhole can be analyzed or dropped to cause disruptions. Along similar lines as a DoS attack, a resource depletion attack may target a battery powered node and force it to respond to or send so many messages and requests that its power is depleted [11].

III. NETWORKARCHITECTURE AND TECHNOLOGIES

As utilities move from proof-of-concept trials to planning and deployment of the wireless infrastructure in order to enable their smart grid initiatives, they face a wide array of decisions that will determine their long-term success. The smart grid will revolutionize the way they run their business—and perhaps it will change their business entirely. Electric utilities' focus is likely to shift from selling power to managing its production and consumption, with economic incentives to increase power efficiency in generation, distribution and consumption, rather than sales.

How can utilities choose the wireless infrastructure that is best suited to their current and future requirements? How can they pick the technology that will most smoothly evolve along with their smart grid applications?

The first step is to get a solid understanding of their overall requirements—initial ones and long-term ones. This might seem straightforward, but it can easily become challenging, since the requirements are dependent on new operational processes that have not been introduced yet. Utilities are bound to find that smart grid applications will, to some extent, work differently than anticipated, so they need some leeway to accommodate change.

For the smart grid home area network (HAN), various media are available with the ZigBee standard currently dominating this industry segment. Many appliance manufacturers have joined the ZigBee consortium which has given it a solid lead for this market. Bluetooth is another viable technology for this area and the Bluetooth consortium is currently pushing to expand their role in the smart grid [12]. With the preponderance of Wi-Fi networks in many homes, it must also be considered as a potential solution. While not significantly mentioned in the discussion of the smart grid, it would seem that power line communication within the home could also be a logical choice for transferring data between the smart meter and the items within a house. For the problem of communication between the customer and the supplier, wireless mesh networks seemed to have taken the lead in the U.S. at this point in the implementation. However, broadband over power lines (BPL) which is also called power line carrier (PLC) has been utilized for many years for other applications and may play a factor in the smart grid. WiMAX as well as cellular phone service networks have also been employed recently.

This report is analyzing how, where, and what type of wireless communications are suitable for deployment in the electric power system and to inform implementers of their options in wireless technologies. We provide a concise summary of the technical underpinnings of each wireless technology. We also outline the feature set and the strengths and weaknesses of each technology.

A. SCADA

Although not the focus of the paper, the existing computerized infrastructure of the electric grid must not be overlooked in regards to security. The U.S. electrical industry has utilized computer control systems for many years to assist in operating the power grid. Supervisory Control and Data Acquisition (SDADA) systems consist of remote terminal units (RTU) located at power generating stations, and substations, and other grid positions along with centralized operator stations. RTUs collect and transmit instrument readings and process control actions from the operator stations. These systems have been designed for supplier and distributor control and monitoring and not for data collection or control of individual customers. They were also predominantly built from proprietary vendor hardware and software and were not necessarily connected to a network. These facts made system security relatively easy to implement with little danger of attack. However, in recent years, the trend has been to software applications run on "off the shelf" hardware [13]. The author recently assisted with the replacement of a SCADA system for a large industrial facility. Even if an attacker was given access to the original system, it is unlikely that much could have been accomplished given the archaic and antiquated hardware and software. However, the new system is built on PC platforms from a known large supplier running a Microsoft Windows OS. Obviously the number of potential knowledgeable attackers that could penetrate the system has now risen dramatically. For this location, mitigating these potential attackers meant ensuring that the SCADA system has no connection to any other network. However, for the smart grid to work, this is not an option for most power producers and distributors. Not only must their systems interconnect more than ever, they must now also interface with thousands or even millions of smart meters located throughout their systems – each a possible point of a network breach.

B. Smart Meters

According to a recent report by Bell Labs, smart meters are the perhaps the weakest link in smart grid security, but they will undoubtedly be the heart of the system [14]. The current method of recording the electricity usage of most customers in the U.S is through the typical manually read meters that have been used for decades. Approximately twenty years ago, some advances in this technology began to be made with the introduction of automated meter reading (AMR) [15]. In many cases, these devices incorporated short range radio transmitters which could be read by a utility employee driving nearby with a receiver. Some more advanced applications used low bandwidth data transmission over the power lines to send this data back to an aggregation point. As with most

 ISBN: 978-1-61208-206-6

projects, cost is normally a major factor and smart meter installations are no exception. With tens of millions of potential installations throughout the U.S., the meters must be inexpensive in order to justify their use. However, this also means that their physical protection is limited. To minimize costs, they don't incorporate anti-tampering devices such as pressure sensors to alert the system that a problem exists or a system breach may have occurred. In addition, due to the priority of maintaining low cost devices, the processing power is comparatively small. This restricts the complexity of the security algorithms that can be used by such devices.

With smart meters sending data to the electricity supplier automatically, there would actually not be a need to have the meter mounted outside the customer premises. Placing the meters inside a garage or other room would provide a much more protected location and aid in the security of the smart grid. This would require moving or extended the power line terminus from their normal location to the interior which would add considerable expense and most likely be prohibitive for any extensive smart grid projects. However, for any new homes built in areas with existing smart meters infrastructure, this may be a useful option.

At the present time, there is no standard solution for communication between the smart meters and the electrical supplier's networks. Figure 1 shows a group of smart homes connected to the grid. Data could be sent wirelessly to an access point at the local power pole or via communication over the low voltage power lines. Large amounts of smart meter data could be collected at a substation and then sent back to the utility. The backhaul connection to the utility might be via a common carrier or a utility owned network. Much depends on the density of meters in a particular area and the distance of those meters from data collection points. No one technology may fit every situation. The design of the smart grid for rural areas may look very different from those in an urban setting. As mentioned previously, the final design and capabilities of the smart grid has not been determined either. For instance, if the smart meters are simply to provide real time usage data every 15 minutes, a relatively slow bandwidth network may be sufficient. If it is expected that the meters will themselves be data collection points for all of a household's appliances and will report this information several times per minute, the transmission of this information may require a very high speed network. The remainder of this paper will closely examine the possible mediums for both the in house network and the meter to supplier side.

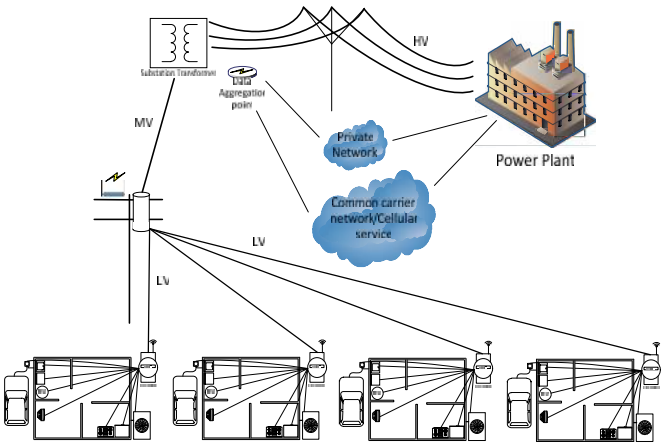


Figure 1: Overall grid diagram

C. ZIigbee

IEEE 802.15.4 defines standards for the MAC and PHY layers for personal area networks. ZigBee is the trade name for a set of applications that run on these standards as defined by the ZigBee alliance. It is a low power, wireless mesh network that is designed to be used in a wide range of applications, including smart home control systems. Although the devices have a short range (10-100m, less in practice), the mesh design means networks can cover fairly large areas. Many smart meters have ZigBee chip sets in order to communicate with smart devices in the home.

For security, ZigBee relies on 128 bit AES encryption. It also includes a 32 bit message integrity code (MIC) and frame counter to address replay concerns. Security is applied by default at the network layer but higher level security is optional and not required.

With its low cost, low power usage, mesh networking, and strong vendor support, ZigBee has many attractive characteristics for a smart home network that can easily attach to a smart meter for total integration. However, its security issues may be a cause of concern. As its importance and use increases, more and more hackers will be drawn to attacking it which may expose even more problems. To use ZigBee for complete power control from the utility, the smart meter will need to share keys with the various appliances of the homeowner. However, due to security concerns, it remains to be seen if the utility would be willing to share these keys, possibly making system integration difficult [16].

D. Bluetooth

Similar to ZigBee, Bluetooth is the trade name for a wireless personal area network (WPAN). Although this technology holds a commanding position in the cell phone accessory industry, it has not made a large impact in the HAN/smart home market. However, the industry consortium behind the technology is promoting itself for

 ISBN: 978-1-61208-206-6

smart grid applications. Unlike ZigBee, Bluetooth is not a mesh network but it is able to transmit at greater speeds (~1 Mbps) while using only slightly more power with an advertised range up to 100 m.

For one aspect of security, Bluetooth utilizes frequency hopping during communication but there are devices available on the market which can match the changes and therefore eavesdrop on any transmissions. One of Bluetooth's features is the ease of "pairing" two devices so that they can communicate. This can be accomplished by placing the device in a discoverable mode. However, if let in such a state, the device may be open to attack. Another possible avenue of attack is the fact that Bluetooth addresses are not encrypted during transmission, even when in a secure mode that encrypts the rest of the message. With a known address, the attacker can initiate communication with a device and potentially upload viruses or other malicious software.[25]

Like other wireless technologies, Bluetooth also uses the 2.4 GHz spectrum so interference is possible with Wi-Fi and ZigBee. Without a mesh network, Bluetooth is more limited than ZigBee in the total area it can cover. It is also at a disadvantage since most smart meters are already designed and shipped with embedded ZigBee chips. However, it does have one advantage in that most computers and smart phones can communicate via Bluetooth which would make integrating the controls for the smart home with devices we already use very simple.

E. Ethernet over Power

Powerline networking or power line carrier (PLC) is a potentially attractive means of connecting the smart meter to the electrical devices in the home. The latest versions of this technology use orthogonal frequency division multiplexing (OFDM) and claim speeds of up to 200 Mbps. Although practical results are probably far lower in most instances, it would still be more than adequate for smart home communication.

To incorporate this technology in the smart grid, the smart meter would need PLC technology built in from the suppliers so that the signals could be injected into the home wiring from the source. Ideally, the smart appliances to be controlled in the home would also have embedded PLC devices but they could also simply connect via an adaptor as described above. In this application, the smart meter would act as the server (if necessary) and poll and/or send control messages to the attached devices.

Having a possibly more secure system is one of the benefits of using this technology. There would be no wireless transmissions like ZigBee, Bluetooth, or Wi-Fi which could be heard by an eavesdropper. However, this does not mean that there are no potential security vulnerabilities. Like all of the systems described, the smart meter itself is still vulnerable and could be attacked and compromised. Also, the typical residential power distribution system supplies several houses from one low voltage transformer. Since these locations are all tied together, any signals injected onto the lines from one house can be sensed at other houses as well. PLC device manufacturers recognize this and incorporate message encryption schemes into their products. Like wireless systems, any signals which are available can be probed by hackers for weaknesses and potentially exploited. The danger is significantly reduced with PLC as the actual power lines would have to be tapped so war-driving would not be possible. In addition, if this technology were to be used, a low pass filter could be installed in the smart meter to prevent these signals from going beyond the home.

Several variations of PLC are in existence and can be dependent upon what portion of the transmission grid is being utilized. As shown in figure 1, through equipment at the generating station, high voltage level (generally 161 kV – 345 kV) electricity is supplied to the grid and carried to substations located closer to the customers. Step down transformers at these substations drop the high voltage down to a medium voltage level (e.g. 14kV). From there it is sent through the local grid to various areas near the customers. Small transformers further reduce the level to the standard 120/240 V level for household use and reach the customer through the individual electric meters. Each of these transformers can act as a low pass filter which effectively blocks high frequency transmissions from passing through. In addition, dependent upon the frequency used, transmissions over power lines suffer from high signal attenuation. Therefore for many applications, repeaters may be required to transmit through the entire grid.

One potential problem with PLC relates to the irradiated signal from the placement of the carrier signal on the transmission lines. Some of the frequencies used overlap with those used by short wave radio operators and other systems and there is a concern that widespread use of PLC could be harmful to that media. In areas where it is currently being used, however, no mention has been found of problems being reported. No mention has been found of any security concerns in regard to these irradiated signals being picked up by eavesdroppers either. Due to the lethal voltages present on the transmission lines, there is built in security protection which the other mediums do not have. It is highly unlikely that an attacker would attempt to tap into this network.

F. Wi-Fi

Wi-Fi is an extremely popular wireless protocol that is found in many homes already for home area networks and Internet access. The latest version, IEEE 802.11n, boasts speeds of up to 300Mbps. While the outdoor range of Wi-Fi can exceed 300 feet, 100 feet or less is more typical of indoor applications. While this

 ISBN: 978-1-61208-206-6

does give at a significant advantage over other technologies, this comes with a price as its power consumption is much higher than ZigBee and Bluetooth. Studies have shown that Wi-Fi would consume more than two times as much power as ZigBee in a standard smart home environment [17]. As the most popular wireless standard, Wi-Fi has garnered considerable interest from hackers and researchers which has revealed several security holes and concerns. However, this has led to improvements in its security protocols, possibly making it more secure than competing technologies now. Refer to the earlier section of this paper for a detailed look at Wi-Fi security.

For Wi-Fi to be used as the smart home communication medium, other concerns would need to be addressed, beyond security and power usage. Obviously, appliance manufacturers would need to add Wi-Fi capability to their products. If this is done, would the utility use the customer's personal Wi-Fi network (HAN) for the communication between these products and the smart meter, or as is more likely, would the utility install a separate network, with the smart meter as the access point? This could lead to interference concerns, especially in densely populated areas.

Furthering this problem is the use of Wi-Fi based wireless mesh networks for the communication between the smart meter and the utility itself. This method and competing technologies for this application will be investigated next.

G. Wireless Mesh Network

Wireless mesh networks are an easily deployable, inexpensive means of providing wireless network coverage over a large area. They are an accumulation of mutually supportive wireless access points (AP) which are arranged in such a manner to allow multiple paths back to some physical location which is normally a wired network or wireless hot spot. Since most mobile devices can communicate via Wi-Fi, mesh networks are normally based on 802.11 protocols with the addition of some means of routing control [18]. In relation to the smart grid, the smart meters could be the APs of the network with an aggregation node located at a local substation which is connected back to the utility through some other media. A mesh network could also be created by installing APs at various locations throughout a city or neighborhood with the smart meters being the clients. Data from the customers would be transmitted from the smart meters through the mesh network to some aggregation point where it would then make its way back to the utility. Some substations are already connected via copper wiring or fiber optic so additional networking infrastructure may not be required. Control commands and information from the utility would flow in the opposite direction. A mesh would provide an inexpensive, yet high speed network for the utility and could be implemented quickly.

Along with the normal security concerns of wireless transmission, the mesh network opens up a number of other worries in regards to the routing protocols that take the information back to the base station or aggregator. A mesh network for smart grid purposes will not be ad hoc, but rather a fixed network where all nodes are known. With fixed nodes, it is then assumed that all the nodes are friendly and there is an expected trust between nodes. Therefore, if an attacker gains access to an AP or smart meter, they may be able to severely disrupt network traffic. In order to maintain low costs for the mesh devices, physical protection is minimal so this is a very real threat. There are three crucial security goals in this regard: having some means of detecting a compromised node, securing the routing mechanism, and ensuring all nodes have equal access to the network [19]. Several articles that are available discuss means for detecting malicious nodes but intrusion detection is an area that must be further studied and improved. Secure routing mechanisms are also available and if used properly should aid in preventing attacks on this protocol. However, even with secure key exchange mechanisms, by physically attacking a node one may be able to gain this key data and impersonate a valid node. Since each node pair should have their own keys, this should not allow an attacker to successfully eavesdrop on other nodes. However, even if no data is compromised, the loss of any functionality to the smart grid with its expected constant data flow may cause reliability issues to the electrical system.

While mesh networks provide extreme flexibility, there very make-up also makes them vulnerable to attackers. In order to safely and effectively use this type of design for the aggregation of smart grid data, further improvements in physical protection and routing protocols may be required. Other technologies may not have the ease of deployment that a wireless mesh enjoys, but security concerns may override this benefit [20].

H. WiMAX

WiMAX (Worldwide Interoperability for Microwave Access) is the trade name for a broadband wireless access medium defined under IEEE 802.16. Initially the standards were limited to fixed, line-of-sight transmission but have since also incorporated standards for mobile, non-line-of-sight access. While the range for WiMAX transmission can be up to 30 miles, three to five miles is more typical in practice. This does provide significantly greater range than Wi-Fi, making it a more useful medium for this application. In addition WiMAX uses the 2.5 GHz spectrum making it less prone to interference from other sources and wireless devices. The latest standards allow for data rates up to 1 Gbps although this bandwidth must be divided between the users. WiMAX service is provided by a base station which then

 ISBN: 978-1-61208-206-6

allows connections by subscriber stations which would be the smart meters in our application. This is essentially the same as cellular phone service and WiMAX is one of the technologies being used for 4G implementations by the cellular providers [21].

For security, WiMAX utilizes the strong AES encryption method and also includes key management and authentication. The first version of its key management protocol was subject to attacks but this has since been strengthened. It is assumed that any new devices for the smart grid would include the latest protection. Like any wireless medium, WiMAX is susceptible to DoS attacks by jamming and scrambling attacks where the jammer only transmits during certain periods to disrupt control information. Other attacks have been proposed involving a weakness in the initial network entry and key exchange [22]. By eavesdropping at the proper time, one could gain enough information to implement a MITM attack, thereby compromising the security of all traffic routed through the node. One may also be able to gain enough access to the system to transmit various control messages which could effectively overload the system. However, since the devices tied to the smart grid are not mobile and constantly changing WiMAX base stations (and therefore exchanging keys and performing authentication routinely), there should be little opportunity to exploit these vulnerabilities in this application.

One question to be answered for a WiMAX implementation is who would own the network. Should a utility install its own private system or rent from a cellular provider? It is expected that a utility would want total control of any network tied to the smart grid but it may be much less expensive to lease network capacity. However, it would have to be determined if the required QoS could be maintained.

I. Wireless Scenarios and Implementations

The desire to reduce electricity consumption, add renewable energy sources to the mix of supply options, and better control the entire electrical system, a new smart grid is being proposed and implemented. The development of smart grid is essential for achieving energy security, economic development and climate change mitigation. It is important to note that there is no single deployment that will define the communications architecture of the electric power systems. The electric power system will require communications with great flexibility and complexity. Common challenges associated with wireless communications are probabilistic channel behavior, interference and jamming, and eavesdropping and interception [23].

One of the challenges in deploying data communication networks is the number of variations in configuration and connectivity that are implemented. The following table shows examples of scenarios to wireless technology implementation.

For obtaining data communications coverage quickly and inexpensively over a large geographic area, both WiMAX and 3G/4G cellular technologies should be considered. WiMAX at the present holds a bandwidth and latency advantage over 3G cellular communications; however, with the imminent LTE deployment from multiple carriers, we believe this advantage will be short-lived. Unlike WiMAX deployments, LTE will mostly reuse existing cellular networks and should be a straightforward evolution of the 3G cellular networks. Both of these technologies operate over licensed spectrum and therefore should be protected against unintended interference. In terms of scalability, we know that the cellular networks are capable of accommodating hundreds of millions of subscribers while providing both voice and data communications. WiMAX networks have been deployed to provide wireless local loop service successfully. However, presently, WiMAX networks only support a small fraction of users compared to 3G cellular networks. Whether using WiMAX or 3G/4G cellular, we recommend a combination of application-level security and virtual private networking (VPN) for transporting electric power system information over these public networks. Smart grids can provide significant benefits to developing countries. Capacity building, targeted analysis and roadmaps – created collaboratively with developed and developing countries – are required to determine specific needs and solutions in technology and regulation.

Table 1. Wireless Technology Suitability(Example Scenarios to Wireless Technology Mapping)[23]

	WiMAX	WiFi	IEEE 802.15.4			HSPA/EDVO	LTE/HSPA+ UMTS
			Wireless HART	ISA100.11a	Zigbee		
Feeder Reconfiguration	S[1]	N [2,4]	NS [2]	NS[2]	NS [2,3]	S[1]	S[1]
Within a Customer Premise	NS [5]	S	S	S	S	NS [5]	NS[5]
Customer Premise to Ctrl Ctr	S[1]	NS[2]	NS[2]	NS [2]	NS [2]	S[1]	S [1]
Within a Bulk Generation Plant	NS [5]	Surveillance and Sensor Aggregation	Sensor Netwks	Sensor Netwks	NS [3]	NS [5]	NS[5]
Transmission System to Ctrl Ctr	S[1]	NS[2,4]	NS[2]	NS[2]	NS [2,3]	S[1]	S[1]
Bulk Plant to Ctrl Ctr	S[1]	NS[2,4]	NS[2]	NS[2]	NS [2,3]	S[1]	S[1]

S= Suitable NS= Not Suitable

1. Wide Area Networks may be overwhelmed by excessive demand created by an emergency, natural disaster, or large public gathering (e.g., Presidential Inauguration).
2. Technology does not possess necessary geographic coverage area.
3. Technology does not offer sufficient security.

 ISBN: 978-1-61208-206-6

4. Unlicensed Spectrum susceptible to significant interference.
5. Wide-area technology not suitable for use within a confined area

IV. CONCLUSIONS

The desire to reduce electricity consumption, add renewable energy sources to the mix of supply options, and better control the entire electrical system, a new smart grid is being proposed and implemented. At the present, there is no one solution to the problem or one network which the industry has settled on. Wireless options are easy to implement and enjoy wide support but present security concerns that could be compromised to disable and damage the infrastructure of the system. Installing wired systems would add excessive costs and power line communication has obstacles to overcome before it can be used in a fully implemented smart grid capacity. Based on the current situation, it is believed smart home networks will continue to be installed for household use but it is unlikely that any serious attempt to completely automate them with the grid occurs in coming years. Most likely we will see a movement toward the system design used by Florida Power and Light which can read meters a few times per hour and provide control messages to quickly drop load if necessary. In such a system, PLC may become the method of choice and would aid in minimizing the security issues of using wireless technology. Separating the hype from the reality of the smart grid is difficult. Even with government intervention and funding, the ultimate design will be driven by the marketplace. Over the coming years, it is predicted that an old technology (PLC) finds more use than the latest wireless infrastructure even with its high speed and ease of use.

REFERENCES

1. INL Critical Infrastructure Protection/Resilience Center, "Study of Security Attributes of Smart Grid Systems –Current Cyber Security Issues," Department of Energy, 2009.
2. Anthony R. Metke, Randy L. Ekl, "Security Technology for Smart Grid Networks," IEEE Transaction on Smart Grid, Vol. 1, No. 1, June 2010
3. Clemente, Judy, "The Security Vulnerabilities of the Smart Grid," Journal of Energy Security, June, 2009.
4. Alperovitch, Dmitri, "Revealed: Operation Shady RAT," McAfee White Paper, accessed via Internet from http://www.mcafee.com/us/resources/white-papers/wp-operation-shady-rat.pdf, November 22, 2011.
5. Finkle, Jim, "U.S. probes cyber attack on water system in central Illinois," Reuters, accessed via Internet from http://www.msnbc.msn.com/id/45359594/ns/technology_and_science-security/t/us-investigates-cyber-attack-illinois-water-system/#.TtlFrlYlpI4, November 25, 2011.
6. Perrig, Adrian et al, "Security in Wireless Sensor Networks," Communications of the ACM, Jun2004, Vol. 47 Issue 6, p53-57.
7. Khurana, Himanshu, "Smart-Grid Security Issues," IEEE Security & Privacy, Volume 8 Issue 1, 2010, pp. 81-85.
8. Sauter, Thilo, "End-to-End Communication Architecture for Smart Grids," IEEE Transactions on Industrial Electronics, Volume 58 Issue 4, 2011, pp. 1218-1228.
9. Guidelines for Smart Grid Cyber Security: Vol. 2, Privacy and the Smart Grid, NISTIR 7628, August 2010, accessed via Internet from http://csrc.nist.gov/publications/nistir/ir7628/nistir-7628_vol2.pdf, November 16, 2011.
10. Souppaya, Murugiah et al, "Guidelines for Securing Wireless Local Area Networks (WLANs) (Draft)," NIST Special Publication 800-153.
11. Yi, Ping et al, "A Survey on Security in Wireless Mesh Networks," IETE Technical Review, Volume: 27, Issue 1, 2010, pp. 6-14.
12. Merritt, Rick, "Bluetooth group explores apps in smart grid," www.eetimes.com, 2/24/2010, accessed via Internet from http://www.eetimes.com/electronics-news/4087913/Bluetooth-group-explores-apps-in-smart-grid, November 14, 2011.
13. Ericsson, Goran N., "Cyber Security and Power System Communication-Essential Parts of a Smart Grid Infrastructure," IEEE Transactions on Power Delivery, Volume 25 Issue 3, 2010, pp. 1501-1507.
14. Budka, Kenneth C. et al, "Communication Network Architecture and Design Principles for Smart Grids," Bell Labs Technical Journal, Volume: 15 Issue: 2, 2010, pp. 205-227.
15. Galli, Stefano, "For the Grid and Through the Grid: The Role of Power Line Communications in the Smart Grid," Proceedings of the IEEE, Volume 99 Issue 6, 2011, pp. 998-1027.
16. Bialoglowy, Marek, "Bluetooth Security Review, Part 1," accessed via Internet from http://www.symantec.com/connect/articles/bluetooth-security-review-part-1, November 12, 2011.
17. Electric Light & Power, "GE study: ZigBee is better than WiFi for smart grid home communications,"December 9, 2010, PennWell Corp., accessed via Internet from http://www.elp.com/index/display/article-display/1328413615/articles/electric-light-power/smartgrid/2010/12/GE_study__ZigBee_is_better_than_WiFi_for_smart_grid_home_communications_.html, November 14, 2011.
18. A. Gerkis, "A Survey of Wireless Mesh Networking Security Technology and Threats," SANS Institute, 2006, accessed via Internet from

http://www.sans.org/reading_room/whitepapers/honors/survey-wireless-mesh-networking-security-technology-threats_1657, November 4, 2011.

19. Salem, Naouel Ben et al, "Securing Wireless Mesh Networks," Laboratory of Computer Communications and Applications, École Polytechnique Dédérale de Lausanne.
20. Yarali, A. & Ahsant B., Rahman S. , "Wireless Mesh Networking: A Key Solution for Emergency & Rural Applications," MESH2009, June 18-23, 2009 - Athens Greece.
21. Yarali, A., Rahman S. & Bwanga M.," WiMAX: The Innovative Wireless Access Technology," Journal of Communication (JCM), Academy Publisher, 3, (2), 53-63, 2008 .
22. Nguyen, Trung, "A survey of WiMAX security threats,"Computer Science Department, Washington University, 2009.
23. Ba Akyol, H Kirkman et al, "A Survey of Wireless Communications for the Electric Power System," Pacific Northwest national Laboratory, U.S. Department of Energy, January 2010.

 ISBN: 978-1-61208-206-6

Timeaxis Design of an Email System for Sustaining and Deepening "KIZUNA"

Kei Matsuoka
Graduate School of System Design and Management
Keio University
Yokohama, Japan
mkk0317@gmail.com

Shuntaro Matsui
Graduate School of Science and Technology
Keio University
Yokohama, Japan
bbmatsui@a5.keio.jp

Koichiro Sato
Keio Advanced Research Centers
Keio University
Yokohama, Japan
Koichiro_Sato@a3.keio.jp

Yoshiyuki Matsuoka
Graduate School of Science and Technology
Keio University
Yokohama, Japan
matsuoka@mech.keio.ac.jp

Tetsuro Ogi
Graduate School of System Design and Management
Keio University
Yokohama, Japan
ogi@sdm.keio.ac.jp

***Abstract*—In this research, we developed an email system designed to sustain and deepen "KIZUNA," by which we mean the precious bonds that exist between individuals and human relationships as one element of spiritual richness, based on a design concept of a KIZUNA Visualizer, intended to satisfy the user's need for spiritual richness, in response to the growing importance placed on KIZUNA by contemporary values. In the design process, we introduced a timeaxis design approach based on multi-time scale and a value growth process, as the design viewpoint to deal with the changes undergone by KIZUNA over time. We also introduced into the email system a self-organizing form-generation system based on bio-inspired design, which is one of the methodologies of timeaxis design. These design developments resulted in us determining to visualize KIZUNA through self-organizing, transforming icons as a design concept. We therefore created 6 functions to show changes in the state of KIZUNA through changes in the shape and color of icons made in correspondence to the exchange of emails. In addition to the proposal of the KIZUNA Visualizer, a new email system that visualizes KIZUNA, which resulted from this design process, we also produced a prototype of the KIZUNA Visualizer. After considering the effects of the system and its prototype from the viewpoint of value growth process, the potential of this system in maintaining and deepening KIZUNA was indicated.**

Keywords-Email; Timeaxis Design; Multi-time scale; Bio-inspired Design; Self-organizing

I. INTRODUCTION

The development of science and technology in recent years has made mass production and mass consumption possible; it has brought material affluence to our lives. However, it has been pointed out that increasing satisfaction with our material wealth has been accompanied by a shift from values that emphasize convenience and efficiency to those that place greater importance on spiritual richness [1]. Specifically, the pursuit of the individuality, including individual lifestyle choices, tastes, and interests, and pursuit of human relationships, such as placing priority on the time spent with family, have come to be more valued [2]. In this context, media content and products that can satisfy this enhanced need for spiritual richness are increasingly in demand.

We focused on the pursuit of human relationships as one element of spiritual richness, in particular, we focused on KIZUNA, namely precious relationships—bonds—between people. Japan experienced the Great East Japan Earthquake in March 2011, and in the same year the Japanese character for KIZUNA was chosen by public vote as the character most represents the events of the year; this suggests a growing consciousness of the importance of personal relationships. We developed a tool to aid the continuance and deepening of KIZUNA, which is so cherished in modern values.

In this research, we focused on the goal of satisfying modern human need for spiritual richness, working with the design concept of a KIZUNA Visualizer, a system to visualize human relationships. This KIZUMA Visualizer is a key to the development of an email system that enables users to sustain and deepen KIZUNA, by facilitating the visualization of the invisible bonds of KIZUNA. We aimed

 ISBN: 978-1-61208-206-6

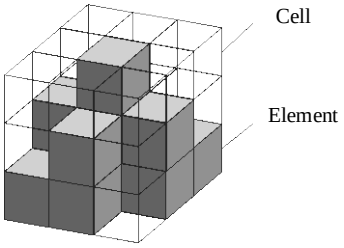
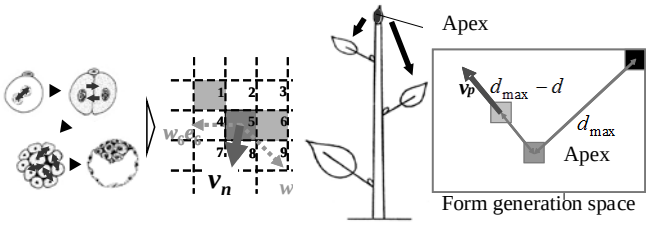


Figure 1. Cellular automaton



(a) Induction (b) Apical dominance

Figure 2. Input vectors

at encouraging users to notice changes in KIZUNA over time, and thereby, encourage and promote better communication. To realize this design concept, we needed to develop our design in a way that considered the relationship between the state of KIZUNA, changeable over time, and the email system. Therefore, timeaxis design [3], which incorporates a temporal axis into the design process, was integrated into the study as its central approach to design development.

II. SELF-ORGANIZING SYSTEM

This section describes the self-organizing email system based on Bio-inspired design.

A. Introduction of Bio-inspired Design

In this paper, we introduce the timeaxis design approach to design, based on the incorporation into design of a temporal axis. One of methodologies that can be used to actualize timeaxis design is bio-inspired design [4][5]. Bio-inspired design is a methodology that is able not only to mimic the structure of life forms but also to adapt to the changing diverse environments of life. By using this methodology, the target of the design is able to change the system itself, making it possible to accommodate changes in the values and usage environments of the user experienced over time. In this study, therefore, we modeled the developmental processes of life using cellular automata, thereby introducing a bio-inspired self-organizing system to generate a variety of forms as the technological seed of the proposed email system. This form generation system makes possible the production of an icon that can transform as it matures into a variety of shapes, as if it were artificial life. The maturation of this icon is linked to the communication conducted over email, and therefore can be considered as a method to achieve the visualization of our design concept of KIZUNA. In addition, in this study we conducted design development that took into consideration the relationship between the changes seen in KIZUNA in accordance with the development of the icon, directly linked to the email system, and the passing of time. The theory of timeaxis design [6][7] is incorporated in the design approach we chose.

B. Bio-inspired Self-organizing Systems

In this section, we discuss the form generation system used to generate the icons to visualize the state of KIZUNA.

The form generation system used cellular automata (CA), as shown in Fig. 1 [8][9], to generate various forms through self-organization. The CA is expressed as

$$C^{[t+1]} = f\left(C^{[t]}, N^{[t]}\right)$$
$$C = \left\{S_1, S_2, \cdots S_{n-1}, S_n\right\} \quad (1)$$

where, S_i is the state of the cell, $\boldsymbol{C}^{[t]}$ the cell state at time step t, and $N^{[t]}$ the status of neighboring cells at time step t, and f the transition function.

This system uses voxels to represent CA elements. Apical dominance and induction, observable as features in the developmental processes of organisms, were introduced as the state transition rules for CA [10]. Induction is the influence of one cell onto its neighboring cells, resulting in those neighboring cells changing to display specific traits. Such induction was modeled as a neighborhood information vector $\boldsymbol{v_n}$ Fig. 2(a) around the noticed element, and the equation is set as

$$\boldsymbol{v_n} = \sum_{i=1}^{26} b_i w_i \boldsymbol{e_i} \quad (2)$$

where, i is the number of the 26 neighboring elements adjacent to the noticed element, b_i is the existence of elements taking a value of 0 or 1, w_i is the integer, from 0 to 8, expressing the size of the recorded effect in the one-dimensional array created randomly for each form generation trial, $\boldsymbol{e_i}$ is the unit vector moving in the direction of the noticed element away from the neighboring elements. Apical dominance is the quality where the dominant element, known as the apex and in control of ontogeny, produces an effect on morphogenesis. This apical dominance was modeled as a locative information vector $\boldsymbol{v_n}$ Fig. 2(b) influencing the noticed element from the apex, and the equation is set as

$$\boldsymbol{v_p} = \left(d_{\max} - d\right)\boldsymbol{e_d} \quad (3)$$

where, $d_{\max}$ is the distance between the apex and the cell that is furthest from the apex, d is the distance between the apex and the element, and $\boldsymbol{e_d}$ represents the unit vector pointing the direction of the element from the apex. This means that the closer an element is to the apex, the greater the impact of

 ISBN: 978-1-61208-206-6

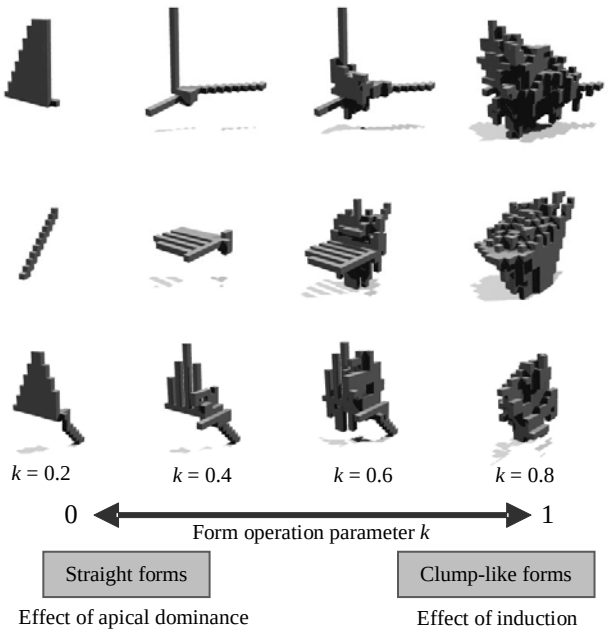


Figure 3. Changes in the features of generated forms

the apex on that element. Next, the CA input vector $\boldsymbol{v_{in}}$ is set as

$$\boldsymbol{v_{in}} = k\,\boldsymbol{v_n} + (1-k)\,\boldsymbol{v_p} \qquad (0 \le k \le 1) \qquad (4)$$

where, k is defined as a form operative parameter expressing ratio where two vectors are bonded. It is possible to adjust the rate of synthesis—the effect of induction and apical dominance—through the value of k. Fig. 3 shows the changes thus generated through form operation parameters of form feature. In equation (4), the closer the value of k is to 0, the stronger the apical dominance, meaning a constant, same-direction effect from the apex; this results in a tendency toward the generation of rod- and plate-like forms. On the other hand, the closer the value of k to 1 in equation (4), the stronger the influence of induction, meaning that multi-directional influences will be exerted by the elements surrounding the noticed element, resulting in the generation of clump-like forms [10]. The features of this system may therefore be useful in allowing us to impart meaning to the shape of icons representing registered users in our email system.

III. DESIGN DEVELOPMENT FOCUSED ON MULTI-TIME SCALE

In this section, we describe the design development process actually undertaken, based on a multi-time scale using a timeaxis design approach. We also dicuss each stage of the process.

A. Extraction of Design Elements

In this process, the design elements required to realize our design concept of the visualization of the state of KIZUNA were extracted. Elements describing state, such as the number ofemails sent and received, and the frequency of communication, and meaning elements, namely the visual changes in the icon representing registered users, were extracted. For the icon generation through bio-inspired self-organizing systems, we worked on the indivdiualization of each icon, and the extraction of meaning element, namely the offer of the enjoyment of not being able to predict growth.

1) Extraction of Time-related Design Elements: Design elements were extracted based on our design concept of the visualization of the state of KIZUNA; this allowed us to connect the meaning element of visual changes in the icon and state elements such as the number of emails sent and received and the frequency at which they were sent and received. These connections allowed us to construct a relationship between KIZUNA and our email system.

B. Element Classification and System Design

In this process, value elements required for the maintenance and deepening of KIZUNA and seminatic elements required for the visualization of the changing state of KIZUNA are classified. In addition, those design elements that were missing were extracted. The following outlines the specific details of the process. In this study, first, value growth process was introduced, and the processes of maintenance and deepening were divided into five phases, with existing value elements ordered within those phases, and the missing elements for each phase is extracted. The classification and extraction of value elements according to this value design process facilitated the clarification of the processes by which KIZUNA is deepened via this email system. Next, the multi-time scale and the value growth process were introduced, in order to classify meaning elements. We extracted additional meaning elements required in the context of our awareness of their relationships with the various value elements. This allowed us to build a KIZUNA visualization system using changing icons. This system uses icons that change according to information received from the email system of which they are part in order to visualize KIZUNA. The parameters that define the icons are threefold: element number, representing the depth of KIZUNA; transparency, representing the deepening phase of KIZUNA; and the element form features, representing the growth phase of the KIZUNA. Element number will vary according to the number of emails sent and received in short time. Transparency will vary according to the frequency at which email is sent and received in medium time. Element form feature will vary according to the number of emails sent and received and the frequency at which they are sent and received over long time.

1) Effects of Introducing the Multi-time Scale: Simply organizing meaning elements is not sufficient to understand their relationship over time, and further it is difficult to build a specific system. However, by dividing meaning space into

short time, medium time, and long time using a multi-time scale, and by clarifying the relationships that exist therein, it becomes possible to clearly order meaning elements in terms of their relationship in time. Specifically, we were able to organize elements in terms of their relationship with units of time; icon growth—according to the number of emails sent and received—is a meaning element in short time (seconds or minutes), transparency changes—corresponding to the frequency of emails sent and received—is a meaning element in medium time (hours or weeks); form feature change—determined by the number ofemails sent and received and the frequency at which they were sent and received—is a meaning element in long time (months or years). By organizing elements in conjunction with units of time, we were able to clarify the relationship between time scales and elements.

2) The Effects of Introducing the Value Growth Process: If aiming for artifice design that will increase in value over time, it is vital that the processes by which value can grow are clarified The introduction of the five-phase-value growth process in value space has the effect of helping to clarify the process of value growth, as well as to facilitate understanding of the values required at each phase. Specifically, we defined these values as: user expectation toward the new email system at the value discovery phase; user surprise at icon transformation at the value realization phase; joy at deepening KIZUNA at the value growth phase; satisfaction at the creation of precious KIZUNA at the value establishment phase; and a sense of security at leaving a record of their communication history at the value as tradition phase. By clarifying these processes, it becomes easier to envisage the scenes in which the email system might be used and the functionality required in those scenario. In this process, then, we introduced a five-phase value growth process, thereby making it possible to have a greater awareness of the relationship between scenanio and functionality and the growth of value.

C. Structuring Design Elements and System Refinement

In this process, in order to refine the system concept gleaned from the previous process, we structured the various design elements. The structurization of these elements focused on the relationship between the meaning elements that make up the KIZUNA visualization system that is at the core of our email system and state elements that are used in the expression of KIZUNA. In particular, we gave specifical numerical values to the changes in value in our three parameters of element number, transparency, and element form feature, as resulting from the meaning elements in our system. In addition to the extraction of the specific meaning elements that comprise convenience and aesthetics in GUI email systems, we also sought to extract as state elements the material properties required to realize those meaning elements. This process enabled us to refine the details of the design.

1) Parameter Settings to Express KIZUNA State: When structuring design elements, we integrated the meaning elements with physical state elements of the KIZUNA visualization system, and simultaneously set specific numerical values to express changes in physical state elements brought about by semanic elements. As an example, if the functional expression of the depth of KIZUNA in terms of the level ofemail sent and received, meets the pre-set condition of ‘send or receivemail’, the element number parameter is set to increase from 1 to 10 according to the volume of email. This method of parameter setting means that actual change can be described as numerical value change in parameter, thereby making changes previously difficult to anticipate from meaning elements alone readily understandable, as well as available to share. It also become possible to understand ongoing changes in parameters in accordance with the value growth process and multi-time scales; this can be considered as increasing the efficiency of actually building a system using a program.

2) Visual Configuation of the GUI: The visual appearance of the GUI is an important factor in determining the overall impression of any email system. Having described the maintenance and deepening of KIZUNA as the clear and specific goals of the system, it allows us to establish a visual concept for the GUI that reflected our design concept. Specific examples here include the positioning of icons in a circle, to recall the way that human relationships spread out like in circles and the use of a bird's-eye view perspective enabling the user to determine the status of all icons.

IV. KIZUNA VISUALIZER PROPOSAL

In this section, we describe the email system, entitled KIZUNA Visualizer, developed via the design development processes discussed in Section 3, as well as details of the six specific functions of the visualization system.

A. KIZUNA Visualizer: System Overview

Fig. 4 shows an overview of this email system. The system uses self-organising self-transforming icons to sustain and deepen KIZUNA, based on a core design concept of the visualization of KIZUNA. Changes in the state of the invisible interpersonal bonds between users are expressed through icons, thereby alerting the user to KIZUNA changes and promoting communication. The icons used to express KIZUNA visually are governed by three parameters: element number, transparency, and element form features. These three parameters vary according to the six functions indicated in Fig. 4, facilitating the visualization of KIZUNA as a result.

 ISBN: 978-1-61208-206-6

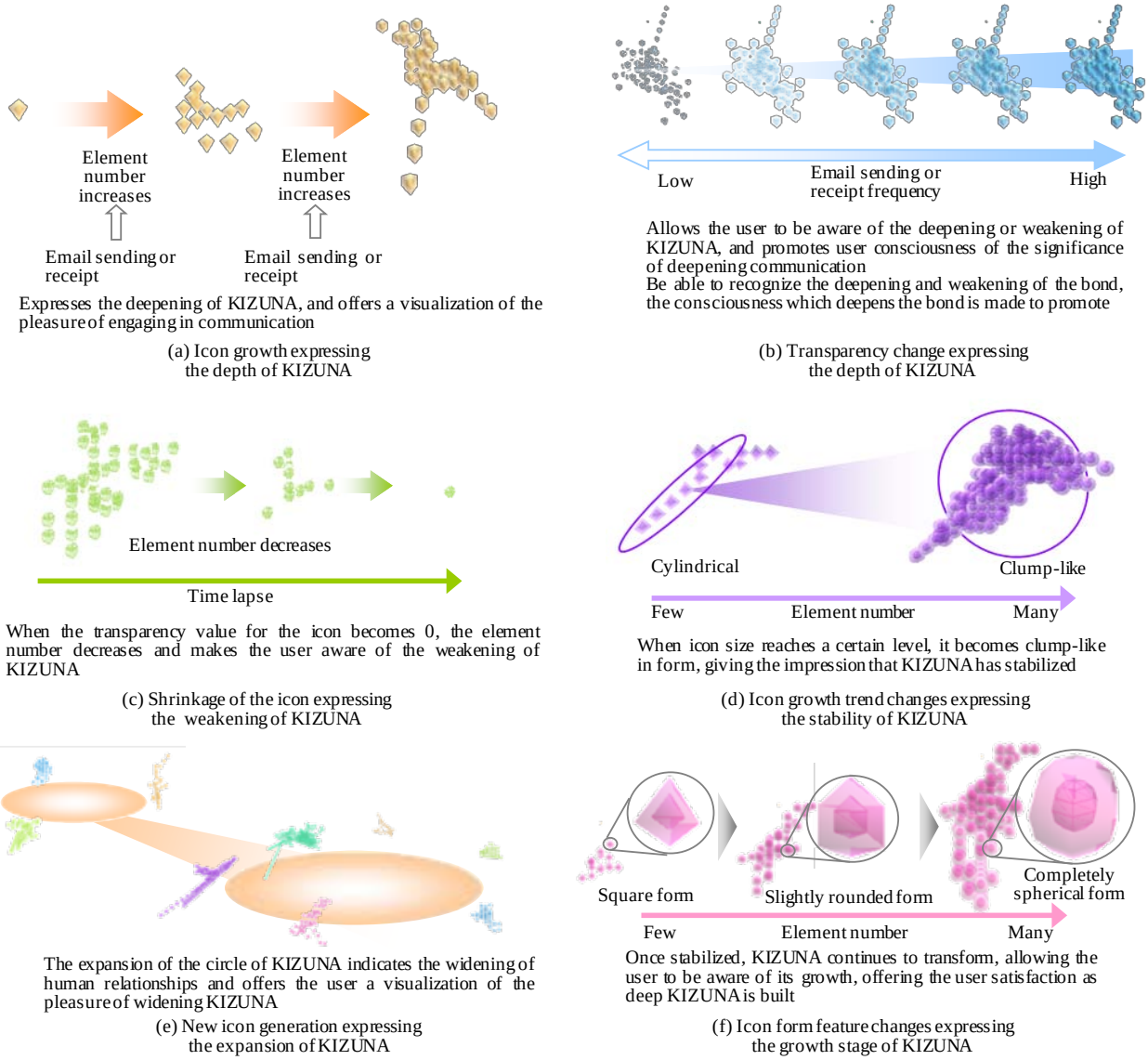


Figure 4. Six functional algorithms used in our system for the visualization of KIZUNA

B. *KIZUNA Visualizer: System Details*

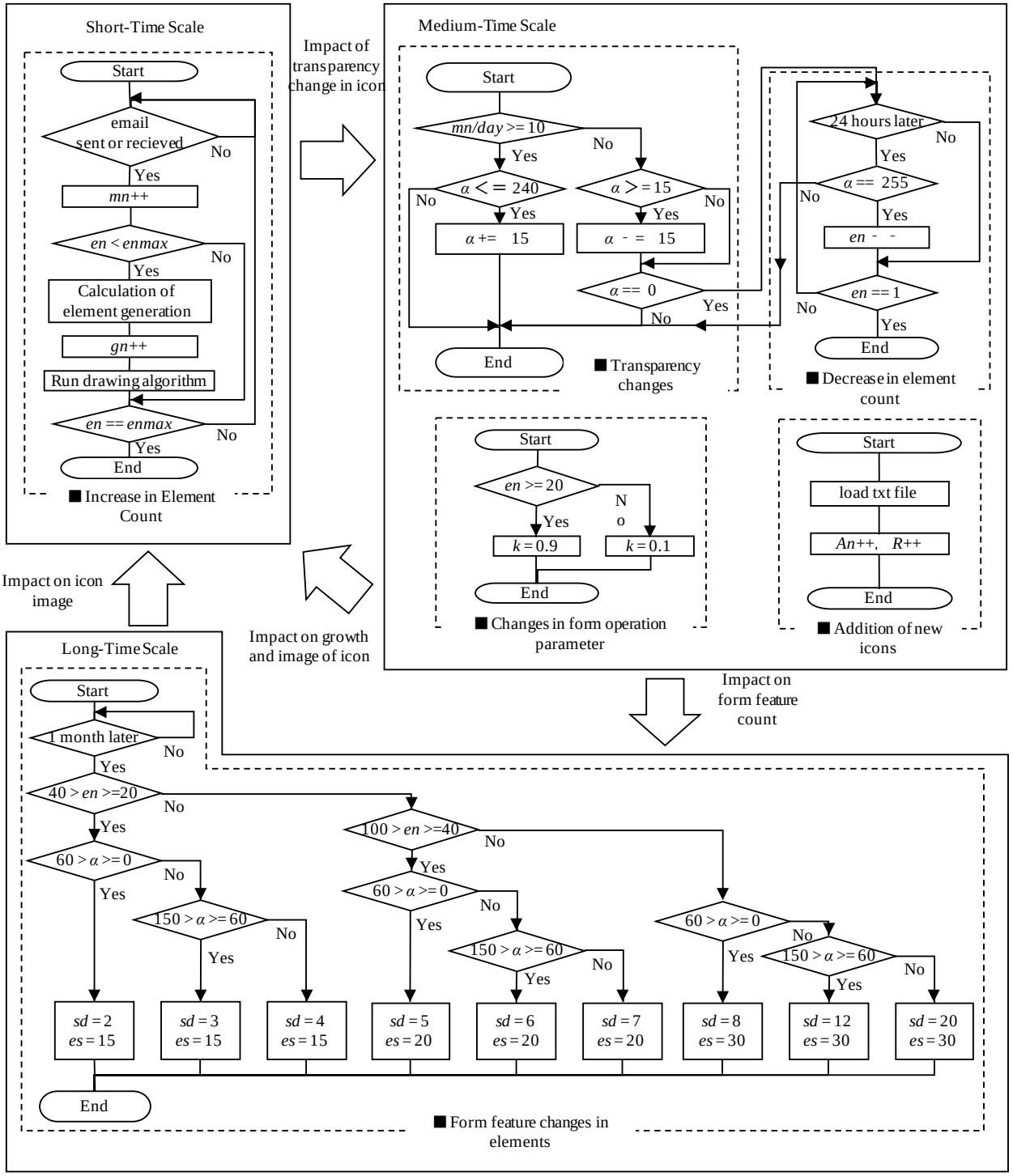
Fig. 5 shows the six functional algorithms used in our system for the visualization of KIZUNA. Here, we will give an outline of each time scale and an explanation of each of the six functions in the context of short, medium and long time scale.

1) Short-Time Scale: The short-time scale functions to increase the element number according to user action, in this case the sending and receiving of emails in units of minute.

When sending or receivingemail, where element number of the icon is less than the maximum element number 150, the bio-inspired self-organizing system will perform a calculation and the number element for the relevant icon will be increased by one generation.

2) Medium-Time Scale: In the medium-time scale, the increase in element number per day is calculated, and the transparency of the icon will change accordingly. The medium-time scale also functions to decrease the element number according to transparency, and to generate new icons.

a) Transparency Changes: Icon transparency takes a value between 0 and 255. Where the value is closer to 0, the level of transparency increases, where it is closer to 255, the icons become more opaque. The rules governing such change are set out below. When the number of emails sent and received in a single day is 10 or more, and the transparency value is less than 240, transparency (α) will



en :Element number
enmax :Maximum element number
gn :Generation number
R :Size of diameter on which icons are distributed
An:Icon number
es :Element size
α :Transparency
k :Form operation parameter
sd :Spherical polygon resolution of elements
gnmax :Maximum generation
mn :Number of emails sent and received
mn/day :Number of emails sent and received each day

Figure 5. Detailed breakdown of KIZUNA Visualization system

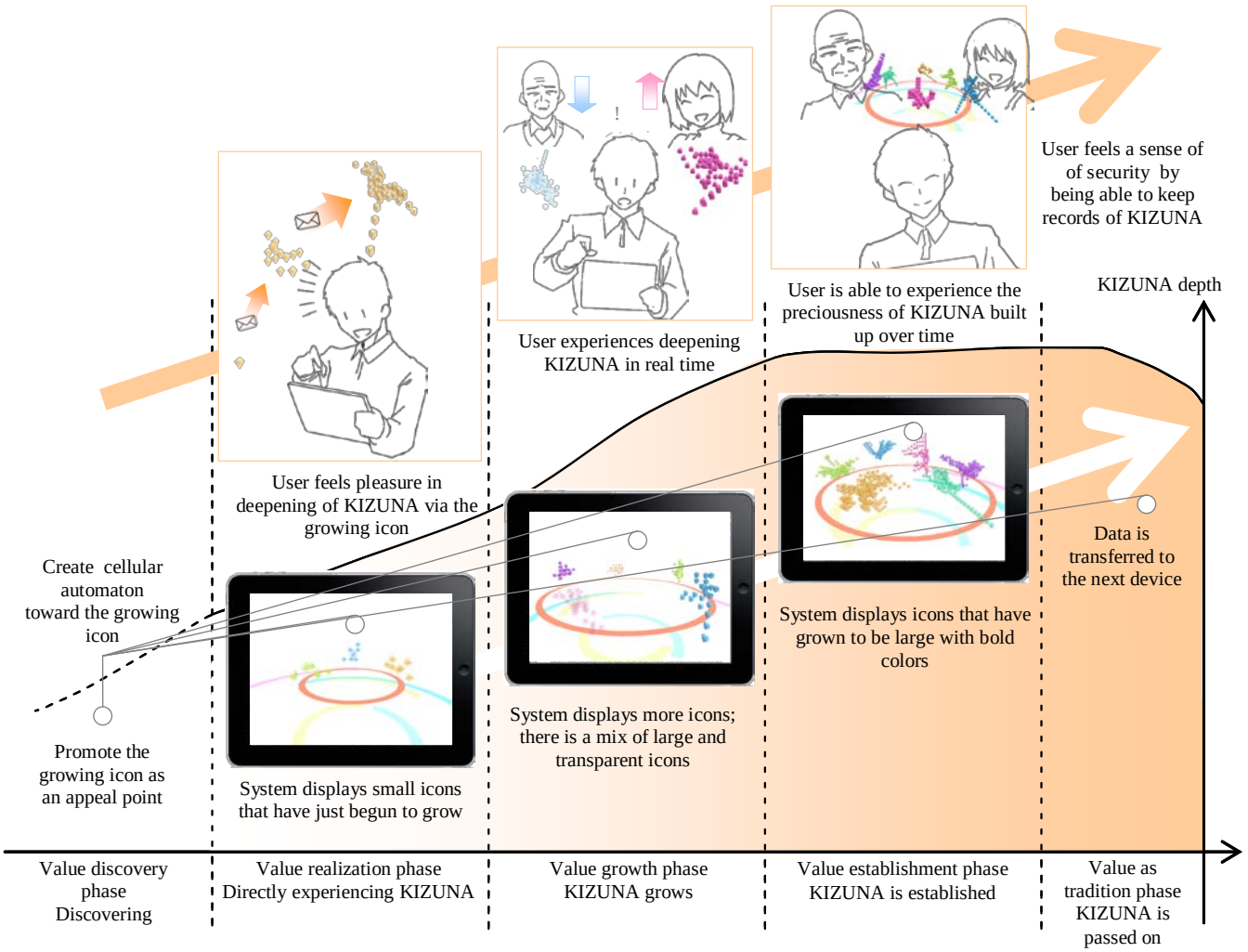


Figure 6. The deepening of KIZUNA through the KIZUNA Visualizer

increase by 15 points. Similarly, when the number ofemails sent or received in a single day is less than 10, and the transparency value is 15 or more, transparency (α) will decrease by 15 points.

b) Element Number Reduction: For every 24-hour period during which the transparency value remains consistent at 0, elements will be deleted one after another, starting with the more recent generation, to reduce the element number. Once element number reaches 1, the default position, the element will not be deleted even when the transparency value is 0.

c) Form Operation Parameter Changers: Changes in the form operation parameter *k* alter the growth trend of the icon. Specifically, where the element number is less than 20, the form operation parameter *k* is set to 0.1, the tendancy is for the icon to grow into a narrow, rod-like shape. Should element number increase to 20 or more, the form operation parameter *k* is altered to 0.9, resulting in a larger, clump-like shape.

d) Adding a New Icon: New icons can be generated by uploading a .txt file containing the name andemail address of themail correspondent to be newly registered. When a new icon is generated, the circle around which the icons are arranged expands to incorporate the new icon.

3) Long-Time Scale: In the long-time scale, the number element (increased in the short term) and the transparency (affected in the medium term) impact and alter the form features of the elements that comprise the icon.

After one month has passed, the resolution of spherical elements and the size of elements will change according to element number and transparency. The lower the element number and the closer the transparency value is to 0, the more the elements will appear rough and angular; the higher the element number and the closer the transparency value is to 255, the more the elements will appear large, smooth, and round.

 ISBN: 978-1-61208-206-6

V. DISCUSSION OF THE KIZUNA VISUALIZER

Fig. 6 shows a conceptual diagram of the deepening of KIZUNA through the KIZUNA Visualizer. Here, we discuss the processes involved in the Visualizer through the value growth process.

- In the value discovery phase, it is necessary to create expectation toward the product in the user. During this phase, product demo videos should be shown in stores and on the web, encouraging users to discover the new conceptualization of interpersonal bonds being offered to them through the product, namely an expression of KIZUNA through transforming icons. This sort of activity should make it possible to increase user expectations.
- In the value realization phase, the user needs to use the actual product and realize its value directly. At this early stage, the icon is still small, and it therefore possible to inspire user expectation as to how the icon will grow and transform. It is also possible to create excitement in the user as the icon responds to the transformation of icons asemails are sent and received, and this allows the user to enjoy the deepening of KIZUNA.
- In the value growth phase, it is necessary that the user senses that the value of the product is increasing with prolonged use. By this stage, some icons will have grown large or very opaque due to frequent communication, allowing the user to gain a direct sense of the maturation of KIZUNA, and encouraging them to become increasingly emotionally attached to the email system.
- In the value establishment phase, the user needs to become familiarized with using the product, and to feel a sense of stability. In this period, more icons will have become larger and developed clearly discernable colors, and the user should come to feel a sense of accomplishment and satisfaction at having successfully built up stable KIZUNA with family and friends.
- In the value as tradition phase, it is necessary to inspire a sense of security in the user, that the user can continue to use the product to which he or she has become attached. In this stage, information on icons that have been nurtured in the product can be transferred to other devices, allowing the user to gain a sense of sescurity that human relationships can be sustained.

As the discussion above shows, the KIZUNA Visualizer encourages user communication, and makes possible the continuance and deepening of KIZUNA.

VI. CONCLUSION AND FUTURE WORKS

In this study, we developed an email system, the KIZUNA Visualizer, designed to sustain and deepen KIZUNA—namely the precious bonds that exist between people—in response to the increasing value placed on such bonds. During design development, we adopted the multi-time scale based on timaxis design, as well as bio-inspired self-organizing systems in order to adequately consider the changes undergone by KIZUNA over time. The results of our \study are shown below.

- We proposed the KIZUNA Visualizer, an email system that enables the visualization of the state of KIZUNA through icon changes corresponding to the number and frequency ofemails sent and received.
- We set up six functional algorithms related to icon changes, and used those to construct an email system that also takes into account the relationship of icon elements with each time scale. We then constructed a workable prototype of the system.
- We considered the usefulness of the KIZUNA Visualizer from the perspective of the value growth process. The functionality of the KIZUNA Visualizer is capable of expressing the state of icons, which correponds to those values required over the KIZUNA deepening process. The results of our study imply that this system can indeed function to maintain and deepen KIZUNA.

Going forward, we will need to use the prototype we have developed to conduct evaluation testing with multiple users, in order to validate the effectiveness of the KIZUNA Visualizer and make further improvements. This will allow us to continue our work in the maintenance and deepening of KIZUNA.

REFERENCES

[1] Public Opinion Survey on the Lite of the Peaple, October, 2011, http://www8.cao.go.jp/survey/h23/h23-life/index.html, 02.12.2012

[2] M. Tachikawa, “Understanding of Peaple’s Needs to Information Technology in Spiritual Affluence Age”, IEICE Technical Report, July 2009.

[3] Y. Matsuoka and K. Sato, “New Design Paradigm : Timeaxis Design”, 4th Conference of Transdisciplinary Federation of Science and Technology, Nov. 2011.

[4] K. Yoshida, “System Design: Paradaigm Shift from Intelligence to Life”, Tokyo: Colona Publishing Co. Ltd., 2008.

[5] Y. Matsuoka, “Another Type of Design”, Tokyo: Kyoritsu Syuppan Co. Ltd., 2008.

[6] Y. Matsuoka, Design Science –Six Viewpoints for Future Creation, Tokyo: Maruzen, 2010.

[7] T. Asanuma, Y. Ujiie, K. Sato, and Y. Matsuoka, “Proposal of Design Method Based on Multispace Design Model and Its Application”, The Science of Design, vol. 58, no. 4, pp. 1-10

[8] S. Wolfram, “Theory and Application of Cellular Automata”, World Scientific, Singapore, 1986.

[9] M. Delorme, “An Introduction to Cellular Automata”, Kulwer Academic Press, Boston, 1999.

[10] K. Sato and Y. Matsuoka, “Application to a Car Body Frame Based on Parameter Guidelines for Deriving Diverse Solutions Using Emergent Design System”, 18th International Conference on Engineering Design, Aug. 2011, published by USB

 ISBN: 978-1-61208-206-6

Instructional Design of the Communicative Blended Learning for Chinese as a Foreign Language

Satoko Sugie
Graduate School of International Media, Communication and Tourism Studies
Hokkaido University
Sapporo, Japan
sugie@imc.hokudai.ac.jp

***Abstract*— This paper proposes research in progress regarding educational practice. The objective of this research is the construction of the communicative blended learning model suitable for CFL (Chinese as a Foreign Language) class in Japan. The problem addressed in the research is that of how to foster and keep motivation for Chinese language learning at CFL classes at a high school in Japan, and how to locate that motivation in the realities of students' own every-day lives. The major contribution of this research is to provide opportunities for increasing contact with young Chinese native speakers through the systematic language learning model utilizing Information and Communication Technology, which helps develop practical Chinese typing skills and enhances CFL learning motivation and satisfaction. In this research, novice learners took part in blended learning with face-to face grammatical practice, web-based training and bulletin board system interaction with Chinese native speakers. The qualitative analysis of students' assessment shows that Japanese learners have an improved feeling of satisfaction and feeling of effectiveness from the experiences of real on-line Chinese verbal communication with native speakers. This communicative blended learning model has highly increased the motivation for Chinese language learning in the non-Chinese speaking environment.**

Keywords-Computer Asisted Language Learning; Network Based Language Teaching; e-learning; blended learning

I. INTRODUCTION

This paper is composed of 8 parts including introduction, previous studies about Chinese language education with ICT, instructional design models, site design and contents, collaborative classwork and online interaction, data collection, data analysis and present findings, and conclusion and future work.

In Japan, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has promoted globalization and the adoption of IT (Information Technology) in high school education since the late 1990s. The "New Reform of Education Guidelines" was announced in 2009, in which measures of digitalization at high school are mentioned, as well as the recommendation of ICT (Information and Communication Technology) utilization in the classroom [1]. At the same time, with the recent rapid economic development of China, the level of interest in learning Chinese is on the rise. However, most high schools continue to bolster English education as the primary foreign language for learners, and Chinese is usually offered as a "Second Foreign Language". There are few professionals of Chinese language pedagogy at high schools in Japan, and the teaching/learning environment (monolingual environment, closed classroom, large class size, and short class hours) makes class management highly difficult. Unfortunately, Chinese education goals are often separated into two extremes: Simply grammatical competence, or just for fun. Most teachers who teach, and students who learn, Chinese, aimed at simply obtaining required grades or passing exams, eventually develop a dislike for the Chinese language.

II. PREVIOUS STUDIES ABOUT CHINESE LANGUAGE EDUCATION WITH ICT

Under the influence of the Internet's growth and development of ICT, the digitization of Chinese language education has gradually been developed. Academic associations and international conferences focused on the introduction of ICT methods in Chinese language teaching and learning have also been established, for example, the "Association for Modernization of Chinese Language Education (AMCLE)" [2] or "The International Conference and Workshops on Technology and Chinese Language Teaching (TCLT)" [3] etc. In this way, practical educational methods with ICT have developed globally and are being applied in many parts of the world.

TABLE I. NUMBER OF PAPERS ABOUT DIGITIZATION OF CHINESE LANGUAGE EDUCATION (AMCLE) [4][5][6][7]

Year	Venue	Theme	Published papers
1995	San Francisco, USA	Collections of Papers	contents unknown (NIS)
2000	Guilin, China	Modernized Educational Technologies and Chinese Teaching and Learning	
2002	Nanjing, China	E-Learning and Chinese Teaching and Learning	
2004	Beijing, China	New Technologies in Teaching and Learning Chinese	79
2006	Hongkong, China	Research and Applications of Digitized Chinese Teaching and Learning	76
2008	Daejeon, Korea	Advancements and Insights of Digitized Chinese Teaching and Learning	103
2010	Yantai, China	Digitized Teaching of Chinese as a Foreign Language (Practice and Reflection)	60

On the other hand, in Japan, in spite of the neighboring country of China, only several research papers related to the practical educational methods with ICT about CFL have appeared at the relevant conferences (see Table II). Also, they have few discussions about the practice of

 ISBN: 978-1-61208-206-6

communication-focused and learner-centered Chinese language education with ICT.

Thus, the practice of the communicative blended learning for Chinese language education is an unexplored field. The research about this field is significantly worthy and meaningful challenge in Japan.

TABLE II. NUMBER OF PAPERS ABOUT DIGITALIZATION OF CHINESE LANGUAGE EDUCATION IN JAPAN [8]

Year	Title of the conference	Published papers
2001 -2011	The Chinese Linguistic Society of Japan	28
	The Japan Association of Chinese Language Education	14
	Japan Society for Educational Technology (JSET)	11
	Japanese Society for Information and Systems inEducation（JSiSE）	6

III. INSTRUCTIONAL DESIGN MODELS

The objective of this research is the design of a communicative blended learning model for CFL. In this paper, the definition of blended learning is the delivery of teaching/learning through the combination of online and face-to-face interaction resulting in improved student learning. [9] It is necessary to design the lesson plan based on a systematic ID (instructional design) process. The most basic and applicative ID process consists of the following steps: (1) Analyze, (2) Design, (3) Develop, (4) Implement, (5) Evaluate (ADDIE model) [10]. Of these five steps, (1) is the most important fundamental.

Chinese language learners in Japan do not have ready access to Chinese-speaking environments and rarely have opportunities to communicate with Chinese people in daily life. A general lack of awareness of the need for Chinese language competence is also an issue; students are not aware of any benefit in learning the language, especially in a closed classroom environment. In this situation, the key to ID is knowing how to analyze learners' needs, context, educational goals, performance goals, and how to motivate learners to learn and use Chinese. Keller's ARCS-V model [11] – a model derived from the synthesis of motivational concepts and theories, namely attention (A), relevance (R), confidence (C), satisfaction (S) and volition (V) – is one of the most helpful concepts of the motivational design for learning (see Table III).

TABLE III. ARCS-V MODEL [11]

Attention	Motivation to learn is promoted when a learner's curiosity is aroused due to a perceived gap in current knowledge.
	Sub category: Perceptual Arousal/Inquiry Arousal/Variability
Relevance	Motivation to learn is promoted when the knowledge to be learned is perceived to be meaningfully related to a learner's goals.
	Sub category: Familiarity/Goal Orientation/Motive Matching
Confidence	Motivation to learn is promoted when learners believe they can succeed in mastering the learning task.
	Sub category: Learning Requirement/Success Opportunities/Internal Attribution
Satisfaction	Motivation to learn is promoted when learners anticipate and experience satisfying outcomes to a learning task.
	Sub category: Natural Consequences/Positive Consequences/Equity
Volition	Motivation to learn is promoted and maintained when learners employ volitional (self-regulatory) strategies to protect their intentions.

In the present study, a Chinese lesson plan is carefully designed to cover each of the elements of the ARCS-V model. Figure 1 shows the communicative blended learning design, which includes learner-centered & communication-focused interaction. This circular process will generate the interest of learners in various aspects of China as a country and foster motivation to learn the Chinese language.

As shown in Figure 1, Chinese novice learners (Japanese high school students) take part in a one-year communicative blended learning class, which is based on the study of grammar in the general classroom and WBT (web-based training) and on-line interaction between Chinese college students in an ICT-equipped classroom. Through the first semester (April to September), Japanese students study basic vocabulary and grammar, and at the same time, practice simplified Chinese typing as preparation for BBS interaction. In the second semester (October to February), in addition to the learning contents above, Japanese and Chinese students start BBS interaction, for their own purpose of practical communication.

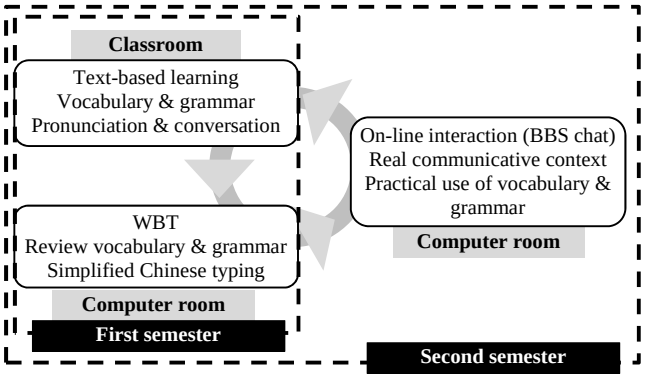


Figure 1. Communicative Blended Learning Design

IV. SITE DESIGN AND CONTENTS

Learners work on the unique web site "Chinese and Japanese Students Interaction Web" (see Figure 2) which was developed on a UNIX server managed by Hokkaido University, built around the free contents management system "Magic3" [12]. WBT and BBS interaction are carried out on this web site. In consideration of security and information protection, users must be pre-registered by an administrator. User access is restricted through the use of a password.

 ISBN: 978-1-61208-206-6

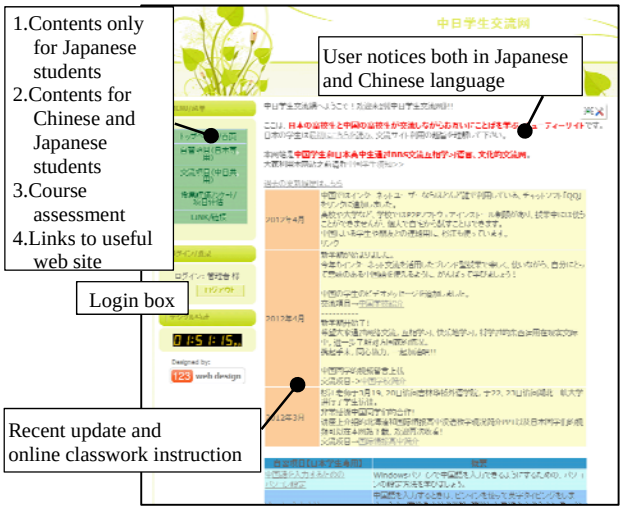


Figure 2. Top Page of Chinese and Japanese Students Interaction Web [13]

The "Interaction Web" site contents consist of 4 major parts, the functions of which are as follows:

TABLE IV. "INTERACTION WEB" SITE CONTENTS

Contents only for Japanese students	Instructions on how to change the PC settings Instructions on how to type simplified Chinese characters WBT (textbook reviews, typing exercises)
Contents for Chinese and Japanese students	BBS Japanese school and class activities introduction Chinese school introduction School annual events introduction
Course assessment	Japanese and Chinese students make assessment online (via Moodle CMS) and give feedback at the end of semester
Links	Japanese and Chinese school web site On-line dictionaries and translation site Chinese grammar explanation site Chinese level certification test information

V. COLLABORATIVE CLASSWORK AND ONLINE INTERACTION

Japanese high school students planed and created video content, namely a "school introduction", text & photo contents regarding "hot trends with Japanese high school students", and video content consisting of Chinese speeches introducing Japanese culture (see Figure 3). In addition, students wrote on topics such as "self-introduction" and "my hobby" on the BBS. 26 Chinese college students saw this content and directly interacted with Japanese students (see Figure 4).

As a basic rule of BBS interaction, Japanese and Chinese learners must use both Japanese and Chinese at the same time. In this way, they not only practice reading and writing in the foreign language which they are studying, but can also demonstrate authentic verbal behavior to each other in their respective languages. However, it is difficult to control the language use of Chinese students all the time; at times, they only write in Japanese because they do not always access the BBS during class hours. They will also take part in this interactive activity as a volunteer after returning to their dormitories.

Figure 3. Japanese school and class activities introduction

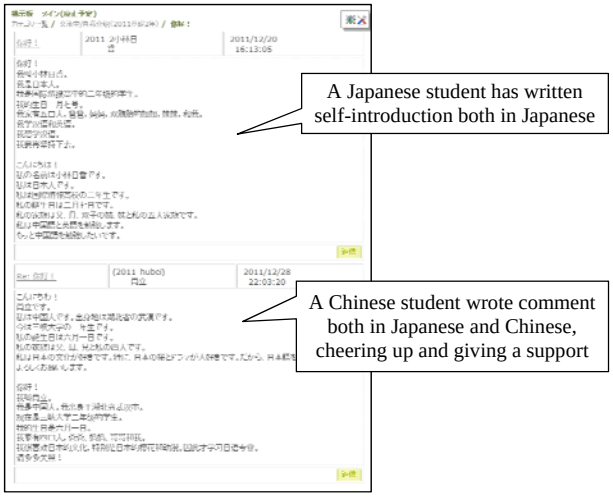


Figure 4. Japanese and Chinese students' Interaction on BBS

VI. DATA COLLECTION

The aim of data collection is to understand the actual feelings of Japanese students towards collaborative blended learning.

The "Chinese and Japanese Students Interaction Web" was established in August, 2009, and content was upgraded annually. In this research, data collection was based on classwork from May to December in 2011. 13 Japanese high school students and 26 Chinese college students directly interacted via the BBS. Japanese students accessed the BBS during Chinese class hours, and Chinese students accessed the BBS from their own computers after class. Data was collected via an online questionnaire (see Figure 5) and a group interview after the second semester.

 ISBN: 978-1-61208-206-6

Figure 5. Online Questionnaire Constructed by Moodle

The online questionnaire and supplementary interview consisted of 3 parts, (1) course design (Q.1-16), (2) collaborative group work (Q.1-20), and (3) outcomes of the communicative blended learning (Q.1-25).

Because of the difference of semester periods between Japan and China, only data from the Japanese students has been collected at the current moment.

VII. DATA ANALYSIS AND PRESENT FINDINGS

In this exploratory research, to understand whether the communicative blended learning design worked as expected or not, the qualitative analysis of learners' subjective personal reaction was the first step in the analysis. 13 Japanese students assessed communicative blended learning for CFL, and their answers show positive improve of ICT skills and a growing motivation for learning Chinese language. Figure 6 and 7 show a portion of the quantitative analysis (closed questions), and Figure 8 shows the qualitative analysis (open questions).

As shown in Figure 6, all Japanese students surveyed showed positive feelings of effectiveness in relation to the communicative blended learning design for CFL.

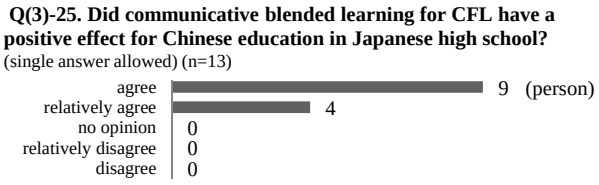
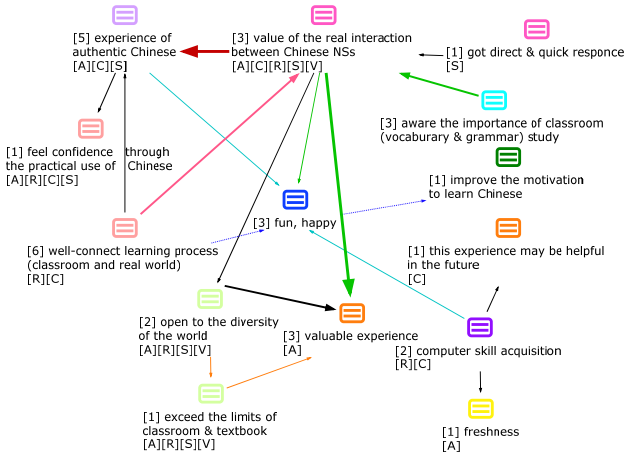


Figure 6. Positive Feelings for Communicative Blended Learning for CFL

As for the reasons for positive feelings of effectiveness, Japanese students mentioned the following, with Figure 7 showing a concept map created via open coding (the heavier the line, the greater number of students mentioning the same concepts in the open questions).

The most remarkable reaction was that 6 students had positive feelings in terms of the course being a "well-connected learning process", which means they felt they could apply language knowledge acquired in the classroom to real interaction situations. This in turn led to other positive feelings such as "there was value in real interaction with Chinese native speakers" or "was able to experience authentic Chinese language". This value recognition of self-directed and practical use of Chinese language in specific interaction situations increased their motivation for learning CFL. Also, some students were "aware of the importance of classroom study", which means they independently recognized a lack of vocabulary or grammatical competence, and the need for classwork to rectify that situation. "Computer skill acquisition" was also an example of positive feedback. Students recognized future demand for an integrated ability of Chinese language, computer skills and ICT.

Returning to the present study's central model of motivational design, the Japanese students' feedback apply well to the five elements in the ARCS-V model.



[A]= Attention, [R]= Relevance, [C]=Confidence, [S]=Satisfaction, [V]=Volition

Figure 7. Open Coding Map: Reasons of Positive Feeling Towards Communicative Blended Learning for CFL

As another significant effect of communicative blended learning for CFL, all participants acquired Chinese IME setting and simplified Chinese typing skills. More than half the participants felt confident about creating Chinese documents and Chinese to Japanese or Japanese to Chinese translation abilities with on-line learning support tools and resources. Indeed, all participants submitted Chinese writing assignments created in MS Word in preparation for BBS interaction, even though some of the participants did not have much confidence in their abilities.

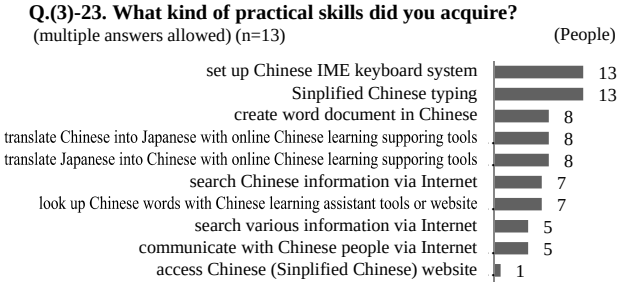


Figure 8. Practical Skill Acquisition

VIII. CONCLUSION AND FUTURE WORK

In conclusion, the communicative blended learning design for CFL highly increased the motivation for Chinese language learning in a non-Chinese speaking environment. The qualitative analysis of students' assessment shows that the Japanese learners acquired an improved feeling of satisfaction and feeling of effectiveness through the experience of real on-line Chinese verbal communication with Chinese native speakers, analyzed according to the ARCS-V instructional design model.

The future challenge is to collect more feedback from both Japanese and Chinese students in order to ascertain the validity of the effect of communicative blended learning for CFL. It is necessary to abstract the feeling of effectiveness through the axial cording (comparing incident to incident) and selective coding (to refine the hypothesis or theory) based on the grounded theory [14], aiming ultimately at the goal of theoretical generalization.

Also, in order to provide real insights to the effectiveness of this communicative blended learning model, the adaptive triangulation must be considered. CFL class size is almost the same every year (about 30 learners for the first year class and about 10 learners for the second year class), therefore it is difficult to validate the evidence solely through qualitative analysis. Therefore, one must be careful to ensure the objectivity of results.

ACKNOWLEDGMENT

I am heartily thankful to collaborators Wang You (Jilin Huaqiao Foreign Language Institute), Chen Lili (China Three Gorges University), and their students, whose encouragement and support ensured the viability of this project.

REFERENCES

[1] Japan. The Ministry of Education, Culture, Sports, Science and Technology (MEXT). "New Reform of Education Guidelines," Section 8 Foreign Language, 2009 [retrived: http://www.mext.go.jp/a_menu/shotou/new-cs/youryou/eiyaku/__icsFiles/afieldfile/2011/04/11/1298353_9.pdf, March, 2012]

[2] Association for Modernization of Chinese Language Education [retrieved: http://www.amcle.org, April, 2012]

[3] The International Conference and Workshops on Technology and Chinese Language Teaching [retrieved: http://www.tclt.us, April, 2012]

[4] P. Zhang, J. Song, and J. Xu (Ed.). "Digitized Teaching of Chinese as a Foreign Language (Practice and Reflection), " Proc. The Association for Modernization of Chinese Language Education (AMCLE). Beijing: Qinghua University Press, 2010.

[5] P. Zhang, J. Xu, and R. Gan (Ed.). "Advancements and Insights of Digitized Chinese Teaching and Learning," Proc. The Association for Modernization of Chinese Language Education (AMCLE). Beijing: Qinghua University Press, 2008.

[6] P. Zhang, S. Lin, C. Fang, T. Xie, J. Xie, and J. Xu (Ed.). "Research and Applications of Digitized Chinese Teaching and Learning," Proc. The Association for Modernization of Chinese Language Education (AMCLE). Beijing: Qinghua University Press, 2006.

[7] P. Zhang, T. Xie, and J. Xu (Ed.). "New Technologies in Teaching and Learning Chinese," Proc. The Association for Modernization of Chinese Language Education (AMCLE). Beijing: Qinghua University Press, 2004.

[8] S. Sugie. "The Construction for Chinese Language Study Support Site Utilizing NBLT (Network Besed Language Teaching)-Interactive Learners' Community between Japanese and Chinese Highschool Students-," Master's thesis, Hokkaido University (Japanese version only), 2011, pp. 31-43. [retrieved: http://eprints.lib.hokudai.ac.jp/dspace/handle/2115/47301, April, 2012]

[9] A. Heinze. "Blended Learning; An Interpretative Action Research Study," 2008 (Doctoral dissertation) [retrieved: http://usir.salford.ac.uk/1653/1/Heinze_2008_blended_e-learning.pdf, April, 2012]

[10] W. W. Lee and D. L. Owens, "Multimedia-based Instructional Design: Computer-Based Training; Web-Based Training; Distance Broadcast Training; Performance-Based Solutions," San Fransisco: Pfeiffer, 2004, p. 3.

[11] J. Keller. "Motivational design for learning and performance: The ARCS model approach," New York: Springer, 2010. [Tras. & Ed. by Katsuaki Suzuki, Tokyo: Kitaoji Shobo, 2011]

[12] Magic3 [retrieved: http://www.magic3.org, April, 2012]

[13] Chinese and Japanese Students Interaction Web [retrieved: http://mithrandir.iic.hokudai.ac.jp/sugie/magic3, April, 2012]

[14] A. Strauss and J. Corbin. "Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory (2nd edition)," Sage Publications: London, 1998.

[15] Y. Nishihori, "Effectiveness of Collaborative Language Learning in a Multicultural Distance Class over Broadband Networks", Proc. AILA 2008. The 15th World Congress of Applied Linguistics Multilingualism: Challenges and Opportunities, August 2008, p. 136.

[16] M. Warschauer and R. Kern. "Networked Language Teaching: Concepts and Practice", 2000, Cambridge University Press.

[17] A. Heinze and C. Procter. "The significance of the reflective practitioner in blended learning", International Journal of Mobile and Blended Learning (IJMBL), 2(2), 2010. In Press [retrieved: http://usir.salford.ac.uk/8823/3/IJMBL_Vol_2_No_2_Paper_2.pdf, April, 2012]

 ISBN: 978-1-61208-206-6

Collaborative Approach to WordNet and Wikipedia Integration

Julian Szymański, Rafał Korytkowski, Henryk Krawczyk
Faculty of Electronics, Telecommunications and Informatics
Department of Computer Architecture
Gdańsk University of Technology, Poland

Email: julian.szymanski@eti.pg.gda.pl, rafal.korytkowski@eti.pg.gda.pl, henryk.krawczyk@eti.pg.gda.pl

***Abstract*—In this article, we present a collaborative approach to creating mappings between WordNet and Wikipedia. Wikipedia articles have been first matched with WordNet synsets in an automatic way. Then, such associations have been evaluated and complemented in a collaborative way using a web application. We describe algorithms used for creating automatic mappings as well as a system for their collaborative development. The outcome enables further integration of WordNet and Wikipedia, which can be used in Natural Language Processing algorithms.**

***Index Terms*—WordNet Wikipedia integration, ontology matching, information retrieval, text representation, natural language processing**

I. Introduction

In today's world, text is the main medium for presenting and exchanging information. According to Royal Pingdom [1] a company that monitors the Web, in 2010 people sent 107 trillion e-mails, 25 billion tweets (Short messages shared via http://twitter.com/), existed 255 million websites and 152 million blogs. Most of such resources are unstructured, thus they are very difficult to process by the computers. At the same time more and more effort is put into developing technologies, which may help processing and extracting knowledge from that overwhelming amount of information automatically.

The Semantic Web [2] is an idea aiming at extending the Web with meta data to support the automatic processing of its content. Typically semantic is introduced by annotating words, pages or other Web resources with references to ontologies [3]. For that to be possible, ontologies need to contain tremendous amount of structuralized information and instantly evolve with the culture and language. It can be only achieved with at least partial automation of their construction. It is an interdisciplinary endeavor engaging such fields as data mining, natural language processing or artificial intelligence and cognitive sciences [4].

The goal of this paper is to present a way to integrate existing linguistic databases to satisfy the need for a robust ontology. In particular, a mapping between WordNet dictionary and Wikipedia will be created. The databases were chosen due to their extensive usage in Natural Language Processing tools [5], however, presented approach is equally applicable to other resources.

Since it is not possible to create accurate mappings entirely automatically, a collaborative approach for evaluation and improvement of automatic mappings has been used. It allows to engage many people in evaluation of automatically created mappings and manual construction of additional mappings.

The paper is constructed as follows: in sections II-IV we describe Wordnet and Wikipedia repositories and the work related to integration of their resources. The next section describes the way for pruning Wikipedia data. In section VI we describe our method that automatize process of creating mappings between Wordnet synsets and Wikipedia articles. In next section we provide results of collaborative evaluation. The conclusions and future work has been proposed in the last paragraph.

II. WordNet

WordNet is a lexical database of English language [6]. It was originally developed and is maintained at Princeton University.It is both a dictionary and thesaurus. It contains nouns, verbs, adjectives and adverbs that are arranged in sets of synonyms called *synsets*. Each synset represents a unique word meaning and has its own definition. For example word horse has five meanings:

- **horse, Equus caballus** *[solid-hoofed herbivorous quadruped domesticated since prehistoric times]*
- **horse, gymnastic horse** *[a padded gymnastic apparatus on legs]*
- **cavalry, horse cavalry** *[horse troops trained to fight on horseback]*
- **sawhorse, horse, sawbuck, buck** *[a framework for holding wood that is being sawed]*
- **knight, horse** *[a chessman shaped to resemble the head of a horse; can move two squares horizontally and one vertically (or vice versa)]*

The synsets are linked together forming a semantic network. Links between synsets are considered the most valuable asset of WordNet. They represent semantic and lexical relationships between different word meanings.

The database in its current 3.0 version contains 155,287 words arranged in 117,659 synsets and 206,941 pairs word-synset (senses). The number of links between synsets amounts to 243,229.

The most widely implemented relations between synsets are:

 ISBN: 978-1-61208-206-6

TABLE I
RELATIONS IN WORDNET

	Nouns	Verbs	Adjectives	Adverbs
Hyponymy/hypernymy	84,427	13,239	-	-
Meronymy/holonymy	22,187	-	-	-
Similarity	-	-	21,386	-
Antonymy	2,152	1,093	4,024	710
Other	86,777	50,575	41,486	3,334
Total	111,766	64,955	62,872	4,044

TABLE II
PHRASES PER SYNSETS

Phrases	Nouns	Verbs	Adjectives	Adverbs
1	42,054 (51%)	8,041 (58%)	11,353 (63%)	2,400 (66%)
2	25,780 (31%)	3,146 (23%)	4,217 (23%)	771 (21%)
3	8,674 (11%)	1,280 (9%)	1,435 (8%)	289 (8%)
4	3,359 (4%)	623 (5%)	595 (3%)	91 (3%)
>= 5	2,248 (3%)	677 (5%)	556 (3%)	70 (2%)

- Hyponyms and hypernyms. A hyponym shares a type-of relationship with its hypernym. For instance *cat* is a hyponym of *wildcat* or *wildcat* is a hypernym of *cat*. Hyponyms and hypernyms have a common root and are transitive. For example if *wildcat* is a hyponym of *tiger cat* then *cat* is a hyponym of *tiger cat* as well.
- Meronyms and holonyms. A meronym shares a part-of relationship with its holonym. For instance *roof* is a meronym of *building* or *building* is a holonym of *roof*. Such relationships are not always transitive and have been divided into six types: component - object (*branch* - *tree*), member - collection (*tree* - *forest*), stuff - object (*aluminium* - *airplane*), portion - mass (*slice* - *cake*), feature - activity (*paying* - *shopping*), place - area (*Princeton* - *New Jersey*) [7].
- Antonym is a relationship between two synsets having opposite meanings, which may be defined for nouns, verbs, adjectives and adverbs such as *work* - *idle*, *ugly* - *beautiful*, *cold* - *hot*.
- Troponym is a relationship between synsets of two verbs with a different intensity of a certain property such as *like* - *love* (by the intensity of emotions), *sip* - *drink* (by the speed of consumption).

Beside relations between synsets belonging to the same part of speech, there are morphosemantic relations, which combine words with the same root such as *assistant* (noun) - *assist* (verb) - *assistive* (adjective).

Another important factor that will be used later in this paper is a number of phrases per synset (Table II). It can be observed that over half of all synsets define only one phrase.

III. WIKIPEDIA

Wikipedia does not need much introduction. It is among ten of the most visited websites on the Internet according to [8]. The project started in 2001. Its aim was to create the biggest and open encyclopedia in the world. It has also revealed a phenomena of collaborative work. Over 10 years its users have created 20 million articles in 268 languages.

Wikipedia uses a concept of an article as the atom of knowledge. An article must conform to a few rules defined in the Wikipedia Manual of Style ,which are easy to present using an excerpt of an article, e.g.:

> **Horse** *[The horse (Equus ferus caballus) is one of two extant subspecies of* Equus ferus, *or the wild horse. It is a single-hooved (ungulate) mammal belonging to the taxonomic family Equidae. The horse has evolved over the past 45 to 55 million years from a small multi-toed creature into the large, single-toed animal of today.]*

Titles of articles must be unique, thus if a word has more meanings, a title is usually concatenated with an additional expression in parenthesis. For instance there are articles titled as *Horse (Equus ferus caballus)*, *Horse (gymnastics)*, *Horse (geology)*, etc.

Different meanings of a word can be found through disambiguation pages. They are special articles, which contain links to different meanings and can be easily recognized as they belong to a special category, use a certain template or have the *(disambiguation)* keyword in their titles. In general other meanings of a word can be also found at the top of an article and they are preceded with *For other uses, see....*

It is also important to note that *Horse (gymnastics)* is not an article, but a redirect to the *Vault (gymnastics)* article. Redirects can be synonyms, but also plural forms or misspellings. If we are redirected to a page, we will see *Redirected from...* at the top.

In addition, *Horse (Equus ferus caballus)* is assigned to 17 categories such as *Animal-powered transport*, *Domesticated animals*, *Equus*, or *Horses*. Categories form a hierarchical structure of Wikipedia. They are not articles, but special entities, which contain a short description and a link to a related article. For instance, *Equus* links to the *Equus (genus)* article. Categories are linked together and can be represented as a graph. Both articles and categories may belong to many other categories. In rare cases we may experience cycles while traversing the graph.

Hiperlinks may refer to different sections of an article, other articles or outer pages. There is a measure of the number of links pointing to a certain article, which stands for its popularity. Hiperlinks may also be used as a supplement for redirects to find different synonyms.

Links to other languages are a particularly interesting aspect of Wikipedia. It is a unique among other encyclopedia's property, which can be used to translate terms.

Wikipedia, in contrast to WordNet, covers much more knowledge. There are 3.8 million articles in English with 77.1 million internal links and 5.2 million redirects according to Wikimedia statistics [9]. On the other hand Wikipedia is less organized and more erroneous than WordNet.

IV. RELATED WORK

In order to integrate different linguistic databases common terms between them need to be found. Ruiz-Casado et al. in their work [10] tag Wikipedia articles with WordNet synsets.

 ISBN: 978-1-61208-206-6

They use Simple Wikipedia, which is a version designated for people learning English with less articles and using only basic vocabulary. In their approach, they apply a disambiguation algorithm based on the Vector Space Model to determine similarity between an article and a synset. They ran the algorithm against 1,841 articles, 33% of which were not matched with WordNet synsets, 34% were matched with exactly one synset and 33% required disambiguation. In case of articles, which did not require disambiguation the accuracy was 98% and 84% in the other case.

The reported results were satisfactory; however, we did not expect to come close to that level when applying the algorithm to the full Wikipedia, because of a significant difference in the number of articles and their complexity. Therefore, we decided to take a different path.

Another approach to the automatic integration of Wikipedia and WordNet has been based on the word co-occurrence analysis. The analysis is performed between a synset definition and a first paragraph of a Wikipedia article [11]. The obtained results (39.51% and 49.28% quality depending on the method) evaluated for 500 test mappings indicate the method can be useful, but the method requires contribution of humans.

The next approach called YAGO is an ontology constructed using Wikipedia and WordNet [12]. Text mining algorithms from those resources allow to extract over 2 millions of objects and 20 millions of related facts. The project managed to construct around 15,000 direct mappings between WordNet synsets and Wikipedia articles in an automatic way [13].

WordNet is developed as a research project in a closed academic environment. The first version of the dictionary appeared in 1993, and now a third version is available. The dictionary is publicly available, but its modification is restricted from internauts. Probably, the reason for that, is the fact that the lexicon is organized as a set of text files in a specific format, which makes it hard to apply cooperative approach for WordNet development. The lack of cooperative editing functionality is the biggest barrier to scale-up a semantic database.

In our research, we develop the WordVenture portal [14], which provides mechanisms for simultaneous work on a lexical dictionary for distributed groups of people and enables cooperative work on the WordNet database. With WordVenture, the user can browse WordNet with a web application, and display its content in a graphical interface based on an interactive graph. It provides a user-friendly way for visualizing very large sets of contextual data. Displaying only selected nodes keeps the presentation clear. Functionality of traversing the graph by selecting nodes of interest allows to explore the semantic network. The user can also query WordVenture to find a specific word and display its senses and related concepts. Connections between nodes (words or senses) are illustrated as edges of a given type. To keep graphs clear, the user can set some constraints to visualize only required types of data [15].

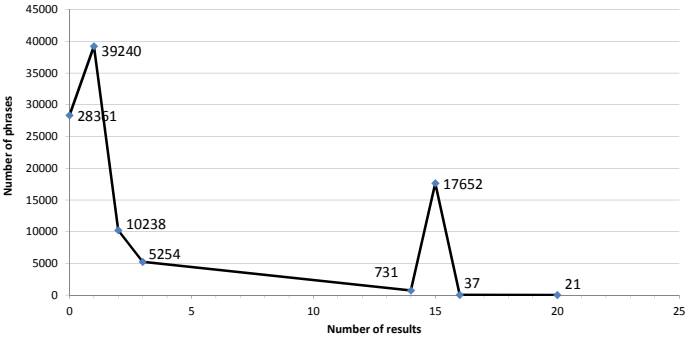


Fig. 1. Wikipedia pruning: results per query

V. WIKIPEDIA PRUNING

In the presence of a significant disproportion between the number of articles in Wikipedia and WordNet synsets, there is a need to pre-process Wikipedia and eliminate articles that are unlikely to be matched with WordNet synsets. The approach we took was to query Wikipedia via the Opensearch API with 117,798 words from WordNet. We set a limit to 20 results per query and found this way 340,000 matching articles.

We have prepared a series of statistics for the returned data. Figure 1 shows that almost half of the queries (43.87%) returned a unique result. The limit of 20 results per query has been reached only for 0.02% of queries, which indicates the parameter for the results limit is high enough.

In addition, 78,6% of articles is unambiguous (Table III), which compared to 51% of noun synsets defining only one phrase (Table II) is a rather high number. It is partially due to the fact that we recognize ambiguous phrases only if they occur both in WordNet and Wikipedia.

TABLE III
WIKIPEDIA PRUNING: PHRASES PER ARTICLES

Phrases	Articles
1	264959 (78,60%)
2	45156 (13,40%)
3	14324 (4,25%)
4	6076 (1,80%)
5	2839 (0,84%)
6	1529 (0,45%)
7 and more	2221 (0,66%)
Razem	337104

VI. MAPPING ALGORITHMS

Based on our analysis of WordNet and Wikipedia structure we have implemented algorithms, which automatically create mappings between these two databases. It is known that not all WordNet synsets can be mapped to Wikipedia articles. Often times general terms are not present in Wikipedia. For instance *friend* (a person you know well and regard with affection and trust) cannot be found in Wikipedia. The closest match we could find was *friendship*. However, more specific terms like *girlfriend* or *boyfriend* could be easily found. It is partially because WordNet is a dictionary whereas Wikipedia is an encyclopaedia. For the mappings to be useful we are less

 ISBN: 978-1-61208-206-6

interested in vague matches and we are looking for exact matches. We also prefer not to create a mapping than create a wrong one.

For that reason in our attempt we valued accuracy over coverage. The accuracy has been measured as a percent of correctly mapped synsets to all mapped synsets. The coverage is a percent of mapped synsets to all noun synsets. Note that mappings are many to many relations and sometimes we find more than one correct mapping for a synset or one article is related to more than one synset. A synset is considered to be correctly mapped when at least one of its mappings is correct.

The algorithm we constructed is combined from four independent approaches.

A. Unique results

The *unique results* algorithm was based on the fact that most of WordNet phrases are used in one synset only (Table II).

If a phrase is unique and querying Wikipedia returns only one result then we create a mapping. Such an observation allowed us to find related articles for 32,232 synsets (Table IV) which is 39% of all synsets. The evaluation for 100 random synsets has revealed an accuracy of 97% +- 3.34%. That gives us 32,024 mapped synsets out of 82,115 total synsets.

TABLE IV
UNIQUE RESULTS

Mappings	Articles
1	31987
2	118
3	3
Total	32232

The *xerox* synset is a good example where the algorithm works well.

> **Xerox, xerographic copier, Xerox machine** *[a duplicator (trade mark Xerox) that copies graphic matter by the action of light on an electrically charged photoconductive insulating surface in which the latent image is developed with a resinous powder]*

Searching for synonyms in Wikipedia gives following results.

> **Xerox**: 14 results
> 1. **Xerox** *[Xerox Corporation is an American multinational document management corporation that produced and sells a range of color and black-and-white printers, multifunction systems, photo copiers, digital production printing presses, and related consulting services and supplies.]*
> 2. **PARC (company)** *[(Palo Alto Research Center Incorporated), formerly Xerox PARC, is a research and co-development company in Palo Alto, California, with a distinguished reputation for its contributions to information technology and hardware systems.]*
> 3. **Xerox Star** *[The Star workstation, officially known as the Xerox 8010 Information System, was introduced by Xerox Corporation in 1981. It was the first commercial system to incorporate various technologies that today have become commonplace in personal computers, including a bitmapped display, a window-based graphical user interface, icons, folders, mouse, Ethernet networking, file servers, print servers and e-mail.]*
> ...
> **xerographic copier**: 0 results
> **Xerox machine**: 1 result
> 1. **Photocopier** *[A photocopier (also known as a copier or copy machine) is a machine that makes paper copies of documents and other visual images quickly and cheaply.]*

Applying the above described algorithm we create a mapping from the *Xerox* synset to the *Photocopier* article, which in fact have a redirect from *Xerox machine*.

It is easy to find an example where the algorithm does not work as expected. For instance the *indorsement* synset is matched with the *blank endorsement* article.

> **indorsement, endorsement, blurb** *[a promotional statement (as found on the dust jackets of books)]*
>
> **Blank endorsement** *[Blank endorsement of a financial instrument such as a check is only a signature, not indicating the payee.]*

It is because Wikipedia returns a single result for indorsement. The right *Testimonial* article is returned for the endorsement phrase, however, it is not matched as it is one of many.

> **Testimonial** *[In promotion and of advertising, a testimonial or show consists of a written or spoken statement, sometimes from a person figure, sometimes from a private citizen, extolling the virtue of some product.]*

B. Synonyms

In the presence of 21.4% synonyms in the pruned Wikipedia (Table III) and 49% in WordNet synsets (Table II), we assumed that if the same article occurs at least twice in the results from querying Wikipedia with synonym words from WordNet then a mapping exists. The *synonyms algorithm* has covered 22% of synsets with 88% +- 6.43% accuracy. That gives us 18,065 mapped synsets, 15,897 +- 1,161 of which are correct.

Harvard, Harvard University [a university in Massachusetts] is an example where the algorithm works well. Querying Wikipedia with the *Harvard* phrase gives us 14 results whereas *Harvard University* 13 results. Both queries return the *Harvard University* article at the top position in the result set, thus it is recognized as the correct one.

An example of a wrong mapping is for the **commission, delegacy, delegation, mission, deputation** *[a group of representatives or delegates]* synset. The algorithm creates an invalid mapping to the **Delegation** *[Delegation (or deputation) is the assignment of authority and responsibility to another person (normally from a manager to a subordinate) to carry*

 ISBN: 978-1-61208-206-6

out specific activities.] article, which is contained in results for *delegation* and *deputation*. The correct article **Delegate** *[A delegate is a person who speaks or acts on behalf of an organization (e.g., a government, a charity, an NGO, or a trade union) at a meeting or conference between organizations of the same level]* is to be found in the returned results, but it is further on the list.

C. Exact matches

A third implemented algorithm created a mapping whenever an article title and a synset phrase were the same, but only if the phrase was used in no more than one synset. As a result 59% of synsets have been matched with articles with a measured accuracy of 83% +- 7.35%. That gives us 48,447 synsets, 40,211 +- 3,560 of which are correct.

The strength of this algorithm lies in the fact that 51% of synsets have exactly one sense and define such unique terms as Lycopodium obscurum, Centaurea, Green Revolution, etc.

Among wrong results the **fishbone** *[a bone of a fish]* synset is to be found, which is mapped to the **Fishbone** *[Fishbone is a U.S. alternative rock band formed in 1979 in Los Angeles, California, which plays a fusion of ska, punk rock, funk, hard rock and soul.]* article. To our surprise manual search did not let us find any matching article.

D. Most used

The last approach was based on an assumption that the first returned result from the Wikipedia Opensearch API is the correct one. If a synset has synonyms, then we select an article that appears the most frequently and at the highest positions among all returned results. This trivial approach was tailored for improving the overall coverage. However, it has introduced a very high number of wrong mappings. As many as 84% synsets have been mapped with a measured accuracy of only 17% +- 7.36%. That gives us 68,976 mapped synsets, but with only 11,726 +- 5,047 correct.

E. Final results

The final run was selected based on the highest F-measure [16]. The F-measure is a weighted harmonic mean of precision and recall and it is defined with formula 1.

$$F = 2 * \frac{precision * recall}{precison + recall} \quad (1)$$

The precision is the number of correct results divided by the number of all returned results, whereas the recall is the number of correct results divided by the number of results that should have been returned. Mappings between synsets and articles can be correct, wrong or non-existing. To simplify calculations of the F-measure we assumed that all synsets can be mapped, thus the recall is the number of correctly mapped synsets divided by the sum of synsets, which are mapped correctly and not mapped at all.

It was an intersection of the Unique Results, Synonyms and Exact matches algorithms (2), which have produced the best results. The algorithms have been run separately and results

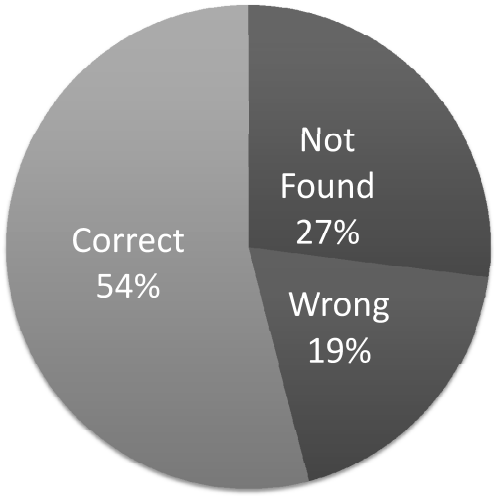


Fig. 2. Final results for Unique Results, Synonyms and Exact Matches

merged. In the effect 60,623 synsets were mapped, which is 74% of all noun synsets with a measured accuracy of 73% +- 8,7%, which is as many as 44,254 +- 5,247 correctly mapped synsets.

The overall results of running all four algorithms separately and in combinations are presented in Table V.

TABLE V
RESULTS OF MAPPING ALGORITHMS

Algorithm	Precision	Recall	F-measure
Unique results (UR)	0,97	0,38	0,55
Synonyms (S)	0,88	0,19	0,32
Exact matches (EM)	0,83	0,54	0,66
Most used (MU)	0,17	0,47	0,25
UR + S + MU	0,37	0,81	0,51
UR + S	0,86	0,43	0,58
UR + S + EM	0,73	0,68	0,70

VII. COLLABORATIVE EVALUATION AND CREATION OF MAPPINGS

Due to the nature of the problem, it is impossible to automatically evaluate created mappings to achieve higher precision. In order to speed up the process of evaluation and creation of missing mappings a system for collaborative work was implemented.

The project – ColabMap [17] enables many users to work simultaneously via the web interface. Their task is to assess correctness of automatically created mappings as well as to manually create new mappings.

The user needs to login in order to start assessing mappings. The authentication allows to track down already assessed items so that they are not presented to the same person twice, but but to resolve the problem of different opinions from different people. Next a random synset is displayed. If a mapping was created, an excerpt from a Wikipedia article is presented The user needs to choose one of four possible actions: Wrong, Acceptable, Perfect, or Skip. Skip should be chosen if the user

 ISBN: 978-1-61208-206-6

do not have enough expertise or certainty regarding accuracy of the mapping.

On the other hand, if a mapping does not exist yet or was wrong the user is asked to create a new mapping. In such a case the user is presented a list of possible articles from Wikipedia. There is also a field, which allows to search Wikipedia manually to find an article that is not on the list. The user may select multiple articles by choosing the Acceptable or Perfect score for each one, which will result in multiple mappings being created at once.

Answers of users are persisted separately so that if an administrator discovers a malicious user, they can be easily deleted. The results are presented on the statistics page. One can find there real-time statistics of evaluated and created mappings. There is also a feature, which allows to export mappings in a text format, but it is not yet exposed via the web interface.

The application back-end is written entirely in Java using the Spring framework. All data including WordNet and pruned Wikipedia are stored in the database. For the efficiency all Wikipedia queries and results are cached in the db as well. The module for accessing dictionaries and mappings can be easily decoupled from the web application and used in other applications through a well defined API. It allows to search for terms in both dictionaries making use of the established mappings.

The most current mappings between WordNet synsets and Wikipedia articles we deployed at web page of our ComputationalWikipedia project [18] aiming at create computational representations of Wikpedia [19].

VIII. Future work

Mappings between WordNet synsets and Wikipedia articles make it possible to use these two resources in Natural Language Processing simultaneously. We think the mappings should improve existing text representations used in the machine processing. The basic assumption is to provide extended information about words in the written text and using it provide elementary meaning of the utterances.

The integration of the resources opens possibilities to improve WordNet development. We plan to mine [20] Wikipedia structure and introduce new significant relations to WordNet. It should considerably extend the cross part of speech relations that are especially slimy defined in WordNet. We also plan to extend WordNet sparse synset definitions with extensive articles' content. Note that the definitions can be translated into other languages thanks to Wikipedia language links, which also enables multilingual linguistic dictionaries development.

ACKNOWLEDGMENTS: The work has been supported by the Polish Ministry of Science and Higher Education under research grant N N516 432338.

References

[1] http://royal.pingdom.com/2011/01/12/internet-2010-in numbers/, (Online, accessed: 2012 June).

[2] Y. Ding, D. Fensel, M. Klein, and B. Omelayenko, "The semantic web: yet another hip?" *Data & Knowledge Engineering*, vol. 41, no. 2-3, pp. 205–227, 2002.

[3] K. Goczyła, T. Grabowska, W. Waloszek, and M. Zawadzki, "The knowledge cartography–a new approach to reasoning over description logics ontologies," *SOFSEM 2006: Theory and Practice of Computer Science*, pp. 293–302, 2006.

[4] P. Buitelaar, P. Cimiano, and B. Magnini, "Ontology learning from text: An overview," *Ontology learning from text: Methods, evaluation and applications*, vol. 123, pp. 3–12, 2005.

[5] C. Manning, H. Schütze, and MITCogNet, *Foundations of statistical natural language processing*. MIT Press, 1999, vol. 59.

[6] G. Miller, "Wordnet: a lexical database for english," *Communications of the ACM*, vol. 38, no. 11, pp. 39–41, 1995.

[7] J. Szymański, *WordNet - bazodanowy system jako slownik jezyka angielskiego*. Politechnika Gdańska, 2006.

[8] http://www.google.com/adplanner/static/top1000, (Online, accessed: 2012 June).

[9] Wikipedia Statistics, http://stats.wikimedia.org/EN, (Online, accessed: 2012 June).

[10] M. Ruiz-Casado, E. Alfonseca, and P. Castells, "Automatic assignment of wikipedia encyclopedic entries to wordnet synsets," *Advances in Web Intelligence*, pp. 380–386, 2005.

[11] J. Szymański and D. Kilanowski, "Wikipedia and WordNet integration based on words co-occurrences," *Proceedings of 30th International Conference Information Systems, Architecture and Technology*, vol. 1, pp. 93–103, 2009.

[12] F. Suchanek, G. Kasneci, and G. Weikum, "Yago: A large ontology from wikipedia and wordnet," *Web Semantics: Science, Services and Agents on the World Wide Web*, vol. 6, no. 3, pp. 203–217, 2008.

[13] F. Suchanek and G. Kasneci, "Yago: a core of semantic knowledge," *Proceedings of the 16th international conference on World Wide Web*, pp. 697–706, 2007.

[14] Szymański, J. et al. (2012, June) Cooperative Wordnet Editor – WordVenture. http://wordventure.eti.pg.gda.pl.

[15] J. Szymański, "Cooperative wordnet editor for lexical semantic acquisition," in *Knowledge Discovery, Knowlege Engineering and Knowledge Management*, ser. Communications in Computer and Information Science, A. Fred, J. L. G. Dietz, K. Liu, and J. Filipe, Eds. Springer Berlin Heidelberg, 2011, vol. 128, pp. 187–196.

[16] G. Hripcsak and A. Rothschild, "Agreement, the f-measure, and reliability in information retrieval," *Journal of the American Medical Informatics Association*, vol. 12, no. 3, pp. 296–298, 2005.

[17] J. Szymański and R. Korytkowski. (2012, June) ColabMap project. http://kask.eti.pg.gda.pl/colabmap.

[18] Szymański, J. et al. (2012, June) Computational Wikipedia project. http://kask.eti.pg.gda.pl/CompWiki/index.php?page=wordnet&.

[19] J. Szymański and W. Duch, "Representation of hypertext documents based on terms, links and text compressibility," *Neural Information Processing. Theory and Algorithms*, pp. 282–289, 2010.

[20] I. Witten and E. Frank, *Data Mining: Practical machine learning tools and techniques*. Morgan Kaufmann, 2005.

 ISBN: 978-1-61208-206-6

Oh, no! Not Another Web-based Desktop!

Anna Goy, Giovanna Petrone, Marino Segnan
Dipartimento di Informatica
Università di Torino
Torino, Italy
{goy, giovanna, marino}@di.unito.it

***Abstract*—Among the advantages of cloud services, the most important are ubiquitous availability and collaboration support. Are the current technological solutions up to the job, in order to face the challenges posed by these two features? To provide an answer, the paper surveys some examples of online collaboration applications and concludes that what is still missing is an environment that acts as a "glue" with respect to all user online activities. We present *TablesPlusPlus* (T++), an online meta-environment handling thematic and collaborative contexts as *tables*. The user sits at to organize and perform her activities, thanks to an effective support to user collaboration. The paper discusses the characteristics of T++ and describes its architecture, together with our proof-of-concept prototype. T++ represents the missing environment, acting as a "glue" with respect to heterogeneous collaborative user activities.**

Keywords-Online collaboration; cloud services; ubiquitous services; activity context; Web desktop.

I. INTRODUCTION

Cloud computing [10] is the paradigm that enabled the most recent step of a trend started with the so called Web 2.0 [37] some years ago: Web sites become more interactive, enabling users to perform various kind of activities online; tools installed on the user's PC are replaced by services offered over the Net and accessed through a Web browser; connection availability increased significantly, enabling users to be almost always online; mobile apps available for smartphones and tablets enable users to connect to online services anytime/anywhere; social software provided over the Internet supports collaboration and sharing among users.

Cloud services (i.e., Web-based applications running "in the cloud") have many advantages with respect to stand-alone applications: e.g., they are less expensive, they are always up to date, they are more secure. However, from our point of view, the two main advantages of cloud services are ubiquitous availability and collaboration support. A cloud service is always available to the user, provided that she has a device with a Web browser (or an app) and an internet connection. Moreover, cloud services provide a flexible and effective support to collaborative activities of users. Users can connect to their office applications from home in order to read or update documents; they can access their family calendar and schedule appointments while sitting on a train; they can participate in a discussion aimed at taking an urgent decision through their smartphones; and so on. Computer Supported Collaborative Work (CSCW) is a research field that dates back to the '80s, but the growth of the Web in the last decades, coupled with widespread internet availability, has brought a huge impulse to the need of supporting user working or living in different places to collaborate on various kinds of activities, even outside the company environment. Moreover, a number of key factors have made Web-based user collaboration an issue of major importance. Such factors can be summarized as follows.

(1) In the last decade there has been a cultural shift towards "24/7 sharing" [20], meaning that people are, or need to be, always online, in order to share content, information, knowledge. In particular, Girard and colleagues claim that people born between 1980 and 2000 can be considered a "share generation": they "grew up digital" and consider sharing information and knowledge as a natural attitude, much more than their parents [20].

(2) Many experts from different fields claim that encouraging collaboration in work environment results in huge benefits for the company itself. Effective collaboration and knowledge sharing among workers could result in an enhanced innovation capacity, decreased time to market, reduced time in the sales circle or in customer care services, reduced travel costs, easier decision making [20].

(3) Private and, in particular, family life has become much more complex than before [33][34]: families have to coordinate many mundane activities, involving parents, children, or both. School activities can require parents participation; children are involved in cultural or sports after-school activities; they have an active social life which has to be supported; parents have to merge work commitments with family needs and personal leisure; and so on.

(4) Work tends to be performed ubiquitously: it is not necessary, or possible, to be always physically at the workplace; people are more and more used to perform work tasks remotely, not only from home, but while traveling, for instance [28]. This trend leads to the idea of a *virtual enterprise* [20][33], in which physical offices are not important, or even do not exist, while many activities and communications take place in the cloud.

(5) Work and private life tend to mix together [20][33]: they are not distinct spheres any more, handled at different times and places, and with different tools. People get used to connect to their cloud office while at home, or on holiday; private and work calendars should be integrated in order to have an holistic view of personal schedules, which enables an integrated management of life activities [27][34].

 ISBN: 978-1-61208-206-6

The question this paper tries to answer is the following: are the current technological solutions up to the job, in order to face these challenges? To answer this question we will briefly survey the various available solutions supporting user collaboration in different contexts (Section II). On the basis of this critical analysis, we will conclude that what is missing is not just another collaborative tool, but a framework supporting the user in easily managing different collaborative tools all together. This goal is reached by proposing an innovative interaction model, implemented by an application that acts as a "glue" with respect to all user activities (Section III). We will conclude the paper highlighting the major open issues of our work (Section IV).

II. RELATED WORK AND MOTIVATIONS

An exhaustive survey of the existing Web-based applications supporting various type of collaboration is impossible to realize, since their number is huge. The AppAppeal Web site [4] provides a thorough review of more than two thousands existing online collaboration tools (grouped in 154 categories). However, we would like to take some of them into account, as representatives of the different categories, in order to provide an overview of the supported functionalities, which should highlight what is still missing. A good and wide survey can be found in [33].

The oldest and most popular applications that, to some extent, support user collaboration are online communication tools, like email, instant messages, and chat managers (e.g., AOL Instant Messenger [3], Windows Live Messenger [31]). More complex multi-party communication applications are Web-based audio/video conferencing tools, usually including file sharing, annotation, whiteboard features, chat, etc. An An example is Skype [39], among many others. Moreover, online file sharing repositories (e.g., Dropbox [13]) enable users to store and to exchange files in different formats. Besides these "historical" solutions, there are plenty of applications enabling collaboration on specific activities. A significant example are online services enabling collaborative word processing, including spreadsheets and presentations editing (e.g., Google Documents [24], eXpresso [16], Empressr [15]).

The major family of applications supporting user collaboration includes groupware and project management tools. Many of the current solutions are Web-based (e.g., EGroupware [14], Feng Office [19], ActiveCollab [1], BSCW [7]), usually support workflow management, and are often integrated with communication tools, productivity applications (e.g., word processing), and document sharing.

Some recent online services provide a more flexible collaboration support. For instance, Cohuman (recently rebranded as Mindjet Connect Action) [9] supports users in coordinating and planning their daily tasks and projects; Kohive [30] is an Web-based collaborative desktop particularly suitable for small businesses and informal groups; Teambox [40] is an open source collaboration tool enabling users to coordinate team members by assigning tasks, managing projects, and sharing ideas and documents.

Moreover, there are many tool suites aiming at supporting collaborative work within the enterprise, like, e.g., Microsoft Office 365 [32] and Google Apps for Business [23]. Such suites typically support email, messaging services, chat, and video-conferencing; collaborative word processing; file sharing, shared calendars, and often also Web site development and maintenance. Other type of enterprise cloud collaboration environments are tools like Cisco Collaboration Cloud [8], addressing teleconferencing environments to help small companies to be present at their customer sites, without traveling burdens.

All these applications are usually oriented to workflow and enterprise content management, and can be hardly exploited to manage the different aspects of everyday activities, merging business and private concerns (as outlined in Section I). Moreover, they are typically based on closed architectures: although they offer many services, the user is forced to abandon her favorite collaborative tools in favor of an exclusive adoption of the groupware application; another consequence of the closed architecture is the impossibility of plugging in external services, to enhance the system functionality answering a user need.

Besides enterprise-oriented applications, there are tools which aim at a simpler handling of to-do lists, thus more suited to informal collaboration contexts. E.g., Google Tasks [24] handles simple tasks as lists of text notes and it is integrated with Google Calendar [24] and Google Mail [24], thus enabling users to easily convert an email message into a task. Other popular task managers are Things [41], for Mac and iPhone, and DoIt [12]. These tools have some strong limitations: their integration with other possible sources of tasks (e.g., instant messages, social networks) is very limited; tasks are handled as simple text notes, with no structure and no integration with other applications supporting their execution; and their collaborative features are very poor.

There are also some environments aiming at providing comprehensive suites including different integrated collaborative tools. A popular example is Zoho suite [42], that includes online business intelligence and CRM tools, besides project management, collaborative word-processing, communication facilities, and so on. Another type of Web application geared towards providing a unified access to different collaborative tools are the so-called *Web-based desktops* (*Webtops*), usually characterized by a desktop-like graphical user interface, often similar to that of Windows or Mac OS, accessible via a simple Web browser. Some popular Webtops are eyeOS [17], Nivio [35].

All these solutions, providing a unified environment for accessing different services, are probably the best answer to the requirements stated in Section I. However, they still suffer a lack of integration with heterogeneous applications, since the applications available in such suites are only those provided by the same provider or by a partner of it.

Finally, there is a particular type of Web sites that, to some extent, enables user collaboration, and that is worth mentioning since it is by far the most popular way people use to communicate and share contents: social networks, like Delicious [11], enabling users to keep their bookmarks online and to share them, or like the more generic Facebook [18] and Google+ [26]. Within social networks, the main goals are communicating and sharing rather than

 ISBN: 978-1-61208-206-6

collaborating. Miller states this very clearly: "I find social network groups especially useful for community groups, far-flung friends, and families. You get just enough functionality to keep everyone in touch with each other" [33]. "These groups lack the advanced collaboration features that help to keep group projects on track" [33]. However, since they are used by a huge number of people, we think that they must be taken into careful account. Thus, in the following we briefly survey the main functionality of the most popular one, i.e., Facebook, and of its most recent competitor, Google+.

Being both social platforms, Facebook and Google+ share many features. In both cases, the main interaction metaphor is accessing a "stream" of content, and the basic activities are reading/publishing posts and state updates, and sharing information. Both Facebook and Google+ enable the user to create private, possibly overlapping groups of contacts, which in Google+ are called *circles*. The main goal of Google+ circles is *selective sharing* (users can publish content available only to some circles) and *selective following* (they can decide to see only the contents published by members of a circle). Chat presence is not selective with respect to circles/groups; however, in both Facebook and Google+, the user can manually configure selective presence with respect to pre-defined lists of contacts. Group chat can be used to plan activities with multiple people, in both cases. Google+ is fully integrated with many Google services (e.g., Google Mail, Google Documents, Google Talk); similar services are provided also by Facebook, but Google services integration is supported by the Google toolbar, which provides notifications concerning the Google environment even when the user is not looking at any Google+ page. Finally, both platforms are easily accessible from mobile devices (through Android and iPhone apps).

Besides these common features, there are also some differences. The first set of differences concerns Google+ circle management (with respect to Facebook groups). Circle names (and thus circles *tout court*) are visible only to their owner, and represent an individual "perspective" on the social network. On the contrary, Faceboook groups are "in the world" and are not simply a "view" of it. When invited, a user receives a notification and is automatically added to the group. The mechanism is similar in Google+: circles can contain people I think are interesting, even if they are not aware of belonging to a circle of mine, and even if we do not know each other; Google+ notifies you if I added you to one of my circles, but does not notify if I move someone, for example, from my "friends" circle to my "ugly people" one. One of the most interesting aspects of Google+ is that users can share a post with people who are not Google+ users: in this case, sharing is done via email. Finally, Google+ offers an innovative functionality, called *hangouts*: Google+ users can access virtual video-rooms where people can meet online to chat or to see a YouTube video all together. An interesting aspect of hangouts is that they do not have an "owner" and control is totally "egalitarian": everyone in it can invite anybody else and can act (play, stop, pause) on a YouTube video shown in the "room".

We would like to conclude this section by highlighting the main reasons why social networks are not enough to support user collaboration in the perspective outlined in Section I. As we stated above, social networks are mainly focused on communication and sharing, enabling the user to move within structured streams of contents. As a consequence, in Facebook groups, collaboration tools are basically limited to chat interaction; in addition, Facebook chat, like other chats, is limited from a workspace awareness viewpoint, since it does not support selective presence based on group membership. Also Google+ circles fail to support user collaboration in a general sense: each circle, in fact, exists only from the viewpoint of its creator, and thus it cannot be used by the circle members for managing the execution of shared activities. Moreover, due to their different goal, social networks, similarly to the other collaborative environments discussed before, lack the integration with heterogeneous services. Thus, social networks, like many other collaboration tools mentioned above, can be seen as one of the possibilities offered to Web users to communicate, share and - to some extent - collaborate online. However, what is still missing is a meta-environment which should be able to manage all the different tools the user is used to, by organizing them in workspaces which have, as their main characteristic, the effective support to a "egalitarian" and user-friendly collaboration. Next section describes our proposal in this direction.

III. OUR PROPOSAL: TABLESPLUSPLUS

The interaction model we propose is based on the metaphor of *tables* the user sits at in order to perform (online) activities. Tables represent activity contexts, and can be created around an interest or a more specific goal. E.g., we can have a permanent table about my interest in Buddhism, but also a temporary table for the organization of a journey to India. The meta-environment enabling users to create and manage tables is called *TablesPlusPlus* (T++). In the following, we will describe a usage scenario, to provide the reader with an intuitive idea of the support that T++ could offer. Then, we will characterize tables in order to differentiate them from currently available proposals, and finally we will present T++ architecture, together with our proof-of-concept implementation.

A. Usage Scenario

Maria is a 40 years old researcher at the local university; she is married with Marc and they have two children, Albert and Paula; Maria is interested in Buddhism, and sometimes she leads travel groups to India. Within her T++ environment, she has (among others) the following tables:

(T1) *Research*, used to manage her collaborations with her research group at the university. Table members are four colleagues of her. Objects lying on this table are: a Zoho Project, used to manage a research project including foreign partners; various documents concerning her current main research thread; some related papers and materials (links to online pdf documents or Web sites); a small workflow, used to handle tasks concerning a national project proposal.

(T2) *Family*, used to manage family life. Table members are her husband Marc, her children, and her mother Louise. Objects lying on this table are some to-do items (e.g., book a

 ISBN: 978-1-61208-206-6

visit to the dentist for Albert), a shared document containing the shopping list, a link to the Genova Aquarium Web site (Paula is going there with her classmates next week). This table is also subscribed to a public publish&subscribe (P&S) service, where children's school office publishes news about interesting events involving families.

(T3) *Buddhism*, used to handle the activities related to her interests in that topic. Table members are Daniel and some other friends. Objects lying on this table are links to articles, books and Web sites concerning Eastern philosophy. This table is also subscribed to a public P&S service, where some associations related to Buddhism publish news.

(T4) *Journey to India*, used to organize the journey she will lead, planned for next summer. Table members are Linda (the secretary of the tour operator organizing the journey) and Daniel (who usually helps her in arranging the cultural aspects of her journeys). Objects lying on this table are links to Web sites related to travel locations and a to-do list with activities concerning the travel organization.

All Maria's tables contain her calendar, shared with the other table members. Visibility can be configured with respect to single tables (e.g., when sitting at the *Research* table, people see that Maria is not available next Friday, but they cannot see that she will be in Genova with Paula).

At lunch time, Maria is in her office; she sits at the *Family* table and notices that both her husband and grandma' Louise are at the table too; so she writes a message on the table blackboard to decide who is going to take Albert to the basket training session and Paula to the jazz-dance class. Louise reads Maria's message and offers to take Paula; Marc asks Maria to contact him later on in order to decide who will take Albert. Maria, by a simple click, transforms Marc's message in a task *Contact_Marc* with deadline at 17 (automatically copied also as a calendar event), and creates a new task, *Take_Paula*, assigned to Louise.

While Maria is at a cafè for lunch, she receives an alert on his smarthphone, notifying her that the *Buddhism* table has been updated. Maria enters T++, sits at the *Buddhism* table and read the new message about a conference on Buddhism in Western countries, arrived from the P&S service. She decides that the conference is interesting, thus, by a simple click, she adds it to her calendar.

Later on, when she is back home, she connects again to T++ through her personal tablet, sits at the *Journey to India* table and starts writing a document (using Google Documents) describing the cultural events for the journey. Daniel appears online and comments on the content that Maria is writing. The collaborative editing goes on for a while; Daniel and Maria also add some references to interesting Web sites they found, as new table objects. When they leave the table, Linda is notified about table updates.

B. *The Role of Tables*

Within T++, tables have been conceived in order to support and facilitate "democratic" and user-friendly online collaboration, by providing, at the same time, a flexible and manageable integrated organization of individual activities: this is the most important aspect underlying T++ design. Moreover, the following features are important in order to understand the role of tables and to differentiate them from simple user groups.

(1) Tables in T++ are meta-structures upon applications and services. The goal is to build a "view" on the user own Web space, used to collaborate and to organize her activities, hopefully not providing yet another tool. In particular, tables represent *thematic contexts*, helping the user to manage separated, coherent and structured workspaces, encompassing all types of activities (from personal to work-related ones). At the same time, tables represent *common places* where users can, synchronously or asynchronously, share information, actively work together on a document, a to-do list, a set of bookmarks, and so on.

(2) Tables are populated by *objects*, rather than links to applications and services. Such objects can be of any sort: documents, to-do lists and workflows, calendar views, bookmarks, images, Dropbox "spaces", projects, and so on. Moreover, they can be labeled as "public" (i.e., visible to all table members) or "private" (i.e., visible only to their creator). Also table messages can be public, i.e., published on the table blackboard and thus visible to all table members, or private, in which case they represent personal notes.

(3) Objects can be tagged, in order to structure them in (possibly multiple) categories, easily accessible through a tag cloud. For example, on the *Journey to India* table, Maria could tag a set of objects as "travel organization", and another (possibly overlapping) set as "cultural evenings".

(4) Tables enable users to collaborate with people sitting at the same table: every table participant is enabled to modify public objects lying on the table. This means that every table participant can, for instance, edit documents lying on the table by accessing an online word processing service, but also that she can organize the table, by adding and deleting objects, as well as by inviting people. Differently from all types of "virtual rooms", tables enable both synchronous and asynchronous collaboration. In fact, they notify table members - according to the notification policy individually configured by each member - about all relevant events occurring on the table (e.g., an object has been added or modified; a new public message has been published on the table blackboard; a new member has joined the table; a task has been completed; and so on).

(5) Tables are shared: they are not a single user's "view" on objects and people, but a "collective view": when a user sets up a table and invites people, everyone who agrees will see the table and will be able to work on it. For this reason, users invited to a table become members of it only if they agree (differently, for example, from Google+ circles).

(6) Tables represents activity contexts enabling workspace awareness and selective presence: differently from standard chat tools, when a user is sitting at a table, the (default) presence panel will show her a list including only table members, and, among them, who is currently online and sitting at that table. When a user is sitting at a table, she remains invisible within other tables, thus she is not disturbed with chat or calls coming from different contexts.

(7) Tables contain members' calendars, shared with the other table members. However, the visibility policy can be configured with respect to single tables: for example, the

 ISBN: 978-1-61208-206-6

user can decide to completely hide her calendar on table T1, to allow complete visibility (e.g., what she is doing during the weekend) on table T2, and to enable partial visibility (e.g. only that she is busy during the weekend) on table T3.

(8) Scheduling of common activities is supported by the *Smart Shared Calendar Management Service*. This service is briefly described in Section III.C (see also [5]).

(9) Tasks, to-do lists, and lightweight workflows are managed by the *Collaborative Task Management Service*, which is briefly described in Section III.C (see also [5][6]).

(9) Other objects are managed by the user's favorite collaborative applications. When double-clicking an object, or choosing the "modify" option from the object menu, the corresponding application is run, enabling the user to view/modify the object.

(10) A person can be member of different tables and an object can belong to different tables (in case of editable objects, like Google Documents items, if the user tries to put on a table T2 an object that already lies on table T1, the system asks her whether she wants to add it in read-only modality or if she wants to create a new independent copy).

There are two further characteristics that are particularly meaningful in T++, since they represent the openness of the environment, by enabling users to link tables to remote services, and allowing the participation of people which are not fully T++ registered users:

(11) Tables can be subscribed to public P&S services, where external services publishes news (e.g., RSS feeds); subscribed tables receive messages from such hubs and publish them on the table blackboard, thus making them visible to all table members (see Section III.C).

(12) People can collaborate to a table work even without being users of the T++ environment. An example scenario of how T++ manages the interaction with people who are not T++ users is the following. Maria would like to invite her friend Ann at the *Journey to India* table, even though she knows that Ann does not want to register to T++. Maria, through the table user interface, sends the invitation (an email with an "accept" link). If Ann accepts the invitation but does not register to T++, she will simply receive an email confirming her membership to the table (and the system keeps track of her through her email address, as a *non_T++_user*). If Maria publishes a public message on the table blackboard, T++ sends Ann an email containing Maria's message. Ann can reply to this email: T++ receives her answer and publishes it on the table blackboard (making it thus available to all table users). The same mechanism enables Ann to receive notifications coming from P&S services the table is subscribed to (see Section III.C).

Finally, it is worth mentioning that T++ is accessible both from desktop PC and from mobile devices (including smartphones); see Section III.C for some details.

C. T++ Architecture and Proof-of-Concept Prototype

The T++ environment is implemented as a cloud application. The proof-of-concept prototype is a GWT [25] application, deployed on the Google App Engine [22], but the same architecture should work on other cloud hosting environments. The cloud services offered by T++ are available both from the GWT client running within the browser and from the Android App, as shown in Fig. 1. We exploit the Android Cloud to Device Messaging (C2DM [2]) to send data (lightweight messages) from servers to the applications on Android devices.

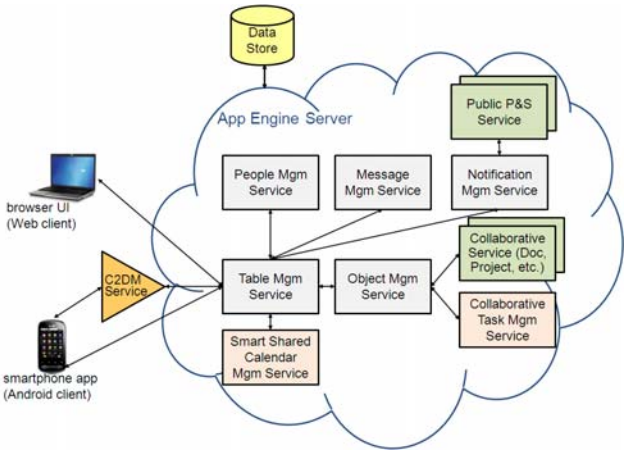


Figure 1. T++ architecture.

Fig. 1 also depicts T++ architecture. The main component is the *Table Management Service*, that handles tables within the environment. The Table Mgm Service exploits the *Smart Shared Calendar Management Service*, that automatically accesses members calendars to find time slots in which they are available (see [5]). The *Object Management Service* handles all the issues related to objects lying on tables. It exploits other collaborative applications in order to offer tools for collaboratively modifying objects: e.g., a collaborative online word processing application (like Google Documents), a project management tool (like Zoho Projects), a social network (like Facebook), and so on. Moreover, it exploits the *Collaborative Task Management Service* (see [5][6]), that enables table members to share tasks, to partially order them in lightweight workflows, and to link each task to the Web tool needed to perform it. The *People Management Service* handles table membership and selective presence. The *Message Management Service* handles user public messages, published on table blackboards, and user private notes. The *Notification Management Service* takes care of the notifications related to table activities. Notifications can be generated by table events (table members performing some significant action on the table), or by external public hubs (*Public P&S Services* in the figure) tables are subscribed to.

T++ exploits the JavaMail API [29] and a T++ email account (on Google Mail) to send and receive messages from people who are not T++ users. The T++ users already registered as Google or Facebook users do not need to register again, given that the People Mgm Service exploits OAuth [36] to give access to users and collect information already available on their Google or Facebook accounts.

All T++ cloud services exploit the App Engine schemaless Object Datastore [21]: they save data objects as entities having properties, i.e., named values of one of

 ISBN: 978-1-61208-206-6

several supported data types. The datastore can execute multiple operations in a single transaction: this is especially useful for distributed Web applications like T++, where multiple users may be accessing or manipulating the same data at the same time.

The subscription of a table to a public P&S service (e.g., Pubsubhubbub [38]) is a simple operation, consisting in adding an URL in the table configuration panel, and is one of the operations available to table members, when sitting at the table. Moreover, tables can be configured in order to react to published events in a more complex way. This kind of integration requires the implementation of some code within the Table Mgm Service. The complexity of such code depends on the format of the data published and on the nature of the internal activity to be triggered (see [5] for more details about remote services integration).

IV. CONCLUSION AND FUTURE WORK

In this paper, after an analysis of some examples of different types of Web-based collaborative tools, we concluded that what is missing is a framework providing the user with a "view" on her own Web space, effectively supporting her in collaborating and organizing her life activities. We thus proposed T++, a meta-environment based on the metaphor of tables, i.e., activity contexts that can be created to handle objects (documents, links, tasks, and so on) related to an interest or a specific goal. In presenting T++, we also took into account the possibility of subscribing tables to public P&S services, in order to get information from remote services, and the possibility, for people who are not T++ users, of collaborating to a table work through their email accounts. These two aspects, in particular, require further work. The integration of T++ with remote services through public P&S services could be enhanced taking into account the semantics of the exchanged data. The interaction with not T++ users, could be enhanced by supporting, within a table context, the usage of other online collaborative applications the user may be registered to (e.g., Facebook).

The need for an effective support to a "democratic" and user-friendly online collaboration coupled with a flexible and integrated organization of individual activities has been elicited by means of informal interviews with Web users used to exploit social networks and online collaborative tools. However, the actual usefulness and usability of a framework like T++ depends on the evaluation of real users; for this reason, we are planning a set of tests with Web users, aimed at evaluating these aspects of our proposal.

REFERENCES

[1] ActiveCollab: www.activecollab.com, 04.11.2012

[2] Android Cloud to Device Messaging (C2DM): code.google.com/android/c2dm, 04.11.2012

[3] AOL Instant Messenger: www.aim.com, 04.11.2012

[4] AppAppeal: www.appappeal.com, 04.11.2012

[5] L. Ardissono, G. Bosio, A. Goy, G. Petrone, and M. Segnan, "Integration of cloud services for web collaboration: a user-centered perspective", in Models for Capitalizing on Web Engineering Advancements: Trends and Discoveries, G. I. Alkhatib, Ed., Hershey, PA: IGI Global, 2012, pp. 1-19.

[6] L. Ardissono, G. Bosio, A. Goy, G. Petrone, M. Segnan, and F. Torretta, "Collaboration support for activity management in a Personal Cloud", Int. Journal of Distributed Systems and Technologies (IJDST), 2(4), 2011, pp. 30-43.

[7] BSCW: public.bscw.de/en/about.html, 04.11.2012

[8] Cisco Collaboration Cloud: www.cisco.com/en/US/solutions/ns1007/collaboration_cloud.html, 04.11.2012

[9] Cohuman/Mindjet Connect: www.cohuman.com, 04.11.2012

[10] M. Creeger, "CTO roundtable: Cloud computing", Communications of the ACM, 52(8), 2009, pp. 50–65.

[11] Delicious: delicious.com, 04.11.2012

[12] DoIt: www.doit.im, 04.11.2012

[13] Dropbox: www.dropbox.com, 04.11.2012

[14] EGroupware: www.egroupware.org, 04.11.2012

[15] Empressr: www.empressr.com, 04.11.2012

[16] eXpresso: www.expressocorp.com, 04.11.2012

[17] eyeOS: www.eyeos.com, 04.11.2012

[18] Facebook: www.facebook.com, 04.11.2012

[19] Feng Office: www.fengoffice.com, 04.11.2012

[20] J. Girard, C. Gordon, and J. Girard, "Knowledge Sharing as an Enabler of Virtual Business". The Electronic Journal of Knowledge Management, 9(3), 2011, pp. 181-187.

[21] Google App Engine Datastore: code.google.com/appengine/docs/java/datastore, 04.11.2012

[22] Google App Engine: code.google.com/appengine, 04.11.2012

[23] Google Apps for Business: www.google.com/apps/intl/en/business/index.html, 04.11.2012

[24] Google Apps: www.google.com/apps/intl/en/group/, 04.11.2012

[25] GWT: developers.google.com/web-toolkit, 04.11.2012

[26] Google+: plus.google.com, 04.11.2012

[27] A. Grimes, and A. Brush, "Life scheduling to support multiple social roles", Proc. 26th Annual CHI Conference on Human Factors in Computing Systems, New York, NY: ACM Press, 2008, pp. 821–824.

[28] D. Hislop, and C. Axtell, "The neglect of spatial mobility in contemporary studies of work: The case of telework", New Technology, Work and Employment, 22(1), 2007, pp. 34–51.

[29] JavaMail API: www.oracle.com/technetwork/java/javamail, 04.11.2012

[30] Kohive: kohive.com, 04.11.2012

[31] Ms Messenger: explore.live.com/windows-live-messenger, 04.11.2012

[32] Ms Office 365: www.microsoft.com/office365, 04.11.2012

[33] M. Miller, "Cloud Computing. Web-Based Applications That Change the Way You Work and Collaborate Online", Indianapolis, IN: Que Publishing, 2009.

[34] C. Neustaedter, A. J. B. Brush, and S. Greenberg, "The calendar is crucial: Coordination and awareness through the family calendar", ACM Transaction on Computer-Human Interaction, 16(1), 2009, pp. 6:1-6:48.

[35] Nivio: www.nivio.com, 04.11.2012

[36] OAuth: oauth.net/2, 04.11.2012

[37] T. O'Reilly, "What is Web 2.0: Design patterns and business models for the next generation of software", Communications & Strategies, 1(65), 2007, 17–37.

[38] Pubsubhubbub:code.google.com/p/pubsubhubbub, 04.11.2012

[39] Skype: www.skype.com, 04.11.2012

[40] Teambox: teambox.com, 04.11.2012

[41] Things: culturedcode.com/things, 04.11.2012

[42] Zoho suite: www.zoho.com, 04.11.2012

 ISBN: 978-1-61208-206-6

Modelling a Fault-Tolerant Distributed Satellite System

Kashif Javed
Turku Centre for Computer Science (TUCS)
Department of Information Technologies
Abo Akademi University
Turku, FIN-20520, Finland
Kashif.Javed@abo.fi

Elena Troubitsyna
Department of Information Technologies
Abo Akademi University
Turku, FIN-20520, Finland
Elena.Troubitsyna@abo.fi

***Abstract*— Ensuring correctness of a complex distributed and mode-rich collaborative satellite system is a challenging task that requires formal modeling and verification. In this paper, we propose a model of a distributed Attitude and Orbit Control System. Mode transitions in such systems are governed by a sophisticated synchronization procedure. We demonstrate how to model and verify such a procedure in order to ensure mode consistency.**

Keywords-distributed mode-rich systems; satellite software; fault tolerance; synchronization

I. INTRODUCTION

Behavior of satellite systems is often structured in terms of modes. Modes – mutually exclusive sets of system behavior define different functional profiles of the system [4,5]. An important problem associated with designing mode-rich satellite systems is to ensure correctness of mode transitions.

In this paper, we propose an approach to modeling and verification of distributed Attitude and Orbit Control System – D-AOCS [1,2]. D-AOCS is a typical example of a mode-rich collaborative system. It consists of two independent mode managers that should negotiate and coordinate their actions. Collaboration between mode managers is not trivial – faults of components might prevent the mode managers from following the agreed course of actions. As a result new negotiations would be initialized to achieve synchronization under the new conditions.

The proper synchronization is paramount for ensuring mode consistency. In general mode consistency can be seen as a high-level guarantee of a proper functioning of a distributed system deployed on the space craft. The complex collaboration procedure precedes each mode transition step.

We demonstrate how to model and verify handshaking protocol ensuring that modes are changed consistently. An important part of our modeling is fault tolerance. We demonstrate how to ensure consistency of not only nominal but also backward mode transitions, i.e., transitions to the degraded modes that are responsible for error recovery. The novelty of the proposed approach is in treating fault tolerance of collaborative systems as a problem of ensuring mode consistency.

Section II explains the state-of-the-art of AOCS structure. Section III presents AOCS architecture covering unit manager, mode manager, and fault tolerance. Handshake protocol is explained in detail in Section IV and the proposed system design using handshake is discussed in Section V. Finally, Section VI provides a brief summary of conclusions and future work.

II. STATE-OF-THE-ART STRUCURE

Attitude and Orbit Control System (AOCS) is extensively used in the design and development of modern satellites. The major objective of an AOCS is to ensure controlled movements of the satellites in order to maintain required attitude and remain in the given orbit. As disturbance of the atmosphere tends to change orientation of the satellites, there is a serious need to continuously control and monitor its attitude. A number of sensors are employed to collect data for the purpose of controlling attitude. Appropriate corrective measures are taken by the actuators to keep the right path and orbit whenever there is change detected in the data sent by the sensors. This requirement is very essential for supporting needs of payload instruments as well as for the fulfillment of satellite's mission.

The top level schema of an AOCS is shown in Figure 1.

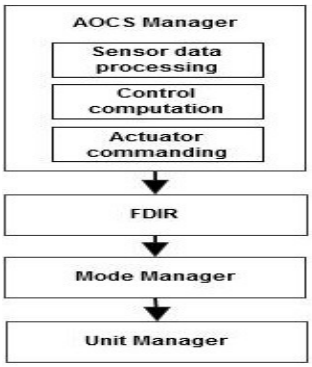


Figure 1: Top Level Schema of AOCS

The AOCS manager consists of three components (i.e., sensor data processing, control computation and actuator commanding). Control computation part handles all the data and measurements using state-of-the-art control algorithms and gives commands to the actuators for ensuring correct path and attitude. Different types of controllers are required for completion of specific mission stages. Normally, two

 ISBN: 978-1-61208-206-6

control algorithms are used during the operational mode of the satellites.

Each unit of the satellite has a unique status (i.e., free, reserved, or locked) for its usage while avoiding conflicts during reconfiguration [10]. An actuator, payload or sensor remains free when it is idle in any mode. The reserved status means that a sensor/actuator/payload is to be used shortly but it is not yet ready. When any unit is allocated and is being used for its required operation, then it is turned into the locked status.

III. ARCHITECTURE

In this paper, we consider a distributed version of Attitude and Orbit Control System. Attitude and Orbit Control System (AOCS) [1] is a generic component of a spacecraft. Behavior of AOCS is structured using the notion of modes – mutually exclusive sets of system behavior. The complexity of designing distributed AOCS lies in the fact that mode management is decentralized, i.e., it is performed by several mode managers. Distributed AOCS (D-AOCS) has a complex architecture. It consists of AOCS Manager, Unit Manager, Several Mode Managers and FDIR (Failure Detection, Isolation and Recovery) Manager. AOCS Manger deals with two controllers -- Control Pointing Controller (CPC) and Fine Pointing Controller (FPC). The purposes of CPC and FPC are to direct line of sight as well as to provide coarse and fine accuracy. Unit level state transitions and mode transitions are managed by Unit Manager and Mode Manager respectively. FDIR Manager ensures handling of branch state transition errors and controller phase transition errors [2]. Two managers -- Mode Manager 1 (MM1) and Mode Manager 2 (MM2) are responsible for the global mode logic of D-AOCS. The architecture of Unit Manager and Mode Managers is described below.

A. *Unit Manager*

The Unit Manager in D-AOCS organizes the internal states of the units. The components of Unit Manager are supervised by the Mode Manager. The controlled units include Earth Sensor (ES), Sun Sensor (SS), Star Tracker (STR), Global Positioning System (GPS), Reaction Wheel (RW), Thruster (THR) and Payload Instrument (PLI). All unit components are responsible for mode synchronization, decision making on unit states, performing branch state transitions and unit reconfiguration [4,5]. SS, STR, GPS, RW and PLI provide data to the AOC Manager. RW and THR execute the commands from AOC Manager. These units are also responsible for detection and reporting the branch state transition errors [1].

Every unit consists of two identical branches -- the nominal and redundant ones. At any instance of time only one branch is active. A unit branch in the ‘on’ state is always assigned locked status and the unit branch in ‘off’ state has unlocked status. There are six states of unit components -- on, off, coarse, fine, standby and science. The internal states of ES, SS, STR, RW and THR are either ‘on’ or ‘off’. Three possible GPS’s operational states are ‘off’, ‘coarse’ and ‘fine’. PLI’s state can be in ‘off’, ‘standby’ or ‘science’ [3].

B. *Mode Managers*

The global mode transitions are managed by the two mode managers -- MM1 and MM2. Each mode manager’s controls different units. Each mode manager is responsible for checking the preconditions of mode transitions, managing the controllers and the units, and initiating and completing the mode transitions. The global modes are correspondingly Off, Standby, Safe, Nominal, Preparation, and Science [10]. Below we give a brief description of each mode:

Off: After the central data management unit completes booting of AOCS software, the satellite instantly goes into the off mode.

Standby: The process of separation of the satellite from the launcher is monitored during the standby mode.

Safe: After successful separation from the launcher, the satellite switches to the safe mode. The satellite obtains a stable attitude and the CPC is activated.

Nominal: After transition to this mode, FPC is activated, while CPC is switched off. PLI is actoviated to provide measurements for FPC.

Preparation: FPC is achieved in the preparation mode and PLI gets ready to perform the necessary tasks.

Science: PLI carries out the required tasks and stays in science mode till the desired tasks are completed.

MM1 and MM2 communicate with each other to synchronize on mode transitions that are performed in parallel. Let us describe the scenario of mode transitions. After a mode transition to off or standby is done, every unit branch goes to off state and both controllers are idle. After that, both mode managers communicate with each other. If there is no error then transition to the next mode is executed. When the mode is switched to safe, the selected branches of ES, SS and RW are turned to ‘on’ state and only FPC remains idle. Both mode managers send messages to inform each other that no error occured in the given modes. After a handshake, they perform the mode transition to the nominal mode. In a mode transition to the nominal mode, the required branches of RW, STR and THR are put to the ‘on’ state and GPS is put into the‘coarse’ state. The messages sent and received by the mode managers notify each mode manager that no unit or controller error has occured. Then the preparation mode is reached, the concerned branches of RW, STR & THR are in the ‘on’ state and GPS & PLI are in the ‘fine’ state and ‘standby’ state respectively. They ensure the correctness of the modes in MM1 and MM2 and make a transition to the science mode. In case of the science mode, the preffered branch of PLI operates with ‘science’ state. All other units keep their previous state. When a mode

 ISBN: 978-1-61208-206-6

transition goes to nominal, preparation or science mode, only CPC remains idle. MM1 and MM2 both inform each other regarding success of mode transition.

C. Fault Tolerance

Fault tolerance aims at providing the system with the means to continue its function in spite of errors of its components. In the D-AOCS backward error recovery is adopted, i.e., if an error occurs, the system gets back to some previous state to handle the error. The roll back error recovery is implemented by the backward mode transitions. The mode roll-back depends on branch state transition errors and phase transition errors.

There are different aspects relating to the branch state transition errors. When a branch state transition error on the redundant branch of ES, RW or SS occurs and there is no error in the remaining redundant branches, then the mode goes back to off mode. If the redundant branch of GPS, STR or THR gets corrupted, it results a mode transition to safe. A mode transition to nominal takes place when there is a branch state transition error on the redundant branch of PLI.

The important error checks are incorporated to deal with the attitude or phase transitions. When the current mode is safe and a non-negligible phase error is produced, it results in a mode transition to off. If the phase error is generated in the nominal, then it goes back to safe. In case the existing mode is preparation and a phase error occurs, a mode transition to nominal takes place. A mode transition to preparation takes place when a phase error occurs in the science mode [3].

In case of unit reconfiguration, a branch state transition error on the nominal branch of any unit causes a unit reconfiguration if there is no branch state transition error on the redundant branches of that particular unit.

If the mode task is not completed within a given time interval or multiple errors occur in the unit branches and controller phases, then timeout signal is produced for safe condition.

IV. HANDSHAKE PROTOCOL

Handshaking is a process in which connection is established among two processes and information is transferred from one process to another without the need for human involvement to set constraints. MM1 and MM2 do handshake with each other to update the condition of their modes. Different scenarios of handshake protocol are explained covering the following key points:

If all conditions of unit states and controller phases within each mode of MM1 and MM2 fulfill their requirements, then mode managers pass the ‘no error’ message to notify that the mode is in the error-free state. It results in the forward mode transition, i.e., the mode manager switches the current mode to the next mode as described in Section III.

If an error occurs during a mode transition of MM1 and there is no error in the mode of MM2, then MM1 sends an ‘error’ message to MM2. MM1 executes error recovery, i.e., starts backward mode transtion according to the Section III. Until the error recovery of MM1 is not completed, MM2 keeps on waiting. After the successful error recovery, both mode managers proceed to the next mode.

When an error occurs only in the mode of MM2, then MM1 receives an ‘error’ message from MM2. MM1 waits until error has been recovered in MM2. The mode managers switch to next mode after receiving the information from MM2 that the error is recoverd.

Upon receiving an ‘error’ message from MM1 and MM2 simultaneously, error recovery starts in both mode managers as mentioned in Section III. The backward mode transitions are executed in MM1 and MM2. After achieving the successful recovery, mode managers move to the next mode.

There are two types of errors -- the unit branch state transition errors and controller phase transition errors. Handshaking algorithm for handling such type of errors is quite complex as specified below:

```
void handshake(int u_MM1, int u_MM2,int c_MM1,int c_MM2) {
// ‘u’ denotes unit error flag and ‘c’ denotes controller error flag
 if (u_MM1==0&&u_MM2==0&&c_MM1==0&&c_MM2==0) {
      /* The associated code illustrates that no error occurs in the unit
      branchs of ES, SS, RW, GPS, STR, THR or PLI and controller
      phase of CPC or FPC in the given mode of MM1 and MM2. It
      accounts the forward mode transition according to the Section
      III. */}
elseif(u_MM1==1&&u_MM2==0&&c_MM1==0&&c_MM2==0) {
      /* The associated code illustrates that an error occurs in the unit
      branch of ES, SS, RW, GPS, STR, THR or PLI in the given
      mode of MM1. It accounts the backward mode transition
      according to the Section III. MM2 stays on waiting until an
      error is recovered. */}
elseif(u_MM1==0&&u_MM2==1 &&c_MM1==0&&c_MM2==0) {
      /* The associated code illustrates that an error occurs in the unit
      branch of ES, SS, RW, GPS, STR, THR or PLI in the given
      mode of MM2. It accounts the backward mode transition
      according to the Section III. MM1 stays on waiting until an
      error is recovered. */}
elseif(u_MM1==1&&u_MM2==1&&c_MM1==0&&c_MM2==0) {
      /* The associated code illustrates that an error occurs in the unit
      branch of ES, SS, RW, GPS, STR, THR or PLI in the given
      mode of both mode managers. MM1 and MM2 account the
      backward mode transition according to the Section III. */}
elseif(u_MM1==0&&u_MM2==0&&c_MM1==1&&c_MM2==0) {
      /* The associated code illustrates that an error occurs in the
      controller phase of CPC or FPC in the given mode of MM1. It
      accounts the backward mode transition according to the Section
      III. MM2 stays on waiting until an error is recovered. */}
elseif(u_MM1==0&&u_MM2==0&&c_MM1==0&&c_MM2==1) {
      /* The associated code illustrates that an error occurs in the
      controller phase of CPC or FPC in the given mode of MM2. It
      accounts the backward mode transition according to the Section
      III. MM1 stays on waiting until an error is recovered. */}
elseif(u_MM1==0&&u_MM2==0&&c_MM1==1&&c_MM2==1) {
      /* The associated code illustrates that an error occurs in the
      controller phase of CPC or FPC in the given mode of both mode
```

managers. MM1 and MM2 account the backward mode transition according to the Section III. */}
else {
/* The associated code describes that it is an invalid condition. Program is terminated.*/} }

V. PROPOSED SYSTEM DESIGN USING HANDSHAKE

The proposed system design has been implemented using SystemC. SystemC can be used at system level for functional verification. The framework also supports event driven simulation environments [6]. It offers application program interface for transaction based verification, handling exceptions and verification tasks [7]. The system model consists of six defined modes named as A (Off), B (Standby), C (Safe), D (Nominal), E (Preparation) and F (Science). Three different operations have been implemented (i.e., forward mode transitions, backward mode transitions, and unit reconfiguration). The flow chart given in Figure 3 describes detailed design structure for only one transition from Mode E to Mode F of the system. When the system reaches to Mode E, it checks the error in the Mode E of both mode managers. Figure 3 shows the operations regarding error condition according to the scenarios and backward mode transitions according to the error types (Unit branch error (redundant/nominal) and controller phase error) they are discussed in Section IV and Section III respectively.

After necessary declarations of modes, units and controllers, the verification of the system are described in the following sections.

A. Verification of Forward Mode Transition

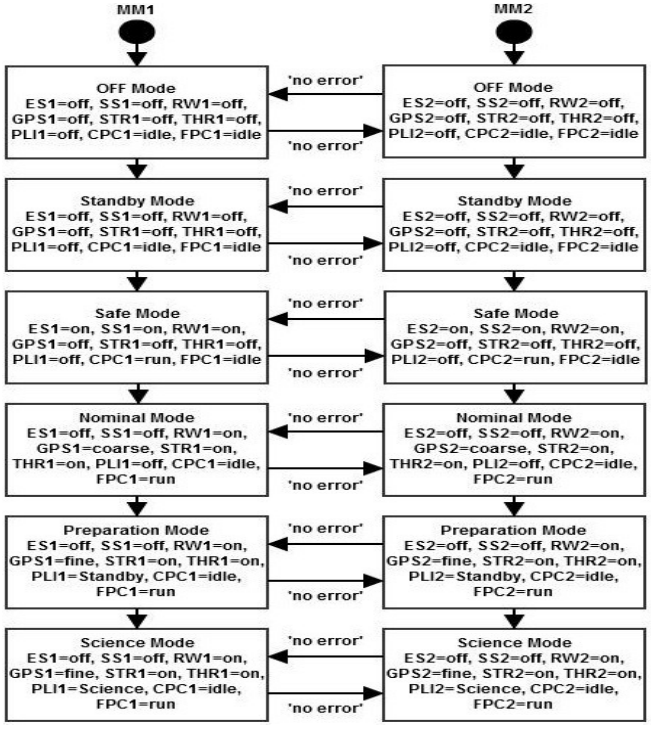


Figure 2: Forward Mode Transitions

When all the units are in off state, controller phases are in the idle phase, and no unit reconfiguration is in progress, then current mode is A in MM1 and MM2. The unit/controller error flag is set to low and mode managers exchange the information ('no error' message) of error-free mode status. After this, the mode moves forward to the next mode (i.e., Mode B) in MM1 and MM2. Hence, when all conditions of unit states and controller phases within each mode of each manager fulfill their requirements, mode managers update each other about the error-free mode conditions. Then the current mode switches to the next mode within each mode manager until it completes its operation after Mode F. Figure 2 illustrates the implemented procedure that corresponds to the forward mode transition for MM1 and MM2.

B. Verification of the Steps in the Backward Mode Transition

The backward mode transition depends on the two types of errors (i.e., unit branch state transition error and controller phase transition error). Handshaking procedure for handling these errors is given below.

1) Verification of the Steps in Unit Branch State Transition Error

Following part of the code segment describes the unit branch transition error in case of Mode E as shown in Figure 2. If there is an error in ES, SS or RW of MM1, MM1 switches to Mode A. If an error occurs in GPS, THR or STR of MM2, MM2 return to Mode C. However, if PLI gets an error in both mode managers, MM1 and MM2 both go back to Mode D. Before backward transition to the desired mode, the messages exchange information between the effected mode manager and the error-free mode manager to acknowledge the error status.

```
// Variable declarations
int FPC1,CPC1,FPC2,CPC2,u_MM1,c_MM1,u_MM2,c_MM2;
// unit states
const int off=0;const int on=1;const int coarse=2;
const int fine=3;const int unit=0;const int Standby=4;
const int Science=5;const int idle=0;const int run=1;
const int A=1;const int B=2;const int C=3;
const int D=4;const int E=5;const int F=6;
/* Each unit has two branches i.e., Nominal and Redundant,
here we deal with redundant branch of the units. */
int ES1,SS1,GPS1,STR1,RW1,THR1,PLI1; // MM1 Units
int ES2,SS2,GPS2,STR2,RW2,THR2,PLI2; // MM2 Units
    if(mode==E) {// Preparation Mode
    if((ES1!=off || SS1!=off || RW1!=on) && STR1==on &&
    GPS1==fine && THR1==on && PLI1== standby &&
    CPC1==idle && FPC1==run && ES2==off &&
    SS2==off && RW2==on && STR2==on &&
    GPS2==fine && THR2==on && PLI2== standby &&
    CPC2==idle && FPC2==run){
        u_MM1=1;c_MM1=0;
        u_MM2=0;c_MM2=0;
        /* The remaining part of the code, by calling the
        handshake protocol function on the basis of unit and
        controller error flag, is mentioned in Section IV.*/}
    else if(ES1==off && SS1==off && RW1==on &&
    STR1==on && GPS1==fine && THR1==on &&
```

```
PLI1==standby && CPC1==idle && FPC1==run && ES2==off && SS2==off && RW2==on && (STR2!=on || GPS2!=fine || THR2!=on) && PLI2==standby && CPC2==idle && FPC2==run){
    u_MM1=0;c_MM1=0;
    u_MM2=1;c_MM2=0;
    /* The remaining part of the code, by calling the handshake protocol function on the basis of unit and controller error flag, is mentioned in Section IV.*/}
else if(ES1==off && SS1==off && RW1==on && STR1==on && GPS1==fine && THR1==on && PLI1!=standby && CPC1==idle && FPC1==run && ES2==off && SS2==off && RW2==on && STR2==on && GPS2==fine && THR2==on && PLI2!=standby && CPC2==idle && FPC2==run){
    u_MM1=1;c_MM1=0;
    u_MM2=1;c_MM2=0;
    /* The remaining part of the code, by calling the handshake protocol function on the basis of unit and controller error flag, is mentioned in Section IV.*/}
else{
    /* The associated code describes that no transitions take place. */ }        }
else cout<<" Program is terminated.";
```

2) Verification of the Steps in Controller Phase Transition Errors

When CPC and FPC do not fulfill the requirement of mode of any mode manager, the error flag is set to high and the affected mode manager is downgraded to previous mode after utilizing the handshake protocol by sending message to error-free mode manager. In case the phase of controllers in the given mode of both mode managers is corrupted, then both managers do the backward mode transition at once after acknowledging each other. The following portion of the code represents the scenario of phase transition for Mode E as illustrated in Figure 2.

```
//Variables are declared in the previous section.
if(mode==E) {// Preparation Mode
if(ES1==off && SS1==off && RW1==on && STR1==on && GPS1==fine && THR1==on && PLI1==standby && CPC1!=idle && FPC1==run && ES2==off && SS2==off && RW2==on && STR2==on && GPS2==fine && THR2==on && PLI2==standby && CPC2==idle && FPC2==run){
    u_MM1=0;c_MM1=1;
    u_MM2=0;c_MM2=0;
    /* The remaining part of the code, by calling the handshake protocol function on the basis of unit and controller error flag, is mentioned in Section IV.*/}
else if(ES1==off && SS1==off && RW1==on && STR1==on && GPS1==fine && THR1==on && PLI1==standby && CPC1==idle && FPC1==run && ES2==off && SS2==off && RW2==on && STR2==on && GPS2==fine && THR2==on && PLI2==standby && CPC2==idle && FPC2!=run){
    u_MM1=0;c_MM1=0;
    u_MM2=0;c_MM2=1;
    /* The remaining part of the code, by calling the handshake protocol function on the basis of unit and controller error flag, is mentioned in Section IV.*/}
else if(ES1==off && SS1==off && RW1==on && STR1==on && GPS1==fine && THR1==on && PLI1==standby && CPC1==idle && FPC1!=run && ES2==off && SS2==off && RW2==on && STR2==on && GPS2==fine && THR2==on && PLI2==standby && CPC2!=idle && FPC2==run){
    u_MM1=0;c_MM1=1;
    u_MM2=0;c_MM2=1;
    /* The remaining part of the code, by calling the handshake protocol function on the basis of unit and controller error flag, is mentioned in Section IV.*/}
else{
    /* The associated code describes that no transitions take place. */ }        }
else cout<<" Program is terminated.";
```

C. Verification of the Steps in Unit Reconfiguration

If error exists on nominal unit branch at any mode of MM1 or MM2, then it is replaced by redundant unit branch in the given mode of mode manager. The unit reconfiguration is done to complete the remaining operation of the system. Unit reconfiguration is, however, a burden on the system and takes some time while switching from nominal branch to redundant branch of the unit. In case of the nominal unit branch in the given mode of both mode managers is corrupted, then unit reconfiguration is done in both mode manager after exchanging the information between the mode managers regarding unit reconfiguration.

The following piece of the code shows the scenario of unit reconfiguration for Mode E as shown in Figure 2.

```
//Variables are declared in the previous section. In reconfiguration module, we also deal with nominal branch of the units. So, both branches of the unit are declared separately.
//Nominal branches of MM1 and MM2
int N_ES1, N_SS1, N_RW1, N_GPS1, N_STR1, N_THR1, N_PLI1;
int N_ES2, N_SS2, N_RW2, N_GPS2, N_STR2, N_THR2, N_PLI2;
//Redundant branches of MM1 and MM2
int R_ES1, R_SS1, R_RW1, R_GPS1, R_STR1, R_THR1, R_PLI1;
int R_ES2, R_SS2, R_RW2, R_GPS2, R_STR2, R_THR2, R_PLI2;
if (mode==E) { //  Preparation Mode
if((N_ES1!=off || N_SS1!=off || N_RW1!=on) && R_ES1==off && R_SS1==off && R_RW1==on && N_ES2==off && N_SS2==off && N_RW2==on && R_ES2==off && R_SS2==off && R_RW2==on ) {
    u_MM1=1;c_MM1=0;
    u_MM2=0;c_MM2=0;
    /* The remaining part of the code, by calling the handshake protocol function on the basis of unit and controller error flag, is mentioned in Section IV.*/}
else if(N_GPS1==fine && N_STR1==on && N_THR1==on && N_PLI1==standby && R_GPS1==fine && R_STR1==on && R_THR1==on && R_PLI1==standby && (N_GPS2!=fine || N_STR2!=on || N_THR2!=on || N_PLI2!=standby) && R_GPS2==fine && R_STR2==on && R_THR2==on && R_PLI2==standby) {
    u_MM1=0;c_MM1=0;
    u_MM2=1;c_MM2=0;
    /* The remaining part of the code, by calling the handshake protocol function on the basis of unit and controller error flag, is mentioned in Section IV.*/}
else if((N_ES1!=off || N_SS1!=off || N_RW1!=on) && R_ES1==off && R_SS1==off && R_RW1==on && (N_ES2==off || N_SS2!=off || N_RW2!=on) && R_ES2==off && R_SS2==off && R_RW2==on ) {   u_MM1=1;c_MM1=0;
    u_MM2=1;c_MM2=0;
```

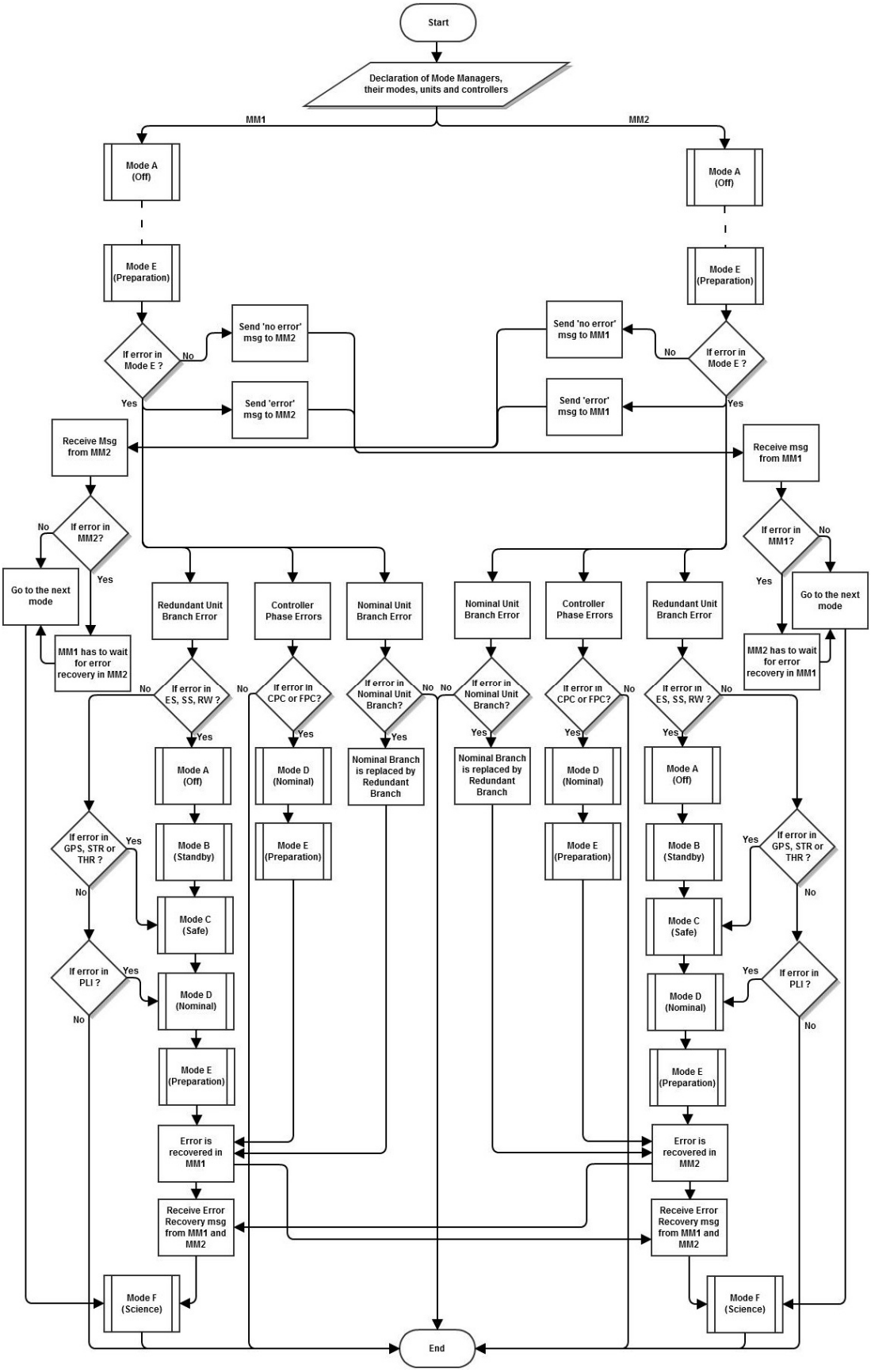


Figure 3: System flow chart for Mode E to Mode F

```
        /* The remaining part of the code, by calling the handshake
        protocol function on the basis of unit and controller error flag, is
        mentioned in Section IV.*/}
    else if((N_ES1!=off || N_SS1!=off || N_RW1!=on) && R_ES1==off
    && R_SS1==off && R_RW1==on && (N_ES2==off || N_SS2!=off
    || N_RW2!=on) && R_ES2==off && R_SS2==off && R_RW2==on
    ) {   u_MM1=1;c_MM1=0;
        u_MM2=1;c_MM2=0;
        /* The remaining part of the code, by calling the handshake
        protocol function on the basis of unit and controller error flag, is
        mentioned in Section IV.*/}
    else{
        /* The associated code describes that no transition takes place.
        */ }          }
    else    cout<<" Program is terminated.";}
```

Our verification efforts are focused on checking correctness of mode syncornization and verification of the proposed collaboration scheme. To obtain quantitative measures of the performance of the discussed protocol we would need to further refine our specification and to integrate model of hardware platform in the loop. We are planning to perform quantitative evaluation as a part of the future work.

VI. CONCLUSIONS AND FUTURE WORK

In this paper, we demonstrated how to model and verify distributed satellite systems with complex mode transition logic. Our approach is validated by a case study – design of a distributed Attitude and Orbit Control System.

The proposed system has been implemented in SystemC language. SystemC specification can be easily interfaced with various model checking techniques to perform formal verification. The work presented in this paper extends our previous work done on modeling centralized mode-rich system. In the current approach, we have put the main focus on mode synchronization aspect and demonstrated how to achieve mode consistency via handshaking protocol.

Our work complements research done on formal modeling of mode-rich satellite systems. The formal modeling proposed by Iliasov et al. [8,9] focused on proof-based verification of centralized AOCS. Formal modeling of the distributed architecture presented in our paper is a completely novel aspect.

As a future work, we are planning to investigate how to interface architectural modeling with our design approach.

REFERENCES

[1] "DEPLOY Work Package 3 - Software Requirements Document for Distributed System for Attitude and Orbit Control for a Single Spacecraft", Space Systems Finland, Ltd., June 2011[retrieved: November, 2011].

[2] "DEPLOY Work Package 3 - Attitude and Orbit Control System Software Requirements Document", Space Systems Finland, Ltd., December 2010 [retrieved: January, 2012].

[3] J. Kashif, and E. Troubitsyna, "Designing a Fault-Tolerant Satellite System in SystemC", ICONS 2012, The Seventh International Conference on Systems, XPS Press, pp. 49-54, March 2012.

[4] M. Heimdahl, and N. Leveson, "Completeness and Consistency in Hierarchical State-Based Requirements", IEEE Transactions on Software Engineering, Vol.22, No. 6, pp. 363-377, June 1996.

[5] N. Leveson, L. D. Pinnel, S. D. Sandys, S. Koga, and J. D. Reese, "Analyzing Software Specifications for Mode Confusion Potential", Proceedings of Workshop on Human Error and System Development, C.W. Johnson, Editor, Glasgow, Scotland, pp. 132-146, March 1997.

[6] N. Blanc, D. Kroening, and N. Sharygina, "Scoot: A Tool for the Analysis of SystemC Models". TACAS'08/ETAPS'08 Proceedings of the Theory and practice of software, 14th international conference on Tools and algorithms for the Construction and Analysis of Systems, Springer-Verlag, Berlin, Heidelberg, pp. 467–470, 2008.

[7] L. Singh, and L. Drucker, "Advanced Verification Techniques: A SystemC Based Approach for Successful Tapeout", Kluwer Academic Publishers, Springer, 2004.

[8] A. Iliasov, E. Troubitsyna, L. Laibinis, A. Romanovsky, K. Varpaaniemi, D. Ilic, and T. Latvala, "Developing Mode-Rich Satellite Software by Refinement in Event B". In: Proc.of FMICS 2010, the 15th International Workshop on Formal Methods for Industrial Critical Systems, Lecture Notes for Computer Science, Springer, 2010.

[9] A. Iliasov, E. Troubitsyna, L. Laibinis, A. Romanovsky, K. Varpaaniemi, P. Väisänen, D. Ilic, and T. Latvala, "Verifying Mode Consistency for On-Board Satellite Software". In Proc. of SAFECOMP 2010, The 29th International Conference on Computer Safety, Reliability and Security, September 14-17, Vienna, Austria, Lecture Notes for Computer Science, Springer, September 2010.

[10] "DEPLOY deliverable D20 – Pilot Deployment in the Space Sector", Space Systems Finland, Ltd., January 2010 [retrieved: March, 2012].

 ISBN: 978-1-61208-206-6

Collaborative Document Classification: Definition, Application and Validation

Juan M. Fernández-Luna, Juan F. Huete, Guillermo Osorio
Dpto. Ciencias de la Computación e I.A. Universidad de Granada, 18071, Granada, Spain
{*jmfluna,jhg*}*@decsai.ugr.es, gosorio@correo.ugr.es*

***Abstract*—Document indexing is mostly a human task, where human indexers assign the most appropriate keywords to texts in order to represent or categorize their contents. It is usually performed as an individual manual task. In this paper we propose an extension where this process is enhanced with two main features: automatic classification, to support the knowledge of the expert, and collaboration between indexers, in order to obtain a more accurate result in the categorization. Then, we present a new approach called *Collaborative Document Classification*, describing their main elements and functionalities, as well as an application to the context of the political initiative indexing problem in the Andalusian Parliament. A computer simulation has been carried out with the aim of determining in a lab environment the possible benefits of this new approach, concluding that in several ways, the collaborative classification improves the indexing task.**

***Keywords*-collaboration; automatic classification**

I. INTRODUCTION

Document Classification or Categorization is the process by which a given document is labeled with one or more categories, which are representative of its content. These categories could be simple keywords or specialized descriptors from a predefined vocabulary (for example, a thesaurus). This process is also known as document indexing. Once a set of documents is categorized, the task of finding information is much easier as they are organized in such a way that similar documents belongs to the same categories.

This process can be performed either manually, by real users, experts or unskilled, or automatically, by means of classification algorithms [9]. Selecting one approach or another depends on several factors, as for example, the amount of information to be classified or the quality requirements in the resultant classification, among others.

This paper focuses on those situations where automatic categorization is configured as a computer-aided task for human experts, alleviating their work load, but at the same time when this process is critical in the sense that there is no room for error in the results. Therefore, it is necessary that an expert validates the quality of the automatic classifier's output, minimizing the risk of misclassified documents. For example, in official or critical documents generated by medical services or national parliaments.

But, another aspect that conforms the context for the research presented in this paper is the need of collaboration in the classification process. Let us suppose that an organization has created a library documentation service to index the documents that are generated. In such environments it is recognized that users usually work individually, applying some learned rules (maybe with the help of an automatic classification tool) that will adequately classify the majority of existing documents. There is a small number of documents, which is more difficult to classify, either because they are more ambiguous and therefore, harder to classify, or because they need more keywords to complete the classification (in multi-label classification problems). In such cases, it is then necessary that different individuals collaborate in order to find out the desired keywords. Then the problem is that there are no computer-supported tools that facilitate the collaboration among them and finally could help them to achieve the final decision.

The motivation for this research was born from the Andalusian Parliament, a regional chamber from Spain, where its librarians manually, and individually, index parliamentary initiatives by selecting a set of appropriate descriptors from the Eurovoc thesaurus. Our hypothesis is that supported by a computer application that facilitates collaboration among them, the indexing process would be more accurate.

Therefore, the objective of our research is to study document classification as a collaborative process: a set of individuals working together to select the most appropriate set of keywords representing the content of a document. The final contribution is a piece of software that implements relevant features borrowed from the Collaborative Information Retrieval (CIR) field [8], as sharing of knowledge and division of labour, applied to the document classification problem, validated by a simulation that reinforces the fact that collaboration is useful in this context. Specifically, division of labour is concerned with the task of assigning a set of jobs to a set of individuals, and knowledge sharing is used to allow communication between them and share information that other users can use to improve their classification.

The union of some parts of CIR and document classification originates a new research field that we have named *Collaborative Document Classification*, area that for the best of our knowledge is the first time that is presented in the specialized literature, configuring this proposal as the main contribution of this paper, which is organised as follows: In Section II, we describe in detail the problem that concerned us, explaining the motivation of this. Then, we explain how we pass from Collaborative Information Retrieval to Collaborative Classification in Section III, analysing the

 ISBN: 978-1-61208-206-6

similarities and the differences with related work. The details of the Collaborative Classification Model presented in this paper are in Section IV and the evaluation of the system is presented in Section V. Finally, Section VI concludes the paper with implications and future works.

II. The Underlying Problem: Classification of Parliamentary Initiatives

As mentioned before, the motivation for this research came from the observation of the current process of indexing of political initiatives in the Andalusian Parliament by the staff of its Library Documentation Service.

Parliament works around the concept of parliamentary initiative, whereby an action taken by a member or political party is discussed in a plenary or specific area committee session. These initiatives are identified by means of an initiative code and are usually composed of a relative short textual description (the subject), plus a detailed body. They are also manually indexed with a set of labels that better represents its content. These labels must be obtained from a controlled vocabulary, more specifically descriptors from the Eurovoc thesaurus (a multilingual, multidisciplinary thesaurus covering the activities of the European Union).

Currently, each initiative contained in the incoming stream is assigned to any of the indexers, following no rules to produce this assignment. This means that all of them are able to index any initiative, regardless of the area to which they belong to, i.e. there are no specialized human indexers in agriculture, economics, education and so on, who could produce a more specific classification, taking the most of the possible expert knowledge.

Then, given an initiative, the human indexer, with a deep knowledge of the Eurovoc thesaurus, is able to assign one or more descriptors to it, which are the most appropriate according to its content (initially using the subject, and in case of any doubt, consulting the body for more information). But this is usually an individual process, in which few times the indexer asks for advice to other colleagues.

We may easily observe that there are three main problems in this process: (1) The indexing process is completely manual; (2) The staff is composed of "general" human indexers, without specialization in any field, and (3) Collaboration between indexers is almost null. Then, we think that this routine could be improved substantially, obtaining much better results and making it more efficient (1) being supported by an automatic classification tool that could help the human indexers by suggesting descriptors for each initiative that they could consider to index it; (2) having a specialized staff, where each indexer is expert in one area, so the indexing could be done with a finer granularity, and (3) collaborating more frequently with the rest of colleagues.

Another problem in the current work flow is the fact that the person who creates the initiative, does not worry about what descriptors, or more broadly speaking, keywords, she would use. This task is assigned to the human indexers. But a true fact is that the representation power of the author for expressing more accurately the content of the text is lost in some cases. Therefore, it can be highly convenient that this person, after writing the text of the initiative could also select the descriptors. Two are the benefits of this approach: on the one hand, the indexing process would gain in quality, as the initiative is indexed in its origin and, on the other hand, the workload of the indexers would be reduced considerably.

In order to allow indexing in origin, two problems must be consider: Firstly, we can not assume that the user has got any kind of knowledge about the vocabulary that she could use in this task, because she is not an expert on indexing and, secondly, the user does not know which are the rules of the organization to index (for instance, what is better the use of narrower or broader terms?). In order to solve these problems, the user could be helped by an automatic classification tool at the first moment, and collaboratively supported by the knowledge of the staff members, who know very well the indexing process. Therefore, there would be a second type of collaboration, in this case not only between the professionals, but also between them and non-experts.

III. Towards Collaborative Classification

Information Retrieval (IR), as defined in [1], refers to the representation, storage, organization and access of information. Traditionally, research in IR has focused on models of individual users but in the last years a new trend based on remotely teamworks, working together to satisfy a need for common information, and supported on advances in distributed technologies and computer hardware, is becoming stronger. Consequently, some researchers have realized that collaboration is an important feature which should be analysed in detail in order to be integrated with professional IR systems, upgrading these to Collaborative Information Retrieval (CIR) systems.

An early definition of CIR was given by S. Dumais et al. in [13] as *"any activity that collectively resolves an information problem taken by members of a work-team"*. P. Hansen and K. Järvelin [14] considered collaboration as an important component in the IR process, defining CIR as *"an information access activity related to specific problem solving activity that, implicitly or explicitly, involves human beings interacting with other human(s) directly and/or through texts (e.g., documents, notes, figures) as information sources in a work task related information search and retrieval process either in a specific workplace setting or in a more open community or environment"*.

CIR systems usually include some common features: session persistence, division of labour, knowledge sharing and awareness. *Division of labour* - Morris's survey in [12] describes ad hoc methods to avoid duplication of effort during a searching task, such as distributing the space of potential keywords, search engines or sub-tasks

 ISBN: 978-1-61208-206-6

among different group members. *Sharing of knowledge* - In any collaborative setting, there will be a large and diverse knowledge base shared among groups of members. Each one will bring their own experience, expertise and topic knowledge to a particular searching task. What is needed is a way to enable the sharing of knowledge within the group [15]. *Group awareness* - Awareness is an essential element in distributed collaborative environments. Over the last decade, a number of researchers have explored the role of group awareness for supporting collaboration between distributed groups. [12]. *Session Persistence* - Storing a search session in a persistent format is a key requirement for facilitating collaboration during the session, revising the search at a later time, or sharing the results of a search with others [12].

Also CIR systems are divided into two types: synchronous and asynchronous. On the one hand, in the first class, teammates are able to interact between them at the same time; on the other hand, in the second type, the interaction is carried out in different time.

Particularly, in this paper, we have considered the *CIRLab* [6] framework. In general terms, it is a groupware framework, for experimenting with CIR techniques in different search scenarios. This framework has been designed applying design patterns and an object-oriented middleware platform to maximize its re-usability and adaptability in new contexts with a minimum of programming efforts.

The other main component of this research is Document Classification [9]. This area is also considered part of the IR and consists of assigning labels to a document, according usually to its textual content. There are three phases in the lifecycle of a text classification system, which traditionally have been addressed independently of each other: document indexing, text classifier learning and evaluation. The document indexing refers to the mapping of a document into a pattern that can be interpreted by the automatic classifier. In the second phase, the automatic text classifier learns from a set of categorized documents and learns the characteristics which define each class. Finally, the text classifier is evaluated to calculate its performance.

These two areas meet in a new one that we have called *Collaborative Document Classification*, in which we apply several features of CIR into the area of Document Classification. Specifically, techniques as division of labour or sharing of knowledge support a tool that helps human indexers to work collaboratively when classifying.

But this is not a mere and direct application from the CIR context. In this new Collaborative Document Classification area, two of the features previously mentioned take a different meaning. *Division of labour* - This is an important component in collaborative document classification, since in general terms it might have a great impact in the final process: The way in which the documents are distributed (divided) among the different individuals will have an effect in the background of the users, and as consequence, their usefulness in a collaborative framework. We analyse some algorithms because it is an important part of the collaborative classification. *Sharing of knowledge* - In our approach, the final decision about whether a keyword is appropriate or not will be lead by an individual, although in the process he/she can share his/her knowledge with others individuals, for instance by asking for keyword suggestion.

Therefore, and in practice, we have a division of labour phase before classifying and a sharing of knowledge phase after this process in order to improve the obtained classification. In Section IV, we show the details of the Collaborative Document Classification Model that we propose in this paper. Group awareness and session persistence take the same meaning as in CIR and are considered explicitly in the Collaborative Document Classification model.

There are few related works about collaborative classification. Most of them do not address the problem of text classification as a collaborative problem or do not use the term of collaboration with the meaning that we are using it, reason why we decide to focus on this topic. Collaborative classification is seen as social classification, i.e., the knowledge or the behaviour of users is used to classify something (documents, bookmarks, etc.). In this way, we mention [2] that proposes a methodology to carry out the collaborative classification idea of considering how similar users have classified a bookmark and [3] that compares a social classification using the uses of users with automatic extraction. This types of classification consist of extracting information about users and using it to classify. A similar work can be found in [11]. The authors propose an architecture that enables users to collaboratively build a faceted classification for a large, growing collection. But, the main difference with our work is that they considered collaboration as a set of individual user-machine collaborations, while we propose collaborations in the terms of user-user (direct communications between users instead of extracting the information from the global communications from the users to the system).

IV. Collaborative Document Classification

In this section, we are going to present the structure of the *Collaborative Document Classification Model* that we propose in this paper, which is graphically represented in Figure 1. The input is a continuous stream of initiatives that have to be indexed and the output is a set of labels (descriptors of a thesaurus) that are assigned to each initiative. Each one will be dispatched to a given human indexer (division of labour), who is responsible for its final classification. Then, the human indexer (using her knowledge, the support of an automatic classifier and the expertise of her colleagues (sharing of knowledge)) will compile the set of the most appropriate labels for representing the content of the initiative. Let us view in detail the different components:

Dispatcher Module: When the initiatives arrive to the system, they have to be distributed among the different

 ISBN: 978-1-61208-206-6

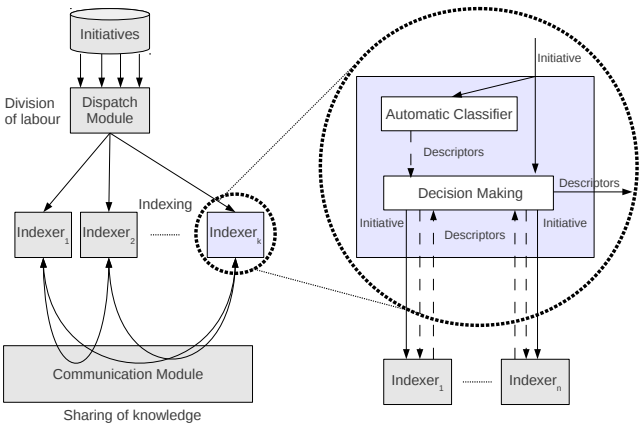


Figure 1. Collaborative Classification Model

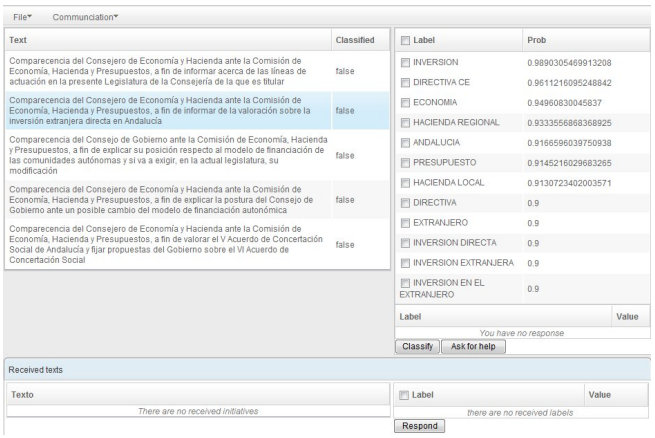


Figure 2. Sharing of Knowledge

human indexers as they will be in charge of the categorization task. This is related to division of labour, a key component of the Collaborative Document Classification process: The way in which the work is distributed among the indexers will determine the background knowledge of the users, the type of communications and also the quality of the classification itself, as we will demonstrate in Section V. Different scenarios can be considered, going from specialized distribution, where an individual only indexes those initiatives in a given field (so we assume that she is expert on that field), to random distribution, where all the indexers have the same probability to index a given initiative (so we assume that the indexers have got a general knowledge about all the possible fields). Nevertheless, it might be considered other factors besides human expertise as, for example, the indexers' workload balance.

Indexing Module: Once the indexer receives an initiative, she starts the classification task itself. The final result is an ordered list of descriptors, sorted by the degree of aboutness of each keyword with respect to the initiative, represented by means of a weight (to what extent the descriptor is suitable for representing the content of the initiative).

Although the indexer can work with no help, in our model we have an additional module for automatic classification that supports the indexer's work by recommending a set of weighted labels for each initiative. This is particularly necessary for those users which have not been trained as indexers (the keywords are proposed in origin).

The automatic classifiers have to be trained in order to learn the classification models necessary to recommend further labels. For this purpose we can use a set of preclassified initiatives, but also after a new initiative is finally classified, it is also used as training input for the automatic classifier associated to its responsible indexer. This helps to fit the automatic classifier to the particular background of its associated indexer. As mentioned before, this process is influenced by the division of labour strategy (dispatch module) since automatic classifiers behave different depending on the training data, which finally depends on the used division strategy. For example, the classification model learned from a set of heterogeneous initiatives (very different topics and randomly assigned to the indexer) is different from that one trained with homogeneous initiatives (all of them framed in a specific field where the indexer is specialized in).

Communication Module: The last phase in the process is referred as sharing of knowledge, part of CIR that allows indexers to communicate between them to work collaboratively during the classification. Sometimes, an indexer has problems to assign all the relevant labels to an initiative, probably because she is not an expert on a topic related to the initiative. In these cases, the indexer has to ask for help to the others colleagues to obtain extra information that helps her to make decisions about the relevant labels, as human knowledge and experience is very valuable in this task. Even though they are supported by automatic classification tools. This is the utility of the communication (sharing of knowledge) module (Figure 2 shows the interface that represents a chat box for synchronous communications).

In this sense, the source indexer sends, synchronously or asynchronously, to her workmates the initiative and the set of selected keywords. Then, they classify the initiative, also with support of their automatic classifiers, and propose a new set of labels to the source indexer who evaluates them. Thereby, an indexer could improve his classification with extra information. Obviously, in complex initiatives, all the indexers can collaborate by means of the sharing of knowledge component in order to get the final classification. This process can be iterated until the initiative has been classified with a high degree of satisfaction. Then, it is reported to all the indexers allowing a global vision of the progress in the classification task. There is no protocol for solving conflicts as the indexer in charge of the initiative is who makes the final decision.

 ISBN: 978-1-61208-206-6

A. Implementation Details

We have shown the details of the Collaborative Document Classification Model designed in order to improve the performance of the indexers of the Andalusian Parliament. In this section we shall present some implementation details.

Dispatching strategies: The particular strategy used to distribute the initiatives among the different indexers will depend on the typology of the working environment. We have considered the following two different frameworks: (1) *Generalized indexing framework.* In this case we are assuming that all the indexers are equivalent for indexing purposes. Then, the context of the initiative is not relevant to determine the indexer in charge of its classification. Therefore, we can use a *Round-Robin* algorithm to distribute the initiatives sequentially between the different indexers. Note that this is the usual strategy used in many organizations, and particularly, this is the one used in the Andalusian Parliament. (2) *Expertise indexing framework.* In this environment, each indexer can be considered as an expert in one particular area (for instance, health services, economy, agriculture, etc.). Therefore, it seems natural that she is the responsible for those initiatives under her field. In order to distribute the initiatives in this environment it might be necessary that a human indexer read all the initiatives, choosing among the indexers the most appropriate candidate for assigning the final descriptors. Then, dispatching will become a critical process, so in this paper we propose a different alternative: This task can be done automatically using the content of the initiatives to select one of the high-level indexing areas.

For this last, purpose we propose the use of the K Nearest Neighbours (KNN) classification algorithm [9], which might be trained using a set of initiatives belonging to the different categories. Note that although some dispatching (classification) error can happened, it can be easily mitigated by the indexer (whenever she is not able to classify properly an initiative, she can use the share of knowledge module to re-distribute it to the proper indexer). Particularly, the KNN algorithm calculates the distances between the initiative to classify and the initiatives in the training set. Then, these initiatives are sorted by ascending order and the k nearest initiatives are selected. The algorithm classifies the new initiative in the category that most appears in the set of the k nearest initiatives (euclidean distance) or randomly if tie.

Helping the human indexers: An automatic classification tool: Independently of the working indexing environment, whenever the indexer receives an initiative she proceeds finding out the proper descriptors from a controlled vocabulary. This process can be done with the help of an automatic classification tools, which proposes a set of candidate descriptors. As mentioned before, this tool is particularly beneficial when the descriptors must be selected in origin. In our approach, this component is implemented using the *REBAYCT* algorithm [4][5] that uses Bayesian Networks for hierarchical text classification in a supervised and non supervised way. (Detailed information about how this hierarchical text classifier works could be seen in the already cited reference). The list suggested by the automatic classification module is evaluated by the human to determine which are relevant for the target initiative, so she could select the most appropriate and add those which she judged also relevant from her point of view. Each indexer has got her own automatic classifier which receives, in a feedback process, those initiatives which have been previously classified by the human as training data, so the automatic classifier can be adapted to the indexers preferences and learn new rules to find out the proper descriptors. Moreover, the automatic classifier is fed with the last initiatives already classified by the human, after the initial training phase, so it is up-to-date and totally adapted to the indexer.

Sharing of knowledge: With respect to the implementation, we have to mention that for the interactive communications between users, we have borrowed the middleware-based architecture used in *CIRLab* [6] framework as it is more appropriate for collaborative applications than a client/server architecture. This software was designed to develop CIR applications. The software implements all the CIR features, although for this application we only use the part related to the sharing of knowledge. The framework provides us many communication techniques such as sending synchronous messages, notifications of user connections, etc. In addition, we can create different collaborative working sessions so users can work in independent groups. In our case, we have integrated instant messaging between users, supporting the sharing of knowledge that concerns us in this application, i.e., the sharing of initiatives and labels. incorporates *CIRLab*.

V. EVALUATION

We have developed a working prototype including all the already mentioned capabilities. The indexer can use the prototype to `search` for the best set of descriptors for a given initiative. Thus, in case of doubts, she can ask for help to the others colleagues (sending a package containing the initiative and a set of descriptors). Each colleague evaluates the proposal and, in case of having some additional labels which might be used to describe the initiative, decides to send them back to the original indexer who has to evaluate this new set of labels to obtain the final descriptors.

Nevertheless, changing the workflow of a (large) organization is difficult, and moving away from isolated to collaborative classification represents an important challenge that has to be evaluated properly. In this sense, we have designed a simulation study with the aim of demonstrating to the organization that working collaboratively and coordinately can improve the overall process.

 ISBN: 978-1-61208-206-6

A. Experimental Design

In our study, we use the same workflow, but replacing the indexer's search of the best set of descriptors by a process in which the indexers only judge those descriptors proposed by their associated automatic classifiers, as described in Section IV. By means of this simplification we can simulate different indexers working in an isolated and collaborative environments: (1) *Indexers working isolately*: Each indexer, i_i, judges an initial set of descriptors, i.e. the top-k descriptors proposed by her associated automatic classifier. (2) *Indexers working collaboratively*: Each indexer, i_i, judges an initial set of k descriptors proposed by her associated automatic classifier. Then, she sends a package to all the indexers, $i_j \neq i_i$. (A different alternative might be to select some of them, but we are focusing on measure the effect of working in a fully collaborative framework.) Each collaborative indexer, i_j, uses her own automatic classifier to obtain also a set of k descriptors. This indexer does not judge whether they are relevant or not for the initiative, but in case of having new descriptors (descriptors(i_j)\descriptors(i_i) $\neq \emptyset$), she sends a return package that will be evaluated by i_i to obtain the final descriptors.

B. Data Sets

In this experimentation, we have considered the initiatives discussed by different committee sessions in the Andalusian Parliament. These committees are usually attended by a reduced number of Members of Parliament (MPs) according to different areas of interest (agriculture, economy, education, etc.). Each initiative contains a subject, a text describing the content, plus a development, i.e. the full transcriptions of all the speeches discussing the concerned topic, although we are only taking into account the text from the subject.

We have two different set of initiatives: The first one, with 317 initiatives, where for each initiative we also know the particular committee session in which it has been discussed. This set is only used to learn how to distribute an initiative by the division of labour module (when necessary).

The second set has 7933 initiatives and is used for evaluation purposes. In this dataset, each initiative contains a subject and the set of descriptors from the Eurovoc thesaurus already assigned by the indexers, important information for validating our approach. This set will be split into training (80%) and test (20%) (none of the initiatives used for training will be then used for test). Training initiatives will be used as inputs for the different *REBAYCT* classifiers.

C. Indexers typologies and working settings

In our study, we shall consider three different indexers typologies which can work in three different working scenarios: the first type of user (U_1) represents a non-specialized indexer, which has a varied outlook of the parliamentary domain; the second type (U_2) is an indexer specialized in narrow or restrictive domains and the last one (U_3) represents an specialist who is in charge of the initiatives in a broader domain. Then we represent to the professional indexers working in the Parliament, as well as those users who could generate initiative. In order to get the area of expertise specialized for the human indexers we have considered the topics of the 6 main committee sessions in the Andalusian Parliament, i.e. the commissions of Economy, Agriculture, Education, Employment, Culture and Public Administration and Justice. The size of committee (in number of initiatives) will be useful to represent the different specialists. Thus, in the case of U_1, each individual *REBAYCT* classifier is trained with 1325 random initiatives; for U_2, the automatic classifiers are trained with 265 initiatives, while for U_3, the training set is composed of 1705 initiatives.

Related to the simulation of the working environments we will consider as baseline the situation in which the indexers are working isolated ($C1$) but also two collaborative settings: the first one, where an indexer works collaboratively in a non-specialized environment, i.e. the rest of the indexers are non-specialized ($C2$), and the second one, where the indexer works with specialists ($C3$).

D. Evaluation metrics

Our aim is to determine the effect of using a collaborative approach in different indexing scenarios. In order to evaluate our approach, we are going to consider two different criterion: On the one hand, the quality of the final classification and, on the second hand, the utility of the communications.

The measurement of classification system's performance relies on two metrics very well known measures in the field of text classification: precision and recall. Precision gives us an estimate of how many of the found descriptors are relevant to the initiative whereas recall estimates how many of all the descriptors relevant for a given initiative were successfully found. The first one is not relevant in our experimentation: We assume that all the descriptors finally selected by the indexers must be relevant for the initiative. The second one, recall, is particularly interesting for our proposal since, in some way, it gives an idea of the number of relevant descriptors which might be found thanks to the collaborative support. Thus, we calculate the recall values for the three type of users measured as the proportion of the relevant descriptors among those suggested to the indexer (by her associated automatic classifier or the rest of her collaborative colleagues) relevant for the initiative:

$$recall = \frac{N^o proposed\ relevant\ descriptors}{N^o total\ relevant\ descriptors}. \qquad (1)$$

The second criteria to evaluate refers to the utility of communications (CU). So, in order to measure the utility of the communications we propose to consider the proportion of return packages (those including new labels, and therefore being able to increase the knowledge of the indexer) with respect to those sent. Note that in this measure we are

 ISBN: 978-1-61208-206-6

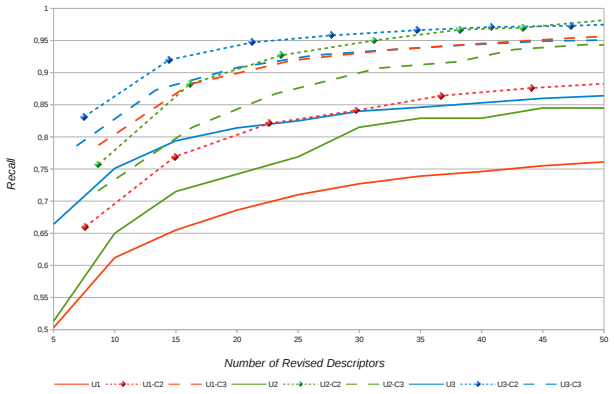


Figure 3. Recall values for the different environments

not considering whether the proposed descriptors are finally selected by the original indexer or not. This is a metric that we have specifically designed considering this problem.

E. Experimental Results

In this experimentation we consider the utility of the user from two different points of view: On the one hand, we shall measure how useful the communications that an indexer receives (incoming packages) are and, on the other hand, we shall determine the usefulness of the communications that an indexer sends to their colleagues (outgoing packages).

C_2	U_1		U_2		U_3	
k	C2	C3	C2	C3	C2	C3
5	10.339	14.679	14.679	14.528	9.906	7.489
10	9.796	12.332	12.264	12.716	8.909	6.739
15	10.188	12.686	11.509	10.83	8.316	6.739
20	9.713	12.196	11.169	11.547	7.724	6.299
25	9.328	11.818	10.603	10.452	7.753	6.228
30	9.381	11.622	8.943	8.452	7.208	5.753
35	9.147	11.486	9.32	7.886	7.043	5.689
40	9.313	11.026	9.396	7.66	6.785	5.495
45	9.049	10.913	8.603	7.396	6.668	5.624
50	9.192	10.815	8.792	7.471	6.504	5.36

Table I
USEFUL COMMUNICATIONS RECEIVED BY AN INDEXER

1) Utility of incoming communications: Table I shows, for each user, the usefulness of the communications under different scenarios. Some conclusions can be obtained: The first one is that the working environment (note that this is finally related to the division of labour strategies) has an effect on the utility of the communications. Thus, a non-specialized human indexer, $U1$, obtains more feedback when working in a specialized environment, whereas an indexer specialized in broad domains, $U3$, obtains more feedback when working in a general scenario. This can be explained because in $C3$ the indexers are specialists in their respective domains, so they are not useful for a specialist but they might be helpful for a non-specialized indexer.

The situation is quite different for the indexer specialized in a narrow domain. In this case, there is no difference if she works in a general or specialized environment. The large amount of useful communications, particularly if we compare with the other specialist $U3$, can be explained because her associated automatic classifier has been trained with less data, being not able to find some general rules learned by the others models. These rules suggests descriptors that could be also applied in this field (independently if these descriptors are valid for the initiative in a narrower domain).

Related to this last point is the study of whether the communications are fruitful or not. In this sense, a fruitful communication will help to find more proper descriptors, and as consequence it will improve the recall metric. Figure 3 can help to understand this situation. Particularly, we show the recall curves obtained under the different scenarios when considering the total number of descriptors analysed by an indexer. We use with solid lines to represent the results obtained when the user works isolated, the lines with dots and diamonds represents the recall values obtained when working in a general collaborative environment $C2$ and, finally, the dashed lines represent the results obtained in a specialized collaborative scenario, $C3$. The first conclusion is that in collaborative scenarios the recall increases considerably, which means that the communications are helpful in all the situations (it is better for the user to ask for help than to keep exploring the descriptors isolated).

Moreover, specialized indexers working isolated obtain best results than non-specialized ones (for $U1$ it might be applied the idea of "jack of all trades, master of none"). Now, let us focus on the situation presented when the indexers work in a collaborative environment. In this case, the specialized ones ($U2$ and $U3$) work much better when working with generalist indexers. The explanation of this fact is found in Table I, because non-specialized indexers propose more useful descriptors. This is particularly true for those specialists in narrow domains, as $U2$. But the situation changes for non-specialized indexers, being preferable to work in specialized scenarios. The reason seems to be clear: asking for help to similar people is good, but we will obtain much reliable results if we take into account the opinion of the specialist. In this sense, we would like to highlight that a general indexer working with specialists can obtain the same recall as the specialists. This results is particularly relevant because it supports the idea that in a collaborative environment it is possible to index at the origin (by the people who proposed the initiative) without worsen the quality of the indexing processes.

Finally, a last conclusion is that it will be convenient that non-specialized and specialized indexers work together in collaborative environments. This result is important because it opens a new research opportunity, i.e. we have to study carefully the way in which the division of labour is performed in the initial steps and its effects in the final results.

 ISBN: 978-1-61208-206-6

2) Utility of outgoing communications: In this section we shall discuss how useful is this particular indexer for the rest of her colleagues, analysing how many useful communications proposes. In Table II we show the obtained results. From this table we can see that, independently of the indexer typology, a greater number of communications is obtained when working in a non-specialized scenario, being the difference particularly relevant when assuming that the original indexer is a specialist. This corroborates the fact that specialized users are helpful in general environments and that broad-domain specialists collaborate more actively. With respect to non-specialized users, it is particularly relevant the large volume of useful communications in a specialized scenarios, becoming more valuable users (they can provide some kind of information that the specialized indexers, focused on a specific domain, are not able to capture).

C_2	U_1		U_2		U_3	
k	C2	C3	C2	C3	C2	C3
5	19.841	18.035	14.679	10.384	23.841	15.974
10	19.328	15.066	12.271	7.99	20.92	13.638
15	18.618	14.659	10.407	6,757	19.645	12.929
20	18.581	13.445	10.211	6,784	19.124	12.084
25	18.581	12.46	9.894	6,001	18.581	11.428
30	17.652	12.263	9.335	5,414	18.316	11.221
35	17.071	11.284	9.252	5,57	17.577	10.943
40	16.83	11.201	8.898	5,433	16.883	9.82
45	16.505	11.271	8.505	5,499	17.215	9.73
50	16.883	10.654	8.03	5,544	17.283	10.008

Table II
UTILITY OF USERS IN A COLLABORATIVE ENVIRONMENT

VI. CONCLUSION AND FURTHER RESEARCH

This paper has presented a new approach for document classification, based on collaborative techniques borrowed from CIR. The motivation for this development was the improvement of the current manual indexing of political initiatives from the Andalusian Parliament. This new technique is based on two important CIR concepts: division of labour and sharing knowledge. Beside, automatic classification is included to support the human indexing process. Then the individual and manual indexing is transformed to a collaborative task, where all the human indexers could be involved to improve the keyword assignation.

In order to determine if this approach could work in a real environment, we have designed and performed a simulation in the context of indexing political documents in this regional chamber, where several scenarios have been represented, considering the expertise of the human indexers (general knowledge about the source; specialized in a broad domain and in a narrow domain) and the working environment where they have been included (working isolated, with general knowledge indexers or with expert ones).

The main conclusion drawn from this evaluation is that collaboration substantially improves the classification process for all types of users in any working setting. More specifically, a non-specialized human indexer would obtain better results when they work with specialized colleagues (non-expert user working collaborative with expert users is able to classify as well as they are), and the other way around: a specialized indexer would improve her performance working with a set of non-specialized workmates.

With respect to further research, the first step is to evaluate the collaborative classification tool with real users by means of a user study in the Andalusian Parliament, once we have shown that the simulation shows these very interesting and good results. Also we are planning to test our model in other contexts, with different problems, for example, indexing of medical articles, where the number of documents is much higher as well as the specialization degree of the indexers.

Acknowledgement. This work was jointly supported by the Spanish Ministerio de Educación y Ciencia (TIN2008-06566-C04-01 and TIN2011-28538-C02-02), Spanish Research Program Consolider Ingenio 2010: MIPRCV (CSD2007-00018) and Junta de Andalucía Excellence Project TIC-04526.

REFERENCES

[1] Baeza-Yates, R. and Ribeiro-Neto, B. *Modern Information Retrieval*. Addison Wesley, 1999.

[2] Benz, D. and Tso, K. and Schmidt-Thieme, L. *Automatic Bookmark Classification: A Collaborative Approach*. 2nd Workshop on Innovations in Web Infrastructure, 2006.

[3] Bogers, T. and Thoonen, W. and van den Bosch, A. *Expertise classification: Collaborative classification vs. automatic extraction*. SIG Classification Research Workshop, 2006.

[4] de Campos, L. M., Fernández-Luna J. M., Huete J. F., and Romero A. E., *Automatic Indexing from a Thesaurus Using Bayesian Networks: Application to the Classification of Parliamentary Initiatives*. LNCS 4724, pp. 865-877, 2007.

[5] de Campos, L. M. and Romero A. E., *Bayesian Network Models for Hierarchical Text Classification from a Thesaurus*, IJAR, 50(7), pp. 932-944, 2009.

[6] Fernández-Luna J. M., Huete J. F., Pérez Vázquez, R. , and Rodríguez-Cano J. C. *CIRLab: A groupware framework for collaborative information retrieval research*. IP&M, 44(1), pp. 256-273, 2009.

[7] Joho, H., Hannah, D., and Jose, J.M. *Revisiting IR Techniques for Collaborative Search Strategies*. ECIR, pp. 66-77, 2009.

[8] Morris, M.R. and Teevan, J. *Collaborative Web Search: Who, What, Where, When, and Why?* Morgan & Claypool, 2010.

[9] Sebastiani, Fabrizio. *Machine learning in automated text categorization*. ACM Comp. Sur., 34(1), pp. 1-47, 2002.

[10] Shah, C., and González, R. *Evaluating the Synergic Effect of Collaboration in Inf. Seeking*. SIGIR, pp. 24-28, 2011.

[11] Wu, Harris and Zubair, Mohammad and Maly, Kurt. *Collaborative classification of growing collections with evolving facets*. Hypertext, pp. 167-170, 2007.

[12] Morris, M. R. *A survey of collaborative web search practices*. CHI, 2008, pp. 1657–1660. 2008.

[13] Dumais, S., Grudin, J., Bruce, H., Fidel, R., Poltrock, S., and Pejtersen, A. M.,*Collaborative information retrieval (cir)*.The New Review of Inf. Behaviour Res., pp. 235247, 2000.

[14] Hansen, P. and Järvelin, K. *Collaborative information retrieval in an formation-intensive domain*. IP&M, 41 (5), pp. 1101-1119, 2005.

[15] Foley, C., Smeaton, A. F., and Lee, H. *Synchronous collaborative information retrieval with relevance feedback*. 2nd Int. Conf. on Collaborative Computing, pp. 1-4, 2006.

 ISBN: 978-1-61208-206-6

Consideration of the Function to Find Friends in Social Games

Kohei Otake
Graduate School of Business Administration
Senshu University
Kanagawa, Japan
e-mail: mm111005@senshu-u.jp

Tomofumi Uetake
School of Business Administration
Senshu University
Kanagawa, Japan
e-mail: uetake@isc.senshu-u.ac.jp

***Abstract*—Recently, social games have been attracting attention. Social games can be enjoyed more by building a relationship with other players. However, many users are playing social games only with their friends. There are functions to find friends through social games and social networking services, but these existing functions are not enough to find friends easily. In this paper, we consider the function to find friends in social game to find friends easily. In addition, we examine the method of visualizing and representing the friend candidates. We find that our visualization method may be effective to find good "like-minded people" easily.**

***Keywords*—social game; SNS; network analysis; community forum; visualization**

I. INTRODUCTION

Recently, social networking services (SNSs) are growing in popularity. SNS are web-based online services that focus on the building and reflecting of social networks among people. The typical SNS in Japan are Facebook, Mobage, mixi and GREE. Usually, these SNS companies sell online advertising on their sites. Their business model is based upon a large membership count. So, it is very important for SNS to assemble a large number of users. In this situation, social games have also been attracting attention [1][8]. It is because interesting social games can gather many users; so, SNS companies have introduced the social games aggressively.

One of the features of social games is in leveraging the player's social network [2]. A player can share his/her game with friends. So, social games can be enjoyed more by building a relationship with other players. For example, FarmVille [15], a farm training game developed by Zynga in 2009, is a very simple and easy game. However, players can share information and their experiences with "like-minded people" and "friends". This game was become popular and has more than 100 million users.

Therefore, in social games, playing with "like-minded people" and "friends" is just as important as the contents of the game. So, it is important for social game developers and SNS companies to provide functions that can support finding "like-minded people" and "friends" easily [7].

Usually, there are two ways to contact unknown users in a social game. One way is through a function, provided by the game, to find friends. However, it is difficult to contact with unknown users through this function, because it is difficult to get enough information to communicate with each other. Another way is a (formal or informal) community forum provided by SNS. We think that this is very good to start new relationships, because it includes a large amount of information. But, this is not enough function to find good "like-minded people" and "friends" easily in a social game.

There has been a lot of research about SNS [3][4][5]. For example, there has been research which focused on the structure of large-scale friend networks [5], analysis of network structures [10][11] and a growth models of SNS [12]. Since users recognize and make friends mutually in SNS, this research is static network research. Moreover, paying attention to the relationships with friends, network analysis using active users and an active link which changes dynamically has been studied [13]. Much of this research used social network analysis (SNA).

The research was also performed on small-scale SNS (Regional SNS). So, the research on social games offered by large-scale SNS has stopped only at the research on a characteristic business model from the height of the novelty.

Social games are attracting a lot of attention in recent years. They have also expanded market size and now service as killer contents of SNS. We think the relationships with friends through social games need to show clearly what kind of influences they were on users. Moreover, we think that it is necessary to examine how to exhibit effectively the function which social games have. In this paper, we observed "the method of finding a new friend through SNS" at the social game which draws cautions in recent years using SNA. But there has been little research about social games.

This paper is organized as follows. Section 2 describes problems of the social game. In Section 3, we consider the characteristics of the functions provided by SNS and social games. In Section 4, we examine our proposed methods. Section 5 summarizes our paper and describes our future works.

II. PROBLEMS OF SOCIAL GAMES

At first, in order to clarify the problems of social games, we carried out a questionnaire to social game players (84 university students). The main questions are as follows.

- What kind of social games do you play?
- What kind of people do you play with?

 ISBN: 978-1-61208-206-6

Through the results of questionnaires, we found that many of them did not make new friends in social games. Many users are playing social games with already known users. They felt social games are fun, but it is difficult to make new friends. So, we interviewed five social game players (two experts and three beginners) about the difficulty mentioned above. Through the results of these interviews, we found that many players felt anxiety when they made contact with unknown users. Moreover, we found following two problems.

1) *Many players of social games who want friends do not know what kind of information is needed to contact unknown players*
2) *It is difficult to contact to the friend candidates, because there are many candidates who have a wide variety of personal information.*

To solve the former problem, we focused on the community forum about the social game that includes large amount of information [6]. We analyzed the bulletin board for friend on "Bandit Nation" a Japanese social game from Mobage. We also categorized the posts that were written on the community forum. To clarify the information that is needed to contact unknown players, we used conjoint analysis based on the above categories. In the results of this analysis, the following three elements have been important in the bulletin board to contact with unknown players, in addition to basic attributes such as their status and conditions for which a partner is asked (For further information, see [6]).

- Manners: local rules of the game or netiquette
- Merits: mutual benefit (ex. replacing items)
- Communication: The frequency of message exchange, and the method of contact

As mentioned above, although we have examined the former problem, we have not examined the latter problem yet. Therefore, we will now focus on the latter problem and we examine a method that supports contact with unknown friend candidates effectively in this paper.

III. CONSIDERATION OF THE FUNCTION TO FIND FRIENDS

By using an existing function in social games, a player can find the friend candidates. But in many cases, there are many friend candidates. Moreover, they usually have a wide variety of personal information. However, players cannot see personal information of individual candidates easily. So, the player is difficult to find "like-minded people". Moreover, contact with unknown users is usually uneasy. Since the information acquired in the game is restrictive, it is difficult for players to judge whether a candidate is appropriate or not. In order to solve this problem, we think that it is necessary to use information indicating the identity of the friend candidates.

Usually, there are following types of information in SNS.

- User profiles
- User preferences

On Mobage [14], a personal page includes following types of information.

a) SNS friends
b) Game titles which the user plays
c) Communities to which the user belongs
d) Favorite channels linked with video-sharing sites
e) Profile (avatar, areas, jobs, age etc…)

By using the above types of information, we think that it is effective for players to judge whether a friend candidates is appropriate or not. By analyzing personal pages in Mobage, we found that many users do not use *d)* Favorite channels, and users often do not publish *e)* Profile. So, it was difficult to use the above types of information. Therefore, we used *a)* Friends, *b)* Game titles and *c)* Communities in this paper.

Moreover, there are many various the friend candidates. In this situation, we think that visualization is also important finding "like-minded people" effectively. So, we will examine the methods to visualize the relation between the player and friend candidates in next section.

IV. EXAMINATION OF METHOD TO VISUALIZE

In this paper, to examine the methods to visualize the relation between the player and friend candidates, we focused on Bandit Nation a major Japanese social game from Mobage and we set up the following situations (Tables I, II).

TABLE I. PLAYER INFORMATION

Game status	Player's preference
Level: 100 Type: Sexy	Number of friends: 8 Number of registered games: 2 Number of communities: 9

TABLE II. SEARCH CONDITIONS

Required game status	Attributes
Level: 50 or more Type: Sexy	Good manners Can cooperate in the game Can communicate in-game or through SNS Initial avatar: Not OK Items replace: OK

TABLE III. PROPERTIES OF 14 FRIEND CANDIDATES

	Friends	Game titles (Except Bandit Nation)	Communities
Average	60.7 / user	7.2 / user	4 / user
Max	286	35	17
Min	8	0	0
Standard Deviation	75.3	8.4	4.6

 ISBN: 978-1-61208-206-6

We extracted users that satisfy at least three of the above conditions. As a result of searching, we extracted 14 friend candidates from about 200 users who wrote on the recruiting community forum in Bandit Nation. Properties of the 14 friend candidates are shown in Table III.

In this paper, we considered the following combination of information (case1, 2, 3) in order to find "like-minded people" effectively.

- Case 1: friends, games and communities
- Case 2: games and communities.
- Case 3: games, game categories and communities

To grasp the relationship between the player and friend candidates easily, we visualize the properties of friend candidates using network analysis. In this paper, we used Pajek, a program for large network analysis, to draw network diagrams. The network diagram is drawn in the Kamada-Kawai layout algorithm that uses spring forces proportional to the graph theoretic distances [9]. The network diagram specifications are shown in Table IV.

TABLE IV. SPECIFICATION OF A NETWORK DIAGRAM

Item names	note
Player node	large gray triangle
Friend candidates' (*fc*) node	small triangle
Friend candidates' friends' node	large circle
Community node	small ellipse
Game title node	small square
Game category node	small diamond
Paths to communities and games from *fc*	black path
Paths to friends from *fc*	gray path
Paths to game categories from *fc*	black and dots path
Paths to game categories from Game	gray and dots path

A. Network diagram using Case 1 data

At the beginning, we used case 1 data and we drew a network diagram (see Figure 1).

At first glance, we found that the overwhelming majority of nodes are friend candidates' friends' nodes. Moreover, as mentioned above, the number of friends had a big difference by friend candidates. Therefore, the friend candidates who have many friends tended to be plotted far from the player when using the Kamada-Kawai layout algorithm. But it is not a negative factor for recruiters. If the player and the friend candidates have a large number of mutual friends, the network diagram may be plotted accurately. Therefore, this method may be effective to apply to closed communities (such as university SNS, enterprise SNS, etc.). However, users who wrote in the recruiting community forum had few mutual friends; so, we think that it is difficult to use this method in this case.

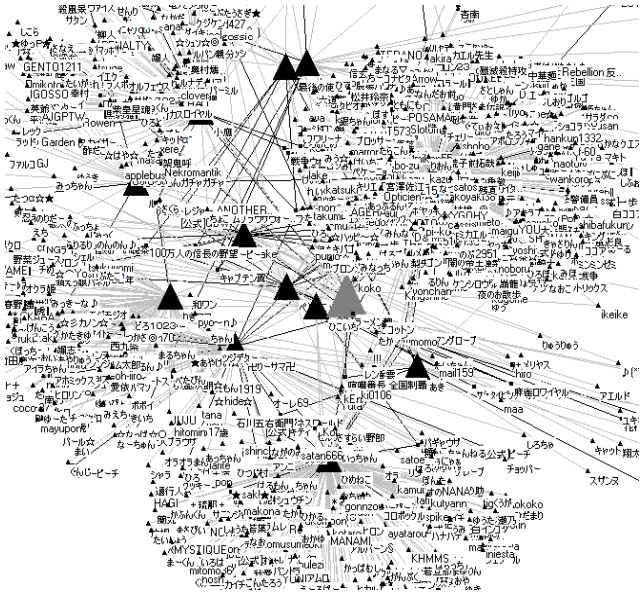


Figure 1. Part of the network diagram of case 1

B. Network diagram using Case 2 data

In case 1, we found that the player and friend candidates did not have mutual friends in the recruiting community forum. Therefore, we thought that it is difficult to use friend candidates' friends' information to draw the network diagram. So, we drew the network diagram by using Game and Community nodes only (see Figure 2).

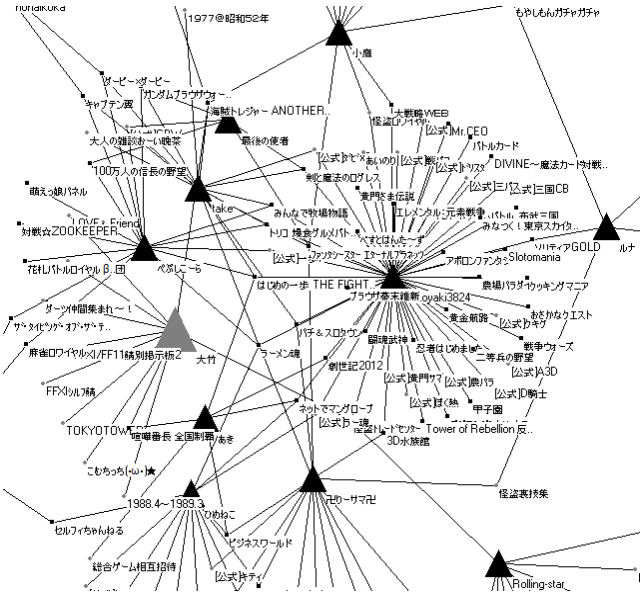


Figure 2. Part of the network diagram of case 2

Although there is a difference in users in case 2, the distance between users is shortened compared with case 1. Users who play the same game or belong to the same

communities are plotted especially near. We think that case 2 can represent an accurate network diagram when compared to case 1. Furthermore, the network diagram of case 2 is easier-to-use than the network diagram of case 1. However, when users are playing many different games, the problem that they will be plotted far from each other in network diagram arises. Playing various games is not a negative factor. If the player and the friend candidates have a large number of mutual game titles, the network diagram may be plotted accurately. But, users who wrote in the recruiting community forum had few mutual game titles, so we think that it is difficult to use this method in this case.

C. Network diagram using Case 3 data

In case 3, we used 10 game categories (RPG, Sports/Race, Puzzle, Action/Timing, Quiz/learning, Simulation/training, Adventure, Board/Card, Gambling, Other) of Mobage to draw a network diagram (see Figure 3).

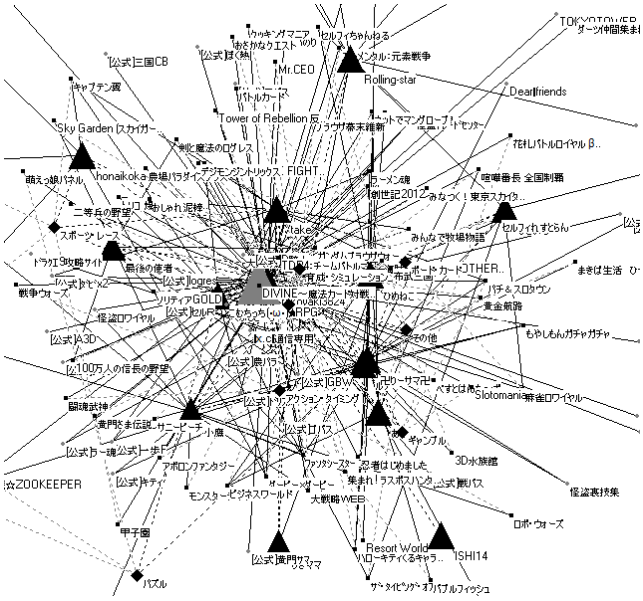


Figure 3. Part of the network diagram of case 3

We think that it is possible to measure the distance accurately by using game categories. Moreover, even if users do not play the same game title, the player can find "like-minded people" in social games easily. We think that case 3 can represent an accurate network diagram when compared to case 2.

To evaluate this network diagram, we judged three users who were plotted nearby the player by analyzing their personal information. Through this evaluation, these three users seemed to be "like-minded people" for the player in this case. So, we think that this method is more effective to find good "like-minded people" easily in a social game than the existing social game's function.

V. CONCLUSIONS AND FUTURE WORKS

In this paper, we focused on social games. Social games can be enjoyed more by building a relationship with other players. However, many users are playing social games with their friends only. They feel that making new friends in social games is difficult. To solve this problem, we focused on the difficulties which arise when a user contacts friend candidates. In order to solve this problem, we think that it is necessary to use information indicating the identity of friend candidates. Moreover, we examine the methods used to visualize the relationship between the player and friend candidates. We considered three cases of combination of information in order to find "like-minded people" effectively. We found that visualization of the relation between the player and friend candidates by using the user's preference information may be effective to find good "like-minded people" easily.

But, we set a same weight to all paths to draw the network diagram. So, there is still room for deliberation. We should research the reasonable weight of the paths. We should also evaluate our proposal. These are our plans for future works.

REFERENCES

[1] "The annual On-line Game industry report in 2009, 2010, 2011" (In Japanese)

[2] "FGH : Famitsu game hakusho 2010, 2011", enterbrain (In Japanese)

[3] Y. Matsuo (2006), "Indivisuals and Collaboration in Web2.0 Environments", Information Processing Society of Japan, Vol. 47, No. 11, pp. 1229-1236 (In Japanese)

[4] L. A. Adamic, O. Buyukkokten, and E. Adar (2003), "A Social Network Caught in the web", First Monday, Vol. 8, No. 6

[5] K. Yuta, N. Ono, and Y. Fujiwara (2006), "Structural Analysis of Human Network in Social Networking Services", Information Processing Society of Japan, Vol. 47, No. 3, pp. 865-874 (In Japanese)

[6] K. Otake and T. Uetake (2011), "Consideration for community activation in social games", The Japanese Society for AI, SIG-KSN-009-01 (In Japanese)

[7] K. Otake, T. Fukutomi, and T. Uetake (2011), "Quality of Community in Social Game", HCI International 2011 posters' extended abstracts Communications in Computer and Information Science, Vol. 173, Part VI, pp. 464-468

[8] M. Nojima (2008), "Why do people buy things why do not form", NTT shuppan sha. (In Japanese)

[9] T. Kamada and S. Kawai (1989), "An algorithm for drawing general undirected graphs information", Processing Letters, Vol. 31, pp. 7-15

[10] F. Toriumi, K. Ishida, and K. Ishii (2008), "Analysis of Network of Regional SNS", IEICE technical report, AI2008-22 108 (208), pp. 33-38

[11] Y. Matsuo and Y. Yasuda (2006), "How Relations are Built within a SNS world - Social Network Analysis on Mixi -", Transactions of the Japanese Society for Artificial Intelligence technical report, AI 22, pp. 531-541

[12] K. Ishida, F. Toriumi, and K. Ishii (2008), "Proposal for a Growth Model of Social Network Servise", Proceedings of Web Intelligence and Intelligent Agent Technology, pp. 91-97

[13] R. Yamaguchi, F. Toriumi, and K. Ishii (2009), "Analysis of user behavior in SNS", IEICE, AI, 108(456), pp. 69-74

[14] <http://yahoo-mbga.jp/>, 01. 30. 2012

[15] <http://company.zynga.com/games/farmville/>, 01. 30. 2012

 ISBN: 978-1-61208-206-6

Context-Aware Content-Centric Collaborative Workflow Management for Mobile Devices

Anna Kocurova, Samia Oussena, Peter Komisarczuk
School of Computing and Technology
University of West London
London, UK
Anna.Kocurova,Samia.Oussena,Peter.Komisarczuk@uwl.ac.uk

Tony Clark
School of Engineering and Information Sciences
Middlesex University
London, UK
Email: T.N.Clark@mdx.ac.uk

***Abstract*—The paper examines mobile context-aware content-centric workflows. With the proliferation of mobile devices, distributed collaborative teams can communicate, share content and remain productive while working out of the office. The collaboration process can be enhanced, more dynamic and efficient by using a workflow management technology that responds to collaborators' requirements, supports coordination of a teamwork and is adapted for context-aware content manipulation. This paper discusses context awareness and proposes to extend the existing collaborative workflow approach by a context-aware content lifecycle in order to make workflow processes more adaptive to collaboration needs.**

***Index Terms*—mobile; peer-to-peer; context-aware; content; workflows.**

I. INTRODUCTION

Collaborators use mobile computing in everyday life and expect to have the same or better services as traditionally available in desktop computing. In contrast to traditional computing, systems targeting mobile devices face a number of constraints in terms of location variability, context changes, network data connectivity and resource sharing [1]. Mobile devices reside in extremely dynamic contexts and mobile systems with the ability to react to frequent context changes can be more flexible and adapted to user needs.

Collaborative workflow management is a technology that supports coordination of geographically distributed collaborators and content manipulation, and can be used in a mobile setting. In order to utilise workflows in ubiquitous environments, adaptability and context-awareness are the features that should be included in the workflow mechanism [2]. Context awareness might have a number of meanings based on the domain to which it is applied. In this work, context is related to two workflow concepts: context-aware content and context driven workflow execution.

A. Context-Aware Content

Context information can semantically enrich a piece of mobile content. Content such as a picture, document or audio file is usually user-generated or adapted for use on mobile devices. For example, context-aware content can be a picture associated with information about the physical location, the time when it was taken or a certain user preference. From creation to disposal, content pass through various stages of its lifecycle. Context information can be added or changed in any stage of its lifecycle. So sharing of context-aware content between workflow participants and managing its lifecycle over a number of devices is challenging, especially if one task can be completed by a number of collaborators. Existing process-centric workflow approaches provide only a limited support for the recognition of a context-aware content lifecycle.

B. Context-Driven Workflow Execution

A context change can control start and termination of tasks or drive the overall workflow execution. How context is integrated in workflows depends also on an underlying management topology. In case of a centralised management topology, only light-weight workflow process support is provided on mobile devices. Decisions made by one or more servers with deployed workflow management system do not consider contexts in which the collaborating devices currently reside. Moreover, this topology is impractical for small-scaled workflows, especially in situations in which servers are not available or in business meetings when colleagues want to share private information. The need for mobile device workflow centric process operating in a completely distributed manner has been recognised [3]. Only in a peer-to-peer (P2P) management topology, management decisions can be based on the device's local, context-related information and workflows can become more context-oriented processes adapted for current collaborators needs.

This paper shows a work in progress and describes a research idea for integrating a context-aware content-centric perspective and context awareness into mobile collaborative P2P workflow management. The combination of the concepts offers promising opportunities which can enhance mobile collaboration. The presented idea is accumulated through an experimental construction of the following artefacts: a meta-model for workflow definition and software prototypes. The structure of the paper is as follows. Related work is discussed

 ISBN: 978-1-61208-206-6

in Section 2. Section 3 describes a case study. Section 4 discusses domain analysis. The research idea is outlined in Section 5. The final section 6 summarises the work in progress.

II. Related Work

This section describes work related to workflow contextualisation and artifact-centric workflow approaches. Workflow meta-models should support context modelling and its use in workflows [4]. Various frameworks for context modelling and management have been designed [5][6]. A number of works address workflow contextualisation [7][8]. These works rather offer general approaches for a wide spectrum of workflows. From our perspective, context awareness should be adapted for the problem it is applied to. Although no new context-related concept is introduced in this work, different approaches to context management and workflow contextualisation are proposed.

Focus on key business-relevant objects, their lifecycles and how services invoke on them has emerged [9]. However object-awareness in process-centric workflows is still very limited [10]. Entity such as content or business artefact is incorporated in an activity-based workflows as an input or output of an activity and the effects of how performed activities influence entity's behaviour are not visible [11]. Our goal is to integrate a context-aware content-centric perspective into workflows.

So, in summary, there is no existing mobile workflow management approach that would support context-aware content management, have a context-aware content lifecycle integrated and operate in a P2P context driven manner.

III. Case Study

The concept introduced in this paper is illustrated by using the following case study. A team of ten designers work on interior design of buildings. Designers often work out in the field using smart phones to communicate and directly share pictures. Although each design project is assigned to a particular designer, design decisions are never done by a single person. The following work pattern is used to complete projects. Based on client's requirements, a designer redesigns the room interior and takes a picture of the new room's look. The designer sends the picture to his fellow team workers in order to obtain at least two reviews within a short period of time. Often no more than few colleagues are at work at that particular moment and moreover, only some of them are able to review the picture within the required time. Ideally, the picture should be sent only to those colleagues who can review it. When two reviews are obtained, the designer is able to assess their comments and send the picture for final approval to client.

In addition, a simple rating system is used to aid in processing the pictures. Designers can add rating to the picture in a range between 1 as 'satisfactory' and 5 as 'not sure'. A designer can set up a preference specifying that only pictures with rating greater than 2 need to be sent for review. Other pictures do not need to be reviewed at the time. However, the preference can be changed anytime.

IV. Domain Analysis

In this section, domain characteristics are discussed.

A. Peer-to-peer workflow management

Without a centralised management unit, there are many challenges introduced. First of all, efficient resource sharing might be an issue. Secondly, each participating device needs to be aware of the workflow process definitions and also all multiple workflow process instances the device participates in. Each device executes only an allocated partition of the workflow and no single device has a complete view of the global workflow state. Finally, no fixed network infrastructure imposes challenges in identity and communication management.

B. Context Definition

Context describes the current situation of a user, a device or an environment regarding a specific purpose. User context can be a user preference, current activity or interest. Device's context might be its connectivity or battery level. Examples of environmental context might be the current time, the actual location or surrounding devices. Social context awareness, a core context to establish cooperative effort, relies on knowing the work context of fellow collaborators, such as their availability, current activity and location [13].

Workflow related context information can be categorised as case independent, case dependent with a priori knowledge and case dependent with no a priori knowledge [14]. In this work, only first two types of context information are considered. An example of case independent contextual information is connectivity. Information about connectivity is important anytime when a device needs to send a task, content or information to another device and is relevant to all collaborative workflow cases. On the other hand, user preferences or work context are information that are workflow case dependent with a priori knowledge. Each workflow case needs to have a predefined set of contexts which influence its execution. In addition, context definition is role-specific, therefore, specified for all roles involved in workflow cases.

C. Context Acquisition and Aggregation Mechanism

Context information that influences workflow execution may depend on a number of other contexts. All context information needs to be gathered and composed beforehand, see Figure 1. For example, *Connectivity* context depends on the current

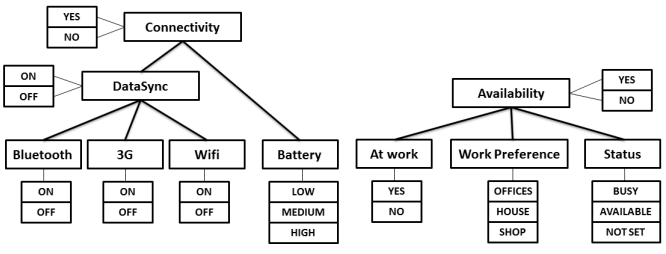


Fig. 1. Context Aggregation Example - Connectivity and Work Context

state of *Bluetooth*, *WiFi* or *3G*. If a context value of any of these contexts is *ON*, then data or content can be transferred. Sending content might be time consuming so it should be ensured that the device's *Battery* level is not *LOW*. The context value of the *Connectivity* is set to *YES* if *DataSync* is *ON* and *Battery* is either *MEDIUM* or *HIGH*.

Another example can be work context. Workflow execution is influenced only by the context value of reviewer's availability: *YES* or *NO*. Whether reviewer is available can depend on reviewer's work status, work preference or current availability. If the reviewer is at work, the picture theme belongs to his work preference and the status is set to *AVAILABLE*, the context information for *Availability* is set to *YES*.

Clearly, context acquisition and aggregation are concepts independent from workflow execution. The workflow management system does not need to know all context values because only the aggregated, final context information influences workflow execution. Therefore, context acquisition and aggregation can be separated and handled by a generic standalone context engine which is used to monitor, manage, aggregate and disseminate contextual information to the distributed mobile workflow management system as already presented in our previous work [15].

D. Context Adaptation

A context adaptation mechanism need to be integrated within the workflow management system. Both synchronous and asynchronous communications must be supported. An asynchronous communication mechanism is needed in order to receive all context information broadcasted by the context engine. Consequently all workflow instances which execution depends on that particular information are informed. In case when the context engine needs to be queried, a synchronous communication mechanism is used.

E. Content Sharing

Content sharing between devices might be a time consuming and costly operation, especially when one collaborative task may be accomplished by a number of actors with the same role but only few of them might be able to perform the task. Sending the piece of content to all of them would be inefficient in terms of transfer cost, device's resource usage and user's time consumption. A workflow management system running on each device would need to cope with the incoming content, store it and trigger an according action. Every participant would be informed about the task despite the fact that he might not be able to accomplish it within the required time.

F. Context-Aware Content and Lifecycle

A workflow process includes tasks that require interaction with content. At any given instant of time, content is in a specific state that is defined by values of ordinary metadata and context information. For example, after a picture is reviewed, it can be labelled as *Reviewed*. Collaborators often directly retrieve all pictures that are stored on mobile devices and would like to know in which content state the picture currently is. Content lifecycle can be described by a set of states and transitions between the states. Transitions between content states can be associated with context driven conditions. These conditions can influence content's behaviour and workflow execution. For instance, a designer decides to increase rating for a particular picture. Designer's preference determines that only pictures with rating higher than 3 can be proceed further in workflow and be sent to fellow participants. So this context change influences the execution of workflow at runtime. In order to sufficiently cope with the events at run-time, the context definition and its association with process definition must be expressed at build time. Moreover, there are two types of context information: workflow active and workflow passive. The workflow active context has an influence on the workflow execution whereas the passive context does not. The changes of context values might trigger certain actions.

V. Context-Aware Content-Centric Collaborative Workflows for Mobile Devices

A simplified example of the proposed adaptation of collaborative workflow for mobile devices is outlined in Figure 2. The collaborative work pattern presented in the case study can be abstracted into the workflow process presented in the middle and carried out by a distributed workflow management system deployed on mobile devices. A picture lifecycle can be integrated with the collaborative workflow process. Each activity that interacts with the picture is associated with a particular content state. Context driven conditions are placed on transitions between two content states. For example, the picture can go to the *Reviewed* state only if the value of added rating is larger than current *User Rating Preference*. Or the picture can go to the *Assessed* state only if the number of obtained reviews is more than the current *User Preference for Number of Reviews*. It is also depicted that the aggregated context values such as *Connectivity* and *Reviewer's Availability* can influence communication activities. Our assumption is that context driven conditions in the content lifecycle and coordinated social context-dependent workflow activities can effectively mediate the constraints of content sharing between workflow participants.

Currently, experiments have been conducted and a solution is under construction. The aim is to express the workflow definition at a metamodel level. A metamodel represents a language independent workflow ontology. An existing workflow process metamodel will be extended by three parts: context definition, context adaptation, and context-aware content lifecycle. A context definition defines the contexts, their aggregations and possible context values which influence the workflow execution. The context-aware content lifecycle part defines context information, states, transitions and context driven conditions for content handled in workflow. The context adaptation part expresses the adaptation itself. The knowledge is also mapped to an XML schema. Each context-aware content-centric collaborative workflow process definition can be described by an XML document that conforms to the XML schema and serves as a software input.

 ISBN: 978-1-61208-206-6

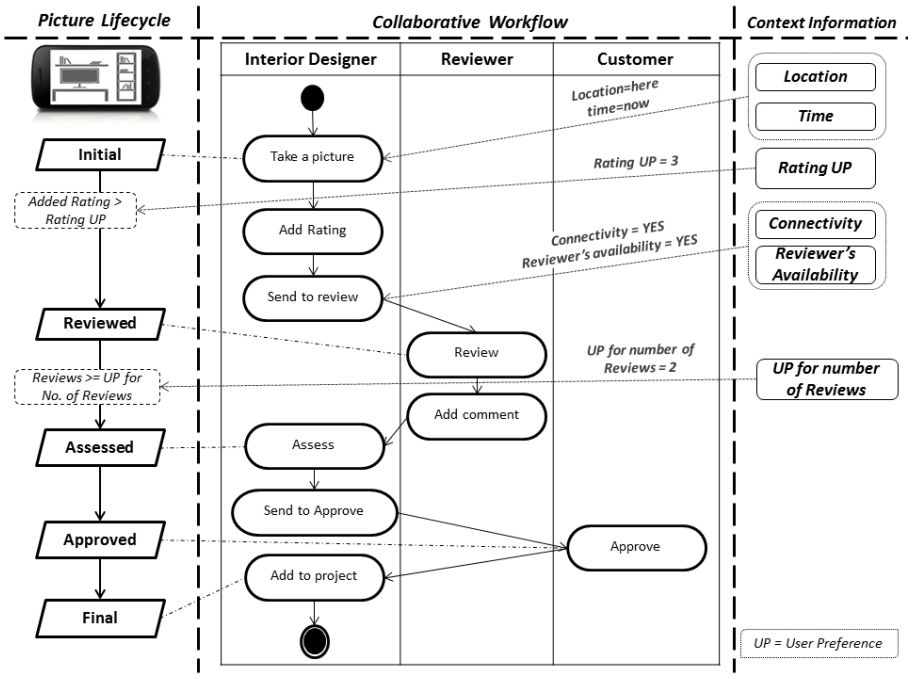


Fig. 2. Context-Aware Content-Centric Collaborative Workflow for Mobile Devices

VI. Conclusion and Future Work

The research aim is to adapt the collaborative workflow technology to mobile platforms with the objectives to achieve better mobile collaborative workflow management capable of processing contextual events and context-aware content manipulation. The proposed adapted workflow is a technology-based solution for mobile P2P collaboration and should have a positive impact for developers of certain classes of mobile applications.

A formal workflow model for context-aware content-centric collaborative workflow definition, management and execution is built. The model contains all necessary information about the adapted workflow process definition, management and execution. Prototypes of a context engine and a distributed mobile workflow management system capable of executing such workflows are under development on the Android platform. The context engine has been released as an open source software [16]. Future work includes finalising and evaluating of the workflow model and software prototypes.

References

[1] Q. H. Mahmoud, Middleware for Communications. John Wiley and Son, 2004.

[2] S. Smanchat, S.Ling and M. Indrawan, "A survey on context-aware workflow adaptations," in Proceedings of the 6th International Conference on Advances in Mobile Computing and Multimedia, 2008, pp. 414-417.

[3] L. Pajunen and S. Chande, "Developing workflow engine for mobile devices," in Enterprise Distributed Object Computing Conference, 2007.

[4] M. Wieland, O. Kopp, D. Nicklas, and F. Leymann, "Towards Context-aware Workflows," in CAISE 07 Proceedings of the workshops and doctoral consortium, 2007, pp.11–15.

[5] R. Reichle, M. Wagner, M. Khan, K. Geihs, J. Lorenzo, M. Valla, C. Fra, N. Paspallis, and G. Papadopoulos, "A comprehensive context modeling framework for pervasive computing systems," in Distributed applications and interoperable systems, 2008, pp. 281–295.

[6] J. Bardram, "The Java Context Awareness Framework (JCAF)a service infrastructure and programming framework for context-aware applications," Pervasive Computing, 2005, pp.98–115.

[7] M. Rosemann, J. Recker and C. Flender, "Contextualisation of business processes," in International Journal of Business Process Integration and Management 3(1), 2008, pp. 47–60.

[8] O. Saidani and S. Nurcan, "Context-awareness for adequate business process modelling," in Third International Conference on Research Challenges in Information Science, RCIS 2009, IEEE, 2009, pp. 177–186.

[9] R. Hull, "Artifact-centric business process models: Brief survey of research results and challenges," On the Move to Meaningful Internet Systems: OTM 2008, pp.1152–1163.

[10] V. Künzle and M. Reichert, "PHILharmonicFlows: towards a framework for object-aware process management" in Journal of Software Maintenance and Evolution: Research and Practice, 2011.

[11] K. Bhattacharya, R. Hull and J. Su, "A data-centric design methodology for business processes" in Handbook of Research on Business Process Management, 2009, pp. 503–531.

[12] I. Vanderfeesten, H. Reijers and W. van der Aalst, "Product based workflow support: dynamic workflow execution" in Advanced Information Systems Engineering, 2008, pp.571–574.

[13] J.E. Bardram and T. R. Hansen, "The AWARE Architecture: Supporting Context-mediated Social Awareness in Mobile Cooperation," in Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work, Chicago, Illinois, USA, 2004, pp. 192-201.

[14] M. Adams, A. Ter Hofstede, N. Russell, N. and W. van der Aalst, "Dynamic and context-aware process adaptation" in Handbook of research on complex dynamic process management: techniques for adaptability in turbulent environments/Ed. MM Wang, Z. Sun, 2009.

[15] D. Kramer, A. Kocurova, S. Oussena, T. Clark and P. Komisarczuk, "An Extensible, Self Contained, Layered Approach to Context Acquisition" in Proceedings of the Third International Workshop on Middleware for Pervasive Mobile and Embedded Computing at Middleware 2011, Lisbon, Portugal, 2011.

[16] https://github.com/deankramer/ContextEngine, 11.04.2012

 ISBN: 978-1-61208-206-6

The Integration of Home Collected Data into the Veterans Administration Health System

The Home Telehealth VistA Integration Project: The Sharing of Computable Data

George C. Blankenship, Jr.
Consultant to Home Telehealth IT PMO
Alexandria, Virginia
BlankenG@GWU.edu

Daniel L. Maloney
U. S. Department of Veterans Affairs
Home Telehealth IT PMO
Silver Spring, Maryland
Daniel.Maloney@VA.gov

Abstract—In 2004, the US Department of Veterans Affairs was confronted with the creation of an enterprise application based upon multiple triage systems supplied by vendors who had dramatically different levels of experience with system integration or with Health Level 7 International Standard. One objective of the application was to leverage the capabilities of the existing Electronic Medical Record and medical software wherever possible. In order to accomplish the objective a strong integration approach was required. The selected approach was the development of a reference engine that could be used to validate the communication between existing applications and newly procured triage systems. The approach also included the development of supplements that are specific to the usage of the international standards. The triage system validation is performed in three phases. The first two phases are directed by a set of functional validation objectives. The third phase is a limited deployment supporting actual patients to minimize risk to patient care during a national rollout. The objectives are the slaving of patient identity and demographics to the enterprise identity management, the collection of patient survey responses, and the placement of triage system generated progress notes and home collected vital signs in an enterprise database. A direct result of this integration is the automatic inclusion of the Home Telehealth program in the standard enterprise outcomes analysis and availability of the program data to whole clinical team. This paper describes the integration process and problems that were confronted during the first five years of the program. The paper represents the opinion of the authors and is not a statement of any official position of the Department of Veterans Affairs.

Keywords; telehealth; home telehealth; telemental health; HL7; CCOW; protocol validation; realtime HL7 transactions

I. VA INTEGRATION OF HOME BASED CARE

A. Background

The United States Department of Veterans Affairs (VA) [1] Home Telehealth program is clinically managed by the Office of Telehealth Services (OTS) [2]. The program is supported by the VA's Office of Information & Technology (OIT) [3] Home Telehealth Program Management Office. The program uses a telemedicine approach for the care of patients with a chronic illness such as diabetes, congestive heart failure or chronic obstructive pulmonary disease. Care is also provided for patients suffering from post-traumatic stress disorder. Equipment is placed in the patient's home to evaluate the health of the patient much as would be done during a home visit by a nurse. The data collected by the home equipment is sent to a triage system that analyzes the data and ranks the patient for attention by a nurse in a remote location.

The VA has an integrated health system based upon an Electronic Medical Record (EMR) that allows clinical personnel to access all patient data that has been collected at any VA medical facility in the US and abroad. A patient's data can be presented as an aggregation independent of the original visit location. The VA's approach to patient care is based upon the ability to access a patient's complete medical record from any VA location. The core component of the health system is the Veterans Health Information Systems and Technology Architecture (VistA) [4].

The objective of the Home Telehealth VistA Integration project is the integration of the Home Telehealth triage systems into the VA health system. This is a real time sharing of data between an individual triage system and the VA EMR. This integration approach starts with the establishment of a patient record in the triage system using VA identifiers and the synchronization of the patient identity using the VA identity management system. With a consistent identity, the triage system is able to send patient data collected at the home to VA systems in a computable form so that the data can be used in standard VA patient care analysis packages.

The approach is for the triage systems to present the collected information to VA systems such that it has the look and feel of data collected by any other VA medical facility. The data is then available to all VA medical personnel and all of the VA medical outcomes analysis processing engines. The home care component of the patient's medical program is no longer an isolated data island, but is a system integrated into the VA's approach to patient care.

B. Veterans Health Administration Home Telehealth Environment

The Veterans Health Administration (VHA) [5] is home to the largest integrated health care system in the United States consisting of 152 medical centers in addition to almost 1,400 community-based outpatient clinics, community living centers, Vet Centers and Domiciliary. The health care system is divided into 23 geographical regions; each region

 ISBN: 978-1-61208-206-6

is called a Veterans Integrated Service Network (VISN). Together these health care facilities provide comprehensive care to over 8.3 million Veterans based upon data from FY2010. In 2000, VHA started two Home Telehealth pilots in two VISNs. In 2003, the number of pilots increased to seven. In 2004, the number of pilots increased to eight. In 2005, the Home Telehealth moved from a set of pilots to a nationally supported program. In 2012 the program is supporting over 70,000 patients across the United States and its territories.

The national program replaced the pilots with standardized systems and a standardized design. The program from its inception included the federally mandated security approach with a strong disaster resiliency and the integration with the VistA. This process started in 2005 with the installation of new Home Telehealth triage systems from each supplier in one VA data center. All the patients in the pilots were migrated to the new systems. Each supplier added a resilient system in a second VA data center. Each supplier was required to replicate their databases between the centers and alternate the active system between the data centers as part of the Home Telehealth program Continuity of Operations Plan (COOP). Once each supplier was supporting patients in the new data centers, they started preparing for VistA Integration.

C. Telemedicine

Telemedicine is the use of technology to bridge geography in order to provide patient care. One, or more, of the care providers (doctors) are not co-located with the patient. The original telemedicine model was consultation via a telephone. Telemedicine has now progressed to the collection of patient information via the collaboration of multiple systems across a wide geography. This use of technology promises to reduce the cost of patient care while actually improving the care. [6] Among the key attributes of telemedicine that make it attractive are:

1. Ability to provide the right care cost effectively,
2. Agility to respond to a sizable space of conditions, and
3. Ability to adapt to integration with other care systems.

D. The Triage System

The program is built around a set of triage systems procured from vendors experienced in providing remote home health care. Prior to the integration, patient identity and demographics information was manually entered into the triage system. The manual creation of the patient identity is impacted by the keystroke errors and the copying of information from other system displays. The unreliable data entry creates a problem when a care nurse wishes to correlate data in the triage system with data in the VA EMR. Vigilant manual correction of patient information is required to create effective reports on care.

The each triage system vendor supplies a device that is placed in the patient's home. The intent of the device is to mimic the actions of a visiting nurse. The patient interacts with the device according to a treatment plan implemented in a Disease Management Protocol (DMP). The DMP defines a set of questions to be presented to the patient by the home unit over a period of days and answered using the home unit. The DMP may also require the collection of vital signs. The DMP is constructed to discover the patient's condition through answers to the questions and the collection of vital signs. The patient interacts with the home unit on a scheduled basis. The data collected by the home unit is sent to the triage system for analysis. The triage system displays the results of the analysis on the clinical desktop used by the care nurse. The analysis ranks each patient under the nurse's care for attention. The average nurse in the VA Home Telehealth program manages around 200 patients.

E. VistA Integration

The VistA Integration plan uses messages defined by Health Messaging Level 7 International Standard [7] (HL7) to communicate with VA medical systems and HL7 Clinical Context Object Workgroup [8] (CCOW) defined application context control to integrate the triage system clinical desktop with the standard VA desktop applications. The VA has an extremely mature HL7 environment. The first challenge of the integration was the verification that each triage system has an HL7 engine implementation that would allow the integration. A special set of tools had to be developed to perform the verification. The second challenge was the implementation of a CCOW environment for the triage system clinical desktop. Each triage system has a complex clinical desktop that requires an extensive validation testing. The solution of these two challenges allowed the program to start the piloting of VistA Integration in 2005 for a limited number of patients out of the rapidly growing population of Home Telehealth patients.

F. Shared Data Implications

The triage system receives data from multiple sources within the home. The use of this data requires that the triage system maintains an appropriate data quality inspection. The triage systems are time synchronized with the VA systems and all patient data is displayed in the time zone of the patient. The home units are synchronized with servicing triage system. However, some of the home equipment can be used in a disconnected mode with internal power and a manual configuration. The disconnected operation allows for the device to loose time synchronization with the home unit. Every submission of each such device must be evaluated for potential time errors along with other data errors.

II. INTEGRATION STRATEGY

In 2004, the VA was confronted with the integration of multiple triage systems developed by vendors with a varied amount of integration experience or HL7 experience. The VA objective of the integration was to leverage the capabilities of the existing VA EMR and medical software wherever possible. In order to accomplish the objective a strong integration approach was required.

 ISBN: 978-1-61208-206-6

The fundamental components of the selected approach was based upon the development of a document [9] that defines all the transactions used by the Home Telehealth program and a reference engine that implements all the transactions and processing rules defined in the document. The document supplements the HL7 and CCOW standards with the specific to the VA encoding definitions and processing rules. The reference engine emulates a triage system to existing VA systems in order to validate the transactions and encoding definitions. The reference engine also emulates VA systems to the triage system in order to validate the conformance and operation of the triage system's HL7 engine and transaction processing. This use of a reference engine presents a reliable base for the integration of the triage systems into the mature VA integrated environment. The triage system validation was performed in three phases. The first two phases were directed by a set of functional validation objectives in two different testing laboratories. The third phase was a limited deployment supporting actual patients to minimize risk to patient care.

The experience gained since the program's inception in 2005 is that successful real time processing of transactions requires a reliable, predictable and consistent performance of the HL7 engine. These required characteristics are achieved by the proper handling of exceptional conditions that occur during transmission and other events that occur during normal system operation. The objective of the first laboratory testing was to verify that each target system is capable of the real time processing requirements required for VistA Integration.

The second phase was performed in the VA Integration Test Laboratory (ITL). The ITL contains a full environment of the VA systems and software that would peer with a triage system. In the ITL, the triage system was evaluated while supporting test patients. VA clinicians evaluated the triage system clinical desktop; VA IT staff evaluated the system logs for proper system performance.

The third phase was a limited national release of a production version using a slow start approach. The production system was first brought into use at a single VA facility for Home Telehealth patient care for a five week evaluation period. A second and the third facility were added to the environment at weeks three and four as the testing progresses. The operation was evaluated at the end of each week. At the end of evaluation period, national use was authorized.

III. INITIAL FUNCTIONALITY

The initial function set design started in the fall of 2004. The first triage system validation started in the fall of 2005. The initial functionality included the transactions for patient synchronization between the triage system and the VA, the automatic generation of patient progress notes, the collection of patient survey responses, the collection of the weekly patient census, and the collection of patient vital signs. Each of these transactions is carried by an HL7 message.

A. Patient Synchronization with the VA

Fundamental to the synchronization of patient information between the VA and the triage system is the addition of the Integrated Control Number (ICN) to the patient record in the triage system. The ICN is a VA defined globally unique number assigned to each patient and part of the registration for health care within the VA. Patients can be established in a triage system either manually via the triage system clinical desktop or via an HL7 transaction from VistA. A patient established manually is considered a legacy patient; that is, a patient that has not been VistA Integrated. A legacy patient becomes VistA Integrated via an HL7 transaction from VistA. All communication between a triage system and a VA system uses HL7 messaging. As part of the VistA Integration process, the Master Patient Index (MPI) is notified by the triage server that it is a treating facility for the patient. Systems registered with the MPI receive identity and demographics updates from the MPI for each patient registered. Processing applications are able to query the MPI for those facilities that have patient data (treating facilities). This allows VA applications to aggregate patient data from all facilities that have serviced the patient.

A side effect of VistA Integration is that the triage system is able to participate in a CCOW patient context on each clinical workstation. VHA requires all clinical applications support CCOW patient context. With patient context, all clinical applications on a workstation display data for the same patient; those applications that do not have access to records of the patient in the context do not display data for any patient. This is a critical patient safety feature in a heterogeneous world where data from multiple databases could be displayed on a single workstation used by a clinician or multiple clinicians. This feature protects clinicians from the confusion that might arise due to the necessary use of multiple clinical applications in the management of patient care. The primary clinical desktop for the VA EMR is the Computerized Patient Record System (CPRS). Patient progress is usually documented in progress notes built using CPRS. Since the Home Telehealth triage systems are accessible only by a Home Telehealth care nurse, the nurse must manually create patient progress notes for the care provider. The "copy and paste" operation is the primary tool used to move data from the triage system clinical desktop to the CPRS progress note editing panel. Without CCOW, there is a significant risk that the information in a manually created progress note contains erroneous information (for example, information from the wrong patient or multiple patients).

B. Progress Notes

The Home Telehealth triage system creates a data island. Patient progress notes created by the triage system are not available to the VA medical staff except via an external method such as the creation of a printed copy. The reports generated by the triage system are not part of the official VA medical record.

 ISBN: 978-1-61208-206-6

The VistA Text Integration Utility (TIU) allows external systems to create a progress note via an HL7 message. The note is placed in the patient's VA EMR for processing by a clinician. The clinician is able to edit the note using CPRS. After reviewing the note, the clinician either deletes the note from the system or electronically signs the note making it an official entry in the patient's medical record. The signed notes are available to the patient's care provider and other clinicians. Through the use of the VistA TIU application, a Home Telehealth triage system is able to create a report that is placed in the patient's VA EMR as a progress note. This process creates a note with all of the proper metadata so that the standard VA analysis routines are able to collect information on the existence of patient progress notes. A major use of the progress note analysis applications is accounting and care tracking.

C. Weekly Patient Census

Each triage system sends a weekly report of patients and equipment to the Home Telehealth Census system. The census includes information about each patient being serviced. Of primary importance is the date of the start of service, the date of end of service, the servicing VistA facility, the equipment in patient's home, the DMP directing the patient care, and the patient's compliance with the care plan. The Home Telehealth Census system supplies the VHA Support Service Center (VSSC) with a list of the patients in the Home Telehealth program along with their service periods, the VA facilities performing the service and the triage system that is monitoring each patient. The VSSC uses this information along with other data collected from VA systems to perform an outcomes analysis of all patients in the Home Telehealth program as it does for all VA other programs. The VA clinicians have access to these reports via the standard VSSC reporting application.

D. Patient Surveys

Each patient is given two evaluation surveys every 90 days on a staggered schedule. The Patient Satisfaction survey is aimed gathering data on the patient's satisfaction with the program and the provided care. The VR-12 ADL (Activities of Daily Living) survey gathers data on the patient's perspective of their medical state. These surveys are sent by the triage system to the patient's home unit. The surveys are presented as part of the DMP with the results returned to the triage system as part of the daily collection. The results collected by the triage system are sent to the Home Telehealth Survey system. Various reports are generated on the survey responses so that a realistic view of the patient's perspective is always available.

E. Patient Vitals

The DMP that directs the patient's care program may require that the patient supply vital signs. Each vital sign may be collected by a device that is directly connected to the home unit or manually entered by the patient into the home unit. Each collected reading is annotated with the date and time of collection. The readings are sent to the triage system. The triage system analyzes the readings and displays the readings along with other data collected as part of the patient's daily session with the home unit on the clinical desktop. The Home Telehealth nurse uses the information collected by the home unit and the triage system analysis to evaluate the patient's condition. The Home Telehealth program currently supports the collection of pulse, pulse oximetry, blood glucose, blood pressure, temperature, weight and pain. As part of the analysis provided by the triage system, the nurse is able to see a trend analysis report for each vital sign collected and other data. The triage system also sends the vital sign collections to the VA's Health Data Repository (HDR). The patient's care provider and other VA clinical team members are able to view all of the patient's data stored in the HDR using the standard VA applications such CPRS and VistA Web. The Home Telehealth data is displayed as part of an aggregation collected from all sources within the VA; each data value source can be easily identified in either a table or trend graph presentation. Home Telehealth data is also tagged with identity of the device that collected the measurement or tagged as self-entered.

IV. INITIAL RELEASE ACCOMODATIONS

The National Rollout of the initial release started in August of 2005. During the first three years of the rollout the program was confronted with a number of conditions that required adjustments to various components of the program.

The major feature of the initial release was the synchronization of patient identity in the triage systems with the VA. This capability was the basis for the integration of data collected by the triage system with data collected by other VA systems and the participation of the triage system clinical desktop in a CCOW controlled patient context. In the seven years of use the synchronization of patient identity has provided the capabilities that were desired. The program is able to report on itself to level of detail that allows for a realistic evaluation of the provision of care.

However, some of the features of the initial release had to be adjusted to accommodate the local autonomy within the VA medical centers and VISNs, to accommodate the use of disconnected end devices in the home, to adapt to an infrastructure that does not normally move real-time transactions and to integrate a system that monitors the enterprise application environment.

A. Local Autonomy Accomodations

The VA EHR system is extremely complex with a number of components that are configured locally to meet the needs and objectives of the administration of an individual medical facility. Administration policy is defined at the national level (VA/VHA), the regional level (VISN) and at the local level (VAMC). The VA provides a significant amount of autonomy so that the regions and local facilities have the flexibility to meet the needs of a diverse set of patients. This autonomy gives the VA a unique agility for an organization of its size. This autonomy presents the VA with a challenge when developing national rules and tailoring systems to operate with a national frame of

 ISBN: 978-1-61208-206-6

reference. Generally the approach is to give the local organization flexibility by pushing the creation of information tagging to the local system. In the case of Home Telehealth, there is no local system; Home Telehealth is a national application. The rules that define the tagging of information must be defined in a manner that a national system is able to meet the requirements. This set of objectives seems to be self-contradictory in a world that allows for local autonomy; however, the VA has positioned itself to confront these types of problems.

Accounting is one item of major importance in any organization. The organization uses accounting information to distribute funding, create staffing level, and other operational related items. Within the VA some of the accounting information is collected from clinics associated with progress notes. Since the Home Telehealth program is a national program, the clinic names must follow a national algorithm and with objectives that are set nationally. The original requirements collection team did not discover the wide variation of local collection requirements. The majority of the VA medical facilities wished to have accounting information collected at a central aggregation point (the VAMC level). A few of facilities wished to have the data collected at the servicing location level. An extremely small number wished to have the accounting information collected using the patient's DMP assignment or diagnosis. The original design had the requirement to collect the accounting information at the VAMC level. It was discovered that the servicing location could easily be accommodated with a minor modification; however, the collection of data based up DMP or diagnosis presented a problem. In January of 2010, the decision was made to start a study group to understand the requirements for accounting aggregation. During the study period the generation of progress notes by the triage systems has been suspended.

B. Vital Sign Date/Time Validation

The home unit follows a medical treatment program that will present questions to the patient and collect vital signs. The questions and the responses are presented and collected through integrated componentry of the home unit. While some of the vital signs could be collected via an integrated collection unit, some cannot. In some cases, the independent device can be connected to the home unit during the collection; otherwise the patient must either manually enter the data from the vital sign collection device or cause the device to transfer the vital sign to the home device at a later time using a stored collection time.

The use of an independent device introduces problems that have not been generally addressed by the manufacturer or a standards group. Some of the problems are intractable and seem insolvable. For example, the reading collected by the device might be from someone other than the patient. The use of the device by someone else in the home is not detectable by the home unit. While the use of the device by someone other than the patient can be precluded with the use of some sort of biometric control, the cost of such a sensor would be prohibitive and the evaluation of the readings can indicate that there is the possibility of a problem with an individual reading.

Other problems, such as incorrect readings can be addressed. There are many reasons for incorrect readings. The reasons range from device failure to a misreading of the device display. Every reading has two components, date/time of the reading (the date/time label for the reading value) and the reading value itself. A wrong date/time label for a reading value will position the value in the wrong place of a trend graph or hide the reading if the displayed date range does not cover the date/time label. Manually entered values use a date/time label assigned by the home unit. However, manually entered values cannot be verified automatically and are not desired by the care providers (doctors). Data collected by devices that are connected to the home unit are generally considered reliable by care providers, and thus preferred. Devices that are connected to the home unit at the time of the collection receive a date/time label from the home unit. Devices that can be used independently of the home unit use a stored collection time based upon an internal clock; thus, they can have an unreliable time. This set of problems was brought home to attention of the Home Telehealth program through the use of battery powered blood glucometers. These glucometers are able to perform a series of observations while disconnected from the home unit; each observation is tagged with distinct set of metadata such as date/time label. If there is a problem with the battery such as fading power, the internal clock may run erratically or the collection analysis may supply incorrect results. Battery replacement may lead to resetting the clock and the collection analysis components of the glucometer. Those devices that allow the internal clock set by the patient are inherently inaccurate.

The VA decided that the problems created by the use of independent devices required a study group. The transfer of patient vital signs from the home to the HDR was suspended until the study group published an acceptable set of business rules covering the use of the devices. The study group was convened in July of 2008; their recommendations were published in August of 2009. In June of 2010, the business rules were approved. The triage system vendors are currently updating their systems to use the approved date/time business rules and will be undergoing the validation during the first half of 2012.

C. Real-time Processing Implications

Historically, the use of HL7 has been to move transactions that do not have real-time processing requirements. HL7 transactions are forwarded (sent) on a publish/subscribe model and many transactions are sent only because they meet a subscription profile. Each application that receives transactions using this model is often flooded with transactions that are not really required. Selected transactions are deemed to be perishable; that is, the information content loses its significance over time. This approach has a tendency to weaken the requirement for a transaction delivery guarantee; that is, a significant number of transactions do not really need to be delivered. The

 ISBN: 978-1-61208-206-6

publish/subscribe approach generally uses a manual action (alert), if a transaction cannot be delivered. If a transaction cannot be processed by an application, an alert is generated for a manual action. The injection of a manual component as the first recovery to exceptional conditions and transient errors leads to large impact on the transaction latency. The bound for transaction latency becomes the response time to an alert. The generation of the alert may be long after the exceptional condition due to an alert skid. The alert may be based upon a queue tolerance and not the lack of delivery of an individual transaction.

With respect to the Home Telehealth program, the mode of the transaction latencies is measured in seconds, generally less than 10 seconds; the median has the same shape. However, the average is impacted by the manual intervention approach. The Home Telehealth program has analyzed all of daily transactions since September 2005. The biweekly moving average latency until 2009 was generally multiple hours due to the response time of the data center and network staff to an alert. The assumption made at the design time of the network support team was that all HL7 transactions had overnight urgency. The response to an exceptional condition could be delayed for hours. The Home Telehealth program generally does not meet this model. The design criteria for the transaction latency bound in the Home Telehealth program is 10 minutes.

In order to achieve the biweekly moving average transaction latency target of 10 minutes, the program changed from an alert driven first recovery to an ordered exceptional condition recovery based upon automated first response. The fundamental problem that needed to be addressed had been clearly highlighted by the daily analysis of the Home Telehealth messages and transactions. The key problem was the delivery of acceptance of messages. The program mandated that all HL7 message delivery was to be keyed to the receipt of a message acceptance acknowledgement within a preset period. If a message did not receive an acceptance acknowledgement within the period, the message was to be resent. Only after the proscribed number of delivery attempts is exceeded is it permissible to base the response on an alert. This allows for the automatic recovery from transient problems and temporary system outages. As a result of this approach to message acceptance, each of the HL7 partners is required to detect duplicate messages and resend the acceptance acknowledgement message. The analysis also revealed that another delivery problem occurred when the HL7 infrastructure cleared a message due to stalled transmission queue. The clearing of messages occurred automatically as part of an assumption that the manual recovery would restart the messages. The program mandated that each HL7 transaction delivery was to be keyed to the receipt of an application acknowledgment within a preset period. If a transaction did not receive an application acknowledgement within the period, the transaction was to be resent. Only after the proscribed number of processing requests is exceeded is it permissible to base the response on an alert. This allows for the automatic recovery from the loss of a transaction in the HL7 infrastructure and system outages. As a result of this approach to transaction acknowledgement, each of the HL7 partners is required to detect duplicate transactions and resend the application acknowledgement. The Home Telehealth program implemented the automated response to exceptional conditions in 2008. The end result of these changes was a dramatic drop in the biweekly moving average transaction latency to the desired target value of 10 seconds.

D. Application Monitoring

A major problem is the realm of enterprise distributed processing is the ability to detect off-line or overloaded dependent entities. All networks are built on the platform of a strong network management with a monitoring element. Trunk utilization is constantly monitored. Network nodes are monitored for throughput. When a network node or a trunk presents a problem a network map is updated indicating the problem area and an automatic recovery should already have been initiated.

Unfortunately the network monitor does not monitor the enterprise applications that really define a distributed collaborative processing system. The Home Telehealth program extends the network approach to the applications that define the Home Telehealth system. The applications are the triage servers with their clinical desktops and the applications that reside on the VA systems shown in Figure 1. The Home Telehealth Network Monitor probes each application element of the Home Telehealth enterprise environment. The results of the probes are displayed on a national map. Figure 1 is the status display for the system components that exchange HL7 transactions with the triage servers. The left hand column of the Network Monitor window changes the display to the results of other probe types. The monitor probes the VA WAN (the VA Intranet) for performance statistics, the Vendor Servers (triage systems) for clinical desktop latency, and the HL7 Servers (HL7 transactions partners). The HL7 transaction partners are probed for operational state and the latency of a test transaction.

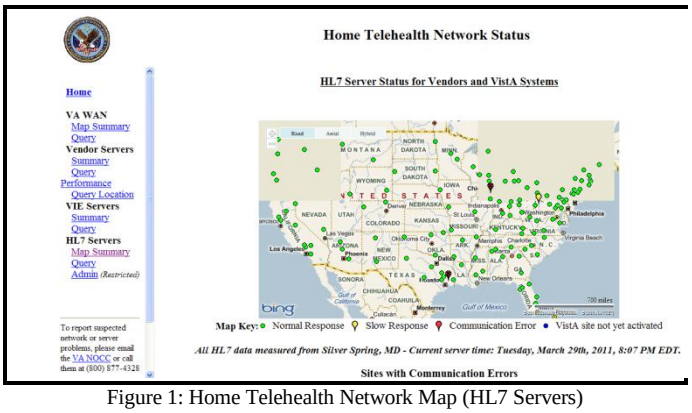


Figure 1: Home Telehealth Network Map (HL7 Servers)

V. FUTURE FUNCTIONALITY

The Home Telehealth program is currently completing its initial capability release and bringing on new triage system

 ISBN: 978-1-61208-206-6

suppliers. The next releases will add automated tools to develop and manage DMPs, medical orders to configure the triage systems, the VistA Integration of a wound care application, and the tracking of home equipment from order to disposal, the mining of the Survey and DMP responses. The following sections give a short description of each of the future capabilities.

A. *Disease Management Protocol Standardizaton*

The current DMPs are a mix of triage system vendor supplied question sets and VA sets supplied to the triage system vendors in printed or printable documents. A future release will include a DMP development tool that will create a machine readable version. The triage system vendor will be able to generate the question set using automation rather than manually creating the question set.

B. *Medical Orders*

Each patient treatment plan is manually defined on the clinical desktop. The treatment plan includes the diagnosis, DMP, home device and sensors to collect the patient vital signs. A future release will include the definition of an HL7 transaction to perform this function.

C. *Wound Care*

Some of the triage systems include a wound care application. The basis of a wound care system is the analysis of pictures of the lesion. The triage system wound care applications will be required to connect to the standard VA image application (VistA Imaging) so that the wound care images can be made available to other VA staff.

D. *Equipment Inventory*

The home units are re-used as patients move in and out of the program. The application will be expanded to track the home units from order to decommissioning.

E. *Mining of Survey Responses*

At the current time the Patient Satisfaction and VR-12 ADL (activities of daily living) surveys are presented only in aggregation reports. The plan is to report at the patient level.

F. *Collection and Mining of DMP Responses*

At the current time the DMP responses are stored only in the triage system. Once the data is placed in the EMR, the DMP responses can be used in the outcomes analysis of the patient's treatment.

REFERENCES

[1] United States Department of Veterans Affairs. United States Department of Veterans Affairs Web Site. 2011; Available from: http://www.va.gov/ [retrieved 4,2012].

[2] United States Department of Veterans Affairs. VHA Office of Telehealth Services. 2011; Available from: http://www.telehealth.va.gov/ [retrieved 4, 2012].

[3] United States Department of Veterans Affairs. Office of Information & Technology (OI&T) Home. 2011; Available from: http://www.oit.va.gov/ [retrieved 4, 2012].

[4] Department of Veterans Affairs Office of Enterprise Development, VistA-HealtheVet Monograph, 2008; Available by request from the authors.

[5] United States Department of Veterans Affairs. VA Health Care. 2011; Available from: http://www.va.gov/health/default.asp [retrieved 4, 2012].

[6] Darkins, A., et al., Care Coordination/Home Telehealth: the systematic implementation of health informatics, home telehealth, and disease management to support the care of veteran patients with chronic conditions. Telemed J E Health, 2008. **14**(10): p. 1118-26.

[7] Health Level Seven International. 2012; Available from: http://www.hl7.org/ [retrieved 4, 2012].

[8] Clinical Context Object Workgroup. 2012; Available from: http://www.hl7.org/Special/committees/visual/index.cfm [retrieved 4, 2012].

[9] George C. Blankenship, J., Home Telehealth HL7 Functions Overview, U.S.D.o.V. Affairs, Editor 2012; Available by request from the authors.

 ISBN: 978-1-61208-206-6

wEnergy: A Field Experiment on Energy Consumption and Social Feedback

Anders Dalén, Timm Teubner, Christof Weinhardt
Institute of Information Systems and Management
Karlsruhe Institute of Technology (KIT)
Karlsruhe, Germany
dalen@kit.edu, timm.teubner@kit.edu, weinhardt@kit.edu

***Abstract*—This paper presents the work-in-progress research project *wEnergy*. The aim of the project is the conception, execution and evaluation of a medium-scale field experiment on the impact of different forms of feedback on electricity consumption in private households. The 45 participating households (students' shared apartments) will be equipped with a non-intrusive and low cost sensor device. Energy consumption is then tracked in a high timely resolution and fed back live to the participants through the project website. After a calibration phase, the actual experiment begins. We employ a between-subject design to test the effect of a) feedback on one's own current and historic consumption (control) versus b) social feedback, comprising the consumption data of a peer group of households (treatment).**

***Keywords*-social feedback; energy consumption; smart metering; experimental economics; field study.**

I. INTRODUCTION

Smart metering is on the rise and consumers are seeing an increase of utility efforts to make the traditional energy meter information more transparent. However, enticing already busy consumers with direct access to their meter data has proven to be difficult. Two of the largest information driven businesses, Google and Microsoft, have both pulled the plug on their energy feedback projects due to lack of interest (google.com/powermeter, microsoft-hohm.com).

However, the potential for energy efficiency in households through more knowledgable consumers still remains: similar households in terms of location, size, appliances and dweller demographics have shown a difference in energy usage with a factor of two(!) [1].

Until now, the impact of direct feedback on energy consumption is not conclusive. There are several research and commercial projects that continue to develop visualizations and flexible control of energy consumption (e.g., luciddesigngroup.com, tendrilinc.com, mysmartgrid.de, rrrevolve.ch, discovergy.com). However, it is still debated to what point end users can be informed and motivated to become more energy efficient. Furthermore, field evaluations of social feedback and mechanisms that allow for comparison and collaboration among energy users are predominately based on questionnaires and lack access to the energy data and the ability to correlate the stated influence to the measured one [2], [3].

By gathering and presenting energy information we want to make the interaction with energy more transparent, and, by adding a social, collaborative component, we hope to explore and promote the effects of interpersonal comparison and sharing of best practices for energy efficiency gains in the scope of the project. We want to evaluate whether a collaborative form of sharing energy information can help sustain the interest for energy information and promote action in a field study. We want to contribute to understanding the effects of making people realize their actual consumption and giving them understandable and easily operable tools for exploring, visualizing, and evaluating this data—both in a private and a social context. To this end, we use non-intrusive hardware that are easy to install and low cost.

The remainder of this paper is structured as follows: Section II provides a brief overview on related literature and projects regarding energy data gathering and sharing. Sections III and IV describe the underlying architecture and user interaction logic of the platform website and give insight into technical related issues such as hardware, measurement, data handling and precision. In Section, V the experimental design and the evaluation approach are outlined. Since the project is work-in-progress, we conclude with a few ideas on methodological and topical extensions and plans for future research.

II. ENERGY DATA GATHERING AND SHARING

Information is understood as a fundamental component of the future, more dynamic and efficient, energy system [4]. Energy consumption metering is traditionally supplied from the utility, but more privately owned measuring devices are becoming prevalent. Having direct access to energy information on total consumption has shown to produce savings of $5 - 15\%$ in a number of studies [5].

With more detailed information on specific appliances users have shown even further behavioral changes like lowering overall standby power consumption and operating appliances more stringently [6].

As energy information become more pervasive and available over the internet, more sophisticated informational campaigns are possible. Improving the access to the energy information is, for example, becoming easier to do through modern portable devices. This is leveraged in the

 ISBN: 978-1-61208-206-6

eMeter project, which has shown great success in making energy feedback more convenient and ubiquitous [7]. Another promising use of energy consumption information, which will be further evaluated in this project, is simply to exchange this information with other participants. Previous studies in this field have found these comparative and collaborative properties to have an exceptionally high impact on consumption behavior [8] [9].

One important distinction to make about social feedback is that there is seldom a feedback model that will be appreciated by every participant. For example, one British study found that the subjects disliked being compared to their peers and questioned its legitimacy, while a similar Norwegian study found a positive response to the comparative information [2] [3]. In general, social feedback has been found to be more effective than self comparison with historic data. This effect is stronger when the proclaimed goal is relevant and precious, and also when participants can relate well to their peers, for instance because they are similar—or in a similar situation [11]. Where previous studies have either evaluated a range of feedback mechanisms, or focused on social feedback in aggregated form, this study aims to combine these approaches. By strictly evaluating the effects of sharing energy information with the aid of highly granular and modern information technology this paper specifically addresses the research gap of social feedback in a smart-meter era.

III. Platform Architecture

The wEnergy visualization framework is designed around a database driven website. Users can log on to their private account with username and password. The platform consists of four sections, the dashboard, the consumption overview, the appliance overview, and the social ranking.

The *dashboard* gives a very direct consumption feedback to the user. The m latest consumption measurements are plotted where m can be selected among different values (25, 50, 100, and 250) in order to enable an intuitive exploration of the data. A status bar indicates how much energy is used at the moment—color-coded from green to red. This measure is normalized to the interval [0, 1] where the current consumption is divided by the 90 percent quantile consumption in the last 2 days. The timely resolution of this plot is 0.2 Hz (one value per five seconds), corresponding to the frequency of the power measurement at the household site. The dashboard shall provide an intuition on how much users currently consume and how the power-on of a particular appliance adds to this value.

The *consumption overview*, lets the users see how much they are consuming over the course of a day, week, or month. Average consumption (in kW) is plotted. The actual consumption of the respective period is indicated in red and half transparent, and the historic average of the user's consumption for the period is plotted unobtrusively in gray

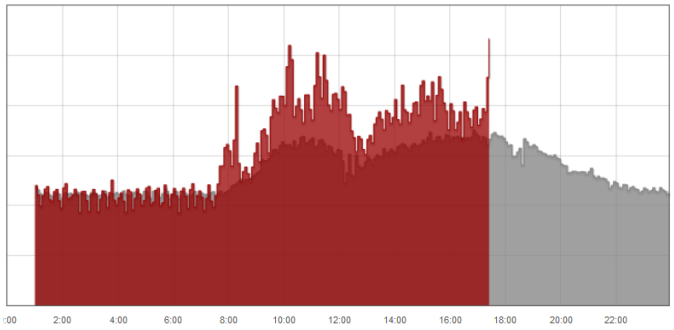


Figure 1. Consumption view as presented to the user, daily consumption, aggregation: 5 minute intervals, red: actual consumption, grey: historic average consumption

in the background (cf. Fig. 1). This enables an instant comparison between actual current and average consumption and enables users to evaluate their current behavior (benchmarked against their own historic average). The timely resolution is 5 or 15 minutes for the day view, 30 minutes for the week view, and 180 minutes for the month view.

The *appliance overview* is an experimental feature and serves as an indicator for users, which of their appliances that are currently active, and how much power these appliances consume. Note, that it is a difficult task to determine when specific appliances are switched on or off, since power signals are noisy, occur simultaneously and interfer with each other. Appliance recognition has been subject to extensive research in the past decades [12] [13]. However, even though progress has been made in this area, most current solutions for disaggregating appliances use highly specialized hardware that is hard to scale to the number of households that could benefit from this feedback [14]. This part of our website functionality addresses this gap and is intended to give users a more intuitive sense of their electricity consumption.

Finally, the *social ranking* lets the users see, how much energy they use compared to their peer group. Thereby, users are ranked not according to their absolute, but relative consumption referred to their own floating historic average. This means that participants, which consume less than usually will occur on top—but find it harder to be on top in the consecutive weeks, since a low consumption naturally decreases the reference value. Each peer group consists of about 5 households, with similar demographic characteristics (see Section V for a more detailed description).

IV. Technical Approach

Our hardware approach to measuring electricity consumption comprises two components, based on the openenergymonitor project (www.openenergymonitor.org). The first component consists of a battery powered sensor, that is attached to the main power lines in the fuse box of the household. The measurement is non-invasive, meaning that

 ISBN: 978-1-61208-206-6

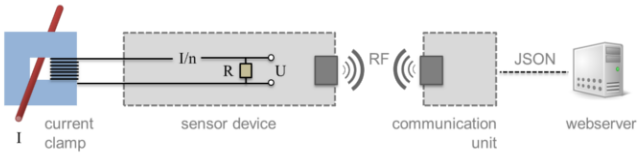


Figure 2. Measurement System Overview: power line (single phase), current clamp sensor, sensor device, communication unit, web server

participants will be able to install the device at home themselves, no expert knowledge or certification is required. However, a student assistant checks on the installations manually to assure reliability. The entire process usually takes not more than 10 minutes.

The German grid provides alternating current on 3 phases, 50 Hz and a nominal voltage of 230V. At the fusebox each phase corresponds to one of the main wires. We attach a ferrite split-core current transformer (CT) with $n = 2000$ turns and a maximum current restriction of $I^{in}_{max} = 100A$.

The data consumption data then is processed on an Atmega micro-controller. It is fed by voltage at $3.3V$, restricting the incoming signal to the analog-to-digital converter (ADC) to a voltage up to this value. This means that the incoming current from the CT must be limited, in order not to put the integrated circuit at risk of an overvoltage. Since most of the fuses in German households have a trigger threshold of $50A$ or less, we chose the on-board burden resistor accordingly. Supposing an ideal transformer ($I_1/I_2 = n_2/n_1$) and using Ohm's law ($U = R \times I$) we deduce the burden resistance to be 66Ω. By using a 60Ω-resistor we leave room for a $5A$ overshoot without sacrificing too much resolution.

The micro controller processes the voltage information from the CT and the burden resistor on a 10-bit scale (2^{10}), which results in a resolution of 8.7 VA/bit. Note that only current—not voltage—is measured. A more detailed analysis of real and reactive power is thus unavailable. However, the hardware can easily be extended to include this measurement, which has been confirmed in initial testing.

The second component (base unit) handles the communication with the central web-server. The sensor and base unit communicate via radio at 868 MHz frequency. The base unit is connected to the router of the household via ethernet and pushes the data objects to our central server using JSON elements. The entire system scheme is depicted in Figure 2.

V. Experimental Design

We aim to assess consumption behavior in a field experiment. Therefore, 45 voluntarily participating households, selected from a mutually comparable student milieu with 2 through 4 residents per household are equipped with the sensor system. Participants are invited to the Institute and are elaborately briefed about the project, use of the hardware, etc. The actual experiment is then carried out in two stages. In the initial calibration phase (2 weeks), the metering devices are installed and consumption is monitored. The participants fill out forms asking for perceived energy consumption knowledge, personal characteristics and general demographic factors. There is no feedback to the households whatsoever in this phase and the website functionality is limited. The calibration phase serves to establish a base level of consumption and to classify the households' consumption profiles. Participants also sign the general terms of use and agree that consumption data is stored and published anonymously.

In the treatment phase, the actual experiment begins. This phase lasts 8 weeks. As stated above, we use a between-subject design. The 45 households are partitioned into two groups, the control group ($n_0 = 20$ and the treatment group ($n_T = 25$). From then on, the participants of the different groups face different website functionalities. The control group can access the dashboard, and the consumption overview, whereas the treatment group can, in addition to that, access the social feedback, which is basically a ranking. The 30 treatment households are partitioned into peer groups of about 5—based on consumption-relevant characteristics such as number of residents, square meters of the apartment, type of the stove (gas/ electric), and consumption profile as indicated in the calibration phase. Every peer group has its own social ranking. The decisive value for the position in this ranking is the current week's aggregated consumption, referred to the own average weekly consumption during the preceding weeks. This ranking value $r_t = c_t/(\frac{1}{t-1}\sum_{i=1}^{t-1} c_t)$ is a percentage value where c_t denotes the electricity consumption in week t. With the beginning of every new week, all ranking values are set to 0. Note that the way the ranking is computed inherently balances the game play of the experiment. A household with a particular low consumption in one week will thereby lower its reference value and thus be less likely to achieve a top position in the ranking—and vice versa. In respect of participant motivation, this is a preferable design characteristic, since the best chances to achieve a high rank vary from week to week.

There are several different approaches for evaluating participants behavior. First, total consumption as the most obvious measure will be analyzed. Second, the idle consumption levels (e.g. during nights or absence of residents) can be used as indicators of how consistently lights, laptops, monitors, standby appliances etc. are switched off. This is suitable for analyzing whether users *care* about their consumption and consciously alter their behavior. Third, the total number and frequency of peak loads potentially explains whether high-load appliances such as water-boiler, vacuum cleaner, or electric heating were replaced by other, less wasting alternatives (broom, gas stove, warm pullover). Also variance, timely distribution, and load quantiles are

 ISBN: 978-1-61208-206-6

interesting points of reference in order to explain what the experiment participants actually do.

Note that, for the participants, there is no monetary incentive to be on top of the social ranking. Nevertheless, we expect the mere presence of the comparison to have an effect on consumption behavior—lowering total consumption. Also, we expect total consumption to differ between the initial calibration and experimental phase for all subjects—irrespective of the treatment.

VI. Conclusion

Academic research on real-life consumption behavior under systematically manipulated conditions is sparse. Lab experiments put participants outside their natural environment, which appears to be crucial for studying consumption behavior, since it is inherently and closely linked to the own home, particular habits and routines. Our project addresses this gap. We are developing an easily installable and flexible platform to enable and evaluate the effects of social feedback and collaboration in the context of energy consumption. We expect that this will lead to a more general knowledge and awareness, and eventually a lower total consumption. It will be crucial to maintain a high level of participation and interest during the experiment.

Beyond the social feedback context we also anticipate other studies within the same framework. For example, communication among the members of a peer group can be introduced in order to foster peer effects like internal collaboration, e.g. sharing of tips for efficient usage. Also competition *between* different peer-groups appears conceivable. Eventually, the provision of applications for mobile devices brings consumption feedback even closer to the users and their daily routines—which ultimately may be a substantial contribution to a more appropriate dealing with electrical energy—and thus welfare and sustainability.

Acknowledgment

This research is made possible by the MFG Stiftung Baden-Württemberg, which funds the project through the Karl-Steinbuch-Stipendium. We would like to extend our gratitude to all members of the MFG team for their magnificent support.

References

[1] C. Swanson, M. Blasnik, and E. Calhoun, "Measuring public benefit from measuring public benefit from energy efficient homes," prepared by Advanced Energy for the U.S. EP, 2005.

[2] S. Roberts, "Consumer preferences for improving energy consumption feedback," prepared by the Center for Sustainable Energy for Ofgem, May 2004.

[3] H. Wilhite, A. Hoivik, and J. G. Olsen, "Advances in the use of consumption feedback information in energy billing: The experiences of a norwegian energy utility," in *Proceedings from the ACEEE 1998 Summer Study on Energy Efficiency in Buildings*, European Council for an Energy Efficient Economy. Paris: ECEEE 1999 Summer Study on Energy Efficiency in Buildings, 1999.

[4] T. Philippine and N. Devernois, *Promoting Energy Efficiency Investments: Case Studies in the Residential Sector*. Paris: International Energy Agency, Agence française de développement Organisation for Economic Co-operation and Development, 2008.

[5] S. Darby, "The effectiveness of feedback on energy consumption: A review for DEFRA of the literature on metering, billing, and direct displays," Environmental Change Institute, University of Oxford, Tech. Rep., April 2006.

[6] T. Ueno, R. Inada, O. Saeki, and K. Tsuji, "Effectiveness of an energy-consumption information system for residential buildings," *Applied Energy*, vol. 83, no. 8, pp. 868 – 883, 2006.

[7] M. Weiss, "emeter: Stromverbrauchsfeedback auf basis eines pervasive energy monitoring systems," in *Energieinformatik 2010*, 2010.

[8] T. Dietz, G. T. Gardner, J. Gilligan, P. C. Stern, and M. P. Vandenbergh, "Household actions can provide a behavioral wedge to rapidly reduce us carbon emissions," *Proceedings of the National Academy of Sciences*, vol. 106, no. 44, pp. 18 452–18 456, November 2009.

[9] H. Staats, P. Harland, and H. A. M. Wilke, "Effecting durable change: A team approach to improve environmental behavior in the household," *Environment Behavior*, vol. 36, no. 3, pp. 341–367, 2004.

[10] C. Grevet, J. Mankoff, and S. Anderson, "Design and evaluation of a social visualization aimed at encouraging sustainable behavior," in *2010 43rd Hawaii International Conference on System Sciences*, January 2010.

[11] P. Petkov, F. Köbler, M. Foth, and H. Krcmar, "Motivating domestic energy conservation through comparative, community-based feedback in mobile and social media," in *Proceedings of the 5th International Conference on Communities and Technologies*, ser. CT '11. New York, NY, USA: ACM, 2011, pp. 21–30.

[12] L. Norford, S. Leeb, D. Luo, and S. Shaw, "Advanced electrical load monitoring: A wealth of information at low cost," Massachusetts Institute of Technology, Tech. Rep., 1999.

[13] S. Patel, T. Robertson, J. Kientz, M. Reynolds, and G. Abowd, "At the flick of a switch: Detecting and classifying unique electrical events on the residential power line," in *UbiComp 2007*. Springer Berlin / Heidelberg, 2007, pp. 271–288.

[14] H. Pihala, *Non-intrusive appliance load monitoring system based on a modern kWh-meter*. Espoo, Finland: Technical Research Centre of Finland (VTT), 1998.

 ISBN: 978-1-61208-206-6

Reactive Binders: A Framework and Prototype for Team-Oriented Web Work

Sven Rizzotti
Department of Computer Science
University of Basel
Basel, Switzerland
Sven.Rizzotti@unibas.ch

Helmar Burkhart
Department of Computer Science
University of Basel
Basel, Switzerland
Helmar.Burkhart@unibas.ch

***Abstract*—The fact that collaboration tools are often ignored to share information may lead to inefficiency and it is a challenge to change that situation. We believe that the entry costs into collaboration tool usage needs to be lowered. Users like a smooth shift from well-known metaphors and prefer models designed for simplicity. We introduce the Reactive Binder (RB) framework, which is based on the common known office model of shelves, binders, and registers. Our binders and shelves, however, are virtual and shared by web teams. RBs targets for reactiveness i.e., document binders are active entities that can react on events. With the RB framework and the PROBINDR prototype, we propose a collaboration solution with low entry costs and claim better user acceptance in distributed teams.**

***Index Terms*—Online collaboration, Data Cloud, Social Sharing, Interactive IR**

I. COLLABORATION TODAY

Today, professional collaboration is heavily based on information technology support. Manifold tools that address collaboration aspects exist and can be categorized as follows:

- *Communication tools* help in direct, personal information exchange and include simple instant-messengers as well as complex audio- and video-conferencing-Systems.
- *Coordination tools* help in management tasks and include project-management tools, work grouping tools, but also mind mapping systems for project preparation phases.
- *Data sharing tools* provide an infrastructure for collective storage. This can be either at a coarse-grain-level such as a file sharing-tool, or at a fine-grain level like bookmark managers for web links.
- *Document processing tools* support the preparation and discussion of shared documents such as collaborative writing and reviewing services, or all kinds of wikis.

A variety of commercial and free products exist [1], [2], but a majority of computer users are still ignoring their existence or do not know about them, which causes inefficiencies. The following list is typical for today's practice.

- *Email, email, email:* Email is still the #1 communication tool, because it is cheap, easy to use, works asynchronous and is universally usable [3]. On the other hand, email has a lot of drawbacks such as information overload, loss of context, content inconsistency, missing authenticity, and non-guaranteed delivery [4], [5]. Therefore, organizations that use email as teamwork and collaboration tool have to manage several obstacles. Email is not only inefficient, but must be considered harmful. Especially, email attachments would require that all receivers immediately delete pointers to older copies or even delete local copies when a new version of a document arrives. Moreover, if new members join a team, all information previously distributed must be resent. Both use cases are not only time and storage-inefficient, but also error-prone. Usage of a data-sharing tool can overcome such problems, but may face issues as mentioned for cloud space below.
  Many users still use email as a generic collaboration solution, even if it has been shown that it is not efficient [6], [7].
- *Shared drives / cloud space:* Shared drives within a single organization can be an effective way to get access to documents. However, the organization of documents and the notification of updates of these documents requires organization policies, which are hard to accomplish. If the filing of a document happens unnoticed, the document might getting stored in another location, with a different name and in a different version. This leads to inconsistent information.
  Another challenge is the freedom of file organization. It might look as an advantage that file systems can be organized individually, but the indefinitely expandable length and depth of hierarchies may become confusing and overcharged. It has been shown by [8] that nine is the maximum number of items that allows effective information processing.
  As soon as collaboration crosses organization borders, it becomes even more difficult to set up a working environment. The burden to create a virtual private network and firewall settings are other hurdles.
  The separation of files and comments cannot be solved with a shared drive alone. Users tend to comment on files or clarify discrepancies, but this process happens uncoupled. This leads to a detached and non-traceable evolution of a filesystem. After a while it becomes impossible to see how a filesystem grew and how the collaborators contributed.
- *Wikis:* Wikis are meant for collaboration and are a great

 ISBN: 978-1-61208-206-6

way to share and work together. Nevertheless, wikis need a certain syntax understanding and for people with little IT knowledge look like programming. Wikis can be used to work on text and with some restrictions also to share files. Most wikis have the possibility to figure out who participated and follow the development of a page. However, it needs additional effort to understand the collaborative parts.
Wikis need administrative work to setup and maintain, which limits their application. Wikis also face the same problems as filesystems regarding hierarchy depths and can even become more confusing due to cross linking of pages.

As explained, each category of tools faces certain difficulties, that can prevent their usage. Usually, a combination of tools is in place, which can lead to additional complications:

- *Universal notifications:* A central part in collaborative environments are asynchronously working participants. Independent working require update mechanisms to see changes over time. Such changes need to be reported across different tools. Information change is only one particular example for events that cause a system reaction. The reactive web demands for a more general rule-based event detection and trigger notification mechanism.
- *Multiple working sites:* A major problem is the existence of multiple, unrelated working sites, which users have to manage. Think of the administration of a lecture series titled “CS 101” within a campus environment. A Lecturer creates a structured folder in his local file system, sets up an e-learning site where teach-ware is placed, communicates by email with tutors who help in the course preparation, and browses for new material in the web. Without usage of a collaboration tool, there would be a file directory “CS 101” for document preparation, a mailbox “CS 101” to store related emails, a courseware entry “CS 101” to upload teach-ware, and a bookmark folder “CS 101” to store pointers. Having a strict naming system might help in keeping things right but the better solution would be an ”federated umbrella approach” in which a single entity “CS 101” represents the information base and interacts with involved collaboration tools.

The paper is structured as follows: In Section II, we describe the RBs framework for collaborative web work environments, which is intended to overcome the discussed problems. The users view of the PROBINDR prototype implementation is treated in Section III. Section IV reports on implementation aspects, Section V shows three practical applications and Section VI concludes with results and lessons learned.

II. THE REACTIVE BINDER FRAMEWORK

There might never be one single tool that fulfills all collaboration needs, but the fact that users tend to ignore tool support is a challenge. We believe that the entry costs into collaboration tool usage needs to be lowered. Users like a smooth transition from well-known environments and prefer models of type KISS (Keep It Short and Simple). Our approach is a contribution towards a more accepted and used collaboration environment.

We propose the concept of *Reactive Binders* (RBs) as a data organization and collaboration mechanism for team-oriented web work as seen in Figure 1. RBs extends the traditional office approach with social software mechanisms and is able to integrate web agent and ambient computing technology.

Shelves, Binders, and Tabs

The classic office organization is based on physical shelves and binders. People have been using binders for more than 100 years as document storage. Their usage has been so successful that specific names are popular in different countries: in Germany *Leitz-Ordner*, in Switzerland *Bundesordner*, and in US *3-ring binder* are terms known by a majority of people. Each binder has a register and labelled tabs, which represent the storage site where documents are placed. Shelves are placeholders for binders and are either private or shared.

One reason for its popularity even in the computer age is its simplicity. However, there are severe disadvantages:

a) Binders are physically bound to an office. While they can be moved and accessed within a certain distance, this is impossible from remote and and in a mobile environment.
b) The access scheme to binders is very restrictive: The physical key encoding defines whether you may enter offices and access shelves and binders. But key encodings define door access, which is much too coarse-granular in order to represent individual rights.
c) Binders are static: They “live” in a shelf, get updated from time to time, and only dust on cover sheets will indicate that content may be outdated or of archive type.
d) Binders have cross-relationships, which are typically represented in a narrow-sense only: e.g., common naming schemes, coloring, and placement of binders. The strict hierarchical single-place organization scheme is insufficient because documents are often relevant in different contexts.
e) The smallest shareable entity is a single sheet.

The RBs concept addresses these problems (see Figure 1):

a) RBs are virtual entities. If you have access right to a binder it is accessible from the internet.
b) Access rights to RBs are fine-granular. You can individually decide for each shelf, binder, tab and entry who gets administrator, editor, and viewer rights.
c) RBs are dynamic. Like objects in object-oriented programming, RBs represent data elements plus methods, that can be applied. For example, translation and data presentation can be universally defined.
d) RBs are reactive. A rule-based event-action mechanism results in live documents. Changes in one section of a binder may automatically result in changes in the same or other binders.
e) RBs are cooperative. All elements are addressable, which provides the functionality to interact with other tools such as web browsers, web services, wikis, and email systems.

 ISBN: 978-1-61208-206-6

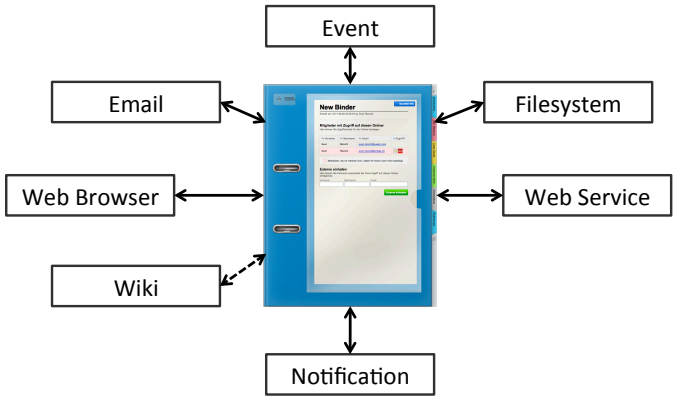


Fig. 1. RBs interfaces to various other systems

Related Work

We accentuate reactiveness strongly in our approach and RBs and its implementation should be viewed as a contribution to the Reactive Web [9]. In addition to collaboration possibilities of other tools, we add workflow functionality and a tighter integration of the real and virtual world to the RBs.

Other binder solutions include Assembla [10], LiveBinders [11], and TeamBinder [12]. Also DataSharing Tools such as DropBox [13] or Springnote [14] have certain relationships. However, these tools have their main focus on data sharing with collaboration aspects such as notifications upon changes, or access control mechanisms.

III. RB AS SEEN BY THE USER

ProBindr is our current prototype for experimenting with the RBs framework. There is a clear defined hierarchy in place for each user, which consists of shelves, binders, tabs, and content items. Each organization is represented as a shelf, which contains a maximum of 33 binders as shown in Figure 2. Whenever a user makes changes to one of the binders, a number on the shelf indicates the number of total changes among all participants.

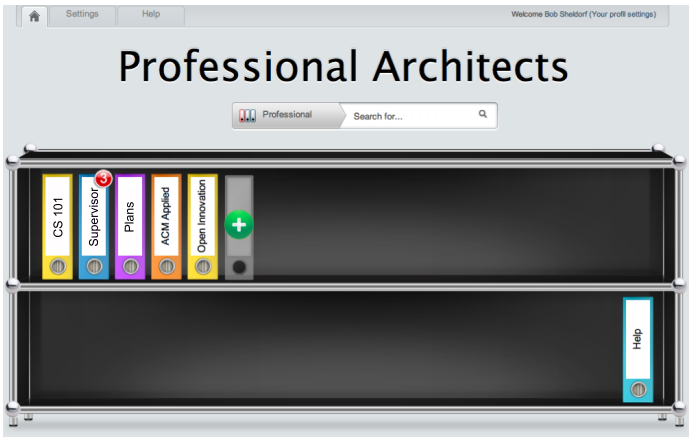


Fig. 2. Fast overview about modifications in a structured way

A binder is a structuring element that contains a maximum of nine colored tabs. Each binder can be shared individually with members of the organization. Additionally external partners can have access to a particular binder as well. Fine-grained access rights define who can administrate, edit, or only view content items.

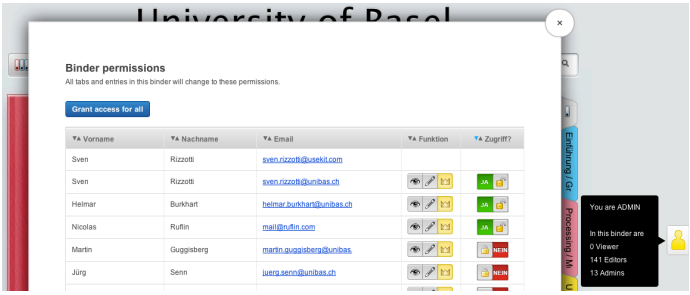


Fig. 3. A simple interface to grant complex permissions

A tab is an endless page that is a compilation of content items. Content items can be files, texts, links, section headings, and custom entries. Each item shows its author, modification date, and if it has already been read. Items can be commented, which replaces referring emails as shown in Figure 4.

Items can be edited or rearranged if a user has the appropriate permissions. The combination of files, texts, links, comments, and structuring elements such as section titles provide a simple and common understood way to collaborate.

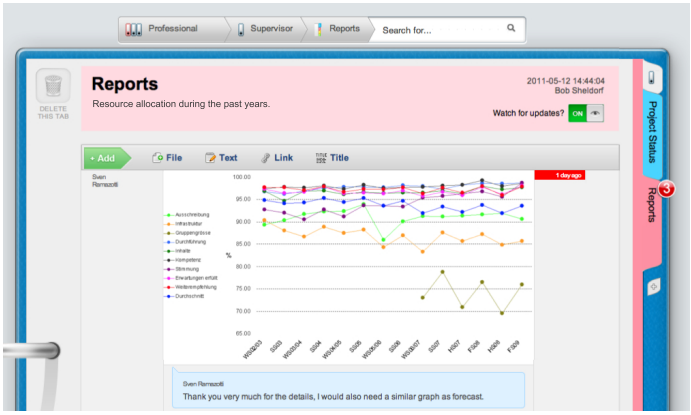


Fig. 4. Comments bound to content items as a way to avoid emails

Permission settings follow an inheritance strategy, known from object oriented development [15]. Settings at a certain level propagate from the shelf down to single entries. On the other hand, simple access is granted in a bottom up strategy. This mechanism allows to give access to a single entry, which makes the tab, the binder, and the shelf visible to the user, but prevents access to other binders. In the other direction, a permission change at the binder level for example inherits the access rights to all tabs and all entries in the binder.

The permission settings use sliders to switch settings on or off at the different hierarchy levels. Figure 3 shows the

 ISBN: 978-1-61208-206-6

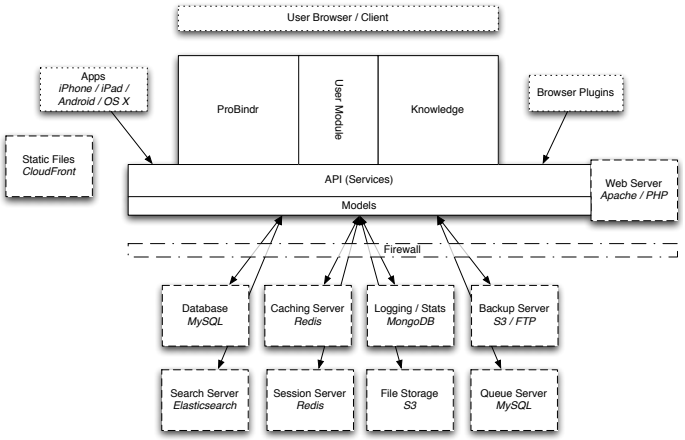


Fig. 5. PROBINDR Architecture

interface, which tries to follow the KISS principle, even if the inherited settings are complex.

IV. IMPLEMENTATION ASPECTS

The PROBINDR platform is completely cloud-based. Figure 5 shows data storage and processing, that are physically separated and distributed to several systems. This procedure offers strong caching possibilities and fast access. From the beginning, the platform has been designed to scale as access numbers increase. A key-value data storage such as used by Facebook allows efficient access. Individual access rights and the hierarchy implemented (user, organization, binder, tab, and content item) result in complex search queries. For instance, these queries are used to trace unread user items.

Beside data access, there are other tasks that are automatically being processed in the background. Search indexing and previews and image thumbnails are for example processed within a task queue. Notification actions are also processed and allow asynchronous completion. All actions happen through authorized APIs, which not only serve as basis for a strict separation of controlling and presentation, but also build the foundation for 3rd party applications. Mobile applications for example use exactly the same API as the platform internally.

V. APPLICATIONS

In three different application area, we currently have field tests for the PROBINDR prototype. All three have in common that different end users with specific interests need to collaborate.

A. Project Management in Architecture

Architects take the responsibility to coordinate among different parties such as craftsmen, administrative offices, building owners, and others. Communication and data exchange is a difficult task in this situation of scattered contact persons. Additionally, all people involved can change during a single project. Large data files, frequent version changes and the organization of all documents require a lot of effort. Thus, it is challenging to keep everyone updated.

The group of architects so far used email for coordination and communication purposes. But the list of their complaints was long:

- Document size often exceeds mailbox limits and cannot be sent.
- Several documents concerning one topic must be sent in multiple emails. Correlations get lost.
- Sending of modified documents ends up in a load of different versions and is not manageable.
- Additional phone calls or emails are necessary to clarify questions.
- No guarantee that information updates reach all recipients.

PROBINDR is currently tested whether it can better serve the architects needs. In addition to the shared information space that a binder provides, its reactiveness feature is used to set up required business rules. For instance, meetings become much more efficient if it becomes transparent who of the attendants has not reviewed recent documents. Logging of user activities in such an environment is not seen as privacy attack but more as a constructive element to reach final project goals.

So far, architects send plans as printouts, which is very expensive. While at later project stages of a construction process, printed plans are mandatory, in early planning phases electronic versions are sufficient. We currently explore the usage of QR codes for the co-existence of physical and virtual items. Together with a mobile application this would allow to quickly check if a printed document is still up-to-date and give access to online comments.

B. Informatics Support for Athlete Coaching

Together with a Center for Sports Medicine we have developed *FMS-Book*, which is an application for the administration of fitness tests of athletes. The sports medical background is an assessment procedure for the evaluation of an athlete's fundamental movement state [16]. Seven basic exercises that require a balance of stability and mobility have to be practiced and a therapist scores the exercises performed. So far, the FMS tests have been documented using paper and pencil, which is inefficient in many ways.

It is a requirement, which PROBINDR fulfills that the user groups involved (athlete, trainer, therapist, and medical consultant) have different access rights to the data collected. Reactiveness of binders is crucial for the final goal to improve athletes movement and stability state: As soon as marks are given in one tab of the athlete's binder, another tab will be automatically filled with exercises proposed by the medical center. These general recommendations prepared beforehand can individually be extended by therapist and trainer. As soon as any changes in the binder are registered, the athlete gets notified. The athlete's binder is a collection of relevant data regarding coaching and training support.

 ISBN: 978-1-61208-206-6

C. Collaborative Course Management

In the fall semester 2011, course preparations, teachware distribution, and student interaction for a computer science service course "Software Tools in Informatics" used PROBINDR as organizational core component. In this course, a heterogenous community of chemistry, nano-science, computer science, and computational science students plus interested students from other fields attended. With over 100 students, efficiency in course management is important and because of their different background in using computers, a KISS-type support system was favored against tools already in place.

In phase 1, lecturer, chief assistant, secretary, and tutors collaborated by using binder "CS102 Admin" for the creation of exercises, reservation of lab space, assignment of tutors to student groups, etc. In phase 2, a second binder "CS102 Content" was in focus.

PROBINDR received positive feedback from the different end user groups. We have analyzed a survey from 123 students out of 12 different disciplines. 77% of the participants noticed the very intuitive usage and effective overview as one of the key strengths of PROBINDR. The majority of users prefers a further usage of PROBINDR to other tools.

VI. CONCLUSIONS

Currently PROBINDR is used by more than 300 companies with over 1000 binders.

With PROBINDR we could prove that it is possible to introduce a new generic collaboration environment that is being accepted. We could also show that the adoption of well-known structures and metaphors substantially contribute to the simplicity and acceptance and therefore also to the actual usage of the collaboration tool.

The RBs concept will now be tested for more complex scenarios: e.g., web spiders may signal within a binder whenever a referenced web site received an update.

REFERENCES

[1] J. Gube. (2008, 10) 15 free tools for web-based collaboration. [Retrieved: May, 2012]. Available: http://sixrevisions.com/tools/15-free-tools-for-web-based-collaboration

[2] A. Dreyssig, *Von Mindmapping bis Projektmangement Die besten Collaboration-Tools*, Lyonel-Feininger-Straße 26, 80807 München, Januar 2012.

[3] T. Yamasaki. (2010, April) Email statistics report, 2010-2014. [Retrieved: April, 2012]. Available: http://www.radicati.com/?p=5290

[4] MessageLabs Intelligence, *2010 Annual Security Report*. NY 10018 New York: Symantec.cloud, MessageLabs, 2010.

[5] Redicati Group, *Addressing Information Overload In Corporate EMail: The Economics of User Attention*. 1900 Embarcadero Road, Suite 206 Palo Alto, CA 94303: Redicati Group, Inc., 2007.

[6] J. Vogel, W. Geyer, L.-T. Cheng, and M. Muller, "Consistency control for synchronous and asynchronous collaboration based on shared objects and activities," in *COMPUTER SUPPORTED COOPERATIVE WORK (CSCW)*, vol. 13, no. 5–6. Springer, 1992.

[7] S. Whittaker and C. Sidner, "Email overload: exploring personal information management of email," in *CHI 96 CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS*. ACM Press, 1996, pp. 276–283.

[8] G. A. Miller, "The magical number seven, plus or minus two: some limits on our capacity for processing information." *Psychological Review*, pp. 81–97, 1956.

[9] P.-L. Pătrânjan, "The language xchange: A declarative approach to reactivity on the web." Ph.D. dissertation, University of Munich, Germany, July 2005.

[10] Assembla, Inc. Assembla workspaces to accelerate software teams. [Retrieved: May, 2012]. Available: http://www.assembla.com

[11] LiveBinders, Inc. Livebinders - your 3-ring binder for the web. [Retrieved: May, 2012]. Available: http://www.livebinders.com/

[12] QA Software Pty Ltd. Teambinder - advanced project collaboration. [Retrieved: May, 2012]. Available: http://www.teambinder.com/

[13] "Free online storage," 760 Market Street, San Francisco. [Retrieved: May, 2012]. Available: https://www.dropbox.com/home

[14] openmaru studio. Springnote - a free online notebook based on wiki. Last checked: 14.4.2012. [Online]. Available: http://www.springnote.com/

[15] E. Gamma, R. Helm, R. Johnson, and J. Vlissides, *Design Patterns: Elements of Reusable Object-Oriented Software*, 1st ed., ser. Addison-Wesley Professional Computing Series. Addison Wesley, 1994.

[16] G. Cook, L. Burton, and B. Hoogenboom, *Pre-Participation Screening: The Use of Fundamental Movements as an Assessment of Function - Part 1*. North American Journal of Sports Physical Therapy, May 2006, vol. 1(2), pp. 62–72.

 ISBN: 978-1-61208-206-6

CollabKit – A Multi-User Multicast Collaboration System based on VNC

Christian Beier Peter Ibach

Humboldt-Universität zu Berlin
Institut für Informatik
Lehrstuhl für Rechnerorganisation und Kommunikation
{beier,ibach}@informatik.hu-berlin.de

***Abstract*—Computer-supported real-time collaboration systems offer functionality to let two or more users work together at the same time, allowing them to jointly create, modify and exchange electronic documents, use applications, and share information location-independently and in real-time. Commonly, such collaboration systems are realised using remote desktop technology or are implemented as web applications. However, none of the examined existing solutions support concurrent multi-user interaction in an application-independent manner. Furthermore, when used in low-throughput shared-medium computer networks such as WLANs or cellular networks, most of the investigated systems do not scale well with an increasing number of users, making them unsuitable for multi-user collaboration of a high number of participants. Therefore in this paper we present a collaboration system that supports concurrent multi-user interaction with standard desktop applications and is able to serve a high number of users in low-throughput environments. Our multi-user multicast collaboration system named CollabKit, realised by integrating and extending existing technologies, was compared against a conventional unicast remote desktop system and found to significantly outperform it when several clients needed to be served. CollabKit supports application-independent concurrent operation by multiple users, per-user graphical annotations and window sharing and scales well with an increasing number of users.**

***Index Terms*—VNC; MPX; Multicast; Collaboration; CSCW**

I. Introduction

Collaboration means working together. Computer-supported real-time collaboration systems allow multiple users to simultaneously edit electronic documents, share multimedia content or use interactive applications – remotely or locally. The *real-time* properties of such systems enable users to concurrently ask and answer questions, brainstorm, and thus to rapidly draw, refuse, or accept conclusions. These characteristics make computer-supported real-time collaboration systems very useful in professional contexts – they enable knowledge workers and scientists to exchange information and to jointly create, share and modify electronic artifacts.

The first area in which common computer-supported real-time collaboration systems are limited though is support of *fully concurrent multi-user interaction*: Though there are current collaboration systems that support fully concurrent multi-user interaction, such systems are confined to one or a few built-in applications specifically designed for that system with multi-user support in mind, they do not allow users to interact with unmodified standard desktop applications. On the other hand, there is a second class of computer-supported real-time collaboration systems that allow participants to use any kind of desktop application, but they only support user interaction in a turn-taking mode where only one user at a time can be in control of the shared desktop and there is only sequential but no concurrent interaction.

The second area in which existing systems have shortcomings relates to *scalability*: when sharing applications or whole desktops – especially on low-throughput computer networks characterised by shared medium access such as wireless local area networks – the user-perceived performance degrades with an increasing number of connected users. This is because the same data is sent to each and every user individually: the more users are connected, the less throughput capacity is available to each one.

In order to address the first problem – *lack of fully concurrent multi-user operation in existing systems* – a computer-supported real-time collaboration system with support for fully concurrent multi-user operation was developed, implemented and tested. Our collaboration system dubbed CollabKit allows its users to *simultaneously* operate several applications on a shared desktop. To achieve this, existing technologies – namely the X11 windowing system and the Remote Framebuffer Protocol RFB used by VNC – were integrated to form a collaboration system with the desired features.

The second problem – *bad scalability in low-throughput networks* – could not be solved by simply integrating existing technologies though. Instead, this required enhancing the way data representing shared applications is delivered to the system's users. This meant designing and implementing an extension to the existing VNC remote desktop technology that would make data transmissions use the shared medium more efficiently. The chosen approach to accomplish this was to extend the RFB protocol with support for multicast data transmission. This allows a high number of users to efficiently use the created collaboration system on a low-throughput shared-medium network.

Figure 1 gives an outline of the envisioned system.

II. Related Work

During a detailed examination [8] of usable related work, it was found that almost all of the considered collaboration solutions support basic remote view and control features, but it was also evident that support for *fully concurrent* multi-user operation is relatively scarce: There are preceding works that support semi-concurrent multi-user operation by essentially time-sharing a single cursor between users [17], but MPX [12]

 ISBN: 978-1-61208-206-6

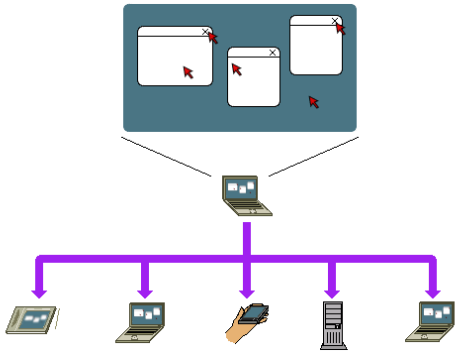


Figure 1: CollabKit is a computer-supported real-time collaboration system that supports *concurrent* multi-user interaction and transmits the shared desktop *once* to *all* clients using multicast.

is the only software supporting fully concurrent multi-user operation with mice *and* keyboards on a standard desktop. Others are either turn-taking, i.e. only supporting sequential operation [10, 13, 9], or confined to some special multi-user applications [5, 16, 6].

Since it was decided within the requirements analysis that *fully concurrent* multi-user support including cursors *and* keyboard foci is needed, the use of MPX for further work was considered somewhat mandatory. Although designed with network-transparency in mind, the X Window System X11 which MPX is based on is not suited well for sharing applications to several users: Within X11, an application can always just be connected to a single X server, without special measures it is thus impossible to display and remote control an application from two different remote computers. Then, X11's network protocol is a *stateful* one: If the connections fails, the application loses its X server and terminates. Finally, the X11 network protocol involves many round trips, which hampers performance on high-latency links [15].

Taking these findings about X11 into account, it was concluded that combining MPX with another remote desktop technology would be a more promising approach. It was also clear that for interfacing with MPX, this remote desktop software would have to be modified to support multiple pointers. Thus, only products with available source code were furthermore eligible. Another prerequisite was that there should exist a server implementation for the X Window System that could be interfaced with MPX.

There are already some remote desktop systems that to some extent support multicast data transmission: most of them are based on VNC [4, 7, 19], RTP [14] or custom protocols [9, 11]. Some of these are view-only and lack remote control support, others are not open source and thus not adaptable to concurrent multi-user support.

However, the main issue with these existing multicast remote desktop systems is that they lack complete multicast flow control with error handling. While the missing remote control features could possibly be added with maintainable effort, the lack of proper multicast flow control and error handling is a more serious problem – IP multicast is based on UDP instead of TCP and thus provides no built-in flow control nor reliable data transmission. These are important though when – to minimise resource usage – only updated parts of the screen are multicasted, as opposed to always multicasting full screenshots. Out of the considered multicasting solutions, only the newer incarnation of TeleTeachingTool [19] and VNCast [14] potentially provide multicast flow control since they are based on RTP, but they still lack multicast error handling.

Because of these shortcomings of existing multicast remote desktop software, it was decided to implement multicast support from scratch, extending an existing unicast remote desktop software. This way proper multicast flow control and error handling could be implemented in a clean fashion while keeping the existing unicast communication paths for loss-sensitive data and as a fallback.

After evaluating different candidates, the Remote Framebuffer Protocol used by VNC was identified as a good starting point: It is an already widely used protocol; thus enabling legacy non-multicast clients to connect as well. In contrast to multicast RTP that supports a lot of features that are not needed for a remote desktop application, VNC is simpler, resulting in a less complex system in the end. RTP has features that are needed for proper transmission of audio data, but are of little use for multicasting of simple image data: anti-jitter buffering, reordering of packets and timestamps. Buffering of incoming data in order to compensate jitter is essential for audio data, but not really necessary for image data. Since multicasted image payloads are split up into relatively small packets that are tagged with size and position information, the order in which packets arrive is irrelevant. Timestamps are essential for transmission of audio data, but of little use for image data. VNCs simplicity also is the reason it was chosen over Microsoft's RDP – it is a lot less complex and the core protocol is open and extensively documented. As a reliable code base to build upon the LibVNCServer/LibVNCClient [3] library was chosen because of its good coverage of standard VNC features *and* useful protocol extensions on the server and client side.

III. CollabKit Design

The different non-functional and functional requirements a real-time collaboration system should meet were identified in [8]. This meant designing CollabKit to provide features useful for concurrent multi-user collaboration while ensuring that the system would still offer the same levels of performance with many user connected. Thus, CollabKit design focused on *multi-user support* on one hand and *multicast transmission of remote desktop data* on the other hand.

A. Multi-User Support

1) Concurrent Multi-User Operation : could be achieved by extending the server application x11vnc included within the LibVNCServer distribution and interfacing it with MPX: when a client connects, it gets its own MPX master pointer and keyboard focus which can be operated independently from other MPX master device pairs. It was found that using differently coloured cursors for mouse pointers is imperative in order not to confuse users. To properly route input events to the client's assigned master devices, all functions, variables

 ISBN: 978-1-61208-206-6

and data structures in the VNC server sources that deal with client input had to be extended to be device-aware.

2) Multi-User Graphical Annotations: were made possible by extending the annotation tool Gromit [2] with multi-pointer support. With Gromit, graphical annotations in different colours can be drawn onto an X display. Since the widget toolkit used by Gromit, GTK+, has MPX support in its most recent versions, the remaining task was to change the application itself to be aware of multiple pointers.

3) Client-to-Server Window Sharing : Because VNC is used for distributing the server's screen to connected clients, it was obvious to use the same technology to export client windows to the central desktop. In CollabKit, this is done by using a mode often called »reverse VNC«: The CollabKit server machine runs a VNC viewer that listens for incoming connections. CollabKit clients run a VNC server software that supports sharing single windows instead of the whole screen.

4) Multicast Transmission of Image Data: Since one of the main uses of the system is to transmit rather bulky image data, the underlying network's maximum throughput poses a fundamental constraint. When used on wireless LANs with 54 MBit/s (802.11a/g) or just 11 MBit/s (802.11b) gross data rate, it is apparent that delivering 25 fps of RGB image data to multiple participants will quickly exhaust the network's capacity. Compression can only alleviate the consequences of this problem but not solve it.

Since the image data representing the shared desktop is the same for all connected participants, an obvious approach to avoid the constraints posed by limited network capacity is to use *multicast* data transmission instead of unicast.

The *Remote Framebuffer* protocol used by ordinary VNC only supports unicast data transmission, relying on TCP at the transport layer. It was deemed adequate to let the extension only transmit framebuffer update messages using UDP multicast since other messages defined by the protocol do not consume nearly as much throughput capacity as these. This way the common TCP unicast communication paths can be used for loss-sensitive data while bulky image data is transmitted to clients via UDP multicast, providing significant channel capacity savings when several clients are connected. As suggested by the RFB protocol specification, the multicast VNC extension was realized by introducing a new pseudo-encoding. This way the protocol can be extended in a backward compatible fashion. The full specification of the MulticastVNC protocol extension is presented in [8]. Nevertheless, since the integration of flow control and error handling sets MulticastVNC apart from other multicasting remote desktop solutions, the next Subsection discusses MulticastVNC flow control.

5) MulticastVNC Flow Control: Flow control is the process of managing the rate of data transmission between network nodes to prevent a fast sender from overwhelming a slow receiver. Since UDP does not provide built in flow control like TCP does, an application layer multicast flow control scheme had to be integrated into the *MulticastVNC* protocol extension: MulticastVNC uses a rate-based flow control scheme coupled with a *NACK*-based error handling mechanism: a message retransmission request by a receiver is interpreted as an indication to lower the send rate. Regarding the actual flow control algorithm, MulticastVNC uses a modified form of the send rate adaptation algorithm proposed in [18]. The modifications to the original algorithm are as follows:

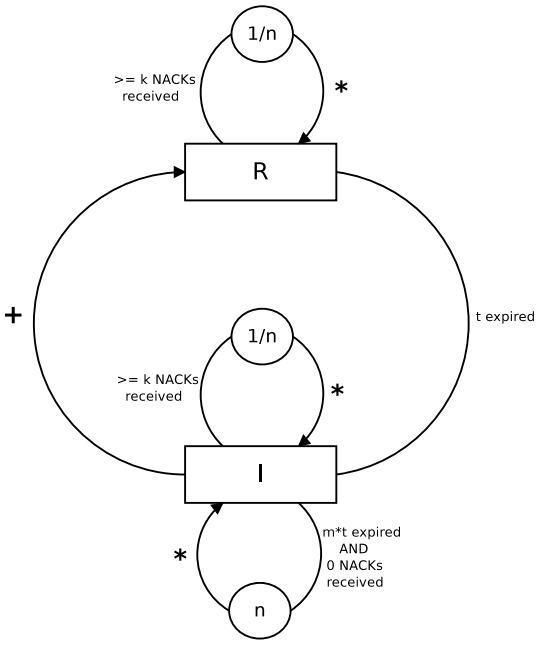


Figure 2: Send rate adaptation algorithm used by MulticastVNC. The send rate *R* is additively *increased* by a certain increment value *I* on expiration of time *t*. *R* and *I* are *decreased* on receipt of *k* or more significant NACKs. The constant parameters *m* and *n* are used to balance the algorithm.

For a rate decrease to occur, MulticastVNC requires a burst of *k* or more significant NACKs. This modification was made because during evaluation it became apparent that the original flow control scheme did not consider networks characterised by relatively high packet loss probability such as WLAN. The NACKs generated for these losses caused the transmission rate to be decreased to a much too low value.

While the original approach used a variable timer value *T*, the MulticastVNC flow control scheme uses a constant timer value *t*. This change was made because with the original flow control scheme, the send rate is increased too slowly when its low but too fast when its rather high. Furthermore, there is no reason to let the increment timer depend on the current send rate: While it is true that more NACKs are generated at a higher send rate because more messages are sent, this does not mean that the send rate has to be increased faster because the number of *significant* NACKs as defined in [18] does not change substantially.

An outline of the flow control scheme used by MulticastVNC is depicted in Figure 2.

IV. CollabKit Evaluation

A. Evaluation of Multi-User Functionality

Unlike other systems which only provide turn-taking, CollabKit features *concurrent* multi-user remote control of a shared desktop, concurrent graphical annotations as well as client-to-server window sharing.

 ISBN: 978-1-61208-206-6

1) Concurrent Multi-User View and Control: The modified x11vnc server used in CollabKit provides every participant with their *own* independent mouse cursor and keyboard focus, allowing users to interact with objects on the server's desktop *jointly* and *simultaneously*, as can be seen in Figure 3

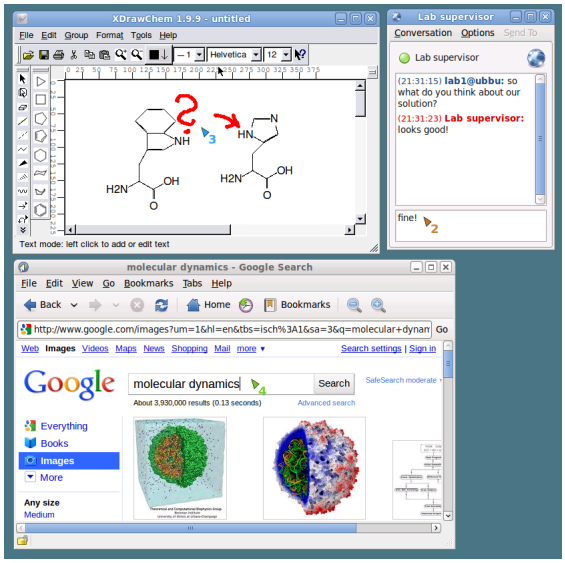


Figure 3: A scientific collaboration use case: three remote participants *concurrently* operating applications on a shared desktop. One is drawing on-screen annotations.

It is important to state though that at the time of writing legacy applications can only be operated flawlessly by *one* user at a time, concurrent interaction on the same desktop is only possible with *different* legacy applications. However, new applications can be designed with multi-device control in mind and existing legacy applications can be modified to be made multi-device aware. In the simplest case, it may be sufficient to just link against a multi-device aware version of the underlying widget toolkit, such as GTK+ 3.0.

2) Multi-User Graphical Annotations: On-screen annotations can be used to either explain something more clearly or to be able to ask more specifically about something on the shared desktop. By using a heavily modified version of the annotation tool Gromit, on-screen annotations can be done *concurrently* by *all* or *some* users: it is possible that only a few clients annotate – others are still able to operate the shared desktop, as can be seen in Figure 3.

3) Client-to-Server Window Sharing: When connecting to a CollabKit server using the CollabKit client, the client-to-server window sharing functionality is easily accessible from within the client application's user interface: after having established a connection to the server, the user may select the »share window« entry out of the »window sharing« menu. The selected window will then appear on the shared desktop. It can be freely dragged around on the shared desktop and also be operated by other participants.

B. Evaluation of the MulticastVNC Extension

The remainder of this paper documents how well MulticastVNC performs compared to traditional unicast VNC. In order to make well-founded statements on unicast versus multicast performance, extensive real-world tests with a total of eight computers were carried out. Up to seven client machines were employed, measuring throughput and latency as well as MulticastVNC NACK and loss ratios.

A single test unit was defined to last exactly 3 minutes, resulting in 180 samples of throughput and latency taken by each participating client instance. In order to put load on the clients, the server machine in all tests constantly sent 640x480 pixels of 32-bit image data with a desired frame rate of 15 frames per second. The VNC encoding used for the majority of tests was Raw encoding. Ultra encoding as the default was considered as well, but ultimately dismissed because with the relatively weak server machine used in the experiments the achievable throughput was found to be CPU-bound instead of being limited by network characteristics and method of data transmission.

1) Throughput Properties: The expected throughput properties of unicast versus multicast data transmission can be formalized as follows: For the *unicast* case, the maximum throughput observable by a client cl can be defined as

$$T_{cl} = \min\left(T_p, \frac{T_{sp}}{N_{sp}}\right) \quad (1)$$

In this metric T_{cl}, the expression T_p describes a concave metric that defines the maximum throughput limited by the characteristics of the network path from server to client: Let $T(n_i, n_j)$ be a metric describing the achievable throughput between two network nodes n_i and n_j and let $p(n_1, n_2, ..., n_m)$ be the path between server node n_1 and client node n_m. Then T_p can be expressed as

$$T_p = \min\left(T(n_1, n_2), T(n_2, n_3), ..., T(n_{m-1}, n_m)\right)$$

Similarly, the expression T_{sp} describes the achievable throughput on the path sp which is the subset of p that the client cl shares with $N_{sp} - 1$ other clients. It can clearly be seen that T_{cl} decreases with an increasing N_{sp}.

However, when using *multicast* data transmission, the maximum client-observable throughput becomes independent of the number of clients that share the same path. The metric then evaluates to a rather simple

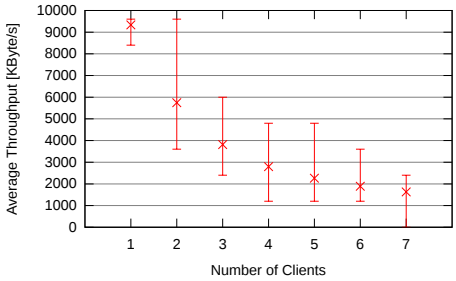
$$T_{cl} = T_p \quad (2)$$

showing that the maximum throughput observable by cl is now independent of the number of other clients it shares the network path to the server with.

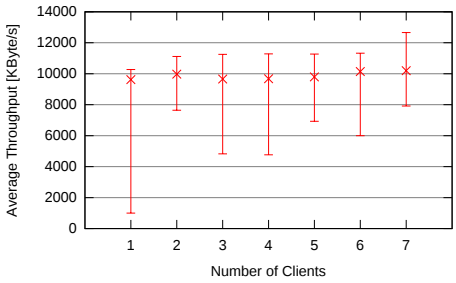
To be able to compare the throughput characteristics of VNC and MulticastVNC on a sound basis, experiments were carried out that measured throughput as seen by clients in different configurations: This included varying the number of connected clients, testing in different network environments (Fast Ethernet LAN and 802.11b WLAN) and changing between traditional unicast VNC and MulticastVNC.

The basic methodology for each test run was to start with one client and increase the number of clients over time. As noted above, this was done every 3 minutes, resulting in 180

 ISBN: 978-1-61208-206-6



(a) VNC.



(b) MulticastVNC.

Figure 4: Average per-client throughput of 1 to 7 clients in a Fast Ethernet LAN using Raw encoding. It can be seen that for unicast data transmission average per-client throughput decreases with an increasing number of connected clients. With MulticastVNC instead, average per-client throughput is independent of the number of connected clients.

samples per client count. This paper presents a subset of the experimental findings.

The first test series measured achieved throughput in a LAN, with all machines being connected through a Gigabit Ethernet switch. Figure 4 shows the results for 1 to 7 connected clients for the VNC and the MulticastVNC case. The graphs show test runs each lasting 21 minutes where an additional client would connect 180 seconds after its predecessor. Values on the y axis are averaged throughput, computed as the arithmetic mean of the samples taken by all active clients during the corresponding 180-second time span. The upper and lower ends of the error bars denote the biggest and smallest values sampled.

With traditional unicast data transmission (Figure 4a), per-client throughput decreases with each new client joining the session. In contrast to the unicast measurements, Figure 4b shows that with MulticastVNC, per-client throughput is not as affected by the number of clients as it is when using traditional VNC. In fact, the graph shows that throughput seen by each client is around 10,000 KByte/s, independent of the number of clients in the session. This matches the theoretical predictions of the metric in equation 2.

2) Latency Properties: Multicast data transmission was also expected to be beneficial for the **latency** of communication taking place, because it cuts down on server answer time. First, for the *unicast* case, the delay or latency observed by a client cl can be defined as

$$L_{cl} = L_p + t_{srv} * (N_{sp} - 1) \quad (3)$$

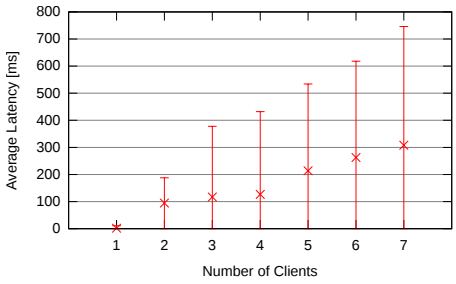
Within L_{cl}, the expression L_p describes an additive metric defining the latency of the client's connection to the server: Let $L(n_i, n_j)$ be a metric that describes the latency between two network nodes n_i and n_j and let $p(n_1, n_2, ..., n_m)$ be the path between server node n_1 and client node n_m. Then L_p can be expressed as

$$L_p = L(n_1, n_2) + L(n_2, n_3) + ... + L(n_{m-1}, n_m)$$

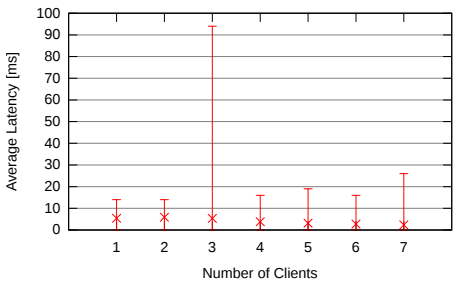
The term t_{srv} in L_{cl} describes the time the server needs to transmit data to a single client. N_{sp} is defined as in the throughput metric above. It can be seen that given a non-zero t_{srv}, L_{cl} increases with an increasing N_{sp}. The higher t_{srv}, the stronger the effect.

The benefit of multicast data transmission is that it eliminates the possible delay a client might encounter while waiting for others to be served: Because data is now sent only once instead of N_{sp} times, the latency observed by cl when using multicast data transmission is described by

$$L_{cl} = L_p \quad (4)$$



(a) VNC.



(b) MulticastVNC.

Figure 5: Average per-client latency of 1 to 7 clients in a Fast Ethernet LAN using Raw encoding. For the unicast case, the graphs show that average per-client latency increases the more clients are connected. For multicast data transmission, test results show a constant average per-client delay.

The latency occurring for different configurations, i.e. a varying number of clients using unicast VNC or MulticastVNC in different network environments, was measured employing the same test methodology as was used in the throughput experiments. The measured latency values reflect the data packet round trip time of the network in use *plus* the time the server takes to reply.

Figure 5 shows the results for 1 to 7 clients in a Fast Ethernet LAN using Raw VNC encoding. Again, the averages are computed as the arithmetic mean of valid samples taken by all active clients, the upper and lower ends of the error

 ISBN: 978-1-61208-206-6

bars denote the biggest and smallest sampled values. As can be seen in Figure 5a, average per-client server answer time increases linearly with more clients to be served, matching the predictions of equation 3. For MulticastVNC, the test results depicted in Figure 5b show a constant average per-client delay unaffected by the number of connected clients as predicted by equation 4.

3) Effectiveness of Multicast Flow Control: MulticastVNC flow control builds upon related work done in [18], but makes two important modifications, described in Section III-A5. This section explains why these changes were necessary and shows that the resulting multicast flow control scheme is in fact working in both wired and wireless network environments.

The corresponding test runs all followed the same basic procedure: A client connected to the server and ran at full receive rate for 30 seconds. After that, it throttled its receive rate to circa 50% and ran in this configuration for another 30 seconds. On expiration of that time span, the client unthrottled again and ran like this for a final 30 second interval. During execution of these high-low-high profiles, the transmission rate of the server's network interface was observed to see how the server adapted its send rate to the respective new situation. Tests were carried out in both a Fast Ethernet LAN and a 802.11b WLAN. The receive rate throttling on the client side was done using the Linux netem emulation layer which allows rate-limiting of incoming traffic by means of a token bucket queuing discipline.

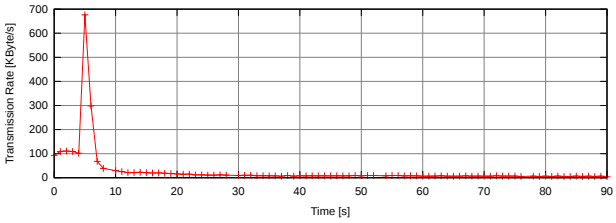
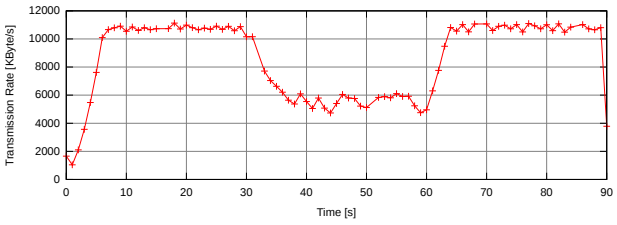


Figure 6: MulticastVNC server transmission rate in a 802.11b WLAN with $m = 10$, $n = 1.2$, $k = 1$, $T = \frac{100{,}000Byte}{R}$. With the unmodified original flow control scheme, the server send rate is almost immediately throttled down to around zero in a WLAN.

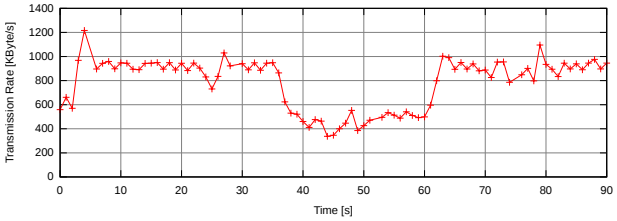
The first incarnation of the MulticastVNC flow control scheme was closely modeled after the original algorithm proposed in [18] and described in detail in Section III-A5. The parameter values of $m = 10$ and $n = 1.2$ used in [18] were adopted for the MulticastVNC flow control. The exact choice of parameters for the variable timer T is left somewhat unclear in the paper though. $T = \frac{100.000Byte}{R}$ was chosen after some testing in a LAN.

While this multicast flow control scheme worked reasonably well in a Fast Ethernet LAN, it failed completely when tested out in a WLAN, as shown by the diagram in Figure 6: The rise in transmission rate at the beginning of the test stems from the client framebuffer initialization which is done via unicast, but then the server send rate is almost immediately throttled down to around zero. Since flow control worked well in a Fast Ethernet LAN before, it was suspected that NACKs generated from occasional packet loss in the WLAN were misinterpreted by the algorithm as a sign for receive buffer overflow at the client side, resulting in the server send rate to be lowered.

This misbehaviour could be fixed by changing the algorithm to only decrease the send rate upon receipt of a *burst* of NACKS. The reason this works better is that the patterns of NACKs generated by occasional packet loss and receive buffer overflow differ: In the former case, NACKs are mostly evenly distributed over time and tightly packed NACK bursts are relatively rare. However, on receive buffer overflow at the client side a relatively large number of packets is dropped at once, resulting in a burst of NACK messages arriving at the server. A burst value of $k = 3$ was found to be adequate for both WLAN and LAN environments.



(a) Fast Ethernet LAN.



(b) 802.11b WLAN.

Figure 7: MulticastVNC server transmission rate in a Fast Ethernet LAN and an 802.11b WLAN with $m = 10$, $n = 1.2$, $k = 3$, $t = 50ms$. With both modifications applied, the revised flow control scheme now works well in both wired and wireless network environments.

While this modification fixed flow control on WLANs, there still was a problem with either too frequent rate increases at high send rates or too slow send rate recovery at low send rates. To solve this, a fixed send rate increment timer value t was introduced instead of the variable timer T that depended on the current send rate R. In fact, there actually is no reason for the send rate increment timer value to depend on the send rate itself: While it is true that more NACKs can be generated at a higher send rate since more packets can be lost, this does not mean that the send rate has to be increased faster – the algorithm distinguishes between significant and meaningless NACKs and marks too high send rates as already decreased. This way, additional NACKs for a certain send rate have no effect. Figure 7 shows that the modified flow control scheme with NACK bursts and fixed send rate increment timer works well in both Fast Ethernet LAN and 802.11b WLAN, respectively. A parameter set of $m = 10$, $n = 1.2$, $k = 3$ and $t = 50ms$ was found to be adequate for both cases. These also are the values used in the throughput and latency experiments presented above.

 ISBN: 978-1-61208-206-6

V. Conclusion and Future Work

By integrating existing technologies and extending them where needed, a computer-supported real-time collaboration system that supports *concurrent multi-user operation* and *scalable multicast transmission of image data* could be created. Source code and documentation are available at the project web site [1].

As opposed to sequential turn-taking where only one user at a time is in control, CollabKit integrates the Multi-Pointer-X extension MPX with the remote desktop technology VNC to give remote participants a per-user cursor and keyboard focus, allowing them to *simultaneously* operate several applications on a shared standard desktop *in parallel*. To make user interaction more expressive, CollabKit furthermore implements simultaneous per-user graphical annotations. For electronic teaching and assistance use cases as well as for professional remote collaboration, a window sharing feature was added that enables users to show local windows to others by exporting them to the remote desktop. A full-featured CollabKit client application is available for Windows and Linux; there is an app for Android and an alpha-stage Mac OS X implementation.

To address scalability with an increasing number of participants and make CollabKit perform well even with a high number of users in a low-throughput network, we extended VNC with support for multicast data transmission. Experiments showed that compared to its unicast counterpart, the MulticastVNC extension performs significantly better when several client computers are connected to the system: While with unicast per-client throughput decreases with additional clients, the use of MulticastVNC makes average per-client throughput largely independent of the number of connected clients. Regarding latency, test results showed that in the unicast case average per-client delay goes up with an increasing number of connected clients while with MulticastVNC it stays at a constant low level. Finally, unlike other examined multicast-enabled remote desktop systems, CollabKit also implements multicast flow control and error handling using a NACK mechanism in order to be able to deploy the system in changing network environments without reconfiguration and to deliver an accurate representation of the shared desktop to its users.

While CollabKit already is a prototype shared view desktop conferencing system, there are further enhancements and feature additions conceivable: Multi-user operation of the shared desktop currently lacks a fine-grained floor control scheme. This could include a concept like window or application ownership where users can take exclusive control of a particular application, which can then be shared with others, passed on or released. Regarding the MulticastVNC extension of the RFB protocol, future work could focus on implementing other VNC encodings than Raw and Ultra or investigate possible encryption schemes for the pixel data sent via multicast. Another interesting topic could be to examine how multicast can be applied to the NACK mechanism so that lost datagrams are not necessarily retransmitted by the server but by other clients that have the requested data available.

References

[1] CollabKit web site. http://wiki.informatik.hu-berlin.de/nomads/index.php/CollabKit – Retrieved: 03, 2012

[2] Gromit web site. http://www.home.unix-ag.org/simon/gromit – Retrieved: 03, 2012

[3] LibVNCServer web site. http://libvncserver.sf.net – Retrieved: 03, 2012

[4] MulticastVNC web site. http://www2.in.tum.de/~ziewer/multicastvnc/ – Retrieved: 03, 2012

[5] PaintChat web site. http://www.paintchat.jp/

[6] SubEthaEdit web site. http://www.codingmonkeys.de/subethaedit/ – Retrieved: 03, 2012

[7] TightProjector web site. http://www.tightvnc.com/projector/ – Retrieved: 03, 2012

[8] Beier, C.: *CollabKit - A Multi-User Multicast Collaboration System based on VNC*, HU-Berlin, Thesis, 04 2011. – http://edoc.hu-berlin.de/docviews/abstract.php?id=39389 – Retrieved: 03, 2012

[9] Boyaci, O. and Schulzrinne, H.: BASS Application Sharing System. In: *Tenth IEEE International Symposium on Multimedia, 2008. ISM 2008*, 2008, pp. 432–439

[10] Coulthart, D. ; Das, S. and Kim, L.: THINCing Together: Extending THINC for Multi-User Collaborative Support. (2009)

[11] Hasan, S. M. ; Lewis, G. J. ; Alexandrov, V. N. ; Dove, M. T. and Tucker, M. G.: Multicast Application Sharing Tool for the Access Grid Toolkit. In: *UK e-Science All Hands Meeting, Nottingham, UK*, 2005

[12] Hutterer, P. and Thomas, B. H.: Groupware support in the windowing system. In: *Proceedings of the eight Australasian conference on User interface-Volume 64*, 2007, pp. 39–46

[13] Masahiro, T. and Lowe, N.: *DrawTop*. ViSLAB School of Information Technologies, University of Sydney, 2006

[14] Ng, C. J. ; Takatsuka, M. ; Smith, S. and Lowe, N.: VNCast web site. http://wiki.vislab.usyd.edu.au/moinwiki/VNCast – Retrieved: 03, 2012

[15] Packard, K. and Gettys, J.: X Window System network performance. In: *FREENIX Track, 2003 Usenix Annual Technical Conference*, 2003

[16] Tse, E. and Greenberg, S.: Rapidly prototyping single display groupware through the SDGToolkit. In: *Proceedings of the fifth conference on Australasian user interface-Volume 28* Australian Computer Society, Inc. (Conf.), 2004, pp. 101–110

[17] Wallace, G. ; Bi, P. ; Li, K. and Anshus, O.: A multi-cursor x window manager supporting control room collaboration. In: *Computer Science Report No. TR-0707-04, Princeton University* (2004)

[18] Yamamoto, M. ; Sawa, Y. ; Shinji, F. and Ikeda, H.: NAK-based flow control scheme for reliable multicast communications. In: *Global Telecommunications Conference, 1998. GLOBECOM 98. The Bridge to Global Integration. IEEE*, 1998, pp. 2611–2616

[19] Ziewer, P. and Seidl, H.: Transparent teleteaching. In: *Proceedings of ASCILITE*. 2002, pp. 749–758

 ISBN: 978-1-61208-206-6

Using "Liminal Spaces" for Web-Based Collaboration and Enhancing Learning

Katya Toneva
International Community School
London, United Kingdom
e-mail: katya147@yahoo.com

John Cuthell
Mirandanet Academy
London, United Kingdom
e-mail: john.cuthell@mirandanet.ac.uk

Abstract—**The informal dynamic knowledge creation in collaborative contexts occurs as participants move from textual communication in a conventional mailing list to blogging, wikis contributions, online video conferencing and other collaborative web environments. Web 2.0 collaborative technology can be seen as creating a "liminal space" – a passage, in which a person moves from one state of being to another. Participants in this liminal space are transformed by acquiring new knowledge, a new status and a new identity in the community. This change is of critical importance if learning is to be successful. This paper aims to extend understanding of liminal spaces and their contribution to the learning process. Evidence from participants (students and teachers) from the International Community School, London, UK and other schools across the world is used to estimate the value of liminal web-spaces (within the global collaborative Flat Classroom Project).**

Keywords–liminal spaces; Bricolage; Flat Classroom Project; social constructivism; collaborative learning; informal and formal learning

I. INTRODUCTION

In the Autumn term 2011, the International Community School (ICS), London, took part in the global collaborative Flat Classroom Project [1]. The Flat Classroom Project (FCP) is featured in Thomas Friedman's book "The World is Flat" [2].

The general goal of the project outlined in [1] is: "to 'flatten' or lower the classroom walls so that instead of each class working isolated and alone, two or more classes are joined virtually to become one large classroom. The project is designed to develop cultural understanding, skills with Web 2.0 and other software, experience in global collaboration and online learning, awareness of what it means to live and work in a flat world, while researching and discussing the ideas developed in Friedman's book."

ICS took part in the global Flatclassroom on the specific topic: "How ICT could improve people's lives". This was linked to the English curriculum. The idea was that students could develop their English language proficiency and academic language skills via the FCP activities. The final product, published at the FCP web-site, was in the form of a video storyboard.

The students used a range of web technologies to complete their project: an educational online network, ning web-site, blogs, photo and video uploading, and a wiki, to create their profile and build a web page on their topic. In addition, they used Elluminate web-conferencing software to showcase their learning.

These collaborative technologies create a liminal space – a term drawn from anthropology that describes a rite of passage, in which a person moves from one state of being to another. In the virtual Flatclassroom participants are observed to be transformed in this liminal space by acquiring new knowledge, a new status and a new identity in the community. If learning is to be successful, this change is of critical importance. Whilst remote and informal learning is largely what has been understood about mobile learning, the concept can now be extended to include these informal spaces in which learning takes place – the liminal spaces that those who push the boundaries of digital possibilities now inhabit intellectually [3] & [4].

This paper aims to extend understanding of liminal spaces and their contribution to collaborative learning process. The processes can be described as a form of Bricolage [5], in which people build new knowledge from what is at hand. We will share our experience within a four month Flat Classroom Project to illustrate these processes. We hope that our case study and analysis will contribute to understanding of the concept of developing and using liminal spaces for learning.

The structure of this study is as follows: Section 2 briefly depicts the context of the project and technical requirements. Sections 3 and 4 outline the project framework and identify some constraints and conflicts. Section 5 provides teachers' and students' feedback in the context of using Flatclassroom approach for collaborative learning. Section 6 outlines the concept of "Bricolage" in the context of knowledge creation. Section 7 clarifies the meaning of formal and informal learning. Section 8 suggests ways for using liminal spaces for enhancing informal learning. The last section draws five 21st Century Learning Themes and summarises possible ways for relevant developments with emphasis on approaches identified in the Flat Classroom Project.

 ISBN: 978-1-61208-206-6

II. BACKGROUND AND TECHNICAL REQUIREMENTS

The theory and practice underlying the Flatclassroom Project described as social constructivism brings teachers and students to international collaborative activities. Social constructivism emphasises collaboration and exchange of ideas [6]. Flatclassroom online learning environment is based on Web 2.0 technologies (wikis, blogs, ning, online conferencing Elluminate tools) that support collaborative forms of learning that can encourage publications, multiple literacy and inquiry.

As suggested by Williams and Jacobs [6], Web 2.0 tools allow learners to develop new ideas, and transform their own understanding through reflection by publishing and sharing their work to a wide audience. Constructivism gives people ownership of their learning, since they are engaged through questions, explorations, and designing assessments [7].

The term 'digital technologies' also encompasses the mobile technologies movement that aims to chart the new conceptual space that Pachler et al. call the 'Mobile Complex' [8].

Our understanding of mobile learning is based on social constructivist approaches to learning. Constructivism creates a collaborative learning environment.

A learner-centred approach is the main focus in our school ICT strategy for using netbooks and Web 2.0 technologies. We have adopted the slogan "IT's not about the technology, it is about the learning" [7].

We have a Google Apps school domain. Google Apps have been used as a school online learning environment since September 2010. During 2011/12 academic year, we extended the school environment using a new Google App called "Course Director".

Teachers and students are confident using Google Apps (Google email system and Google docs). We have started pilot projects supported by other Web 2.0 technologies, such as Glogster, YouTube and blogs. For example, we had already used a blog for the E-safety Project management [9] and embedded video storyboards created by the students – this was a good initial teacher and student preparation for a web-based collaboration.

The Flat Classroom Project™ [1] has four mandatory components for students:

- An audio or video introduction posted as a blog post on the educational network (Ning);
- A written collaborative report using a wiki - Students will edit the wiki and discuss the topic on the discussion tab of the page in teams;
- A personal multimedia response (digital story/video) - Topic as assigned on the project matrix;
- A post project reflection - Students will post their reflection on the process to the project Ning.

The school has not invested in expensive and "flashy" technology to participate in the Flatclassroom activities. Our focus is not the technology itself, but how we use the technology to enhance teaching and learning.

Since September 2010, the school has provided netbooks for all students and staff with Internet connectivity via the wireless network. Students have used netbooks with Wi-Fi connectivity and free Web 2.0 technologies to complete their project tasks.

III. PROJECT FRAMEWORK

There were 16 schools and 347 students taking part in the Flat Classroom Project across the world (USA, Australia, Canada, UK, Germany, Korea, Japan and China).

We involved a DPP EFL group of six students (Diploma Preparation Programme - English Language for Learning) in the global Flat Classroom project topic "Mobile and Ubiquitous (M&U)".

The school core curriculum objectives were linked directly to our specific Flat Classroom topic "How ICT could improve people's lives". Explicitly, our English curriculum goal was: "Developing English language proficiency skills and academic language skills including:

- Researching/reading/speaking/writing skills;
- Collecting, analysing, evaluating, reporting and presenting information.

In addition, our project objectives included developing key skills such as communication skills, team working skills, using ICT tools for presentations, online collaboration and networking which also fit very well with the Flat Classroom Project approaches.

IV. CONSTRAINTS AND CONFLICTS

At the beginning of the Flat Classroom Project, there were inherent conflicts between the fluid, chaotic and inchoate nature of the Liminal Space of the ICS' Flat Classroom Project and the technical demands imposed by the need to produce high-quality resources that will be uploaded into a virtual web space to be used asynchronously. This is particularly critical when the resources are to be used by other projects (by participants from other schools). The synchronous is inhibited by the needs of the asynchronous. These constraints needed to be recognised by all participants. The Flatclassroom processes, however, are ones that are constantly evolving, both as available technologies change, and as participants become more adept at acting within and across the zones of liminal space.

For example, the students needed to contribute to wiki spaces to introduce themselves and to plan their projects. They needed to use Flatclassroom Ning space to share

 ISBN: 978-1-61208-206-6

examples, to communicate with other Flatclassroom students across the world and to provide peer support and feedback. The students needed to understand the principles of working online and to adopt new skills and behaviours, including: understanding security and copyright issues and developing skills for online communication, collaboration and networking. The students have found these demands much more challenging than the actual development of the final project product (video storyboards presenting their topics).

V. LEARNING: HOW; WHY; WHERE

The conventional ecosystem of learning is based on the separation of home, the school, neighbourhood, work: all of these are bound into a system. This system operates the constraints of age, class, money and expectations, all of which act as gatekeepers for the system.

We share mutual understanding that in educational projects the learning process is more valuable than the final product.

It was a project requirement for the students to create a video storyboard on their Flatclassroom topic as a final product. The technical skills to develop a video clip have been achieved easily by all participants. In the context of enhancing students' learning skills, it was more important to help students to achieve the curriculum objectives and also life skills, like communication, presentation skills and global awareness.

As part of our qualitative evaluation of the project outcomes we share both teachers' and students' reflections on the process of project development and learning [10].

For example, the ICS leading teacher has identified a range of positive project outcomes such as increasing students' confidence in communication, enriching English language vocabulary, enhancing skills for research, selecting, analysing and presenting information, global awareness, skills for providing peer feedback and support online, reflective skills and a range of technical skills.

One of the collaborating teachers (Korea) commented: "With regards to the four students that I brought to participate, the change in them around school is palpable. They are more sure of themselves, sure of their ideas, and confident that their ideas merit respect and consideration.

They are empowered to speak up, volunteer, and give suggestions within a small or large group. In essence, it's as if working with students from other cultures to come up with real-world solutions to real world problems has made these four female students see that what they do every day can contribute to something bigger" [11].

Another leading teacher (USA) shared: "I watched as these dynamic youth obliterated racial, ethnic, religious, and cultural barriers to build innovative collaborative projects … projects, that when realized will address some of our worlds' most pressing social issues" [11].

The students appreciated the opportunity to communicate with peers across the world, to exchange educational and cultural ideas and values and the feeling of being part of a global competition for developing a challenging project product.

A teacher from Japan commented: "As a teacher, I can definitely see the value in a well-organized project that allows us to make the students more aware of things like online behavior and safety. The added benefits, of course, are also quite substantial. Since this is a global project, our kids remain motivated to complete their tasks on time because they are out to prove themselves to the world as opposed to their teacher or classmates. In addition, the online computer skills that they acquire throughout the process will last them a lifetime" [11].

The students from ICS were excited about the opportunity to establish their identity on the Flatclassroom liminal spaces (wiki and ning), to provide and receive support from their peers online and were proud to share their final video storyboards at the FCP web-environment and to participate in the final awards for completion of the project [12].

VI. THE KNOWLEDGE CREATION PROCESS AS BRICOLAGE

Participants in the liminal space apply the instructions they have to the task in hand, and try to learn the routines as they go along. The use of the tool becomes shaped by the outcome, and the skills develop through use, because the intentional outcome is to develop new knowledge. The practice becomes one of "do-it-yourself", analogous to one in which items are taken "off the shelf" and used in whatever way the participant sees fit.

The French term for this is "bricolage" – whether for a do-it-yourself store, a builders' merchant or the act of constructing new knowledge and understanding in this way.

In "The Savage Mind" [5], Levi Strauss used the term "Bricolage" to describe the way in which the non-literate, non-technical mind of "primitive" man responds to the world around him, as someone who works with his hands and uses devious means compared to those of a craftsman, and who has nothing else at (his) disposal. Levi Strauss describes the bricoleur as adept at performing a large number of diverse tasks, with the rules of his game, always to make do with "whatever is at hand" [5]. Whereas an engineer works with concepts, Levi Strauss describes the bricoleur as working with signs, the very concrete objects with which meaning is constructed [5].

The process involves a "science of the concrete", which is carefully and precisely ordered, classified and structured by means of its own logic. The structures are "made up", and are ad-hoc responses to an environment. They establish homologies and analogies between the ordering of nature and that of society, and "explain" the world and make it able to be lived in. The bricoleur constructs the "messages" whereby "nature" and "culture" are caused to mirror each other. Levi Strauss saw bricolage as a way in which pre-

 ISBN: 978-1-61208-206-6

scientific societies construct a belief system which explained their world [5].

Papert [13] used the concept of bricolage in relation to the concept of "chunking" [14], a process in which knowledge is broken into "mind-size bites", which enables new knowledge and understanding to be constructed from it. His thesis was that the use of previously learned strategies could be used as a tool in concept formation.

Levi Strauss' explanation of bricolage and the bricoleur offers an insight that is, perhaps, applicable to Flatclassroom participants: "… a bricoleur is someone who works with his hands and uses devious means compared to those of a craftsman … (he) has nothing else at (his) disposal. … The bricoleur is adept at performing a large number of diverse tasks … the rules of his game are always to make do with 'whatever is at hand" [5].

The process, then, is one of working from the specific (the task that must be completed) to the general (learning from that experience to apply to future experiences). The signs by which they work are those of the Graphical User Interface, with its buttons, toolbars and the ability to undo errors. The "devious means" that they use utilise a range of Web 2.0 technologies, making do with "whatever is at hand" [5]. Their work gives an account of their lives in a world where allusion, reference and quotation seem the only possibility.

The synthesis must be that learning is seen as experiential, observational and a semiotic experience.

Web 2.0 applications and social software have significantly changed the way of using computers from consumption to creation. A series of studies including our Flatclassroom project have provided rich evidence of the ways young people are using technology and the Internet for socialising, communicating and for learning.

Within the Flatclassroom online learning environment, many web pages and wikis and blogs contributions bring together ideas, own images and videos or links and materials from other sources, almost like a remediation of the original source material. Using these, students create their own online identity through their own tastes and interests. In the same time, students enjoy being a part of an online team or community.

VII. LEARNING: INFORMAL OR FORMAL

Pachler and al. [8] suggest that the key defining aspect of informal learning is one of agency: that is who determines the learning goals. They view informal learning as a natural activity by a self-motivated learner. This could be in a group, without a tutor being aware of such activity; it could be either intentional or tacit learning, in response to some stimulus; it could be what they term "serendipitous", without the learner necessarily being aware of what is being learnt.

So, who determines the trajectory and outcomes of learning – the institution, or the learner? Should learning only be intentional, or is incidental learning equally valid? Formal learning provides the structure, signposts, and scaffolding for a beginning learner. Informal learning, on the other hand, builds on the foundation of existing knowledge, and a sense of context that provides the framework for understanding.

Some working definitions for formal, informal and non-formal learning have been provided by The European Commission on Education and Training [15]. The question of whether these are seen as a blueprint for further work, or as a way of recognising the needs and progress of the individual, rather than those of the organisation, is yet to be resolved. What is of further concern is that these definitions (and embedded assumptions) are predicated on both a utilitarian basis (recognised in the labour market and by society in general) and are restricted to adults.

"Learning that takes place in formal education and training systems is traditionally the most visible and recognised in the labour market and by society in general. In recent years, however, there has been a growing appreciation of the importance of learning in non-formal and informal settings. New approaches are needed to identify and validate these 'invisible' learning experiences" [15].

VIII. LIMINALITY

As the Flatclassroom participants have expanded and developed the range of technologies and affordances used in the project, so the concept of social constructivism has accommodated these and expanded into the liminal spaces that are no longer constrained by temporal or physical boundaries, and are therefore truly mobile.

The extension of social constructivism theory builds on evidence that the praxis of those participants in the liminal space of the Flatclassroom is one that constructs knowledge: "the working heuristic of discovery" [16]. They take for granted the constraints and difficulties within which they work. What they produce is a result of their discovery of the ways in which the information given, created and found, with the tools in their hands and the time available – all transmuted into their knowledge creation.

The existential reality of learning is very different from the functionalist expectations of learning yet - so much policy is predicated on limited functionalist outcomes.

In this context, many young people's transformational learning experiences outside school are now significantly different from the traditional routes practiced in school.

They build credible identities in social networking sites that are important to them, but their experience in this field rarely takes them into deeper learning stages. Is this perhaps the right time for teachers to consider the potential of Web 2.0 to create a simulating environment for informal learning through the new ways of obtaining, creating, sharing, and organising information, communicating and participating, and to take students' social networking into a more challenging collaborative learning realm?

 ISBN: 978-1-61208-206-6

The following Table I presents a comparison produced by HELIOS about e-learning 2000 (e-L 2000) and innovative e-learning 2010 (i-e-L 2010) projects [17]. Furthermore, to illustrate the Flatclassroom practices, we outlined Web 2.0 liminal spaces we used to support innovative e-learning (both collaborative and personalised learning) - the third column in Table I.

TABLE I. FROM e-LEARNING 2000 TO INNOVATIVE e-LEARNING 2010 [17] AND OWN ADAPTATION BASED ON FCP

e-L 2000	**i-e-L 2010**	**E-learning within Flatclassroom liminal spaces**
Distributes consolidated knowledge	Generates new knowledge	Building collaborative knowledge via class wiki and ning spaces, YouTube, Wikipedia, Flickr.
Is still e-teaching	Is owned by the learner	Personalised learning achieved via wiki spaces; sense of ownership of project outcomes.
Is delivered by a single provider/institution	Is the result of and a tool to support partnership	Collaborative learning as a result of email and online forum communications, blogs, ning, wikis).
Ignores the learner's context and previous achievements	Builds on the learner's contexts and previous achievements	Learning based on examples stored in archives of previous projects, tagging, linking, restoring.
Depresses the learner's creativity through transmissive logics	Stimulates the learner's creativity by enhancing the spontaneous and playful dimension of learning	Encouraged creativity via edutainment (FCP video storyboards, online presentations via Elluminate web-conferencing software).
Restricts the role of teachers and learning facilitators	Enriches the role of teachers and learning facilitators	Enhanced students' peer-to-peer feedback and teachers' facilitation role via email, discussion groups, and Elluminate video conferences
Focuses on technology and contents	Focuses on quality, processes and learning context	Enhanced life skills for communication, collaboration and global awareness (via wikis, ning, blogs).
Substitutes classroom sessions	Is embedded in organisational and social processes of transformation	Embedded Flatclassroom learning activities in English curriculum (facilitated by FCP web-spaces).
Privileges those who already learn	Reaches and motivates those who were not learning	Ubiquitous access to Flatclassroom environment, the accessibility, flexibility and ongoing support stimulate all learners.

IX. CONCLUSION AND FUTURE WORK

A. *21st Century Learning Themes*

There are five substantive themes that emerge from much of the work on 21st Century Skills. They are Collaboration, Creativity, Assessment, both of and for Learning, Knowledge Management (what we often understand as personal productivity), and the use and management of Personal Learning Networks. If these themes are to be fully realised (and deployed) by education they need to be contextualised [18], [19] & [20]. The Liminal Spaces for learning identified in this paper need to be incorporated in the building of spaces, the building of contexts and collaboration for learning.

B. *Building spaces for learning*

Create a 'community of learning' orientation to classroom, school and university cultures. This community approach should enhance links between learners, teachers, parents and the wider community. These liminal spaces for learning incorporate the spatial, the temporal, the social and the technological. Learners should be supported and involved in creating their own learning spaces: this is critical in contexts where social inequalities impact on the ability of learners to undertake homework. Our Flat Classroom Project case study highlighted how to build an awareness of globalisation, demographics, the capacity of technology, collaboration and personalisation into learning

 ISBN: 978-1-61208-206-6

contexts. These can expand learners' conceptual learning spaces.

C. *Building contexts for learning*

One vital element is the creation of quality learning time: the ways in which social inequalities constrain learning opportunities. Consideration must be given to the ways in which learning takes place – and the fact that repetitive exercises do not necessarily provide quality learning time or opportunities. Our Flatclassroom experience provides an example of how to redefine learning for a technology rich, diverse, 21st Century Global Environment. Teachers should be supported to learn about, and then generate expertise in, multiple pedagogies. We should also champion the use of multiple authentic measures of accountability for student learning.

D. *Collaborating for learning*

Incorporate a learner centred, knowledge-building conception of the learning process. Provide learners, teachers, schools and communities with opportunities to collaborate in the development of partnerships in the learning process. This can be within schools, localities, countries or internationally, and could be enhanced through online communities of practice [21]. The Flatclassroom school liminal spaces and project activities provide specific examples of how such collaboration could be achieved.

Traditional exams and testing regimes militate against collaboration, but current innovations in all fields are brought about by collaboration.

The 21st Century Learning Themes identify an appropriate way to frame this exploration of learning, and the three umbrella headings: the re-conceptualisation of the role of the teacher; the re-definition of the learning and assessment process and learning spaces and learning opportunities are, in reality, cross-integrated with the Collaboration, Creativity, Assessment, both of and for Learning, Knowledge Management (what we often understand as personal productivity), and the use and management of Personal Learning Networks [20].

We hope that by analysing our experience within the Flat Classroom Project in the context of using liminal web spaces for enhancing collaborative learning, we have enlightened the above themes.

ACKNOWLEDGMENT

Thanks to the English teacher Sarwat Siddiqui who organised and led a student group in the International Community School, London, in taking part in the global collaborative Flat Classroom Project.

REFERENCES

[1] Flat Classroom Project web-site: http://www.flatclassroomproject.net/about.html (Accessed 22/02/2012).

[2] T. Friedman – The World is Flat book, 3rd edition, Chapter 13, "If it's not happening it's because you're not doing it", pp. 501-503, 2011.

[3] J. Cuthell, C. Preston, L.Cych and T. Keuchel - iGatherings: From professional theory and practice to praxis in work based teaching and learning WLE Centre, Institute of Education, University of London, 2009, Available: http://www.wlecentre.ac.uk/cms/index.php?option=com_content&task=view&id=343&Itemid=85 (Accessed: 22/02/2012).

[4] J. Cuthell, L.Cych and C. Preston - Learning in Liminal Spaces, In Proc. Mobile learning: Crossing Boundaries in Convergent Environments, Bremen, pp 51-52, 2011, Available: http://www.virtuallearning.org.uk/ (Accessed: 22/02/2012).

[5] L. Strauss – The Savage Mind, Oxford, Oxford University Press, 1962, p.17.

[6] J.B. Williams and J. Jacobs – Exploring the use of blogs as learning spaces in the higher education sector‖, *AustralasianJournal of Educational Technology*, vol. 20 (2), pp. 232-247, 2004.

[7] K. Toneva – Using netbooks and Web 2.0 technologies to facilitate mobile learning, Proc. 10th World Conference on Mobile and Contextual Learning (MLearn 2011), Beijing Normal University Press, Beijing, China, 18-21 October, 2011, pp. 511-515

[8] N. Pachler, B. Bachmair and J. Cook – Mobile Learning: Structures, Agency, Practices, New York: Springer, 2009

[9] International Community School, London – "Liminal Space" on an E-safety project blog: http://ict4teachers.blogspot.com/2011/05/welcome-to-my-blog.html, (Accessed 22/02/2012).

[10] International Community School, London – "Liminal Space" on the Flatclassroom Ning: http://flatclassroomproject.ning.com/group/ics-london-dppz, (Accessed 22/02/2012).

[11] Flatclassroom web-site – Teachers' feedback: http://www.flatclassroomproject.net/testimonials.html, (Accessed 22/02/2012).

[12] Flat Classroom Project 2011-3 Awards: http://fcp11-3.flatclassroomproject.org/Awards, (Accessed 22/02/2012).

[13] S. Papert – Mindstorms Children, Computers and Powerful Ideas. Brighton, The Harvester Press, 1980.

[14] G.A. Miller – The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity for Processing Information. Psychological Review, 63, 81-97, 1956.

[15] European Commission Education and Training – Lifelong Learning Policy, Validation of non-formal and informal learning. http://ec.europa.eu/education/lifelong-learning-policy/doc52_en.htm, (Accessed: 22/02/2012).

[16] J. Bruner – Beyond the information given. London, Allen & Unwin, 1974.

[17] HELIOS – From e-Learning 2000 to Innovative e-Learning 2010, 2007, Available at:

 ISBN: 978-1-61208-206-6

http://www.menon.org/publications/HELIOS%20thematic%20report-%20Access.pdf (Accessed: 22/02/2012).
[18] ISTE - Maximizing the Impact: The pivotal role of technology in a 21st century education system, 2007, available at: Partnership for 21st Century Skills Web site: http://www.setda.org/web/guest/maximizingimpactreport (Accessed: 23/02/2012).
[19] B. Trilling - Toward Learning Societies and the Global Challenges for Learning-With-ICT, 2005, Available at: Tech & Learning Web site: http://news.techlearning.com/techlearning/pdf/events/techforum/ny05/Toward_Learning_Societies.pdf (Accessed at 23/02/2012).
[20] J. Cuthell - Thinking Things Through - Collaborative Online Professional Development. In: Lindberg, J. O & Olofsson, A. D. Online Learning Communities and Teacher Professional Development: Methods for Improved Education Delivery. Hershey, IGI Global, 2009
[21] K. Toneva, K. Doncaster and D. Bravenboer – Using Virtual Spaces for Learning Communities to Facilitate Project Development and Collaborative Learning, Proc. in Press The Fourth International Conference on Mobile, Hybrid, and On-line Learning eL&mL 2012, January 30 - February 4, 2012 - Valencia, Spain, Programme available at: http://www.iaria.org/conferences2012/ProgrameLmL12.html (Accessed: 22/02/2012).

 ISBN: 978-1-61208-206-6

Collaborative Preference Elicitation Based on Dynamic Peer Recommendations

Sourav Saha
Fellow Program and Research
Indian Institute of Management Calcutta
Joka, Kolkata, India
souravs08@email.iimcal.ac.in

Ambuj Mahanti
Department of Management Information Systems
Indian Institute of Management Calcutta
Joka, Kolkata, India
am@iimcal.ac.in

***Abstract* — Recommender Systems, in order to recommend correctly, demand huge information related to the past transactions and behavior of the user. In the events, where the data is inconsistent or sparse, the systems show a decline in its predictions or recommendations. Here we propose a new preference elicitation system that is based on preference from closed user group. The implicit behavior of the user is tracked when the user picks up an item. The explicit behavior is tracked by the user-ratings for the given item. The user-preference is computed on a memory-based model taking in account the implicit behavior. The peers are identified based on user-similarity on the explicit-preference indicator. The peer preferences are used on the test-dataset to find the percentage of preference that could be matched. The algorithm has been tested on MovieLens dataset and has given competitive results over the comparable techniques like sliding window method or collaborative filtering methods in isolation.**

Keywords - Memory-based Recommender; Changing Preference; Movie Lens Mining.

I. INTRODUCTION

Researches on Recommender Systems have focused on two principal aspects, Rating Prediction and Ranking. In case of Rating Prediction, the user behavior is explicit, meaning that whatever the user feels about a particular item, it is represented in a predefined-scale. Generally, higher rating indicates higher preference. Such explicit ratings have been successfully implemented by many e-commerce portals like Amazon. Such ratings are collated, compared with similar users and then they are aggregated based on likelihoods. The most popular method for getting such likelihood is collaborative filtering [26, 27, 28]. In case of collaborative filtering the data from several users are compared and a set of users, similar to the given user is found out. Once a set of similar user has been obtained, the research focus shifts to the ranking problem whereby the users are ranked according to some pre-defined metrics. The procedure discussed requires accurate data input from the users. The problem with explicit ratings is that human by nature is lazy and they rate only a small fraction of items which they have purchased. Another problem with explicit rating is the validity [15]. When the rating is immediate, sometimes it might not capture the long-term user gratification with a given item. An item just after being procured might immediately fetch a premium rating but only when the performance degrades after sometime, the perception changes. The user, in most cases, does not return to re-rate such items or the functionality is missing altogether. Hence, the two major issues that the researcher has to deal with the explicit ratings are the rating validity and the data sparsity.

The implicit rating on the other hand has been successfully employed in the web-mining space, where the higher returns or clicks on an item indicate the user propensity for the given item-set. One major challenge here is identifying the right item that suits the user taste. During an implicit rating case, the data tends to be noisy and sometimes for a user with habitual browsing behavior, it becomes difficult to find the set that closely defines the user preference. This calls for a method that would try to aggregate or filter the user preference first, categorize the aggregation and based on the relative occurrences, put them in various groups. Once such segregation has been done, the user ratings if available might be used to fine-tune such categories or groups.

Moreover, the user preference changes with time and the occurrence of such shift is difficult to identify. In a genuine case, the user develops a new interest that finds its own place in user preference patterns. Sometimes such new interest erodes the old-interests slowly with time. In another kind of case, due to over-specialization, the user gets bored with his earlier likings. The earlier preferences have become permanent in nature but the user might choose to explore newer preferences. During such a case, the preference takes a sharp bend and explores through several interest categories before stabilizing on one or a few interests that the user has found suitable. Thus, the same user when asked to rate identical items at different time-frame behaves differently

In this particular paper, we will discuss a heuristically guided algorithm that creates the user preference dynamically based on recency pattern of the implicit ratings. The explicit user ratings have been used to determine the user taste based on similar-likelihood and rating patterns of interests. The algorithm has been tested on the MovieLens dataset for 1-million ratings. Results are promising against comparable algorithms like Sliding Window [25].

The paper has been organized as follows. Section I provides an introduction to the recommender systems. The section briefly discusses the necessity of our work. Section II highlights the motivation for our work. Section III talks about some existing works in this particular domain and outlines our domain of work. In Section IV, we have

 ISBN: 978-1-61208-206-6

introduced the proposed model and the algorithm that has been designed for this process. In Section V, we validate this model using a popular dataset, the Movielens-1M dataset. Section VI discusses the results and future scope of work. Section VII concludes the paper with future direction of work.

II. MOTIVATIONS

Recommender Systems make heavy use of Machine Learning [29, 30], and, as a result, the computation is very expensive in terms of both computation resource as well as time. Due to such huge data, small pieces of information or recent changes are initially ignored. This makes the system non-adaptive to sudden trends. From the literature, we have found instance that refers to the use of complicated techniques like genetic algorithm [21] in machine learning and its widespread application. We have also had cases where swarm intelligence like that of Ant-Colony Optimization (ACO) being used for the above purpose [22]. While these algorithms have been proved effective in some cases, there has been limited effort to use the human-memory model to find out the preference of human subjects. Our objective has been to construct a model that is computationally not very intensive, easy to understand and can mimic human behavior. The proposed human-memory model is borrowed from clinical research [23, 24] and unlike most other methods can work in isolation. To model the friend suggestions, popular techniques like collaborative filtering have been used to find a similar user set based on the ratings pattern. The friend's preferences are used as a support for the user decision in the event that the user needs decision for unexplored items. The contribution of the work is to use the biological framework of human memory and blend the same with the social framework of friend selection by the means of likelihood to identify nearest neighbors.

.

III. EXISTING WORKS

Recommender Systems have gained quite prominence due to the increasing popularity of e-commerce. Research in this arena has attracted attention of academia as well as the industry [1]. When it comes to recommender system, the problem that people likes to tackle are mainly the prediction problems.

Prediction problems as outlined earlier require huge temporal data in order to make meaningful predictions. The popular methods to deal with temporal data are the ones that apply time-weighted function to the data points. This further amplifies the issues with data sparsity since missing data-points tend to insert negative-bias in the system.

Most of the previous works [8, 9, 10] are mainly different variations of assigning weights to data. The basic approach used is to assign a greater weight to new data, and discount old data so as to decay or remove the effect of old data. In [8] decreasing weights are assigned to old data, which implies that the old-preference even if currently active gains a lesser importance. In [9], Massa and Avesani have introduced the concept of item-similarity when considering time-based weights. They have added the new weights to handle the issue of reoccurrence of user interests. In [10], Massa and Avesani propose using weights for items based on expected future preference of the users.

Most of the earlier works have formulated the problem as a prediction accuracy problem. In [3], Saha et al. have proposed a novel method to capture the interest-shift has been computed for individual based on their temporal transaction history. The method decays the older preference only when the recurrence pattern stops. We have simplified the model reducing the memory-components from five holders to three holders akin to the human memory [23] and adding the social component as support from the neighbors. Individual preference only holds limited information. The potential preference space might cover additional features that are equally likely to recur when exposed to the similar user. Mining preference pattern of a closed group [18] helps uncover additional knowledge for items unseen by the user.

IV. PROPOSED MODEL

In the proposed model, we are interested to establish a relationship between the user and their closed group. We would like to show that when friends are selected properly, they can help increase the accuracy of predicting the user preferences.

While running the implicit preference generation process, the presence of an item / item-set in a user transaction indicates the user affinity towards the given category of item(s). Such implicit indicator is then mapped to the user transaction. The feature-set from the item in the given transaction is then derived and finally the feature(s) are put in the users' preference basket. Both the aspects of time and preference are taken into account during such categorization process. The process finally ends with the generation of the user preference-basket that has categorization of the user's permanent as well as the changing tastes. The implicit preference mining is a little deviation from the methods suggested in [3]. We have considered 3 categories of user memory, based on human-memory models as proposed by Atkinson and Shiffrin [23], namely sensory memory, short-term memory and long-term memory.

In the proposed algorithm for implicit preference generation, there are mainly three entities; the User Memory, the transactions per user and the preference signature in each of the transactions. The features and uses of the different memory levels are discussed as below:

Sensory Memory: This memory is very short-lived for the human and can be thought as the touch and go memory. Sensory memory doesn't even register with our conscious mind. Only when the sensory memory is nurtured, we start noticing it and then it registers in our conscious brain. In our algorithm, first time preferences are initially stored in the sensory memory. If such preference doesn't repeat, it quickly gets wiped out leaving any traces.

Short Term Memory: Unlike the sensory memory, short-term memory do gets registered in our conscious mind. The short-term memory is like a temporary working register. We use the short-term memory for a specific purpose and don't care to carry that for future use. For example, we won't have any problem remembering our last visit to the

 ISBN: 978-1-61208-206-6

supermarket. With little difficulty, we might even recall the amount spent in the last trip. However unless someone is extremely meticulous or gifted with great memory, the quantity and the amount paid per item would be difficult to remember. This memory remained with us during the last visit to the store and got into the oblivion zone since it was not necessary. The similar model has been used for the short-term memory register in our algorithm. Above a certain threshold, the sensory-memory becomes short-term memory. Since the memory has to be retained for some-time, we allow some grace-period when the penalty-function remains dormant. If such preference doesn't get repeated during the grace-period the penalization functions starts and quickly erodes it off. This feature has been considered in the algorithm allowing differential grace-window for preferences that lie at different spectrum of the memory model.

Long-Term Memory: This might be thought of as a permanent memory, which remains with the user for a considerable time. The elements in this memory repeats regularly hence making it permanent. In the proposed algorithm, the long-term memory has been allowed a greater grace-window. Once within the long-term memory, the process of erosion is also much slower. Thus once an item gets into the long-term zone, only few recurrence incidents are required to retain the status of such memory. Of course even with such leeway, long-term memory can also fade and even goes into oblivion. This also has been taken care of by the drifting model. Once a preference at the long-term memory stops recurring, the penalty starts kicking in. The penalty gets intensely steeper and finally such preference gets removed from the memory altogether.

The proposed implicit-preference algorithm outlined below (Algorithm-1) is sensitive to the relative occurrence of the transactions. Depending on the sequence, the user-preference is affected. This is totally in line with the assumptions that the more recent transactions that occur repeatedly are more prone to remain in the working memory compared to old ones that occur just once in awhile.

The algorithm starts with an empty memory per user. The non-performance penalty is $q(M_j)$ and the waiting window is $w(M_j)$. For every user, each transaction is decomposed to individual items. When the memory is initially empty, the item(s) are placed in the sensory memory. With more reinforcement of the same item in future transactions, the item moves from the sensory memory to the short-term memory and likewise with further repetitions, it finds place in the long-term memory. This is akin to the working of human memory where continuous reinforcement or trainings makes a memory permanent. In the event, when the item(s) stops recurring, a penalty is applied depending on the stage of the memory, the item is currently placed, being higher for volatile memories and lower for permanent memory. The waiting-window/grace period varies once again depending on the state of the item, being higher for the permanent and lower for sensory.

Algorithm - 1

```
let U denote a set of users
while (all_user_not_processed)
  foreach user Uq do
    initialize user_memory();
    repeat
      foreach item I in user transaction
      M ← compute_memory_matrix (Uq, I);
    until no_more_transactions
  goto next_user()

procedure compute_memory_matrix(Uq, I)
  decompose I into preference indicators dj
  If (dj in Mj)
    then Mj(dj) ← Mj(dj) + 1
    If Mj ≠ MLong-Term and Mj(dj) >= threshold(Mk)
      Mk(dk) ← Mj(dj) ∀ threshold(k) > threshold(j)
      delete dj from Mj
      update memory
  else
    Insert dj in Msensory
    set Msensory(dj) ← 1
    set non_occurence(dj) = 0
  Do process_penalty(I)
end-procedure

procedure process_penalty(I)
  For all dj not in I
    If activation_function h(Mj, wait(dj)) = 1
      then Mj(dj) ← Mj(dj) - Penalty(Mj)
     if Mj(dj) < threshold(Mi)
       if Mj = MSensory
        then delete dj from MSensory
       else
         Mi(di) ← Mj(dj) ∀ threshold(i) < threshold(j)
         delete dj from Mj
    else wait(dj) ← wait(dj) + 1
end-procedure
```

After the implicit-preference building process is complete, the preference footprints are analyzed for every user for the presence of the explicit indicators in the form of user-ratings. The common set of transactions is selected for every pair of users. Unlike the Algorithm 1, the order of the data doesn't matter when the correlation is computed from the explicit ratings.

The friend selection algorithm is a computing-intensive task. It can be done over the entire set of items common to the users and can be performed offline as well if the matching transactions are known beforehand. In our work, we have generated the preference-lists from the training dataset. Once such preference generation is completed, the matching transactions are used to find the friends of the user. We have considered the Pearson-Correlation coefficient [31, 32] with the ratings data to get user-user similarity. The Pearson-Correlation coefficient is computed for every user-pair and stored in the database for use during the testing process. We have run the testing process, varying the number of friends and computed the results.

The formula for the Pearson-Correlation coefficient (r) is as follows:

$$r = \frac{\frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

where,

X_i = rating of user X for an item i

Y_i = rating of user Y for an item i

$\bar{X}$ = average rating of user X for common items

$\bar{Y}$ = average rating of user Y for common items

n = items rated in common

The Pearson-correlations computation process is resistant to grade-inflation problem. Thus even if the two users rate items differently, the score would be inline as long as their rating pattern for the corresponding interest matches. The value of the Correlation-index (r) lies between -1 and +1. When the value is +1 it means that the two-users are perfectly correlated. When the value is -1, it means that the users tastes are opposite in nature. When the value of correlation is 0, it means that the two users are not at all correlated.

V. MODEL VALIDATION

To validate our proposed model, we have run the process on the Movielens data with 1 Millions ratings. The data has 1,000,209 ratings from 6,040 users on about 3900 movies and has been recorded from years 2000 onwards. The data has been arranged chronologically. We have used the ratings data and the movie-definitions file.

The following attributes were selected before our model building process:

- USER_ID (a unique user identifier)
- MOVIE_ID (a unique movie identifier)
- MOVIE_GENRE (genre for the given movie)
- USER_RATING (rating on a scale of 1 to 5)
- TIMESTAMP

We have had followed a 80:20 partition scheme on the data, where 80% data is used for training and 20% for validation. For the convenience of model-building, the first 20% data has been exclusively reserved for training purpose. A quarter of the rest 80% data is picked at random for cross-validation purpose using a Monte-Carlo method – the remaining gets added to the training-set. We have deliberately not resorted to a k-fold validation since each of the k-parts needs to be mutually exclusive. In our case, each subsequent transaction is dependent on the previous one making a difficult proposition for aforesaid technique.

The MOVIE_GENRE has been assumed to be a proxy for the user preference. Users indeed have propensity to movies of various genres. For example some users might find Action movies entertaining while some would prefer Comedy. In total the movies contained a concoction of 18 genres, namely: Action, Adventure, Animation, Children's, Comedy, Crime, Documentary, Drama, Fantasy, Film-Noir, Horror, Musical, Mystery, Romance, Sci-Fi, Thriller, War and Western. Each movie had at-least one genre with the maximum number of genre for a particular being as high as six. A majority of the movies were composed of one or two genres.

Figure-1 gives an idea of the working of the algorithm.

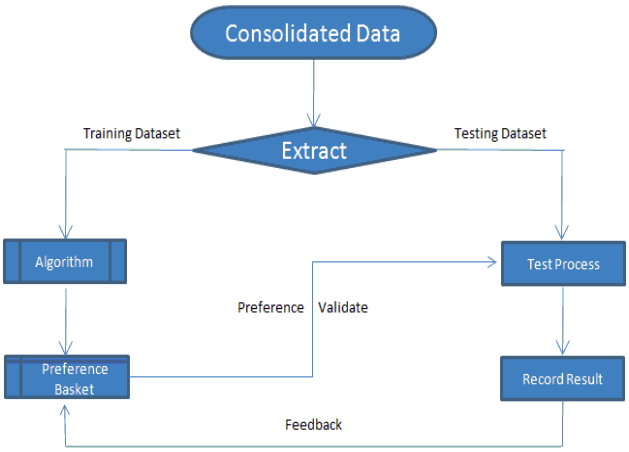


FIG-1: MODEL BASED ON ALGORITHM 1

A. Environment Setup

The window size before decay starts and the non-performance penalty is context dependent. We have found the median and the mode values for the "mean transactions

to repeat". For the Movielens-1M dataset, the median value came out as 3 and the mode was 1. Based on the findings, the window size is constructed as below. Since every transaction adds 1 to the strength of the preference, the quartile values have been fixed as the non-performance penalty depending on the preference category.

Non-performance penalty $q(M_j)$ for different categories j

$$p(Mj) = \begin{Bmatrix} 0.25 : j \in [\text{"}Long-term\text{"}] \\ 0.50 : j \in [\text{"}Short-term\text{"}] \\ 0.75 : j \in [\text{"}Sensory\text{"}] \end{Bmatrix}$$

The wait-window $w(M_j)$ for different categories j

$$w(Mj) = \begin{Bmatrix} 4 : j \in [\text{"}Long-Term\text{"}] \\ 3 : j \in [\text{"}Short-Term\text{"}] \\ 2 : j \in [\text{"}Sensory\text{"}] \end{Bmatrix}$$

The activation-function for penalty, $h(j, w)$ assumes binary values for a given delay " w " for memory type " j "

Thus h ("Sensory", 2) = 1 while h ("Long-Term", 2) = 0.

B. Algorithm Workings

During the testing-phase, the Algorithm-1 runs on the user's transactions and separates the genres. Once the genre gets separated, the algorithm determines that whether such genre should be considered for Sensory, Short-Term or Long-Term memory. Once the algorithm completes, we get a preference-basket per user having few to none entries per memory category. We had run the explicit process in parallel to compute the user-user similarity via the Pearson Correlation Coefficient. For a given user, a friend is defined by the top few users that have the highest correlation value.

The friend generation process in two-parts. In the first case, we consider the explicit user ratings and then determine the friends from the explicit-ratings applying Pearson on it. Next we use the user-memories that have been obtained as a result of the algorithm. Each of the preference components in the memory has a score. Dividing the score by the number of observations for each component, we get strength of the memory component or the "MemStrength" matrix. Pearson correlation is applied on the matrix per preference value. This result is also stored.

C. Algorithm Testing

We have tested the algorithm individually considering the best five friends of the users and seeing that how their memory preferences can support the user preferences. We have not considered the sensory memory but only the short-term and the long-term memory is considered while looking for a match. For the testing-purpose, we have taken the sensitivity expressed in percentage, defined as:

$$sensitivity = \frac{true\ positive}{true\ positive + false\ negative}$$

Since a movie might comprise multiple genres and the user might only be interested in one or few genres from the set, hence we have taken a majority matching approach. If the algorithm can match the majority of the genres in a given movie in the test set, then we consider the case as a "true positive" case.

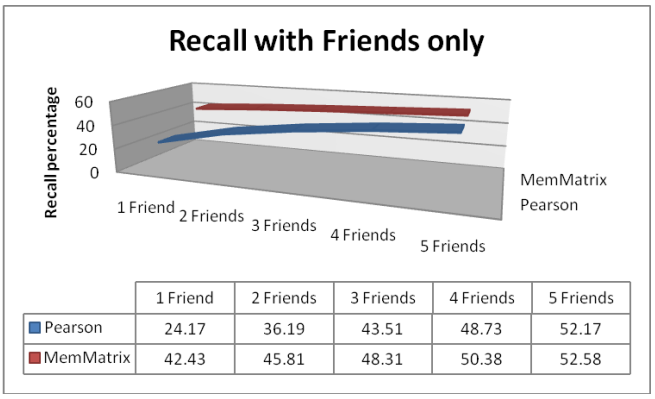
VI. Results and Discussions

The algorithm could successfully predict 73.244% of the total genres present in the test-set taking one user at a time.

Using a majority match in the *Algorithm Testing* part of Section V, the algorithm could properly account for the genre composition in 86.236% of the test dataset.

The friend computation has been outlined in *Algorithm Working* in Section V. Taking assistance from five "Pearson Friends" using explicit ratings, the genre composition prediction increased to 93.30%. Using the same number of friends from our "MemStrength" matrix, the algorithm could successfully account for 94.04% of the genre composition in the test dataset.

We have also computed a scenario, where the friend's-preference is taken as a proxy of the user's preference. The sensitivity or the recall result is shown below:



	1 Friend	2 Friends	3 Friends	4 Friends	5 Friends
Pearson	24.17	36.19	43.51	48.73	52.17
MemMatrix	42.43	45.81	48.31	50.38	52.58

FIG-2: MODEL BASED ON ALGORITHM 1

The results show that the "MemMatrix"- based friend computation starts with a high-recall or sensitivity value of 42.43% compared to 24.17% when the assistance of only one friend is sought for. The performance of the two methods show that the Pearson based friend process moves at a higher rate compared to the "MemMatrix" based friends and performances are nearly equal with 5 friends. The slow

 ISBN: 978-1-61208-206-6

movement of the "MemMatrix" is owing to the fact that the process selects users with very similar tastes so dispersion is relatively lesser. The test-process accounts for 20% of the dataset so during the latter part of the data, some new memories might be created as well as destroyed. Since the friend generation process is a one-time activity, such drifts could have resulted in a change in the friend composition as well. This has not been captured in the current work. As discussed earlier, the process of friend creation is a very computation intensive process so it would be a good area to look into for future works.

We have considered a step-descent function for memory decay process. The time-decay functions have performed poorly as discussed during the literature survey part. However, there are other decay functions like the Gaussian-model. It would be interesting to create hybrid decay models and test the algorithm.

To benchmark this work, we compared the performance with a sliding window technique. In a sliding window technique, the items from the last few transactions are considered for all practical purposes. The name is indicative of the fact that the preference window slides by one-unit at every new transaction. For our model comparison, we have used the last n transactions as the proxy of the user preference. In this example, we consider all the unique items that appear in the last 5 transactions as the user preference set. The sensitivity results are as follows:

TABLE-1: SENSITIVITY/RECALL WITH A SLIDING WINDOW SIZE 5

Size of the Window	Recall Values (rounded)
3	54%
4	61%
5	66%

The result above indicates that in the present problem scenario, our proposed algorithm has devised superior results. This can be justified by the fact that our algorithm holds both the short-term and the long-term preferences, computed through a stepwise non-volatile mechanism contrary to the sliding-window technique described above that only takes into account the preferences in the most recent transactions. This forsakes the long-term preferences of the user for the short-term ones.

VII. CONCLUSION AND FUTURE WORK

We have introduced a human-memory based technique to find the user preferences taking into account the implicit behavior and transaction atomicity. The process creates dynamic user memory matrix that can be updated based on simple rules. When the recommendation needs to be made under dynamic situation using limited memory and time-resources, our experiment shows that the proposed biologically inspired heuristic is expected to perform better than the comparable existing techniques. Members in isolation can be observed. The algorithm has been tested on a huge dataset and result motivates further research in the direction. This algorithm works on the principle of memory models and thereby opens up the scope for application to allied domains of machine learning and artificial intelligence. We would like to extend this work in the domains of travel, more specifically weekend travels whereby user's travel interest could be categorized and recommendations can be suggested. We would be most interested in using the model to control viewer censorship in televisions whereby contents to the young audience would be suggested as per preference set by the parents or the guardians. With the smart-televisions finding their ways in home, we hope to get enough data to validate our model for television censorship.

ACKNOWLEDGMENT

The authors would like to thank Prof. Sanjog Ray of IIM Indore for his valued feedback during the ideation and evaluation of this particular work. Special thanks for Prof. Indranil Bose and Prof. Asim Pal for valuable inputs to the memory model.

REFERENCES

[1] P. Massa and P. Avesani : "Trust-aware collaborative filtering for recommender systems". In: Proceedings of the Federated Int. Conference On The Move to Meaningful Internet, (2004)

[2] J. Herlocker, J. Konstan, A. Borchers and J. Riedl : "An Algorithm Framework for Performing Collaborative Filtering". In: Proceedings of SIGIR, ACM, 1999, pp. 77-87.

[3] S. Saha, S. Majumder, S. Ray, A. and Mahanti : "Categorizing User Interests in Recommender Systems". In: New York, 2010, pp. 282-291.

[4] J. Donaldson : "A hybrid social-acoustic recommendation system for popular music". In: Proceedings of the 2007 ACM conference on Recommender systems, 2007, pp. 187–190.

[5] P. Viappiani, P. Pu, and B. Faltings : "Conversational recommenders with adaptive suggestions". In: Proceedings of the 2007 ACM conference on Recommender systems, 2007, pp. 89–96.

[6] A. Z. Broder : "Computational advertising and recommender systems". In: Proceedings of the 2008 ACM conference on Recommender systems, 2008, pp. 1–2.

[7] M. Kagie, M. van Wezel, and P. J. F. Groenen : "Choosing attribute weights for item dissimilarity using clikstream data with an application to a product catalog map". In: Proceedings of the 2008 ACM conference on Recommender systems, 2008, pp. 195–202.

[8] P. Massa and P. Avesani : "Trust-aware recommender systems". In: Proceedings of the 2007 ACM conference on Recommender systems, Minneapolis, 2007.

[9] P. Massa and P. Avesani : "Trust-aware Bootstrapping of Recommender Systems". In: Proceeedings of ECAI Workshop on Recommender Systems, Italy, 2006.

[10] P. Massa and P. Avesani : "Trust metrics on controversial users: balancing between tyranny of the majority and echo chambers". In: International Journal on Semantic Web and Information Systems.

[11] B. Mobasher, R. Burke, R. Bhaumik and C. Williams : "Towards Trustworthy Recommender Systems: An Analysis of Attack Models and Algorithm Robustness". In: ACM Transactions on Internet Technology, 2007, pp. 23-38.

[12] A. Rashid, G. Karypis, and J. Riedl : "Learning Preferences of New Users in Recommender Systems: An Information Theoretic Approach". In: SIGKDD Explorations, 2008, pp. 90-100.

 ISBN: 978-1-61208-206-6

[13] B. Sarwar, G. Karypis, J. Konstan, and J. Riedl : “Item-based Collaborative Filtering of Recommendation Algorithms”. In: Proceedings of the 10th International WWW Conference, Hong Kong, 2001.

[14] S. Berkovsky, T. Kuflik, and F. Ricci : “Distributed collaborative filtering with domain specialization”. In: Proceedings of the 2007 ACM conference on Recommender systems, 2007, pp.33–40.

[15] O. C. Santos : “A recommender system to provide adaptive and inclusive standard-based support along the eLearning life cycle”. In: Proceedings of the 2008 ACM conference on Recommender systems, 2008, pp. 319–322.

[16] X. Amatriain, J. Pujol, N. Tintarev, and N. Oliver : “Rate it again: increasing recommendation accuracy by user re-rating. In: Proceedings of the third ACM conference on Recommender systems, no. 4, 2009, pp. 173–180.

[17] F. P. Lousame and E. Sánchez : “View-based recommender systems”. In: Proceedings of the third ACM conference on Recommender systems, 2009, pp. 389–392.

[18] B. M. Marlin and R. S. Zemel : “Collaborative prediction and ranking with non-random missing data”. In: Proceedings of the third ACM conference on Recommender systems, 2009, pp. 5–12.

[19] P. Symeonidis, A. Nanopoulos, and Y. Manolopoulos : “MoviExplain: a recommender system with explanations”. In: Proceedings of the third ACM conference on Recommender systems, 2009, pp. 317–320.

[20] N. Kawamae, H. Sakano, and T. Yamada : “Personalized recommendation based on the personal innovator degree”. In: Proceedings of the third ACM conference on Recommender systems, 2009, pp. 329–332.

[21] H. S. Lopes, M. S. Coutinho and W.C. Lima : “An evolutionary approach to simulate cognitive feedback learning in Medical Domain”. In: E. Sanches, T. Shibata and L. A. Zadeh(eds.) Genetic Algorithm and Fuzzy Logic Systems: Soft Computing Perspectives, Singapore:Word Scientific, 1997,pp. 193-207.

[22] M. Dorigo, G. Di Caro and L. M. Gambardella : “Ant algorithms for discrete optimization”. In: Artificial Life, 5(2), 1999, pp.137-172.

[23] R. C. Atkinson and R. M. Shiffrin : "Chapter: Human memory: A proposed system and its control processes". In : K. W. Spence and J. T. Spence, The psychology of learning and motivation (Volume 2). New York: Academic Press, 1968, pp. 89–195.

[24] U. Fayyad, G. Piatetsky-Shapiro, P. Smyth and R. Uthurusamy : Advances in knowledge discovery and data mining. Menlo Park, CA: AAAI Press/ The MIT Press, 1996

[25] Chang-Hung Lee, Cheng-Ru Lin, and Ming-Syan Chen : “Sliding-window filtering: an efficient algorithm for incremental mining”. In: Proceedings of the tenth international conference on Information and knowledge management (CIKM '01), Henrique Paques, Ling Liu, and David Grossman (Eds.). ACM, New York, NY, USA, pp. 263-270.

[26] John S. Breese, David Heckerman, and Carl Kadie : “Empirical analysis of predictive algorithms for collaborative filtering”. In: Proceedings of the Fourteenth conference on Uncertainty in artificial intelligence (UAI'98), Gregory F. Cooper and Serafín Moral (Eds.). Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 1998, pp. 43-52.

[27] Jonathan L. Herlocker, Joseph A. Konstan, Al Borchers, and John Riedl : “An algorithmic framework for performing collaborative filtering”. In: Proceedings of the 22nd annual international ACM SIGIR conference on Research and development in information retrieval (SIGIR '99). ACM, New York, NY, USA, 1999, pp. 230-237.

[28] Jonathan L. Herlocker, Joseph A. Konstan, Loren G. Terveen, and John T. Riedl : “Evaluating collaborative filtering recommender systems”. In: ACM Trans. Inf. Syst. 22, 1 (January 2004), pp. 5-53.

[29] Raymond J. Mooney and Loriene Roy : “Content-based book recommending using learning for text categorization”. In: Proceedings of the fifth ACM conference on Digital libraries (DL '00). ACM, New York, NY, USA, 2000, pp. 195-204.

[30] Geoffrey I Webb, Michael J Pazzani and Daniel Billsus : "Machine Learning for User Modeling". In: User Modeling and User-Adapted Interaction, Springer Netherlands, vol 11, issue 1, 2001, pp. 19-29

[31] Grace A. Falciglia and Philippa A. Norton : “Evidence for a genetic influence on preference for some foods”. In: Journal of the American Dietetic Association, volume 94, issue 2, February 1994, pp. 154-158

[32] Tong Queue Lee, Young Park, Yong-Tae Park, A time-based approach to effective recommender systems using implicit feedback, Expert Systems with Applications, Volume 34, Issue 4, May 2008, pp. 3055-3062.

 ISBN: 978-1-61208-206-6

Measuring the Efficiency of Digital Communities: A Case Study

Farid Shirazi
f2shiraz@ryerson.ca
Ted Rogers School of Information Technology Management
Ryerson University, Toronto, Canada

***Abstract*— A new type of citizen participation has recently emerged in the Islamic Middle East countries through discourse on social media Websites, which opened up opportunities for citizens' participation in socio-political movements. Despite Internet restrictions in the form of heavy imposed state filtering and censorship, the Internet and its various applications provide effective communication channels for acquiring free information and disseminating thoughts, ideas, opinions, reflections and information sharing about socio-cultural, political, environmental and economic matters. The results of this empirical study show that there is a linkage between information usage and citizens' organized social actions, in the form of waves of street demonstrations, as we have seen across the region, as citizens demand a more open society, freedom and democracy. By applying the theory of new media communication, this study has found that Information and Communication Technology (ICT) has not only played an important role in building digital communities across the region, but also citizens' who use effectively and efficiently ICT communication channels are more likely to participate in political discourse and mobilization.**

Keywords - Social Media; ICT; Web 2.0; Information Use; Public Discourse; Digital Community; Data Envelopment Analysis.

I. INTRODUCTION

Information and communication technologies (ICTs) are viewed by many scholars as an environment for promoting freedom of expression, social inclusion [1, 2], and as a catalyst in elevating public discourse, political participation and mobilization [3, 4, 5, 6]. In this context ICTs have created a new powerful social actor called "digital citizen" or "e-citizen" [7, 8, 9]. Other scholars view ICTs as a source of emancipation [10] in which citizens are involved in communication discourse with the aim of improving human lives and creating a more just and fair society [11]. The increased popularity of the Internet has not only resulted in increased citizens' participation in public discourse, but also enabled them to request for more transparency and accountability [12, 13] from public servants, elective representatives and government officials. In other words citizens are able to actively participate in dialogues with democratic actors by raising concerns regarding local, national and global issues.

In non-democratic countries, however, the role of ICTs in communication discourse is a more complex process than those of free nations. On the one hand, ICTs have provided citizens the opportunity to access free information, learn more about the world outside of their home countries, (otherwise not available in the official print and broadcasting); on the other hand, these ICT communication channels are heavily monitored and censored by the elites in power. Stahl [11] points out that in many developing countries, ICT may not only be able to address numerous social issues, but more importantly, it should be viewed as "a solution to a range of social ills" ([11], p.162). In this context the overall aim of ICT is emancipating citizens with the ultimate goal of improving society. ICT through its various applications such as the Internet, TV and radio broadcastings, mobile SMS and MMS messages, e-mail, chat and so on, enabled people around the world to exchange political, social, cultural, science, history, literature and in short information in a borderless format and in shortest possible time. The Internet, for example, made it possible for millions of bloggers and users, in social networking sites, such as Twitter and Facebook, around the world, to create their own version of news or of cultural agencies. Youtube created a magnificent collection of video clips ranging from political, social, cultural, news and entertainment posted by people around the globe, a phenomenon that could not be predicted a few decades ago.

However, these ICTs are subject to heavy monitoring and filtering arrangements. According to various reports published by independent institutes such as Freedom House, Reporters Without Borders (RWB) and OpenNet Initiative (ONI), ICT censorship and content filtering is a common practice in countries controlled by authoritarian governments (see [14] for more details).

By using the theory of new media communication, the aim of this study is to investigate the intensity of ICT information usage in the Middle East to better understand the communication discourse in the region and their mobilization impacts on recent public unrests.

The rest of paper is organized as follows: Section II presents the theoretical basis of the concepts new media communication that we are using in our study; Section III investigates the efficiency of ICT usage in the Middle East; Section IV presents the Data Envelopment Analysis (DEA) of archival data, Section V discusses the findings of empirical results, and finally Section VI concludes the paper.

 ISBN: 978-1-61208-206-6

II. THE THEORY OF NEW MEDIA COMMUNICATION

Drawing on Manual Castelles' [15] work *The rise of the network society*, it is argued that the new media has shaped today's social organizations and institutes to a large extent. This study applies the theory of new media communication [16, 17] to investigate the impact of ICTs on communication discourse within in the context of the Middle Eastern countries and particularly in Iran.

A modern networked society consists of organizations, individuals and groups in which they engage in communication discourse by the means of ICTs. The importance of the new technology is rooted in its ability to accelerate information dissemination and social interaction among individuals and groups [18] in a global search for fresh ideas and opportunities. ICT tools and services such as the Internet and mobile cell phones have created a new form of media called *mass self-communication* [16], in which the traditional one-way, one-to-many media structures (e.g., print and broadcast agencies) have transformed into a new form of communication which are in nature pluralistic, two-way and many-to-many communication. There is ample evidence that citizens use the new media to effectively and efficiently participate in communication discourse and political mobilization by challenging the dominant power.

Within the context of democratic institutes, Lievrouw [17] defines the pluralistic nature of new media in two broad categories or domains: an *institutional aspect* and a *personal/relational aspect*. While the institutional aspect of information exchange is mediated through the media, political, business and cultural structures (see Figure 1), coupled with ICTs, the personal/rational domain is a social network structure in which individuals and groups are able to not only share and disseminate information, but also participate in communication discourse.

As depicted in Figure 1, these two domains interact with each other by the means of ICTs. At the crux of this model, there exists a flow of information from and between these domains in which individuals and groups can effectively participate in democratic decision making processes. Such participation can impact the institutional arrangement by inventing and reinventing social and cultural organizations. However this process is influenced by many other parameters including, but not limited to the availability and accessibility of ICT resources and the capacity of individuals and groups in using such tools and services. In other words, the capacity of individuals/groups is influenced by personal factors such as ICT skills, motivation, social intelligence and communicative competencies, as well as the social, economic and cultural environments [17].

In other words, the capacity of individuals and groups in using ICTs is directly related to the efficiency of ICT information usage which will be discussed later. It is also important to note that ICT is widely used for communication discourse, in both democratic and non-democratic countries, despite the fact that in non-democratic countries, such as Iran, media is heavily controlled by the elites in power.

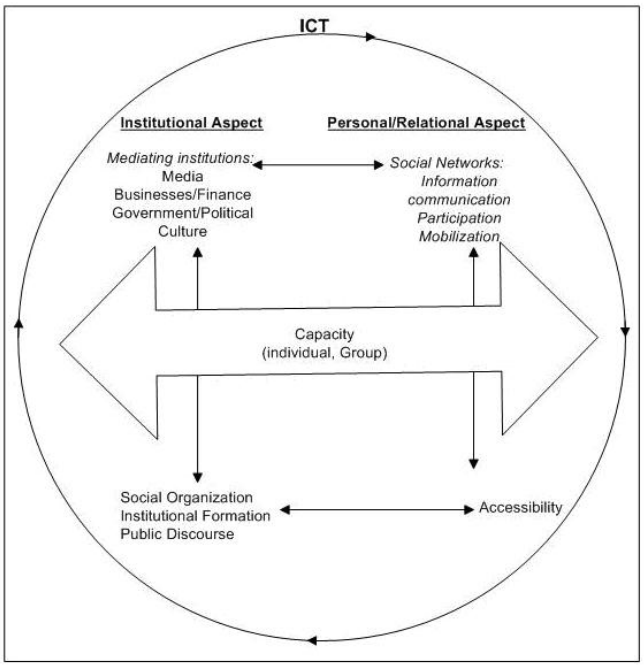


Figure 1. New Media Communication in a Networked Society
Adapted and modified from Lievrouw

A. *Web2.0 Technology*

O'Reilly [19] defines Web 2.0 as a network platform spanning all web-enabled devices by the means of delivering software as a continually-updated service through consuming, mixing and remixing data from multiple sources. Database management as a platform for knowledge management is an essential part of the new technology. For example, as mentioned by O'Reilly [19] Google is not just a collection of software tools, it's a specialized database, without data, the tools are useless; without the software, the data is unmanageable ([19], p.20). In contrast to the non-interactive top-down approach as seen in Web 1.0 publishing tool, Web 2.0 offers a new feature called participation which is essentially a bottom-up approach allowing a two-way communication between the publisher and the end users (e.g., blogs) [19, 20]. As such, Web 2.0 technology arrives with many new features as means of interconnected web of services such as blogs, wikis, social networking and content sharing websites (e.g., Facebook, Twitter and Youtube). These services and applications provided citizens the opportunity to participate in communication discourse more efficiently and effectively, or as noted by [20] the opportunities for citizens' political engagement via "the propagation of political content over multiple applications and rich user experiences on political websites" ([20], p.19). Using the new technology made it also possible for grassroots broadcasters and journalists to document events as they occur and post them on the social network sites (broadcast) and blogs, a phenomenon that was once the job of professional reporters working for expensive professional multinational broadcasters such as TV networks.

 ISBN: 978-1-61208-206-6

As discussed above, central to Web 2.0 technology is data storage and data sharing characterized by aggregation of huge amounts of information [20]. As such, those who can successfully mine, refine, and use these services are likely to engage in political discourse [20, 21]. In the context of this study, the citizen engagement in public discourse can be identified through the published articles and posted video clips and pictures on blogs and social networking and content sharing sites as well as users' comments and views about published documents. However these services are also the main target of state filtering and censorship as practiced extensively in the Middle East.

III. MEASURING ICT EFFICIENCY

ICT tools and services played a vital role in public discourse and mobilization in the recent wave of popular unrest in the Islamic countries of the Middle East and North Africa. While the official media controlled by governments were publishing the political and ideological agendas of the elites in power, the digital communities were established on the Net, particularly around social networking sites such as Twitter and Facebook. These communities were actively engaged in public discourse by disseminating thoughts, opinions and concerns about various socio-political and economic matters. Despite heavy filtering and censorship mechanisms imposed on Internet and mobile communication channels, many citizens in these countries used free anti-filtering tools and utilities available on the Net including proxy servers, to successfully bypass the filter and connect to other digital communities in the region and around the world. The intensity of street demonstrations and popular unrest identified as the "Green Movement" of Iran and the Arab Spring of the region indicate the vital role of the new media in public discourse.

This study used archival data for eleven Middle Eastern countries (Bahrain, Iran, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia and the United Arab Emirates) to investigate the efficiency of ICT information usage in the region for the period 1995-2007. Two different analytical methods were used for this investigation.

A. Method I: Regression Analysis

Based on the theory of new media communication discussed earlier, this study takes into account four main factors that may influence the level of ICT information usage in each country. These factors are the availability of ICT network infrastructure (variable *networks*), the level of educational attainment in each country, the level of human development index (variable *HDI*) and the level of economic growth as measured by per capita Gross Domestic Product per capita (variable *GDPP*).

It is important to note that the above variables are not the only factors that may influence the level of ICT information usage in each country. There are other factors that may directly or indirectly influence the level of information usage in each country, including, but not limited to, the existing level of democratic institutions, culture and the level of infrastructure development (e.g., roads, power plants etc.) However, these factors are beyond the scope of this study.

To measure the efficiency of ICT information usage (variable *infouse*) in the Islamic Middle Eastern countries the following regression model was considered:

$$infouse_{it} = \alpha_0 + \alpha_1 .networks_{it} + \alpha_2 .edu_{it} + \alpha_3 .hdi_{it} + \alpha_4 .gdpp_{it} + \varepsilon_{it} \quad (1)$$

where the subscript *i* is and index of each country of this study over the period *t*; α_0 is a constant and α_1 through α_4 are unknown vector parameters. The error term is captured by ε_{it} .

B. Data Collection

For the purpose of this study four sets of data were considered, the first set of data was related to ICT indicators such as ICT network infrastructure and ICT information usage introduced by ITU-Orbicom [22] and ITU [23]. In its 2005 and 2007 publications *Measuring the Information Society*, ITU presented some indicators to measure the level of ICT expansion and ICT usage for each country on a global scale. These indicators shed light on our understandings about the pits and falls of ICT development in general and its usage in particular through an intensive comparative study. This study pooled two main indicators namely the *networks* index and the information usage index (*infouse*) related to eleven Islamic Middle Eastern countries from the above sources. While the networks index is composed of indices such as main telephone lines, cell phones, international network bandwidth (kbs per inhabitants), digital lines and cable TV, as well as the number of Internet secure Servers. The *infouse* index on the other hand is a complex variable of two other sets of variables, one measuring the information uptake by populace of each country and the other measures the intensity of such uptakes in form of the number of Internet users, the number of personal computers in use as well as the intensity of broadband and international telecom traffics (incoming and outgoing) among others (see [22, 23] for more details). Other data used in this study are related to variables such as the level of educational attainment (e.g., primary, secondary and tertiary), the level of human development index (HDI) and the level of economic growth in each country (GDPP).

Following the previous literature, we assume that the level of ICT expansion and the intensity of its usage are correlated with the level of economic development in each country. ICT tools and services require individuals as well as firms and public organizations to have enough economic resources to spend on these resources (e.g., PCs, servers, laptops, cell phones and the Internet). That is why people living in developed countries invest more on ICT tools and services than people in the developing countries. Therefore, we can expect that there is a positive correlation between the presence of communication networks and information usage and the level of economic development in each country as measured by GDPP. Data related to HDI index was collected from UNDP's database (http://hdr.undp.org)

 ISBN: 978-1-61208-206-6

while GDPP data was mainly obtained from ITU, UNDP and the World Bank database [24].

C. Regresion Results

The measuring the efficiency of information usage was conducted in two separate yet interrelated steps. In the first step the standard Ordinary Least Square (OLS) regression method was applied on equation (1). Table I shows the results of regression analysis reported by STATA software version 9.1. As shown in Table I there is strong relationships between variable information usage (*infouse*) and parameters such as networks, GDPP and education as reported by the positive signs of variable coefficients and their related t-values and p-values. These impacts are statistically significant at 95% level while variable *HDI* was reported as statistically insignificant.

TABLE I. OLS REGRESSION

Number of obs = 121		R-squared = 0.9273				
F(4, 116) = 369.99		Adj. R-squared = 0.9248				
Prob > F = 0.0000		Root MSE = 15.141				
networks	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**95% Conf.**	**Interval**
infouse	0.7728	0.0345	22.25	0.000	0.740	0.8416
hdi	-37.4838	22.5821	-1.66	0.100	-82.2107	7.2429
gdpp	0.0013	0.0003	4.45	0.000	0.0007	0.0002
edu	0.1644	0.0906	1.82	0.072	-0.1494	0.3438
_cons	-3.4078	12.3614	-0.28	0.783	-27.890	21.0758

In the second step of our regression approach, we obtained the score of each country with regards to their ICT efficiencies by using a post estimate equation-level analysis of the variance matrix. This process is a pretty standard method in which a fitted value of variance matrix is estimated in such a way that the sum of the residuals is set to zero.

TABLE II. UN-WEIGHTED ICT INFORMATION USAGE SCORES

Country	Score
Iran	41.042
Lebanon	40.039
Bahrain	38.889
Jordan	30.046
Qatar	29.899
UAE	26.534
Kuwait	21.929
Syria	20.028
Yemen	18.978
Saudi Arabia	17.814
Oman	17.630

The resultant vector is then used in a second run of regression by involving the other two main variables namely *networks* (a reference to ICT network infrastructure) and *infouse*.

This process is referred to an un-weighted score estimation. The results of the second regression are reported in Table II. As shown in this table, three countries had the highest efficiency scores with regard to their ICT information usage: Iran, Lebanon and Bahrain with Iran at the lead with an efficiency score of 41 units.

The next step was to conduct an efficiency analysis, using a weighted method for comparison purposes and as a means of having a better estimation analysis of the digital communities across the region. The method used for this purpose is called DEA analysis.

IV. METHOD II: DEA ANALYSIS

DEA is a deterministic and non-parametric model [25] built around the stochastic frontier model [26]. The method is used as a means of benchmarking the most efficient unit(s) within a particular system.

The core component of DEA is a unit called the Decision Making Unit (DMU). Each DMU represents a complete set of recorded observations in which data are grouped as units of inputs and outputs. In other words, DEA calculates efficiency of each DMU within a dataset. A DMU can represent any type of measurable data, including metrics related to educational attainment and ICT data, such as the number of Internet users, the number of personal computers and/or the number of cell phones and fixed telephone lines in use. If DMUs are constructed using a simple model (e.g., single input and output) then the efficiency of DMU_i is defined by the following simple formula:

$$efficiency_i = y_i / x_i \qquad (2)$$

where y_i in equation (2) denotes the output of observation i and x_i represents its related input.

In a more complex situation where, DMUs are defined using multiple inputs and outputs, each of which contains different weighting metrics, then the efficiency of DMU_i is defined as the sum of weighted outputs divided by the sum of the weighted inputs as depicted in following equation:

$$efficiency_i = \sum_{i=1}^{n} \alpha_i Y_i / \sum_{i=1}^{n} \beta_i X_i \qquad (3)$$

where α_i and β_i denote the weighted values for the output variable Y_i and the input variable X_i respectively.

As depicted in equation (3), the results of efficiency calculation are strongly correlated with the selection of input and output weights. This is one of the main issues that should be addressed. In other words, we should answer the question of how do we setup values of the weights so that the ultimate results do not discriminate the other units to favour a particular DMU or several DMUs within a system.

 ISBN: 978-1-61208-206-6

DEA solves this problem by estimating the efficiency of each DMU through the implementation of a weighting mechanism that fits best for each DMU in the system [27]. In other words, the system allows the efficiency of each DMU to be maximized and then it will benchmark the most efficient ones. For the purpose of this empirical analysis the same dataset used in Method I was used in Method II. Based on countries performances in ICT information use (variable *infouse*) and the existing level of network infrastructure (variable *networks*) development, as depicted in Figure 2, four countries Yemen, Iran, Lebanon and Bahrain have been placed on the efficiency curve.

Name	Minimum	Maximum	Mean	Standard Derivation
Edu	56.95	131.03	96.0373	20.9109
Networks	13.21	113.29	59.7327	32.511
HDI	0.46	0.8422	0.7465	0.102
GDPP	798.82	20233.55	10494.2897	6828.1155
InfoUse	28.4	132.73	79.1609	33.6799

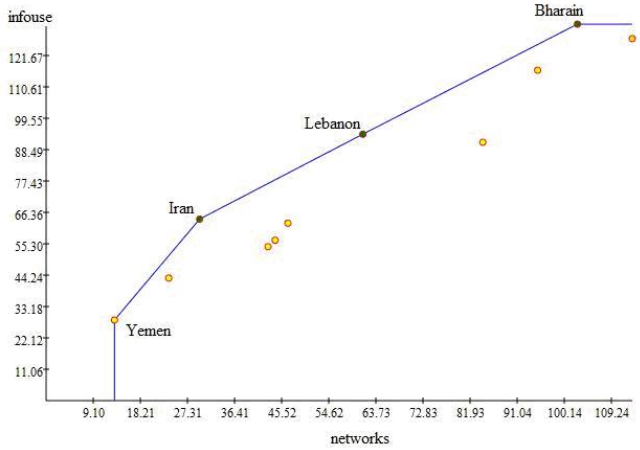


Figure 2. Descriptive statistics and the efficiency curve

A further investigation of the efficiency scores of countries in this study, as shown in Table III, indicates that among the Middle Eastern countries of this study, Bahrain and Iran had the highest efficiency scores and therefore were benchmarked as the most efficient countries in ICT information usage.

In addition, the DEA frequency analysis indicates that both Bahrain and Iran had the highest frequency scores with regards to their information usage and networks in comparison with other DMUs in the dataset. Lebanon and Yemen were placed thereafter. It is important to note that the efficiency scores are estimated based on the maximized weighted score that fits each country's performance the best.

In this context, albeit Yemen has the least developed ICT infrastructure, but when it comes to citizens' usage of information the country's efficiency index scores higher than other ICT developed nations such as Kuwait, Qatar and UAE.

V. DISCUSSION ON FINDINGS

Citizens in counties located on the efficiency curve (see Figure 2) namely: Yemen, Iran, Lebanon and Bahrain had the highest online presence during the popular unrests in the region. This is mainly associated with level of ICT adoption among citizens of these countries particularly among the younger and educated citizens. Information technology adoption is argued as one of the main sources of emancipation [11, 16, 28, 29]. The role of social influence in technology acceptance has been argued as one of the main drives behind citizens' acceptance of the new technology. Individuals engaging in the adoption of new technology achieve not only social status gains but also the pace of such an adoption is in part a result of individuals' desire in response to the social conditions [29]. Thurman [30] argues that the adoption of established news websites in expressing their views is driven by social and technological conditions in which low cost online content management tools helped facilitate a rapid growth in the number of and popularity of independently published websites and blogs that overlap the space traditionally occupied by the mainstream news media.

TABLE III. WEIGHTED CROSS-COUNTRY INFOUSE VS. NETWORKS EFFICIENCY

DMU	Efficiency	Bahrain	Iran	Jordan	Kuwait	Lebanon	Oman	Qatar	Saudi	Syria	UAE	Yemen
Bahrain	100	100	100	68.18	82.24	95.63	87.22	95.96	83.22	82.02	86.42	81.48
Iran	100	100	100	68.18	82.24	95.63	87.22	95.96	83.22	82.02	86.42	81.48
Jordan	68.18	100	100	68.18	82.24	95.63	87.22	95.96	83.22	82.02	86.42	81.48
Kuwait	82.24	100	100	68.18	82.24	95.63	87.22	95.96	83.22	82.02	86.42	81.48
Lebanon	95.63	100	100	68.18	82.24	95.63	87.22	95.96	83.22	82.02	86.42	81.48
Oman	87.22	100	100	68.18	82.24	95.63	87.22	95.96	83.22	82.02	86.42	81.48
Qatar	97.87	100	59.5	45	80.2	71.89	72.71	97.87	62.4	47.94	85.23	81.48
Saudi Arabia	83.22	100	100	68.18	82.24	95.63	87.22	95.96	83.22	82.02	86.42	43.65
Syria	84.55	59.94	100	58.66	50.04	71.15	59.24	56.87	62.07	84.55	52.23	81.48
UAE	86.42	100	100	68.18	82.24	95.63	87.22	95.96	83.22	82.02	86.42	99.7
Yemen	99.7	59.94	100	58.66	50.04	71.15	59.24	56.87	62.07	84.55	52.23	81.48

 ISBN: 978-1-61208-206-6

As such, the digital communities in these countries adopted and utilized ICT media effectively for mobilizing citizens in political discourse. Millions of pictures, video clips, text messages and articles posted on social networking sites, blogs and video sharing sites such as YouTube document the intensity use of ICTs in these countries in particular from Iran, Bahrain and Yemen.

Despite some differences in results reported by the weighted versus un-weighted analysis with regards to the efficiency of ICT usage in the Middle East, both methods scored Iran, Lebanon and Bahrain as the most ICT efficient countries in the region. The differences in reported scores (weighted and un-weighted) with regards to Yemen is due to the weighting mechanism deployed in DEA to benchmark the best performer(s) within the DMU dataset. In this context the un-weighted scoring mechanism used by OLS regression is different than the method used by DEA. The study of the Iranian digital community as the most efficient community in the region warrants a future discussion about this community. Despite the fact that the Iranian ICT network suffers from advanced technologies such as broadband, the Internet users in Iran are utilizing the existing bandwidth more efficiently that other countries in the region. Poor infrastructure development in Iran is one of main barriers to access to the information highway. To highlight this according to the 2009 ITU report, in year 2008 almost 32.5% of the population in Chile were connected to the Internet (measured based on the number of Internet users per 100 inhabitants) while 8.5% of these users were broadband users. In the same year 31.4% of Iranians were connected to the Internet, but only a very small number of users (0.41%) were connected to the Internet by the means of broadband. A comparison between Bahrain and Iran also reveals important information with regards to the poor ICT development in Iran, while 52% Bahrainis were connected to the Internet in year 2008, 14.18% of these users were broadband users.

Despite the underdeveloped infrastructure the digital community of Iran has created the largest blogosphere in the Middle East. Currently there are over 60,000 active blogs in Iran. In addition, the Iranian Facebook users constitute a bloc of over nine million users. In addition, on average Iranians exchange millions of SMS messages on a daily basis. This value increased to a remarkable high number of 110 million SMS per day during the 2009 presidential election in Iran. Many of these messages were politically motivated and caused the hardliners to shutdown the entire mobile network for a few days starting from June 11, 2009, which was the day before the election in Iran [31, 32]. The above examples show the intensity of ICT usage in Iran, confirming the results of the regression, as well as our DEA analysis based on data collected from sources such as ITU, The World Bank and UNDP.

The results of this study indicates also, that, despite intensive efforts by the Iranian authorities in filtering Internet contents, the digital community of Iran was able to bypass the imposed filtering through various methods, including the use of proxies, VPN and anti-filtering software available on the Net.

VI. CONCLUSION

ICTs changed the nature of interaction among individuals, civil society, democratic institutes and business activities. In particular, many individuals and protest movements were organized by utilizing ICTs in their campaigns. As we have seen in recent popular unrests in Middle East and North Africa, ICTs provide the means for building the capacity to participate in democratic discourse, and mobilize masses for radical social change in constitutional and legal arrangements.

Since the introduction of Internet in Middle East in 1995, the digital communities in the region were able to effectively use the new technology for not only as a means of communication and interaction among people, but also to organize social-political events. Despite governmental control and filtering the content of Internet including the block of blogs, critical websites, Facebook, Twitter and email systems, the digital communities in the Middle East were able to use advanced anti-filtering tools and software, as well as proxies, to bypass the imposed restrictions on the Net and participate in discourse with digital societies across the globe. By using the theory of new media communication coupled with empirical analysis of archival data, this study tried to investigate the intensity of ICT information usage in the Middle East in order to better understand the nature of communication discourse in the region and their mobilization impacts on recent public unrests. The results showed that citizens who are actively engaged in digital communities and use ICT tools and services more efficiently are more likely to participate in public discourse and mobilization.

REFERENCES

[1] B. Loader, “Cyberspace Divide”, London: Routledge, 1998.
[2] P. Foley, X. Alfonso, and, M. Al Sakka, (2006) “Information sharing for social inclusion in England: A review of activities, barriers and future directions”, Journal of Information, Communication and Ethics in Society, vol. 4, no. 4, 2006, pp. 191-203
[3] P. Norris, “Who Surfs? New Technology, old voters and virtual democracy in the 1996 and 1998 US elections”, in: E, Kamarck, (ed.) “Democracy.com?”, Cambridge: Hollis, 1999.
[4] D. Ott and M. Rosser, “The electronic republic? The role of the Internet in promoting democracy in Africa”, Democratization, vol. 7, no. 1, 2000, pp. 137-155.
[5] A. Jones, “Wired world: Communications technology, governance and the democratic uprising” in: F. Webster (ed.), Culture and politics of the information age, London: Routledge, pp. 145-163, 2001.
[6] S. Suarez, S. “Mobile democracy: Text messages, voter turnout, and the 2004 Spanish general election”, prepared for Annual Meeting of the American Political Science Association, September 1-4, 2005.
[7] J. Katz, “The Digital Citizen”, Wired, vol 5, no. 12, pp. 86-82, 1997.
[8] D. G. Lenihan, “Realigning Governance: From E-Government to E-Democracy”, OECD Discussion Paper, for the Public Sector Management division’s E-Government Working Group, Centre for Collaborative Government, April 2002, http://kta.on.ca/pdf/cg6.pdf [retrieved: June, 2007]
[9] S. Clift, “E-Democracy, E-Governance and Public Net-Work”, 2003, available: http://www.publicus.net/articles/edempublicnetwork.html [retrieved: April, 2007]
[10] R. Hirschheim, and H. K. Klein, “Realizing Emancipatory Principles in Information Systems development: The case for ETHICS”, MIS Quarterly, vol. 18, no. 1, 1994, pp. 83-109.

 ISBN: 978-1-61208-206-6

[11] C. B. Stahl, “Empowerment through ICT: A critical discourse analysis of the Egyptian ICT policy”, Social Dimensions of Information and Communication Technology Policy IFIP International Federation for Information Processing, 282, 2008, pp. 161-177.
[12] A. Cigler and L. Burdett, “Interest Group Politics”, 5th edition, Washington: Congressional Quarterly Press, 1998.
[13] B. J. Oates, B. J. ‘The potential contribution of ICTs to the political process’, Electronic Journal of e-Government, vol. 1, no. 1, 2003, pp. 33-42.
[14] F. Shirazi, “The Emancipatory Role of Information and Communication Technology: A Case Study of Internet Content Filtering within Iran”, Journal of Information, Communication & Ethics in Society, vol. 8, no. 1, 2010, pp. 57-84.
[15] M. Castells, “The Rise of the Network Society”, 2nd edition, Oxford: Blackwell, 2000.
[16] M. Castells, “Communication, Power and Counter-power in the Network Society”, International Journal of Communication, vol. 1, 2007, pp. 238-266.
[17] A. L. Lievrouw, (2001). New media and the ‘pluralization of life-worlds’: A role for information in social differentiation, New media & Society, vol. 3, no. 1, 2001, pp. 7-28.
[18] M. Marsili, F. Vega-Redondo, and F. Slanina, “The rise and fall of a networked society: a formal model”, Proc. Natl Acad. Sci. USA, vol. 101, 2004, pp. 1439–1442.
[19] T. O’Reilly, “What is Web 2.0: Design patterns and business models for the next generation of software”, Communication & Strategies, vol. 65, no. 1, 2007, pp. 17-37.
[20] A. Chadwick, “Web 2.0: New Challenges for the Study of E-Democracy in an Era of Informational Exuberance”, I/S: A Journal of Law and Policy for the Information Society, vol. 5, no. 1, 2009, pp. 9-42.
[21] S. Wattal, D. Schuff, M. Mandviwalla, and B.C. Willams, “Web 2.0 and politics: the 2008 U.S. presidential election and an E-politics research agenda”, MIS Quarterly, vol. 34, no. 4, 2010, pp. 669-688.
[22] ITU-Orbicom, “From The Digital Divide To Digital Opportunities: Measuring Infostates for Development”, Montreal: Claude-Yves Charron, 2005.
[23] ITU, “Measuring The Information Society 2007: ICT Opportunity Index and World Telecommunication/ICT Indicators”, Geneva: ITU Publication, 2007.
[24] World Bank, World Bank Development Indicators (WDI) CD-ROM, 2007.
[25] S. Perelman and T. Serebrisky, “Measuring the Technical Efficiency of Airports in Latin America”, Policy Research Working Paper 5339, The World Bank, Latin America and the Caribbean Region Sustainable Development Department, June 2010.
[26] W. Greene, “Reconsidering heterogeneity in panel data estimators of the stochastic frontier model”, Journal of Econometrics, vol. 126, no 2, 2005, pp. 269–303.
[27] C. Vercellis, “Business Intelligence: Data Mining and Optimization for Decision Making”, London: John Wiley & Sons, Ltd, 2009
[28] E. Karahanna, D. W. Straub, N. L. Chervany, “Information Technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs, MIS Quarterly, vol. 23, no. 2, 1999, pp. 183-213.
[29] V. Venkatesh, M. G. Morris, G. B. Davis, F. D. Davis, User acceptance of Information Technology: Toward a unified view, MIS Quarterly, vol. 27, no. 3, 2003, pp. 425-478.
[30] N. Thurman, Forums for citizen journalists? Adoption of user generated content initiatives by online news media, New Media & Society, vol. 10, no. 1, 2008, pp. 1-30.
[31] A., Aramesh, “Iran Filters and Jams Internet to Combat the Opposition”, 2008, available: http://www.insideiran.org/critical-comments/iran-filters-and-jams-internet-to-combat-the-opposition/ [retrieved: December, 2010].
[32] G. Esfandiari, “Misreading Tehran: The Twitter Devolution”, 2010, available: http://www.foreignpolicy.com/articles/2010/06/07/the_twitter_revolution_that_wasnt [retrieved: August, 2010].

 ISBN: 978-1-61208-206-6