Application of Human Profiling by Agent for Activating Human Communication

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***Abstract*—In this paper, we propose to put an agent in the network to help activate human communication. Our hypothesis is that human behavior depends both on a static profile and a dynamic context. So, we verify our hypothesis by performing repeated experiments. In our experiments, one author acted as the agent and collected many responses from members in an organization. As a result, an effective messaging style can be found by understanding their profile. Next, we categorize their profiles into stubborn one and flexible one. A small amount of data could not make any impact on the members with the stubborn profile, but made an impact on those with the flexible profile, depending on their context. So, we confirm that the agent should understand the profile and context of the object persons, and transform the data to effectively convey the client's intention. Finally, we address a design method of human profiling agent.**

Keywords- context; profile; agent; human communication; message; CPS.

I. INTRODUCTION

People spend a lot of time in the cyber world in business and daily life because of the popularity in World Wide Web services [1][2]. Combining sensor data with the Web by Internet of Things (IoT) [3], data in the physical world are applied for various context-aware applications [4]. Even a hand gesture can be interpreted in cyber world with the advanced wearable devices [5]. Such trend suggests a Cyber-Physical System (CPS) will gradually be positioned, in which various context data can be handled.

However, we often feel frustrated in communication. Reference [6] broadly defines communication as all procedures by which one's mind affects another. The authors have categorized problems of communication into three levels: i) accuracy of transmitted symbol, ii) preciseness of conveyed symbol, and iii) effectiveness of received meaning to lead the receiver's conducts. Our objective is the 3rd level, that is, to build networking environment where the information sender can effectively transmit his/her intention, emotion, dearness and so on.

On the other hand, problems for the receiver are predominantly caused by the imbalance between the human perception and the volume of input data. It is known that the average human ability to percept information through eye or ear is limited to 223 bps or 105 bps, respectively [7]. So, excessive data will interfere in the human cognition, and will frustrate people, as follows.

A) People take a lot of time mining data with value.
B) People receive many data that could miss the mark. For example, although they hit the category like classical music, they never hit the favorite composer in a short time.
C) People receive data when it is not useful. For example, the announcement of the disruption of the commuting train service just before they arrive at the transit station is too late.

In summary, a data sender wants to convey his/her intent to a receiver. Then, we envision that a software agent mediates between them through the network since the agent could quickly process a lot of data without vital limitation or emotional barrier.

We will model the human agent and verify its effect. In Section II, we briefly review the trend of past studies about context awareness and an agent as the related works. In Section III, we show our hypothesis on human behavior that is based on the static profile and the dynamic context of object persons [8]. In Section IV, we describe the model of the proposed human agent and its role. In this paper, the human agent aims to activate the receiver's reaction by modifying the input data from the client. In Section V, we evaluate the effectiveness to figure out the profile and the context to activate the reaction of the object persons through repeated experiments. In our experiments, an author of this paper acts as the agent in place of the software program. In Section VI, we discuss how to design the human agent. Here, the design procedures in our experiment are categorized into those that are programed by designers and those that are automatically implemented as algorithm by the agent.

II. RELATED WORKS

Many studies on context awareness have been performed in the past decade [9]. Typical use scenarios are a dynamic resource allocation by referring to user status and network environment [10] [11]. Other scenarios are service control, such as the screen structure of a mobile terminal that is switched depending on the user's location [12]. Most studies have assumed that the role of the context information could be common to everybody. However, the significance of

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context information must be different to each person. So, we want to coordinate the context and the human profile.

We proposed to have an agent assist the data process in place of person. Actually, a lot of studies on the agent have already been done from various viewpoints [13]. The typical applications of agent is personal assistance [14][15] and the agent provides the means of a specific issue. For example, an agent categorizing data was proposed for personal data market [16]. A personal agent mediating personal knowledge management like transformation between tacit and explicit knowledge was proposed too [17]. The design of the multi-agent has already begun to be studied and the agent's ontology model was proposed [18][19]. Further, remarking the penetration of Artificial Intelligence (AI) speaker or personal agent in mobile phones, it is clear that a conversation between a person and AI has progressed [20][21].

Our viewpoint is different from others since we assume three kinds of stakeholders, i.e., a client, object persons, and 3rd parties. Our agent assists the client to preferentially convey his/her messages to the object persons while referring to the profile of the object persons and the context around them.

III. REQUIREMENTS AND HYPOTHISIS

A. General requirements for human communication

Let us describe our approach to activate human communication. Problem A) in Section I will be resolved by searching valuable data and filtering out trivial data by an agent understanding human profile such as concern or taste. Problem B) can be improved by matching between the input data and the receiver's profile. Problem C) is caused by missing the receiver's timely requests. This issue will be resolved by understanding his/her external context. Repeatedly, the value of input data is varied depending on various elements such as the personality, mind, timing and place. Therefore, we have proposed to put an agent in the network, which figures out the profile and the context of the object persons [8].

B. Hypothesis and terminologies

Let us discuss factors that affect a person who may react. We divide the impact factors into a static human profile and a dynamic human context, as shown in Table I and Figure 1.

A person grows through the experience with sensory information and language [22]. Then, the personality has been formed for a long period and it is relatively static. The personality is thought the principle how to feel, think and act, and cannot easily be changed by a small number of messages. We call the abstraction of the personality a human profile (profile from now on) which a third party characterizes through the observation.

On the other hand, we call the dynamic elements a human context (context from now on). Further, we categorize the contexts into 3 elements: (1) internal context, (2) external context and (3) data input [8][23]. An internal context is the internal state of a person such as mind, an emotion and a vital condition. It is thought to be the dynamic part around the profile and can be changed even by a small number of messages. An external context is an external state around the person such as time, place, company and belongings. Data input is a kind of change of the external context. However, we conveniently divide the data input from the external context since the data is an object which Information and Communication Technologies (ICT) can process, even though the data is originally generated based on the sender's intention. Further, the person cannot control most of the external context like time. However, the person can switch the various external contexts by acting such as talking with colleagues, writing a document, walking or running, etc.

TABLE I. IMPACT FACTORES ON HUMAN BEHAVIOR

	Elements	Examples of element affecting person
Static	Profile	Full name, Mother language, Gender, Age, Contact address, Address, Career and title, Financial resource or borrowing, Record of health/illness
Dynamic	Internal Context	Will, Desire, Mind, Emotion, Physical condition
	External Context	Time, Place, Accompanies, Belongings, Social events, Natural phenomenon
	Data input	Dialog, Chat, E-mail, Phone call, SNS, News, Papers, Books

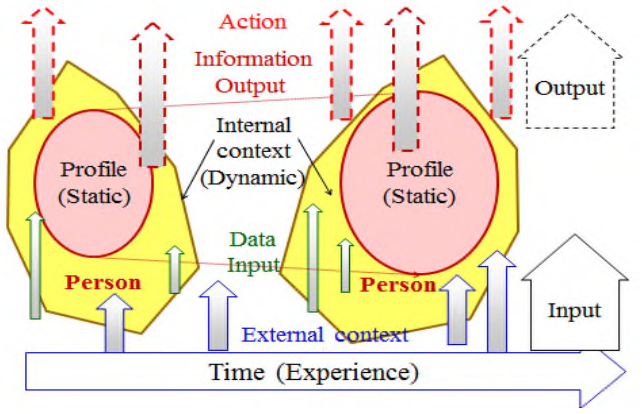

Figure 1. Hypothesis about impact factors on human reactions.

The horizontal line of Figure 1 represents time. The person encounters various external contexts including data input. Although the profile grows gradually, the internal context is dynamically moved by the change of external context. As a result, the person will react by talking with friends, writing a document, expressing emotion, and going somewhere.

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IV. PROPOSAL OF HUMAN AGENT

A. Proposed human agent for activating communication

We propose to introduce a human agent between a sender of information and a receiver of data. The agent prompts receiver's reaction according to the intention of its client [23]. Here, a client is defined as someone who specifies the role of the agent. Not only the object person oneself, but also somebody else could be the client. For example, the object person oneself may hire the agent as his/her secretary, and his/her parents may hire the agent as a tutor of their child. It is noted that the client must have a piece of the profile because they have already accompanied the object person.

Figure 2 shows the basic model of the human agent between the client and the object persons. The agent tries to make the lively reaction of the object persons by moving their internal context. It temporarily keeps input data which the client sends, and transforms the data so as to meet the client's intention. At that time, the agent refers the profile of the object persons. It is noted that the profile is just an abstraction of the personality through observation. So, the profile is not necessarily true. Further, it is not fixed forever, since the person grows. Therefore, although a designer initially sets the profile which is told by the client, the agent should update it through the observation of the persons' actual reaction. So, the agent must have a feedback mechanism which monitors the information output or reactions to the data input because it is difficult to directly measure the internal context.

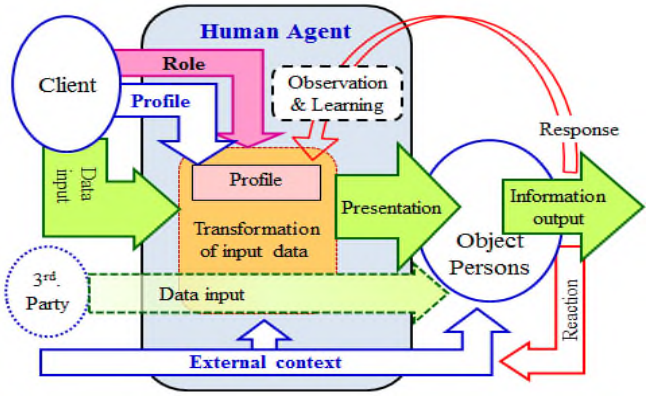

Figure 2. Model of human agent for activating communication.

Currently, we position the agent as an application program to communicate with the client, the object persons and a huge number of third parties, as in Figure 2. Any computing resource is acceptable to carry on the agent program, such as terminal equipment and the node in the Internet or a data center as long as it can communicate with the above stakeholders. If we were to use one word, the entity for the agent should be located at the center among the stakeholders to save network resource [8].

B. Transformation of input data from the client

This paper focuses on the agent to convey the intention of the client to the object persons, even though the object person must be frustrated due to the excessive data of little interest. We assume that the agent is prohibited to abandon or change any data from the third parties since it could be significant to the receiver. What the agent can do is to transform the input data from the client.

Table II is the alternatives of transformation to affect the person. To senior people, for example, message with high volume voice can easily be understood, but small size letters are never welcome. It cannot be doubted that *A*, *B* or *C* in Table II are effective depending on their profile such as age and mother tongue. Therefore, we will evaluate the effect of *D* and *E* in the remaining sections.

TABLE II. POSSIBLE TRANSFORMATIONS OF INPUT DATA BY AGENT

Transformed objects	Example of transformations
A) Language	Translate message to mother language
B) Displayed form	Select displayed form such as voice/text/graph/picture/animation/video
C) Size or volume	Adjust letter size or audio volume
D) Message style	Select message style and arrange timing to send
E) Expression or rhetoric	Change tone of words such as order, modest request, or heartstrings

C. Metric of human agent for positive response

Let us assume a scenario where a client wants to know lively opinions of members in his/her organization. Then, the client hires the human agent profiling a set of object members. The agent tries to have the members respond as much as possible by transforming the request message for the opinion survey. The mere repeat of requests must be annoying and ineffective since the human recognition capability has a limit. So, the agent must find a smart presentation style of the data from the client without increasing the amount of data. Considering the above, we define "response rate" as a metric for activating their level.

- Response rate (r) of a person is expressed by n_o/n_i
  n_o: the number of output information, i.e., response
  n_i: the number of input data, i.e., request for response
- Response rate (R) of a set of object persons is expressed by $\Sigma\ (n_o/n_i)\ p(n_o, n_i) / N$.
  $p(n_o, n_i)$: the number of members such that n_o responses to n_i requests. Here, N is the total number of object persons, i.e., examinees in later.

The human agent cuts and tries to transform the request message from the client to collect many responses while observing the reactions of the object persons.

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V. EXPRIMENTS

A. Method of agent's simulation

Considering that a software agent is developed by designers, it cannot execute logical judgement beyond that of the designers. In our experiments, an author, M. Katoh, acts as the agent in place of the designer since he knows the clients profiles and recognizes their context. Next, we analyze our procedure from the view point of the feasibility by software. The purposes of the experiments are as follows.

1. Verifying hypothesis that the profile of the object person is essential to move him/her in experiment I.
2. Verifying hypothesis that the context of the object person is important to activate him/her in experiment II.
3. Addressing how to design the agent which refers to the profile and the external context of the object person.

Instead of the software, Katoh requested to return examinees' opinions as much as possible by e-mail. The number of examinees "N" is 42 or 30 in the experiments I or II, respectively. The question form includes 3 or 4 choices for answer so that they will respond for a few minutes. The deadline of response was for 48 hours so that they have couple of chances to check their received e-mails.

For experiment I, Katoh modified the message style and expression, and observed responses from 42 examinees to find out an effective presentation style. Table III summarizes the presentation styles for 7 trials. One request mail includes one question and choices for answer as indicated in APPENDIX. Here, we took care that the content of the question does not impact their reaction since we want to observe the impact by message style or expression. That is, the questions should be nearly equal to interest them in each trial. So, considering that all examinees are researchers on ICT, he asked them about the high-level view about ICT.

TABLE III. PRESENTATION FOR EXPERIMENT I
(Examinees N=42)

Trial) Date	*D) Message style*	*E) Rhetoric (Naming, Additional data)*
#1) 1/24	(I)	① Minimum as standard
#2) 1/29	Requset: 1 to N	② ①+Result of #1
#3) 2/1	(multicast by mailing list)	③ Individual name + Result of #2
#4) 2/6	Response: 1 to 1	④ ③+Confidence policy + Result of #3
#5) 2/14	(II)	⑤ Individual name
#5.5)	Request: 1 to 1	⑥ Remind for #5
#6) 2/20	Response: 1 to 1	⑦ ⑤ + Result of #5
#7) 2/27	(III) Request:1 to 6 groups Response: 1 to group (sharing in the group)	⑧ Division to 6 groups. What is your group's choice?

Here, the presentation style such as *D) message style* and *E) rhetoric* was changed for the series of trials. Figure 3 shows 3 message styles. The style (I) is that the request was sent in multicast (1 to N) by using the mailing list. Each examinee returns his/her answer to Katoh's address (1 to 1). The style (II) is a normal 1 to 1 communication. In the styles (I) and (II), all responses were gathered by only Katoh. To avoid this moral hazard due to the asymmetry of information, the style (III) adopts a mesh type communication (n to n). Here, 42 examinees were divided into 6 groups, and they shared his/her response in the group.

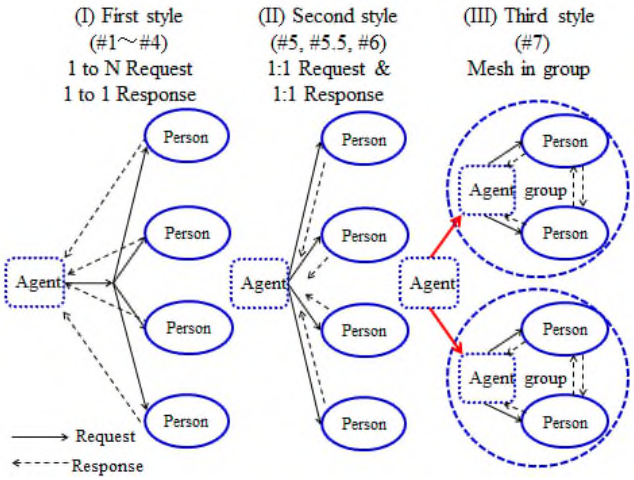

Figure 3. Message styles for experiment I.

TABLE IV. REQUEST TIMING FOR EXPERIMENT II
(Examinees N=30)

Traial) Date	*D) Message style*		
	Style	*Request timing*	
#1) 5/24	(II) Request: 1 to 1 Response: 1 to 1	Visual check	Absence
#2) 5/29			Presence
#3) 6/4		Due to open scheduler in the organization	Before meeting
#4) 6/14			During meeting
#5) 6/21			During meeting
#6) 7/17			Available
#7) 8/1		Visual check	Presence
#8) 8/7			Presence

In experiment II, Katoh sent the request mail for an opinion survey to 30 examinees. In this experiment, the message style was fixedly (II) since we wanted to find out not an effective style, but an effective context. Table IV summarizes requesting timings for 8 trials of this opinion survey. One mail includes one question and 3 or 4 options for answer, as in APPENDIX. Again, the contents for question should equally be interesting to them. So, he asked them about "working style" as a popular issue in Japan.

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B. *Results of experiement I*

Figure 4 shows the results of 8 trials during about 6 weeks. The blue bars represent the number of responses, and the red broken line represents the response rate (R).

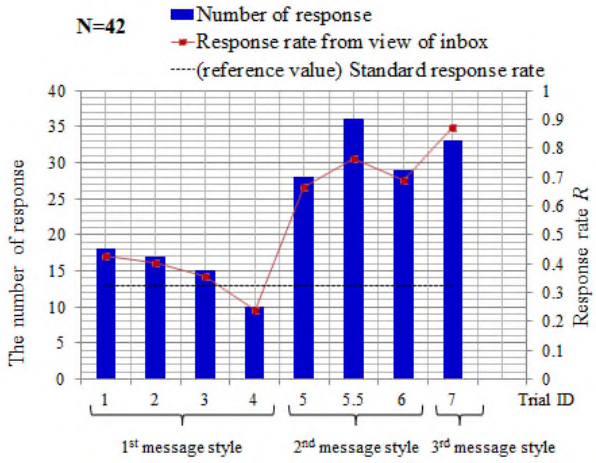

Figure 4. Transition of reactions in the experiment I.

In the message style (I) using mailing list for 42 examinees, the number of responding examines declined from 18 in the trial #1 to 10 in the trial #4. Although their curiosity seemed being stimulated at the trials #1 or #2, they may have gotten fatigued after trial #3. According to reports of opinion surveys for business persons, more than 2,300 in Japan, the average number of received and transmitted e-mails per day are about 40 and 13, respectively [24]. So, the average rate of information output to data input is 13/40 = 0.32 as a standard response rate. R in the message style (I) declined from 0.42 to 0.24, which is lower than the standard response rate. During this period, the rhetoric was devised with an addition of the result for the previous trial, as in Table III. However, we could not observe the effectiveness at all. Rather, we observed that 62% of responses were returned within 2 hours. About 10 new e-mails pile in one's inbox during a meeting of 2 hours. So, the most valuable e-mails must first be responded after returning to his/her desk. As a result, the priority of the voluntary reaction becomes lower than secondary. That is, the effectiveness of our request is gradually weakened and lost for a couple of hours.

In the message style (II), Katoh sent 42 request mails to 42 examinees by using individual addresses. Further, the rhetoric is changed as in Table III. For example, the addressing style changed from "Hi, everybody" to "Addressing by individual full name". The number of responses of the trials #5 and #6 are 28 and 29, respectively. It can be recovered in a V-formation, and R is over 0.67. So, we conclude that individual name and mail address play an important profile to get many responses. In the trial #5.5, he sent explicit reminder e-mails to 14 examinees having not responded yet, and then received 8 responses. It is noted that the response rate 8/14 of the second request for reminder is slightly lower than that of the initial response rate of 28/42. This fact means the request for only cool persons for the voluntary activity is lower than the average.

In the message style (III), we divided the 42 examinees into 6 groups according to the actual project in the organization. Katoh sent request mails to 6 groups and asked to share the response in the group. This style was effective to stimulate each other in the group. The number of responses became 33 and the response rate R became the best, 0.87. The first reason is due to the effectiveness of one request. Since one request mail is shared for 7 examinees, the probability that 7 examinees are incognizant can be reduced. The second reason is due to the reminder being sent several times. That is, someone's response is shared, and so it can play a role of reminding others that they have not responded yet. That is, an original request will repeatedly be valid. So, we conclude that the organization structure as their profile plays an important role to get many responses. In fact, the response times were slightly more distributed than others.

C. *Results of experiment II*

Figure 5 shows the results of 8 trials during about 10 weeks. Katoh sent the request mail to return their opinions by the message style (II). The blue bars represent the number of responses, and the red broken line represents the response rate R. In the trials #1 and #2, 26 examinees have responded, and R is unexpectedly high 0.87. So, we had to try to reduce R by finding out an inconvenient time due to their schedule management system. That is, for the trials #3, #4 and #5, he sent the request mail just before or during the meeting time. As a result, the number of responses was reduced to 21 or 22, and R became lower to 0.7. We succeeded to reduce the number of responses, but it was not so dynamic. We think that the request timings in Table IV are all during working hours, so there is no drastic change of the external context. We got just 20 responses in the trial #6 even though we sent request mails at an available time according to the calendar. We think that the calendar is not necessary true to express their actual availability.

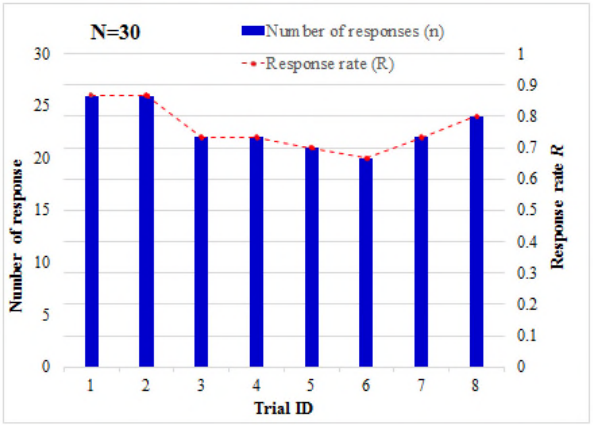

Figure 5. Transition of reactions in the experiment II.

It is sure that the variation of response of Figure 4 is more dynamic than that of Figure 5. That is, the mail address of the request message is the most dominant factor to get a positive response even though the request timing slightly impacts their reaction.

Figure 6 shows the examinees' characteristics. The horizontal line is the number of responses for 8 trials and the vertical line is the number of examinees. We can categorize 30 examinees into 3 groups. Group *A* is a set of positive 15 (50%) examinees who responded to all requests. Conversely, group *B* is a set of cool 2 (6.7%) examinees who never responded to any requests by voluntary cooperation. We define their profile as "stubborn", which strongly dominates their reaction. In other words, a small number of messages cannot impact their reaction.

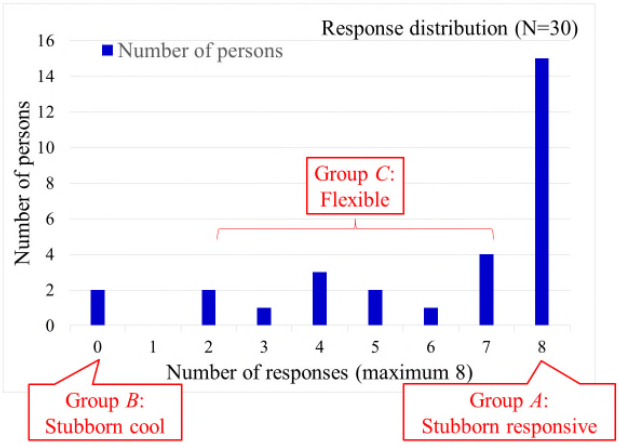

Figure 6. Characteristics of examinees and the category of profile.

Group *C* is a set of "flexible" 13 examinees who responded 2~7 times. Such reaction depends on external context. That is, if they receive the request when they are available, they respond for a couple of hours. Nevertheless, they lose the chance to return their opinions. Therefore, we conclude that the response of our questionnaire dominantly depends on the stubborn profile. Next, the reaction of flexible examinees depends on their availability, that is, their context.

VI. CONSIDERATIONS

A. Verification of our hypotheisis

➢ *Effectiveness of predetermined-profile*

Static profile such as individual name, email address, etc., can be pre-determined. It was clear that such profile played an important role to adopt the messaging style (II) to activate reactions of object persons. Further, by knowing the structure of the organization, the agent was able to adopt the message style (III), and got very high *R*, such as 0.85. If the client did not respond, the agent would have to try the possible arrangement of 6 groups from 42 persons. Considering that there are $42!/(7!)^6 = 8.57\text{x}10^{28}$ combinations, such cut and try approach is never feasible.

➢ *Effectiveness of learned-profile*

Through two experiments, we learned examinees personality, and were able to roughly predict the response rate *R*. Table V shows the result of the additional trial using the message style (III) for 3 groups consisting of 7 examinees. Before this trail, we averaged past response rate in experiment I for each examinee (in the second column of Table V). The third column shows our expectation of the number of responses in the group, in which Bernoulli trails are assumed. The right columns are the results, which are close to our expectation.

TABLE V. EXPECTED RESPONSE NUMBER BASED ON PAST RESULTS

Group	Average response rate in the group	Our expectation based on Bernoulli trial	Result
X	0.142	0.99	1
Y	0.751	4.0	6
Z	0.768	5.38	5

That is, the agent can roughly predict *R* by learning the profile through a number of trials, and brush up the profile of object persons. The group *Y* was more active than our expectation based on Bernoulli trials. This means that the reaction in group *Y* is more active than an independent trial, as described in Section V-B.

➢ *Effectiveness of context awareness*

We observed that examinees' reactions depend on their external context, as described in Section V-C. Especially, the request timing is crucial in order for flexible persons to be aware of the client's message and to react.

B. Design Methodology

Although an author played the role of an agent for experiments, the agent must be described as a software program. Then, a key question is whether our cut and try approach in Section V can be described as a software. So, we classify the procedures into the manually coded ones and the algorithm based one. The former must be developed by designers based on the intent of the client, and the latter can automatically be executed by the agent. Figure 7 shows our current view. The dashed arrows represent the message flow by the human agent.

➢ *Manually coded procedures by designer*

A designer should define the role of the agent based on the client's requirement. The designer specifies the measurable metric to evaluate the effectiveness of the operation by the agent. Simultaneously, the client tells the designer the predetermined profile of the object persons. Next, the designer must set the possible methods which the agent can choose. In our experiments, alternatives such as 3 message styles, rhetoric transformation and request timing are set prior to the actual operation.

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➢ *Automatic procedure by algorithm in the agent*

In the online operation, the human agent dynamically chooses one method among pre-set alternatives for data input from the client to effectively transfer the client's intention. In the procedure, the agent refers the profile and the context of object person. Concerning rhetoric transformation, it is feasible to replace some words into stylized words based on a rule. Further, the agent measures the effectiveness of the selected method by monitoring reaction, and brushes up the profile.

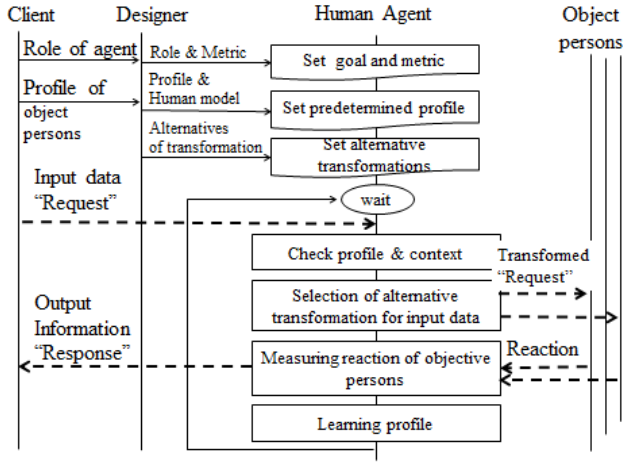

Figure 7. A design method of the human agent.
- Manual programming or Algorithm -

VII. Conclusion and Future Work

We have verified our hypothesis about human behavior through repeated experiments. One of the authors acted as the human agent to activate communication in an organization. As a result, we have found the effective messaging style that got about 1.5 times of responses by understanding predetermined profiles such as individual name and email address, and organization structure. Next, we have categorized examinees' profiles into "stubborn ones" and "flexible ones". The behavior of examinees with stubborn profile could not be changed by a small number of messages. However, the examinees with flexible profile became reactive by requesting it at their available time. So, we conclude that human communication can be activated by figuring out the profile and the context of the object persons. Therefore, the human agent should have the knowledge about the context as well as the profile of the object persons. Further, we have clarified that the agent was able to brush up their profile by observing the actual reaction of the object persons. Finally, we classified the procedures in our experiments into manually coded by designers and automatically implemented by algorithm implemented in the agent to address our design method of the human agent.

In the near future, we will refine the suitable location of processing entity to execute the agent program. In this paper, we assumed a stand-alone agent between the client and the object persons. Considering that a huge number of agents play various roles in the entire network in the future, the communication between agents will be required. This is also an open issue.

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APPENDIX

Table A-I and Table A-II shows actual contents of the opinion survey, i.e., question and choices for answer for our experiments I and II, respectively.

TABLE A-I. INQUIRIES AND CHOICES FOR ANSWER FOR EXPERIMENT I

Trial	Inquiry	Choices for answer
#1) 1/24	Memorized telephone number	a) 0~2, b)3~5, c) more than 5
#2) 1/29	Communication tool for close friend or family	a) Phone, b) Chat, c) Others including e-mail
#3) 2/1	Number of transmitted e-mails per day	a) 0~10, b) 11~20, c) more than 20
#4) 2/6	How many terminals can you have for a walk?	a) 0~1, b) 2, c) more than 2
#5) 2/14	Can you allow AI to join your meeting?	a) Yes, b) No, c) Others（case by case）
#6) 2/20	What impression if AI compliments you?	a) Good, b) Not good, c) Others（timing）
#7) 2/28	Have you heard the terminology “network effect” and “information asymmetry”?	a) None, b) One, c) Both

TABLE A-II. INQUIRIES AND CHOICES FOR ANSWER FOR EXPERIMENT II

Trial	Inquiry	Choices for answer
#1) 5/24	Do you like to listen to music during your job?	a) Often, b)When it is noizy, c) No
#2) 5/29	Where do you have lunch?	a)In office, b)Restaurant in company, c)Restauramt outside, d)Others
#3) 6/4	How to get news?	a)Broadcast, b) Internet, c) Newspaper, d) Others
#4) 6/14	Expression that makes you feel respected	a) Thanks, b) Interesting, c) Admire, d) Others
#5) 6/21	Expression that makes you feel discouraged	a) No response, b) Not interesting, c) Consecutive questions, d) Others
#6) 7/17	Are you satisfied with communication?	a) Enough, b) Not enough, c) Others
#7) 8/1	What do you feel happy the most during R&D activity?	a)Achievement, b)Discovery, c)Acceptance, d)Others
#8) 8/7	What is an obstacle to your R&D time?	a)Regulation, b)Side job, c)Private issue, d)Others

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