A Dynamic Service Composition using Semantic Ratiocination on Integrated Home Network System

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***Abstract*—Recently, the ubiquitous technologies allow general household appliances to be connected within the network at home. Since a number of researcher have tried to provide these environment as their own field such as UPnP, DLNA, OSGi and ECHONET, The home network systems (hereafter referred to as HNS) are comprised of a networked appliances to provide various services and applications for end users. Therefore, HNS has been realized with an integration of features of multiple appliances. However, to integrate services still has several challenges that a providing of a composed service considering of a policy influences to composite services because an element of the composed service are dynamically changed by priority of the policy. In this paper, we proposed the dynamic service composition using semantic ratiocination on integrated home network system. Our research provided the solution to semantically decide a service element, which is dynamically changed according to a service objective with considering the priority on the ground of the policy. Moreover, our system is able to include an external ontology model by importing its name space. Such distributed development of a service model will improve scalability of the service model.**

***Keywords*-Service Composition; Semantic Ratiocination; Home Network Service.**

I. Introduction

For more than a decade, ubiquitous/pervasive technologies allow general household appliances to be connected within the network at home[1]. Since a number of researcher have tried to provide these environment as their own field such as Universal Plug and Play (UPnP) [3][2], Digital Living Network Alliance (DLNA) [4], Open Services Gateway Initiative (OSGi) [5] and Energy Conservation and Home care Network (ECHONET) [6]. HNS is comprised of such networked appliances to provide various services and applications for home users. Therefore, HNS has been realized with an integration of features of multiple appliances. Especially, providing integrated services to end-user with briefly establishment of the appliances has been considered for actualizing ubiquitous home network environment.

A service (or application) composition method for integrated service in HNS can be divided into two approaches: Proactive (Static) service composition, and Reactive (Dynamic) service composition[7]. For example, ICARIS [8] and eFlow [9] proposed a template based dynamic service composition system that supporting applications involving complex interaction patterns such as conditional branch or iteration which is problem with static service composition.

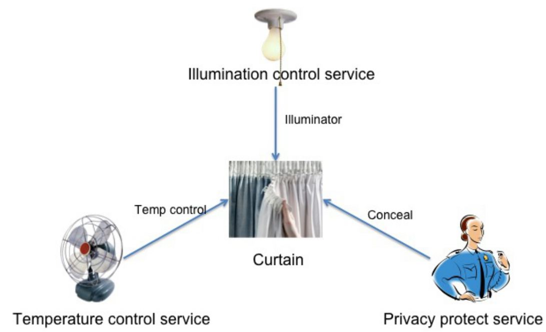

Figure 1. Example of services on semantic considering

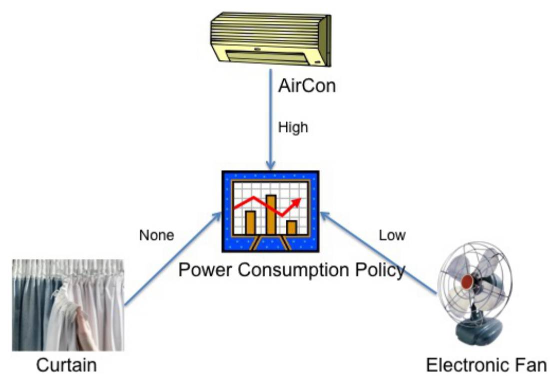

Figure 2. Example of services with policy

Since the dynamic service composition does not depend on a human to compose a service, it may have difficulty in composing services. To compose a service dynamically

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without a manipulation of the human, an agent has to understand a meaning of an objective of the service that the agent would provide. In addition, the agent need to recognize what possible service does it has semantically for composing the service.

To solve these problems, Ninja [10] and SeGSeC [11] created an execution path from a user request by performing interface matching based on semantics. These solutions are considered how to matching the interface between services. However, fundamentally, the dynamic service composition in the home network system is needed to perform flexibly depend on home environment.

Imagine the scenarios illustrated in Figure 1. Providing a temperature control service with cooling, when an air conditioner is stopped with trouble, the agent has to decide substitution such as electric fan, window and curtain even these substitution can't reach to target temperature. In this case, the agent has to understand that the curtain can cooling a temperature by excluding a solar heat. As illustrated in Figure 2, If the agent need to consider a policy of the power consumption during provide the cooling service, priority of possible service is changed to the curtain before the air conditioner.

These dynamic service compositions using the semantics are need to resolve number of general issues that the ontology engineering has, suitable definition every notions, representation of extremely diverse relationship between components and optimization of a reasoning engine. Nevertheless, the dynamic service composition has the potential to provide flexible and adaptable services by properly selecting and combining components based on the user request and context.

In this paper, we proposed the dynamic service composition using ratiocination on integrated home network system. Our research provides a flexible service composition in various home environments by making the system to semantically understand an objective of a service. Moreover, it is possible to realize extendable services and priorities, since these semantic descriptions can be built separately in their own area by a name space. In the rest of this paper, Section II gives background of characteristic of a home appliance and brief of proposed idea. Section III discusses our system model about service representation and process annotation. Section IV describes our simple experimental result and Section V gives our conclusions and discusses future works.

II. Background

Recently, functionality of an appliance has been composed by one or more process. Moreover, these processes are possible to used as one by one for other service by defining an interface of each process as showing Figure 3. It means that an agent, which is centralized management system, can use these independent processes to compose (or de-compose) virtual service. For example, the agent can use temperature sensor that is included in air conditioner for measuring the temperature of a room.

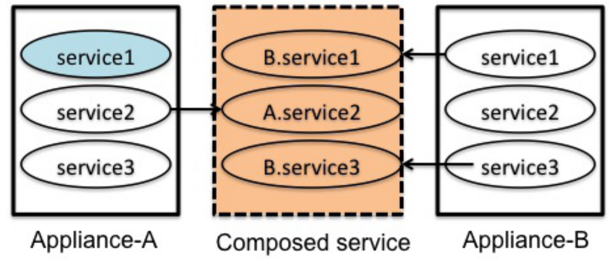

Figure 3. Example of the Service Composition

As we mentioned above, the appliance can provide multifunctional service according to an objective of a service. However, to provide service automatically, the agent need to understand a meaning of these service, since the home appliance may have different meaning depending on service objective. For example, the curtain could be included in illumination service, temperature control service and privacy protect service. Another important issue is that a priority of the service is changed by policy. As we consider air condition service with energy consumption, an electric fan or curtain consumes less energy than an air conditioner. However, as considering of capability, the air conditioner may have higher priority than other elements. Hence, the agent needs to understand various policies as many as possible and decide a service according to the policy.

To solve above challenge, we need a knowledge based machine-readable service representation because the agent need to understand a semantics of services and a relation between services. Also, we need to consider a decentralized development setting for defining many of a political matters.

Basically, our system considers that providing a flexible service composition in various home environments as follow.

- Semantical service composition – understanding an objective of service
- Policy based composition – composed element could be changed depend on policies
- Robust to an environment variation – when an element in composed service is stopped, substitution could be found

III. System model

Architecture of our proposed system is shown in Figure 4. First, the agent registers the information of atomic process that can't be divided any more from appliances to the process registration. These atomic processes have an information that is a process description and resource type of input/output. Secondly, when the agent gets request with composing service, the service composition decides what elements will be used based on the semantic representation. Finally, the

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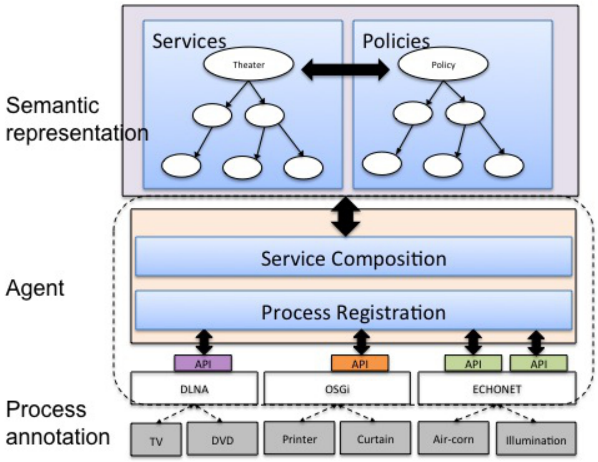

Figure 4. System Architecture

semantic representation defines services semantically using ontology modeling. The service model provides to consider with various policies as importing the policy model. In this section, we discuss specifies of our system. Especially, it'll be focused on representing relations between services and policies.

Figure 5 is that describes the system flow of the service composition module. The service composition module maps a service model with policy by including outside models. When user requests service composition, the service composition module queries with several conditions such as temp, cooling and energy saving. Obtained elements from the mapped service model will be matched with process information from the process register. Finally, process register provides process list to service composition.

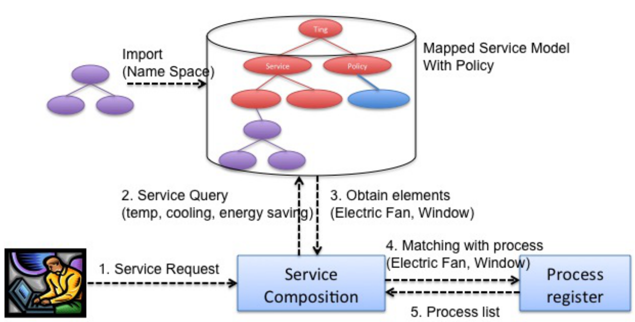

Figure 5. System flow of the Service Composition Module

A. Semantic Service Representation

To define services semantically using ontology modeling, we used a web ontology language (OWL) that is designed for use by applications that need to process the content of information instead of just presenting information to humans[12]. We discuss how to build the service model within a temperature control service as a representative service in this section.

1) Modeling the service structure: As a service structure modeling, it's needed to describe property that service has. For example, temperature control service has a temperature control descriptor as a property. The temperature control descriptor has subclass of functionality of temperature as follow.

- Heating : High, Low, Variable
- Cooling : High, Low, Variable

In addition, the service structure model has information of relation between services. For example, the possible services to use for temperature control are an air conditioner, electric fan and window.

2) Modeling the Services: In the service modeling, the services are represented by their features. the service has property within the service descriptor that is described by the service structure model. For example, each service has property of heating and cooling capability as follow.

- AirConditioner
  - Heating Capability High
  - Cooling Capability High
- Electric fan – Cooling Capability Low
- Window – Cooling Capability Variable

3) Modeling the Policy: As we mentioned before, providing service with considering the policy is influence to composite services because elements of composed service are dynamically changed by priority of the policy. The problem is that only one system could not define much kind of these policies. We believe that ontology will solve the problem by importing a policy, which is already defined. Hence, the policy model provide various point of view to understand services such as following example of power consume policy.

- AirConditioner – High Consumption of Power
- Electric fan – Low Consumption of Power
- Window – None Consumption of Power

B. Services annotation

To annotate a process of appliances, we used an OWL-S (semantic markup for web service) that is an ontology of services that makes these functionalities possible[13]. The OWL-S provides to discover, invoke and composite a web service. However, there is a difference of a characteristic between the web service and home network service as shows follow.

- Appliance has an area of effect or not
- Service has occupancy or not
- Service has depended on capability of a device

When the agent composites a service, service's area of effect has to be defined, since some appliance provides only limited area such as display service or cooling service. These services have another characteristic of the occupancy.

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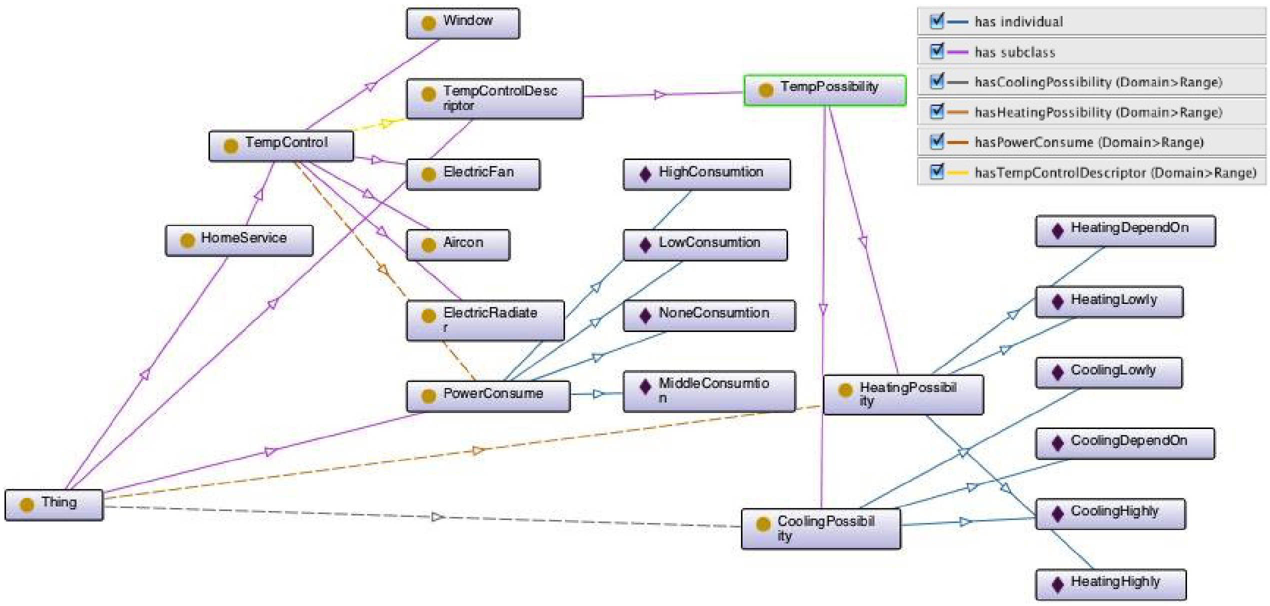

Figure 6. Description of the Serivce Model

For example, if agent already used display service, other composited service cannot use it. Finally, the appliances have their own capability of process. When the agent decides element among atomic processes that performs as same functionality, the decision will be capability of an appliance.

IV. EXPERIMENTAL RESULT

We have designed and built a simple prototype to demonstrate the reasoning of services elements using semantic service representation. To build an ontology modeling of service and policy, we used the protege that is open-source platform to construct domain models and knowledge-based applications with ontologies. In addition, for reasoning, we used the FaCT++ that is the new generation of the well-known FaCT OWL-DL reasoner. FaCT++ uses the established FaCT algorithms, but with a different internal architecture.

As an experiment, we gave two different queries to find a service element as a scenario. 1) The agent semantically finds the service elements that are can provide cooling the room as illustrated in figure 7. 2) The agent considers an energy saving policy while providing same service with 1) as illustrated in figure 8. We defined number of services such as window, electric Fan, Air Conditioner and Electric Heater as the service model. In addition, we defined the policy of power consumption about appliances.

In case of 1), the reasoner searched possible elements

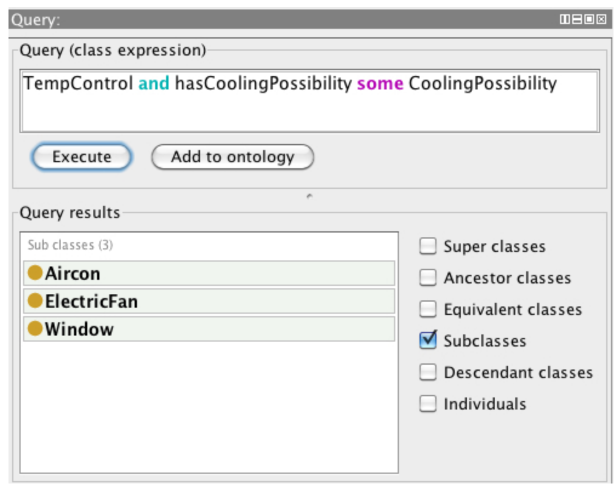

Figure 7. A result of the temperature control serivce

such as Air Conditioner, Electric Fan and Window. Since the window represented its functionality on the semantic, the agent could infer that the window has functionality of the cooling. It's meaning that agent can understands diversified functionality of services according to the service object.

As a result of case 2), we can see that Air Conditioner is excepted in query results by considering of power consumption. Thus, a priority of service elements could be

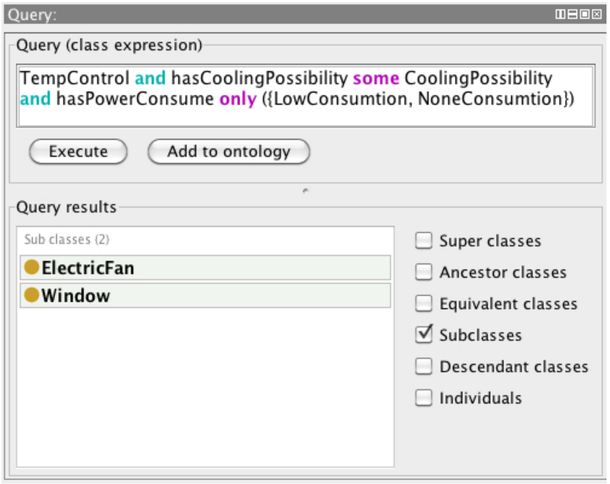

Figure 8. A result of the temperature control serivce with the consumption policy

changed by considering the policy. We believe that our system provides to infer a relation between services and policy.

Since there are many semantic representations according to services, to represent all meaning in a single representation is actually impossible. The name space of ontology solves such problems by combining the different ontology model. Our system is able to include an external ontology model by importing its name space. Such distributed development of a service model will improve scalability of the service model. In the near future, a distributed environment for developing home service is going to be needed by service provider. Our system provides a platform to deploy a service that was made by an external service provider into the home network environment smoothly.

V. Conclusion

As we discussed, service composition needs to dynamically change according to service objective and various policies in the home network environment. In this paper, we proposed the dynamic service composition using Ratiocination on integrated home network system. Our system provides machine-readable service representation to understand the semantics of services and the relation between these services. It is also possible to provide a distributed developing environment using a name space.

We believe that our research provides the solution to decide a service semantically according to service objective considering the priority on the ground of a policy. Furthermore, since there are many semantic representations according to services and policies, to represent all meaning in a single representation is actually impossible. The system that used an ontology model can solves the challenge by importing the policy model from external service providers.

However, we still have several challenges such as suitable ontology mapping between policy models and service models, automated collecting of a policy which is needed when agent decide a service.

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