國立交通大學

資訊管理研究所

博 士 論 文

以使用者共識為中心的服務導向塑模方法-

以智慧環境為例

A User Centric Service-Oriented Modeling Approach: A Case Study on Intelligent Environment

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中 華 民 國 九 十 九 年 十二 月

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中文摘要

隨著服務導向架構與雲端計算的蓬勃發展，網路服務已成為網際網路趨勢。而服務品質對於服務的使用者來說則一直是很重要的課題。如何選擇服務對於非功能性的服務品質則可以被視為一個多目標決策的問題。本研究則是提出一個以使用者為中心的服務導向方法，利用模糊理論與理想解模式進行使用者共識的計算，將其與服務元件架構結合，用以處理網路服務的選擇，使其可以同時滿足多個使用者的需求與偏號，並且將其應用在動態的環境。服務的使用者可以利用語言變數輸入對於服務的評價與偏好，本研究透過轉換成模糊集合表示之，並利用共識積分將其轉換成數值後，再進行共識的計算。而服務元件架構則是用來將這些計算方法、軟體、硬體可以快速的結合在一起，提供一個良好整合的平台與環境。

本研究以設計一個智慧環境為案例場景，以冷氣服務、除溼服務與燈光服務為評估的對象，讓使用者對於不同的溫度、溼度與亮度進行案例的評估，以得到群體使用者對於舒適度最大共識下的設定值；本研究並利用一個 8*8 的 LED 模擬服務執行的場景，用以證明服務的選擇與執行可以透過服務元件架構良好的結合在一起。在成熟的資訊通訊技術發展上，可以降低資訊系統建置的複雜度與異質環境整合的難度。我們也將成功利用的將本研究所提出的方法應用到一個智慧節能的計劃之中，該計劃是利用資訊通訊技術(Information Communication Technology, ICT)將家庭用電狀況搜集後，利用感測器搜集資料後利用 Zigbee 網路傳回資料中心，經過分析後給予使用者在使用家電設備時的建議，提供使用者對於節約能源的共識形成有一定的助益。

關鍵字：網路服務，綠能資訊通訊科技，服務決策，群體共識、服務組合架構

A User Centric Service-Oriented Modeling Approach

- A Case Study on Intelligent Environment

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ABSTRACT

With rapid development of service-oriented architecture and cloud computing, web services have been widely employed on the Internet. Quality of service (QoS) is a very important criterion for service consumers to measure and select services. The selection of web services with respect to non-functional QoS criteria can be considered as a multiple criteria decision making (MCDM) problem when multiple consumers need to share a service. This study presents an evaluation method based on the technique for Order Preference by Similarity to an Ideal Solution to help service consumers to select web services in a fuzzy environment. The linguistic variables, parameterized by triangular fuzzy numbers, are used to evaluate the weight of various criteria and the ratings of each alternative web service. Then the fuzzy TOPSIS method is employed to transform the linguistic terms into crisp numbers and obtain the preference order of available alternative web services.

*This paper describes a framework which is featured by integrating fuzzy TOPSIS and service component architecture to facilitate web service selection and to effectively satisfy a group of service consumers' subjective requirements and dynamic preferences on a cast study on intelligent environment. The proposed framework is also able to re-aggregate users' feedback on the services which are air-condition, dehumidify, and lighting service. User could evaluate these services and find out the group consensus. We also design a simulated environment that includes 8*8 LED matrix on a circuit board that corresponds to an office with different appliances to demonstrate the dynamic service selection and binding. The simulation is used to assess the computational efficiency of the fuzzy TOPSIS method and the flexibility and efficiency of the proposed system. We also apply the proposed method into a project of ICT for energy efficiency. It not only collected electronic current but also analytic the status of power consumptions from data center by ICT. It helps users to form the consensus on energy-saving and service-using.*

Keywords: Web Service, Green ICT, Service Selection, Group Consensus, Service Component Architecture

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本論文得以順利完成，首先得感謝我的兩位指導教授－羅濟群教授(台灣)以及趙國銘教授(英國)於研究過程中的悉心指導。在就讀交通大學碩、博士的修業過程中，感謝羅濟群教授一路上的教導，使我在研究方向的規劃、研究能力的養成上能有顯著的進步；在專案開發、研究計劃的經驗，為我累積了許多技術上的基石，並鼓勵我旅英進行研究，給我長足的時間與空間，使得我能夠有愉快且充實的國外求學經驗。

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Content Index

Table Index

Figure Index

Chaprt 1. Introduction

In this chapter, research background and motivation of the dissertation, and organization of the dissertation are introduced.

1.1. Research Background

With rapid advancement of service-oriented architecture (SOA), the use of web services has made rapid growth. The advantages of Web services are highly interoperable and loosely coupled software components which can be published, located, and invoked on the web. The growing number of Web services available within an organization and on the Web raises the new challenge in search problems which involve service discovery [20], service selection [58], and service composition [9][10] [41] [58][59]. Three layers of SOA depict as Figure 1.

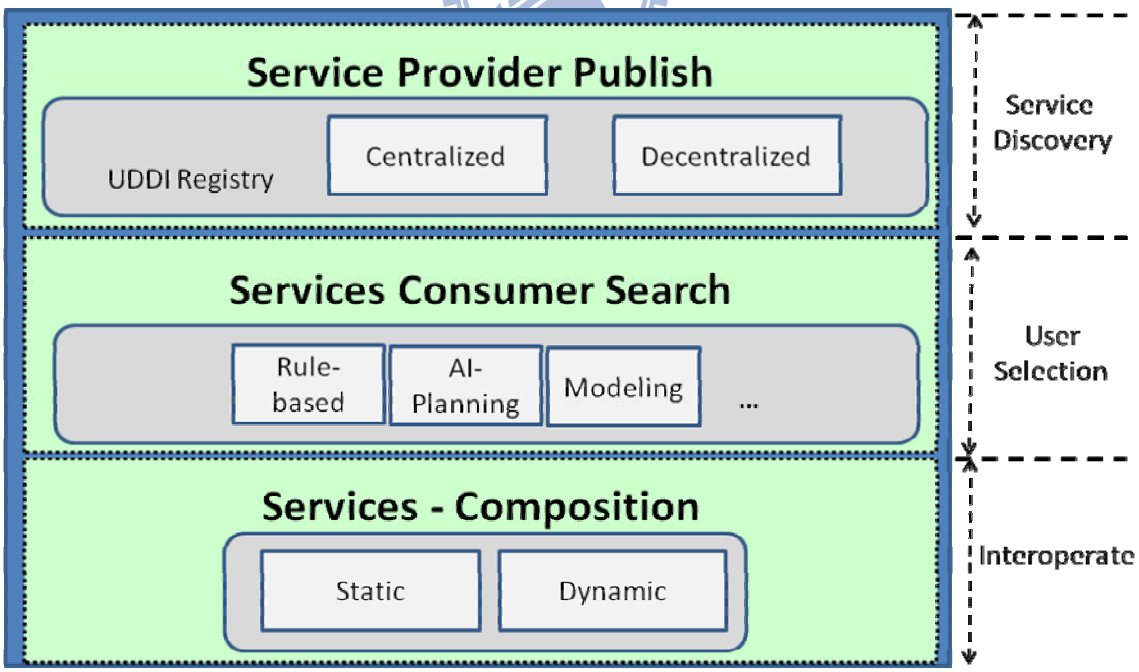


Figure 1 Research background of SOA

Therefore, service discovery allows service providers to publish service profiles and descriptions in UDDI repositories that store information about businesses, services and other related details. Efforts in this area focus on providing rich and machine-readable representation of service properties, capabilities, and behavior as well as reasoning mechanisms to support automated discovery. Service composition is a process to compose selected services in a logical way to meet the user requirements which can take place at the design time or runtime. Most services are designed as loosely coupled components to increase their independences. The relationship among the services is determined and established at the composition process. In other words, a number of services can be composed as a composite service to provide required functions.

In this study, we discuss the scenario of energy consumption and environment setting issues. Group of people face the problems which need to decide the setting of environment such as brightness, temperature. They would encounter a dilemma which is turn on/off the air-condition or how to set the temperature. The decision making of group people sometimes is hard to making while the choices exist trade-off. Especially, tackling global warming, improving resource management, and reducing carbon are the global challenges that need addressing and treating urgently. Many researchers and organizations mentioned that how the Information and Communication Technology (ICT) effects Green policy and action. Here, we use the ICT instead of Information Technology to represent the idea of Green IT.

However, one of the major issues raised by ICT systems concerns the connection of people and technology. Web Service provides modeling, implementation, and integration. Green ICT is becoming most development direction in industry associations, research issues, and government for reducing negative environment effect. In this research, we will proposed a user centric service-oriented modeling

approach in order to conquer the difficulty between users to decide the environment configuration which is multiple criteria decision making problem, and give a case study on intelligent environment.

1.2. Motivation and objective

Smart home or environment often involves numerous hardware devices and software components to sense and control the environment. The integration of these devices and components is an important task. The communications and interactions among sensors, objects, and human participants, however, are inherently complex, as they often involve different protocols and languages. It can be viewed as configuration problem that requires various components to work together in cooperative and coordinated manner in order to produce an optimized environment to meet the system and user requirements. Service-Oriented Architecture (SOA), which offers a way to view sensors, objects, participants as services, can provide an effective approach to improve their communication and coordination, so the human participants can effectively interact with the system and offer their opinions and preferences through a coherent technology. SOA could be a potential approach to maximize users' satisfaction degree, and minimize the cost of software design, implementation, application installation, and system maintenance.

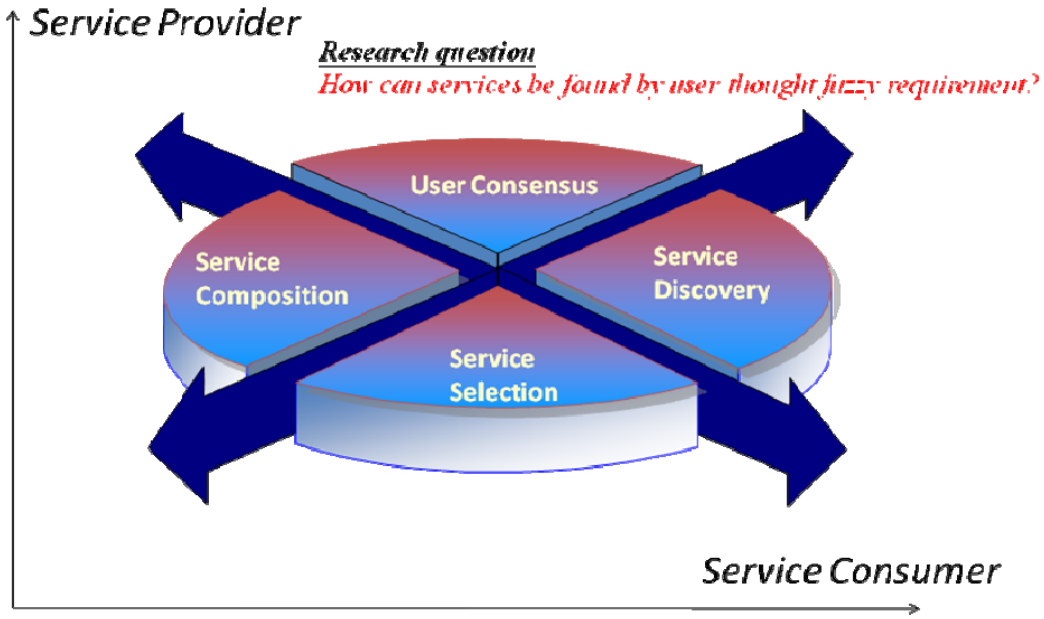


Figure 2 Research objective of this study

A web service, a supporting technology for SOA, can be invoked and executed by a number of consumers simultaneously. Most service discovery and recommending systems recommend a list of services according to the functional and/or non-functional requirements given by service consumers. Thus, the service consumer can choose the best one. This kind of cases is based on an assumption that the cardinality between an instance of service and a service consumer is built upon one to one relationship. However, in some cases such as smart environment, an instance of a service needs to serve a number of consumers. In other words, an instance of a service needs to meet various requirements specified by different service consumers. It, however, can be very difficult to design a service when conflicting requirements occur. For example, the staffs in one office use a collection of the same devices or functions provided by the system. Each function is intended as a service such as light service, air condition service, heating service, and ventilation service, etc. Service consumers could have different preferences or requirements on the services such as room temperature. Some users may subjectively feel hot for the current room temperature, but some may feel cool or comfortable. How to set the temperature for air condition/heating service according to these consumers' preferences can be a challenging issue. A system would encompass the capacities such as group consensus reaching mechanism to improve system adaptability.

1.3. Research approach

In this research, four research steps are adopted to solve the problems of service composition mentioned above. These are described as follows:

(1) Overall literature review: reviewing the existing works about the Web services, Web services composition, Service Component Architecture (SCA), Enterprise Service Bus (ESB), and the tools for realizing these concepts.

(2) Research concept: we present an evaluation method based on the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) to help service consumers to select web services with fuzzy user requirements involved. The linguistic variables, parameterized by triangular fuzzy numbers, are used for evaluating the weight of various criteria and the ratings of each alternative web service. Then the fuzzy TOPSIS method is employed to transform the linguistic terms into crisp numbers and obtain the preference order of available alternative web services.

(3) Architecture development: the proposed framework including Service Component Architecture offers a coherent systematic process and approach to model heterogeneous hardware and software components as services in order to increase flexibility for system configuration and organization in a dynamic environment.

(4) Architecture verification: the proposed approach will be tested through the experiment in this study which demonstrate a case study of intelligent environment. We designed 8*8 LED matrix on a circuit board to simulate an office with different appliances to demonstrate the dynamic service selection and binding.

1.4. Thesis outline

This paper is organized as follows. Section 2 reviews the background and related works. Section 3 concentrates on a number of definitions of fuzzy sets theory which are utilized and presents the fuzzy TOPSIS method in this study. Section 4 provides an illustrative example to clarify the application of the fuzzy TOPSIS method in the problem of selecting QoS-aware web services in order to find out the group consensus on environment setting. Section 5 gives a case study and describes the simulation which shows the services binding and execution by means of a LED matrix device. Performance evaluation and extended case study and are presented in Chapter 6. Concluding and future work are given in Section 7. Finally, the reference are attached at the end of the thesis.

Chaprt 2. Literatures Review

In this chapter, first review the characteristics and related works of Green ICT and Service-Oriented Architecture. We then review web services. Moreover, we discuss some service composition problems which may happen to SOA. Furthermore, a review on the existing approaches on web service selection and an analysis on their pros and cons will be reported. Then, we illustrate a number of group decision making methods that can assist users in reaching consensus. In the end, we introduce the Service Component Architecture for service modeling and composition as well as Enterprise Service Bus for service management and service transportation. This paper also offers insights on these issues from the multiple perspectives of development in industry and research in academic.

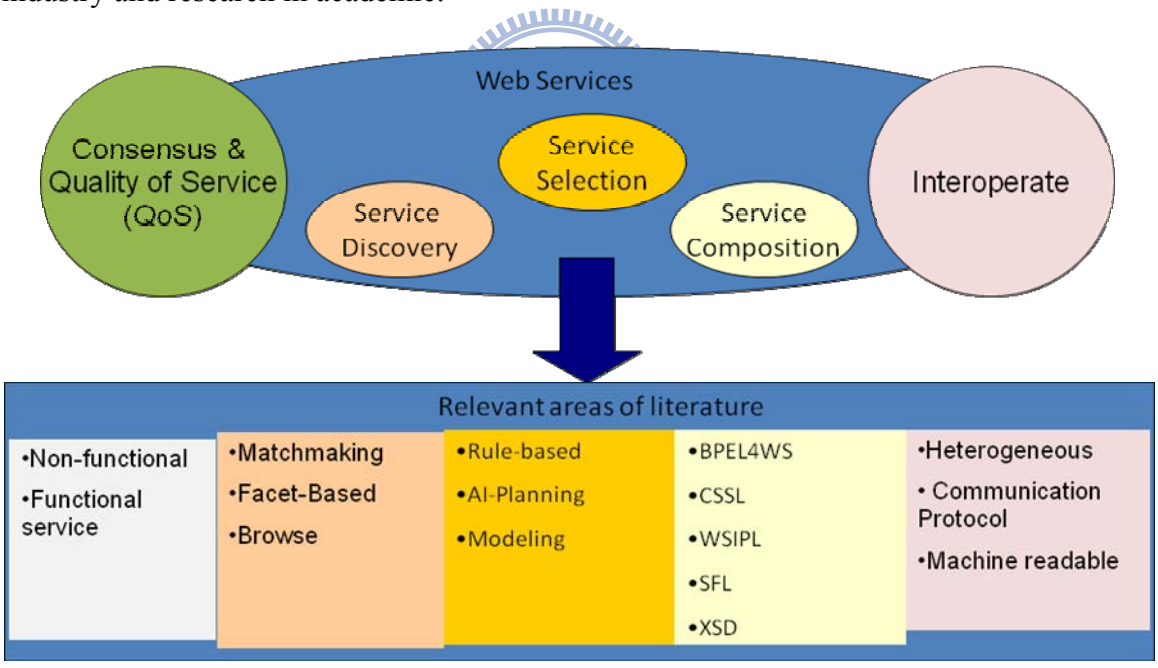
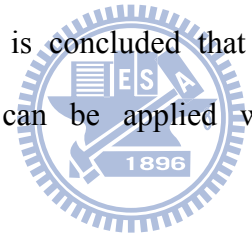


Figure 3 Relevant areas of literature

These surveyed researches will be introduced respectively as follows. This chapter is organized as follows. Section 2.1 introduces the Green ICT. Section 2.2 describes Green ICT and SOA. Section 2.3 discuss the research background on web service selection. Section 2.4 focus on service composition.

2.1. Green ICT

In this section, we review the current state-of-the-art in the field of Green *Information Technology* (IT), reports several issues and future research directions. The materials used to conduct this research include journal and conference papers, research projects and websites etc. This work can help the readers to have better understanding of Green IT, and to show how other related technologies can address the challenges of Green IT. *Information Communication Technology* (ICT) and *Service-Oriented Architecture* (SOA) have gained attention in recently. Service-oriented approaches are used for developing green applications and energy-saving that can be sourced as resource. What new conceptual frameworks and theoretical perspective are appropriate for studying *Green ICT* (GICT) and service-oriented technology? It is concluded that a more predictive and feasible design/implementation, which can be applied within a service-oriented GICT application.



"Green of ICT" is interested in developing technologies and methods to increase efficiency in ICT energy usage without compromising its performance and Quality of Services. Green of ICT is also known as green computing. It involves different stages of ICT life cycle from hardware system design, manufacturing process, and component maintenance to disposal of computers and their recycling methods. ICT products could be computers, servers, and associates subsystems-such as monitors, printers, storage, network devices, and communications system. Some research projects focus on software design to make use of computers as energy-efficient as possible by developing efficient algorithms, removing unnecessary processes in software flexible resource allocation and effective power management.

The development trends of Green of IT in industry include:

1. Substitution CRT with LCD: the substitution of old CRT (cathode-ray tube) with LCD (liquid crystal display) can gain significant efficiency in energy usage and the introduction of long-lift OLED (organic light emitting diode) will enable further improvements.

2. Virtual IT and Organization: the virtualization technologies can reduce the number of physical devices to be deployed and increase the level of their utilization. Virtualization such as data-centre will enable significant reduction in the number of deployment for both servers and storages while end-user devices can be consolidated.

3. Green Computer Room/Data centre: energy efficiency solutions and approaches for design of a data centre can improve organization's capabilities such as virtualization, automation and orchestration. The approaches could include reconfiguration of aisles to a hot/cold aisle layout, the introduction of pod style enclosed units, having localized cooling solutions for hotspots, adopting thigh performance workloads and making use of free cooling through outside air.

4. Label of energy-saving mark on IT facility: label of energy-saving are the widespread instrument in many country of the world, such as United States, Canada, Australia, United Kingdom, and New Zealand. In the United States and EU, ENERGY STAR label indicates the energy efficiency of ICT equipment to enable users be aware of their efficiency.

5. Recycle and process on IT facility: parts of IT facility may contain some polluting substances. It is important to have appropriate procedures to deal with them during the processes to protect the environment from contamination. So, it does not only consider the main production phases in life cycle namely R&D, manufacturing, use, and disposal, but it also needs to focus on the recycle of computers.

"Green by ICT" stands for using ICT to reduce environment burden, which are applying ICT into various fields and application is to reduce the energy and resource

consumption, and minimize CO2 emissions by using sensor networks or other technologies to offer a sustainable environment. The applications of “Green by ICT” include: Smart City Planning, Smart Grid, Smart Logistics, Food miles, Smart Building, Renewable energy power, Virtual IT, Smart Working, Optimization on power saving, Smart Transportation, Smart Car, Smart Monitor, and Smart logistics etc. Green by ICT has very diverse and broad applications.

Green ICT is a research and application area involving multidisciplinary technologies and concepts such as including automation control, communication and networking, computing, and distributed and embedded system etc. With the rapid development of Green ICT, numerous applications related with these issues have been envisioned. Later, we will give further discussion of the research directions with these applications.

Energy efficiency is increasingly important for information and communication technologies (ICT), because of the increased usage of ICT, together with increasing energy costs and the need to reduce green house gas emissions that decrease the overall energy consumption. Green ICT could affect our lives on various degrees and aspects depending on to the scope of applications such as green city, green building, green office, and green home which could change the way we work and live. EU has great interests on the concept of Green ICT by initiating several research programs to explore new research agendas. We give more descriptions and discussions on smart city, smart building, smart office, and smart home respectively in the following sections.

Most modern cities face the issues related to traffic jam and huge car flow. Traffic management system uses ICT such as sensor, camera, and traffic light control to smooth car flow or reduce traffic volume by adopting Intelligent Transportation System (ITS) technologies which could change the public’s behaviors of using

transports. The public would prefer taking public transport to private car. For examples, the introduction of a real-time road pricing system can make the private car drivers aware of the true cost of usage which is usually much higher than the public ones. ITS road systems can operate the traffic more efficient by funneling traffic via dynamic speed limits and traffic signals to route around congestion. Furthermore, people can search location-based services such as restaurants and shops, real-time traffic reports, smart electrical grids on smart phone through 3G network from Internet in order to reduce unnecessary journeys.

The needs for transportation are growing, as globalization logistics becomes a phenomenon. The logistics activities comprise package, transportation, storage (inventory management), buying, and recycle. As the concerns for the environmental issues rise, firms need to take more into account of the cost associated with reduction of energy consumption and environment pollution in order to reduce its impact on climate change. The green logistics has also received strong research interests from the communities such as Green supply chain, Green purchasing and food miles. By using ICT in logistics, firms can minimize the package materials, the volumes of stock, energy consumption, and mileage to achieve more sustainable balance economic and environment.

From previous discussion, there have been numerous studies in the literature dealing with the diverse of applications. There is considerable disagreement among systems about the design and implementation of the Green by ICT applications. Some practical project have been reported that are based on the concept of wireless sensor network (WSN) and web services. In the following section, we will describe the problems in Green ICT system ,and rethinking how to solve these problems.

2.2. Green ICT and SOA

Green ICT is formed by numerous components such as operation systems, database systems, sensors, control systems and communication protocols facing a set of challenges in integrating and coordinating these heterogeneous systems, enabling technological agility and reducing the complexities of their development platform. The activities involved to address integration challenge include alleviate the barriers caused by heterogeneity in transmission protocols, hardware platforms, and execution processes. Moreover, inconsistent data, incoherent control signals between devices and software system, and tightly-couple programs have increased the difficulties in integration. Also, inconsistent information and data formats between sensors make development tasks harder for developers to design green systems.

To manage those above challenges, system designers and programmers need to adapt service-oriented architecture approach to the design of system structures, models, processes, and operations. Service-Oriented Architecture is a process-centric and component architecture rather than a program-centric IT architecture. Service-Oriented Architecture offers a practical and viable approach to model and assemble services in response to users' needs. The combination of Service-orientation and Green ICT, a new trend of ICT architecture, becomes a new paradigm for producing loosely coupled and flexible Green application systems. In this new paradigm, all the components, regardless hardware devices or software modules, are considered as services, so the traditional tightly coupled software and hardware components can turn into loosely coupled services.

2.2.1. Heterogeneous

There are several impediments to widespread, heterogeneous data and knowledge fusion. While integrating heterogeneous information system, it could be difficult to deal with three type of problems which are technical, data model, and semantic heterogeneity. We give the detail of challenges in following.

1. Technology Heterogeneity

It means that the data in the process of exchange and transmission needs to consider the difference in stored location, file format, and data type, programming language, or platform.

2. Data Model Heterogeneity

Data model heterogeneity, also known as schema heterogeneity, is another barrier for enabling system interoperability. This occurs due to using incoherent data representation, column naming, and data types in the multiple databases. Many researchers tried to convert different local schema into a global schema which contains a common consistent data model. The existing approaches lack systematic intelligent automatic schema mapping mechanism to ensure that the schema conversion can be carried out efficiently and effectively. The task is a time and resource consuming process, as schema designers may need negotiation to produce a compromised solution.

3. Semantic Heterogeneity

Semantic heterogeneity could result from conflicting data naming, incoherent interpretations on data meaning and data content.

2.2.2. Communication Protocol

The mainframe systems such as the IBM System/360 series which were used mainly for bulk data processing first introduced in the 1960s. One of the main critical mainframe applications was to provide sufficient computational functions for businesses such as enterprise resource planning, and financial transaction processing. The computation result is stored in tapes which are mass storage devices. The availability of communication and networking infrastructures and the mature technology for real-time interactions between systems, real-time trading transactions across companies in the finance markets can be realized. In the beginning period, real-time access was accomplished through socket. Over time, Network File System (NFS) and File Transfer Protocol (FTP) protocols emerged that abstracted out the complexity of sockets. After that, "middleware" software was designed to deal with messaging and communications between servers or peers. Eventually, the ability of applications to compute in distributed environment became feasible through remote procedure calls (RPCs).

The technology coupled with the growing maturity of network enabled many kinds of functions to be called by remote computers. By the 1980s, personal computers had not only widely used but also its computing power exponentially increased. While the price of hardware came down, the number of servers increased significantly. These trends led to two important progresses in distributed computing. In January 2000, the Simple Object Access Protocol (SOAP) based on eXtensible Markup Language (XML) was introduced. It supported system communication to facilitate a much higher degree of interoperability between programming languages.

After that, Web service which was defined by the W3C provided a standard means of interoperating between different application systems over the SOAP protocol with

an XML serialization. Service, an abstraction which encapsulates software to provide functions, is the basic concept in SOA model. Developers can aggregate these services to develop solution for business needs. The evolution of integration between heterogeneous information systems is depicted in Figure 4.

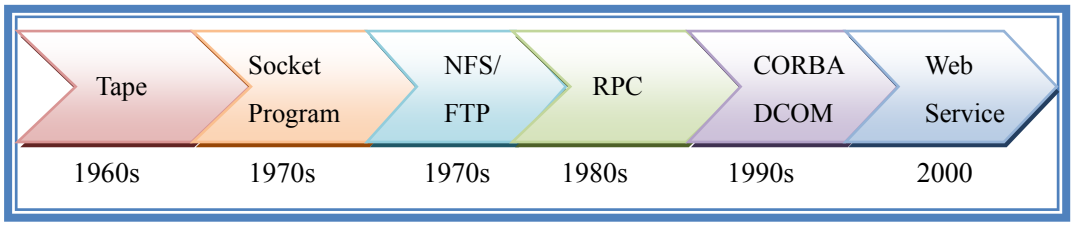


Figure 4 Evolution of integration between heterogeneous information systems

2.2.3. Machine readable

Green application systems need to take advantage of environmental information to enhance the interaction with the user. For example, environment monitor applications should be able to deal with fusion of multi-sensor data. Sensor data cover multiple aspects of the environment, such as the location, identity, temperature, humidity, pressure, brightness, activity and state of people, groups and objects, and so on. Many of the captured data are analogous in nature making the chance of finding a specific term quite good. However, the integration of heterogeneous sensor data into a single system can be difficult.

One of key characteristics that green applications should possess is the ability to acquire information from heterogeneous sources, perform context interpretation and carry out dissemination of context to interested parties. Each device or subsystem in the application might contain a set of variables to accommodate raw data about its surrounding environment sent by sensors or other devices. It, however, lacks a well-developed mechanism for defining sensors, their attributes and classifications. It also does not have a standard high level language to prescribe the required inputs and outputs as well as to control their actions.

Green applications acquire information from surrounding environments through sensors or from other information systems where the events take place. It needs to establish an information and knowledge level of collaborative grid among green computer systems to share and reuse machine-interpretable conceptualizations to maximize their utilities. The realization of semantic web and ontology is one of most promising approaches to meet this need.

There are a number of languages available for representing the concepts in ontology e.g. RDFS (Resource Description Framework Schemas), OWL (Web Ontology Language), and OWL-S. Ontologies provide end-user service and ICT

support system developers a common base for efficient and effective services definitions as well as integration and utilization of ICT systems and resources. Therefore, a solution to integrate the data from multiple sources or interpret the semantic of heterogeneous sensors with different capability is needed in green application systems. To support these tasks in a context-awareness system is needed and more often it is based on ontologies that enable reasoning automatically and efficient knowledge sharing from traditional stand-alone systems to the highly distributed green ICT system.

There are many standards and middleware equipped with different protocols such as Java Intelligent Network Infrastructure (JINI), Home Audio/Video Interoperability (HAVi) and Universal Plug and Play (UPnP), and Open Service Gateway Initiative (OSGi) for connecting heterogeneous systems. JINI, however, cannot directly interact with some devices such as TVs due to lack of HAVi. Although it can use a service gateway to control and connect different appliances, it leads to different levels of difficulties in usage and maintenance. These technologies offer different alternatives for interconnecting heterogeneous devices and services. UPnP supports ad-hoc networking for devices and services, and it is easy to develop. OSGi specification defines a service framework to support multiple Java based devices to run collaboratively, so a new device can be easily added to an executable environment using plug-play technology in order to increase flexibility and dynamics of a system.

1. Remote Method Invocation (RMI)

Remote Method Invocation (RMI) is a Java application programming interface that is equivalent of remote procedure call (RPC). RMI enables a client to obtain a reference of the remote object and to execute it. RMI with IIOP protocol provides the core interfaces and mechanisms for the client and server to communicate through stub and skeleton objects. Even though it has naming service to search the required objects,

semantics for naming service is not supported. Besides, it only supports interoperability between JVMs, non-Java embedded systems have difficulty to participate.

2. CORBA

CORBA, proposed by OMG, provides technical standards for integration and collaboration for heterogeneous application systems. Distributed software based on CORBA objects can increases its reusability and expandability. Many researchers take the advantages of these features to develop middleware environments to support large scale distributed applications. The Interface Description Language (IDL) is a programming language independent specification to describe the interface for client and service communication, so CORBA supports multiple languages and platforms. CORBA was widely accepted technologies by academic and industry communities, but it lost its popularity due to its complexity and industry commitments.

3. JINI

JINI based on the Java technology was developed by Sun Microsystems for spontaneous services and resources networking. JINI provides the ability to assemble service component and cope with distributed computing.

4. HAVi

Home Audio Video Interoperability (HAVi) is a standard specification for connection, communication protocols and APIs that allows Audio and Video hardware products from different vendors to be networked together and controlled from one primary device. HAVi offers plug-and-play capabilities for smart home configuration and it models home networking services as software element. Each object has a unique name and identifier. Objects use messaging to request services from other objects. The advantage of HAVi is that it can bridge with JINI to extend its greater services. The problem is that the actual message passing may differ between vendors.

5. UPnP

Universal Plug and Play (UPnP) is Microsoft peer-to-peer networking initiative. UPnP supports ad-hoc networking for devices and services, and it is easy to develop. Further, it has minimal configuration requirement, and its automatic discovery process uses IP address which is compatible with the existing protocol such as TCP/IP, UDP, HTTP and XML, so a device can leave the network smoothly and automatically. Both controllers and devices can be implemented on a variety of platforms including personal computers and embedded systems.

6. X10

Power-line networking is increasingly becoming an important component for home networking systems. X10 is a standard for communication among electronic devices which are used for home automation using power-line wiring for signaling and controlling. It belongs to horizontal integration between physical devices.

7. OSGi

The protocols mentioned above are not compatible with each other due to their design, so without introduction of extra mechanism to them the communication among them is impossible. The Open Services Gateway Initiative (OSGi) is a universal middleware supported by industry paving a standard way to connect devices such as home appliances and security systems to the Internet. OSGi framework can integrate popular protocols such as UPnP, Jini, DPWS, Zigbee, and Bluetooth. With the application of extensible technologies based on OSGi framework and the supports of context-awareness mechanism, ‘off-the shelf’ affordable smart house could become available to the market, so the user can install monitoring devices or others without the aid of engineers.

Green ICT system could shift its focus on the adoption of service-oriented architecture for system design and implementation to alleviate the insufficiency in

integration and interpretability. They also need to transform traditional tightly coupled modules into more loosely coupled services. Although they need to sense environmental changes, receive messages from other sub-systems, and produce appropriate responses, they need to have capability to reallocate their resources dynamically according to demands and priorities. In such heterogeneous systems, the resources which could be software or hardware can be considered as services. The software would be composed by a number of other software components to perform certain functions. The hardware can be devices such as smart lighting, smart table, or sensors which are responsible for controlling environments and collecting information about changes.

Service-Oriented Architecture (SOA) offers a practical and viable approach to implement services. The key advantages of Web services provide capability for developers to create applications through reuse of existing loosely coupled components and utilization of Web protocols and open XML standards to enable interoperability between systems. From service consumers' point of view, it is important for service consumers to answer three questions: what services are required; where they are located; how the service can be invoked. In other words, there are three questions corresponding to three key mechanisms service discovery, service selection, and service composition in SOA. Similarly, service consumers could be an end user or a service. In this section, we discuss four major characteristics and research directions. Four major characteristics are composed of framework, middleware, automatic control, and semantic sensor network.

2.3. Web Service Selection

Service contains a collection of functions. Services can be classified into atomic or composite services [43]. An atomic service is a basic unit which cannot be decomposed further. Atomic services on their own normally cannot satisfy the full requirements given by the users, so they need to be composed. A composite service is made of a collection of existing services which can be atomic or composite. Service selection is an important step in service composition. Service providers could offer a variety of applications and services with similar functions and QoS. They can publish their services on UDDI repositories, so a consumer could search her/his required services according to some keywords or other criteria. However, the consumer may discover a collection of services providing same function, so a service selection process based on non-functional attributes to refine possible services is required. Once the appropriate services have been identified and selected, the composition process can take place. The following diagram shows their relationship (see Figure 5). The rest of this section will give more detailed reviews on these topics.

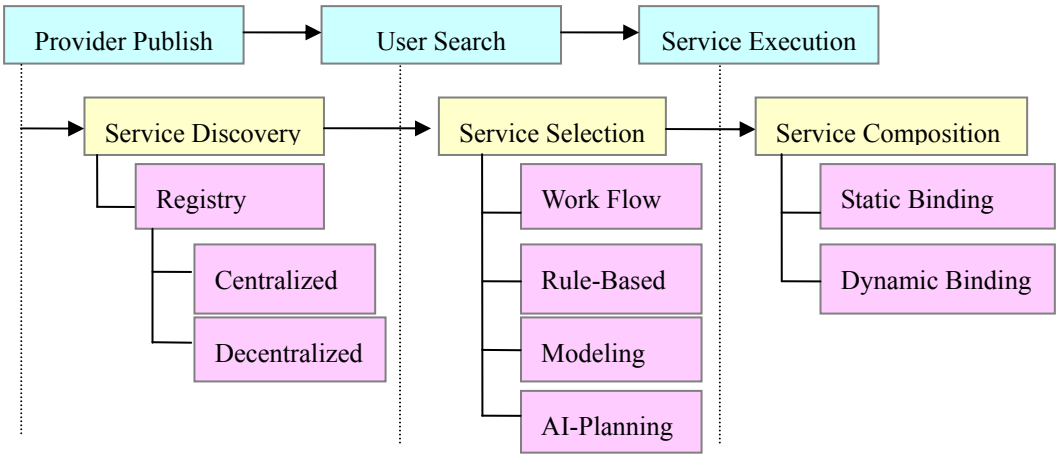


Figure 5 The revolution for the Web Service

Many researches focus on facilitating service-oriented system development by proposing different service discovery protocols [24][50][56] to increase accuracy in service discovery and selection. One of the most widely used protocols for publishing service is Universal Description, Discovery and Integration (UDDI) specification [5] that enables service specification to be advertised in a service registry. In our previous studies on the UDDI specification [37], we used the tModel to represent the QoS for web services discovery, selection, and composition. Several researchers have designed the semantic query mechanism into UDDI registry to map RDFS upper concepts with semantics to UDDI data model to increase the precision in service selection [2] [3][34].

Catalogues and P2P solutions are the well-known techniques in Web Service Discovery. In Catalogues, the services are stored in a central node which provides a standardized specification framework as meta-schema to describe services for service discovery and advertisement such as UDDI. When a number of UDDI nodes exist in a network and can be linked together, so they become a decentralized architecture and can be regarded as a virtual node, this is called UDDI cloud or federation [46]. P2P-based Web service Discovery (PWSD) presented in [49][51] is built upon Peer-to-Peer (P2P) technologies which provides a distributed environment and infrastructure for service routing and service locating. So each node in the network provides routing and data location service and also acts as a server providing service access. PWSD also includes ontologies to publish and search for web services descriptions. An agent-based solution proposed in [44][65] called DASD (DAML Agents for Service Discovery) enhances effectiveness in service discovery and selection with an intelligent mechanism. It provides a matchmaking service that allows web service consumers and providers to discover each other more efficient.

A number of researchers have introduced different approaches such as workflow-based approach, Artificial Intelligent (AI) planning, and other modeling methodologies to the service composition process. Semantic Web Service composition methods are based on Model-Driven Architecture (MDA) [6][47][66], and UML [4]. These composite services are specified by using standard UML model to generate system specifications and using MDA approaches to produce applications. Composing services to form an application is a complex and error-prone task, so researchers in AI have proposed different planning techniques in attempt to automate the composition process.

Most existing service discovery or selection techniques, however, do not take into account service customers' preferences and opinions. Huang et al [20] applied semi-order preference model and content-based service discovery concept to improve effectiveness in service discovery and selection. Their work attempts to assist service providers and consumers in discovering appropriate services by considering their opinions and preferences. Wang et al [58] introduced a new QoS-aware service selection approach by including a fuzzy model to prioritize the service consumers' and providers' QoS preferences as they often cannot be expressed precisely and they are normally associated with uncertainty.

Table 1 Comparison of Web Service Discovery, Selection, and Composition

	Acceptable Criteria
Service Discovery	Keyword, Semantic, Attribute, Functional
Service Selection	Keyword, Semantic, Attribute, Functional, QoS requirement
Service Composition	Keyword, Semantic, Attribute, QoS requirement, Functional requirement, Nonfunctional requirement

From the previous discussion, the web service selection and composition is one of the decision making for user to determinate. However, decision making can be one of the most complicated administrative processes in management. In the

decision-making process, decision maker may suffer affected by multiple criteria for evaluation. Moreover, Multiple Criteria Decision Making (MCDM) is one of the most well known branches in decision making. MCDM can be divided into two categories: MODM and MADM. A further discussion about MODM and MADM can refer to Hwang and Yoon [23]. Thus, MADM has been widely used by decision makers in management processes to evaluate and rank possible alternatives.

In the decision making processes, a group of decision makers could be involved and it is called Group Decision Making (GDM), so members' opinions or preferences have to be considered. Most of the GDM problems are of strategic dimensions and can be complicated due to their multi-criteria framework involving many subjective and quantitative factors. Optimal utilization of the time and resources is a key element sought by many GDM methods. Various researchers have focused their attention on increasing the ability of the group to make the quality decisions [6], [8], [11], [18], [19], [23], [27], [28], [52], and[63].

An effective web service discovery mechanism should be able to search and assess services based on their QoS and service contents as well as users' requirements. The service assessment or selection often involves multi-criteria decision-making process [31]. So, the GDM is applicable to service selection when the service consumers have inconsistent or conflicting requirements, as it can be considered as a reasoning process for reaching group consensus on their requirements for service selection.

TOPSIS method has become a popular multiple criteria decision technique due to (1) its theoretical rigorousness [17], (2) a sound logic that represents the human rationale in selection [55], and (3) the fact that it has been proved in [64] as one of the best methods in solving rank reversal. Recently, some researchers have focused on developing fuzzy TOPSIS methods to deal with imprecise information. Sun et al [56]

applied fuzzy TOPSIS to evaluate the competitive advantages of shopping websites. Chamodrakas et al [16][65] employed fuzzy TOPSIS to help suppliers evaluate customers within the purchase order acceptance process so that the resource allocation and the priority of orders could be optimally identified. Chu et al [14] designed a fuzzy TOPSIS model based on interval arithmetic of fuzzy numbers. Kahraman et al [30] proposed an interactive group decision making methodology based on fuzzy TOPSIS to select information system providers under multiple criteria. Chen et al [15] extended the TOPSIS method based on interval-valued fuzzy sets in decision analysis. Abo-Sinna et al [1] extended the TOPSIS approach to solve multi-objective large-scale non-linear programming problems with block angular structure. Lin et al [34] applied fuzzy TOPSIS for order selection and pricing for make-to-order products when orders exceed production capacity. Li [36] developed a Compromise Ratio (CR) methodology for fuzzy multi-attribute group decision making (FMAGDM), which is an important part of decision support system. Wang and Chang [60][58] utilized fuzzy TOPSIS to help the Air Force Academy in Taiwan select optimal initial training aircraft under fuzzy environment. Wang and Lee [61] generalized TOPSIS to fuzzy multiple-criteria group decision-making by proposing two operators, Up and Low, which satisfy the partial ordering relation on fuzzy numbers, to find positive and negative ideal solutions.

2.4. Service Composition

Achieving service compositing dynamically, there are two important concepts which are Service Component Architecture and Service Execution Engine. In the end, we introduce the Service-Oriented framework and Green ICT. We describe the detail in the following sections.

2.4.1. Service Component Architecture (SCA)

Service Component Architecture (SCA) [41] is a set of specifications which describe a model for building applications and systems by composing and deploying new and existing service components. SCA builds upon an open standard such as Web services and complements to the existing approaches in service implementation. It is based on the idea that business function is supported by a series of services, which can be assembled together to create solutions and to serve a particular business need. The composite applications can contain both new services and business functions from existing systems and applications [12][68].

Furthermore, SCA is aimed to encompass a wide range of technologies to support service component accessibility and web service connectivity. For components, this includes not only different programming languages, but also framework and environments commonly used with those languages. These binding technologies include Web services, Message systems and CORBA IIOP. Bindings are handled declaratively and independent of the implementation. Thus, we can develop a smart system regardless of programming languages. The SCA assembly model deals with the aggregation of components and the linking of components through wiring. The client and implementation specifications address the required services and client side programming.

The SCA specification is divided into a number of documents, each documents dealing with a different aspect of SCA. SCA assembly model deals with the aggregation of components and their linkages. The assembly model is independent of implementation language. SCA is a set of specifications which is used to build applications and systems by deploying new service and composing existing components. The Assembly Model deals with the aggregation of components and the linking of components through wiring using composites. In SCA, a composite is a collection, or assembly, of components or services. A composite considered a "service" when it's wrapped for external consumption. Furthermore, a composite can contain properties and reference to other components or services. A component is not necessarily intended to be exposed for external consumption. A service in SCA is a self-contained unit of functionality. The benefits of building software based on the reusable building blocks of components and composites have been espoused for several decades. Moreover, SCA does not only extend and complement prior approaches to implementing services, but also provide a programming model for building applications and systems based on a SOA.

Table 2 Comparison of service Composition

Service Composition Method	**Service Binding**	**Dynamic**	**Flexible**	**Feasible**
Static Web Service Composition	Fixed	Low	Low	Easy
Dynamic Web Service Composition	Run time Binding	Highly	Highly	Hard

2.4.2. Enterprise Service Bus (ESB)

The heritage of ESBs is derived from enterprise application integration (EAI). Enterprise Service Bus (ESB) provides a run time environment for service binding and execution environment. One important advantage is that an ESB allows architects to exploit the value of messaging without writing code. In an enterprise application system making use of an ESB, an application will communicate via the bus, which acts as a message broker between applications. When the ESB receives a message, it routes the message to the appropriate application. ESB provides a good data connectivity that includes HTTP (SOAP), XML, FTP, SFTP, File, JMS, et al. Hence, data transfer between different services under multiple protocols can implement easily. Furthermore, UDDI binding component is used to look up service by using the UDDI protocol. A good data connectivity that provided the interface for sender and receiver. For example, email binding for sending and receiving emails though IMAP, POP3 and SMTP.

Moreover, File Binding (FB) connectivity provides a transport service to a file system. A transport service pools inbound message and stored into a file in a specified directory on server side. On the other hand, for client side put message into file in a designated directory. There exists a defect for inbound message processing which is prohibited overwriting by threads. It only once written by one thread in the same time. Hence, data transfer between different services under multiple protocols can be implemented straightforwardly. In our development environment, we use the diverse binding property of ESB to achieve transparent between services.

ESB supports flexible data transformation and intelligent routing which can provide content-based routing based on message properties or inline statements in XML via XPath and XSLT. Furthermore, the custom API enables developers to add

customized adapters or components in the ESB. Individual applications or services can be attached to the bus via adapters. The architecture of ESB is shown as follows (see Figure 6).

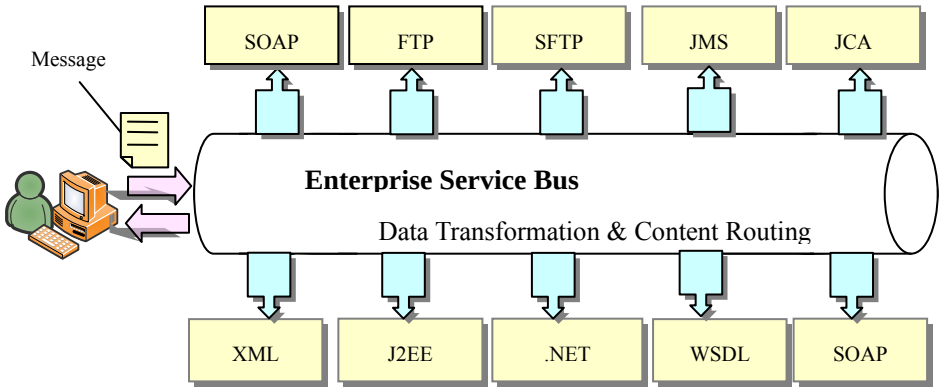


Figure 6 Architecture of Enterprise Service Bus

2.4.3. Service-Oriented Green ICT framework

There are several ways to compose services at the design time. Model-driven Architecture (MDA) is a software architecture framework proposed by the Object Management Group (OMG). MDA consists of a set of standards that assist the system in creation, implementation, evolution and deployment. The key technologies of MDA are Unified Modelling Language (UML), Meta-Object Facility (MOF), XML Meta-Data Interchange (XMI) and Common Warehouse Metamodel (CWM).

MDA emphasized the importance of modeling for the software architecture design. MDA suggests a three-layered approach. The Computation Independent Model (CIM) describes a system from the computation-independent point of view to address structural aspects of the system. The Platform Independent Model (PIM) defines a system in terms of a technology-neutral virtual machine or a computational abstraction. The Platform Specific Model (PSM) consists of a platform model that captures the technical platform concepts and a model geared towards the implementation technique. The lifecycle of MDA development is shown as Figure 7.

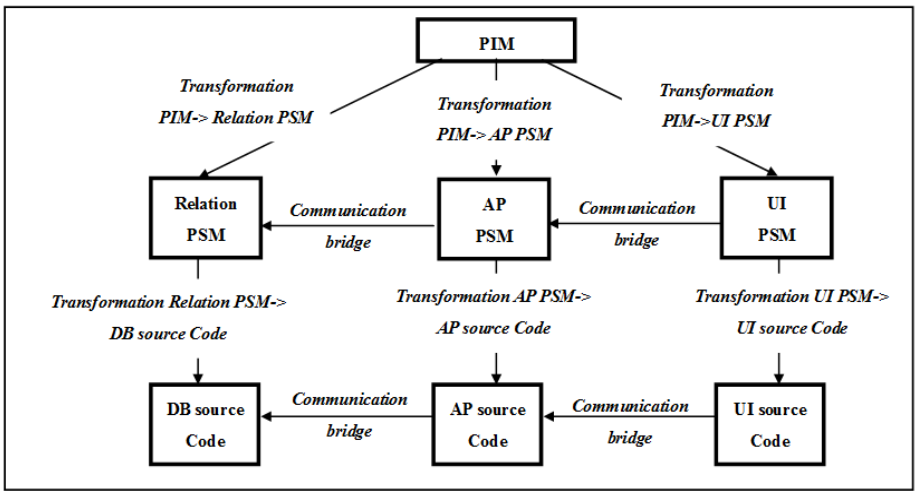


Figure 7 Lifecycle of MDA Development

There are four kinds of models in MDA. During initial phase, the business analyst analyzes the user requirement in CIM. Next, the PIM based on the outcomes derived from the previous phase to define the functionalities, the structure, and the behavior of a system. The PSM focuses more on implementation and execution platform which could be a specific programming language or database.

Context-awareness is an essential aspect for service utilization, especially when frequent interactions take place between users and environments. In this paper, a solution for developing context-aware web services applications is proposed. The methodology includes a model driven approach to separate the web application functionality development from the context adaptation at the development phases (analysis, design, and implementation). In essence, context adaptation takes place on top of the web application business functionality to facilitate system evolution.

SOA framework provides an easy and uniform way for service composition in a controlled environment, and leverages Web service standards with efficient communication mechanisms. Various definitions of SOA have been given by different groups, vendors, and business analysts. W3C defined SOA as: "*A set of components which can be invoked, and whose interface descriptions can be published and discovered.*" CBDI

defined SOA as: "*The policies, practices, frameworks that enable application functionality to be provided and consumed as sets of services published at a granularity relevant to the service consumer that can be invoked, published and discovered, which are abstracted away from the implementation using a single, standards based form of interface.*" Gartner defined SOA as: "*Service-oriented architecture is a client/server software design approach in which an application consists of software services and software service consumers (also known as clients or service requesters). SOA differs from the more general client/server model in its definitive emphasis on loose coupling between software components, and in its use of separately standing interfaces.*" IBM defined SOA as: "*A Service-Oriented Architecture is an enterprise-scale IT architecture for linking resources on demand. These resources are represented as business-aligned services which can participate and be composed in a value-net, enterprise, or line of business to fulfill business needs. The primary structuring element for SOA applications is a service as opposed to subsystems, systems, or components.*"

The service-oriented applications are different from traditional software architecture, as the traditional software is relative static at runtime compared with service-oriented ones. Therefore, a new service-oriented application can be composed at runtime using existing services. In the Green ICT, it not only provides a framework for the software design and deployment, but also offers an analytic way to indentify services. In the SOA approach, a lot of physical and logical entities can be considered as services, for example, infrastructure as a service, platform as a service, software as a service (SaaS), device as a service, data as a service and etc. In order to coordinate these services, a well governance of SOA architecture is needed. IBM proposed a SOA Framework that reviewed from the two type views of service consumer and service provider. The SOA Framework can see Figure 8and Figure 9.

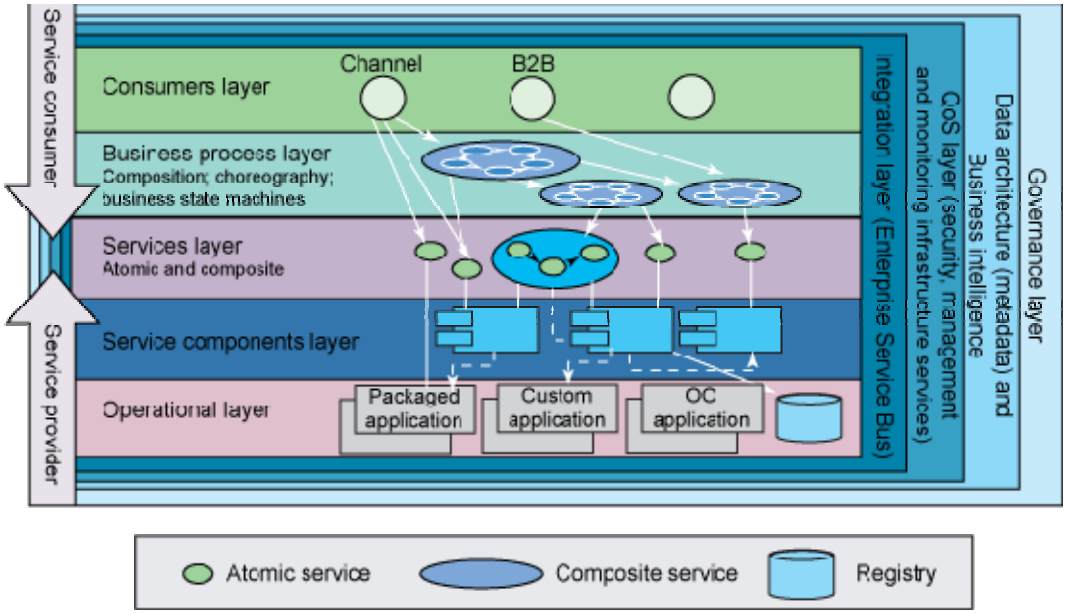


Figure 8 SOA Framework track[1]

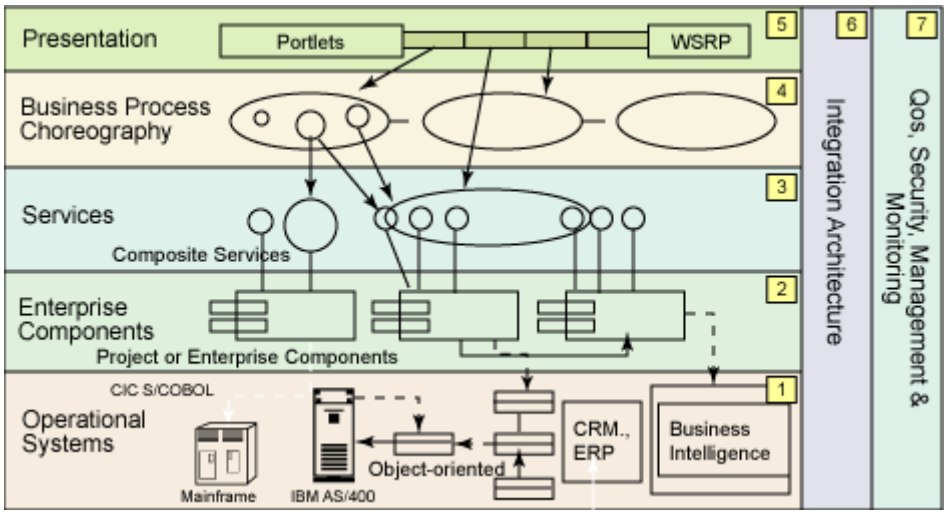


Figure 9 SOA template Framework [2]

These services based on the framework can be organized into grids. Grids are the platform to enable collaboration and aggregation of heterogeneous resources such as high-speed supercomputer, cluster, store repositories, database, and application

[1] Armonk, NY, December 16, 2003. Available at: http://www.ibm.com/developerworks/webservices/library/ws-soa-enterprise2/ (Last accessed on 15.09.2010). Also available at: . http://www.allhands.org.uk/submissions/papers/81.pdf

[2] Mamdouh Ibrahim, Gil Long, Service-Oriented Architecture and Enterprise Architecture, Part 1: A framework for understanding how SOA and Enterprise Architecture work together, http://www.ibm.com/developerworks/webservices/library/ws-soa-enterprise1/

systems owned by multiple organizations or individuals which are connected by networks. Grid system architecture based on Web service concepts and technologies, which include large-scale data management, information transfer, and distributed computing, gains its momentum and becomes a popular trend.

Thus, the OpenGridForum defined necessary standards for grid architecture and explored their practicality to gird based applications and infrastructures in distributed computing. The Open Grid Service Architecture (OSGA) represented an evolutionary grid system architecture based on web service concepts and technologies. The Open Grid Service Infrastructure (OGSI) provided a distributed system framework which can offer the standard factory and registration interface for creating and discovering grid services.

Chaprt 3. A FUZZY TOPSIS METHOD FOR WEB SERVICE SELECTION

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method, which is initially proposed by Hwang et al [21], is one of the best-known multiple criteria decision making (MCDM) methods. The TOPSIS method introduces the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS) to determine the best alternative. While the PIS is to maximize benefit criteria and minimize cost criteria, the NIS is to maximize cost criteria and minimize benefit criteria.

TOPSIS uses triangular fuzzy numbers representing linguistic variables of the weights of criteria and of the ratings of web services which can be transformed into crisp numbers. The transformation is performed by the graded mean integration representation method proposed by Chou [12]. The canonical representation of the addition and the multiplication operations on triangular fuzzy numbers is then used to obtain the PIS and the NIS. To avoid the problem with doubling weightings on each alternative, the distance of each alternative web service from the PIS and the NIS is measured by Minkowski distance function [39][40]. As a result, the preference order of available alternative web services can be identified accordingly. Based on the graded mean integration representation of triangular fuzzy numbers and the canonical representation of addition and multiplication on triangular fuzzy numbers, the procedure of fuzzy TOPSIS method can be performed in an efficient way. This property can reduce the computational complexity in the decision making process.

3.1. Fuzzy Number and Fuzzy Theory

In this section, some basic and related definitions of fuzzy sets will be briefly reviewed.

Definition 1. *Fuzzy set*. Let X be a universe of discourse. Where $\tilde{A}$ is a fuzzy subset of X; and for all $x \in X$, there is a number $\mu_{\tilde{A}}(x) \in [0, 1]$ which is assigned to represent the membership of x in $\tilde{A}$, and is called the membership of $\tilde{A}$.

Definition 2. *Normality*. A fuzzy subset $\tilde{A}$ is normal if and only if

$$\exists x \in \square, \quad \vee_{x} \mu_{\tilde{A}}(x) = 1. \tag{1}$$

Definition 3. *Convexity*. A fuzzy subset $\tilde{A}$ is convex if and only if

$$\mu_{\tilde{A}}\left(\lambda x_1 + (1-\lambda) x_2\right) \geq \mu_{\tilde{A}}(x_1) \wedge \mu_{\tilde{A}}(x_2), \forall x_1, x_2 \in X, \forall \lambda \in [0,1]. \tag{2}$$

Definition 4. *Fuzzy number*. A fuzzy number $\tilde{A}$ is a normal and convex fuzzy subset of X.

Definition 5. *Triangular fuzzy number*. Let $\tilde{A}$ as a fuzzy set and its values will be located between 0 and 1. It is a triangular fuzzy number $\tilde{A}$ can be defined by a triplet(a, b, c), as shown in Fig. 1. Its membership function is defined as

$$\mu_{\tilde{A}} = \begin{cases} 0, & \text{if } x < a, \\ \dfrac{x-a}{b-a}, & \text{if } a \leq x \leq b, \\ \dfrac{c-x}{c-b}, & \text{if } b \leq x \leq c, \\ 0, & \text{if } x > c. \end{cases} \tag{3}$$

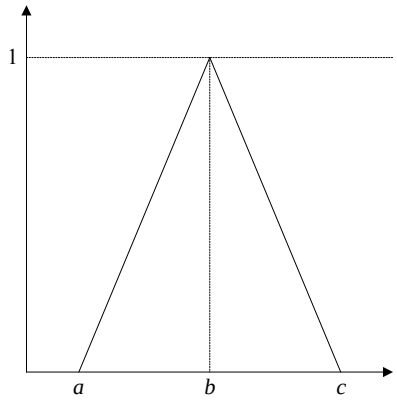


Figure 10 Triangle membership function

Definition 6. *The graded mean integration representation on triangular fuzzy numbers*. Let $\tilde{A}$=(a, b, c) be a triangular fuzzy number. The graded mean integration representation of $\tilde{A}$ is defined as

$$P\left(\tilde{A}\right)=\frac{1}{6}\left(a+4b+c\right). \tag{3}$$

Definition 7. *The canonical representation of addition and multiplication operations on triangular fuzzy numbers*. Let $\tilde{A}=\left(a_1,b_1,c_1\right)$, and $\tilde{B}=\left(a_2,b_2,c_2\right)$ be two triangular fuzzy numbers. Then the canonical representation of addition and multiplication operations on triangular fuzzy numbers can be defined as follows.

Addition operation $\oplus$:

$$\begin{aligned} P\left(\tilde{A}\oplus\tilde{B}\right) &= P\left(\tilde{A}\right)+P\left(\tilde{B}\right) \\ &= \frac{1}{6}\left(a_1+4b_1+c_1+a_2+4b_2+c_2\right) \end{aligned} \tag{4}$$

Multiplication operation $\otimes$:

$$\begin{aligned} P\left(\tilde{A}\otimes\tilde{B}\right) &= P\left(\tilde{A}\right)\times P\left(\tilde{B}\right) \\ &= \frac{1}{6}\left(a_1+4b_1+c_1\right)\times\frac{1}{6}\left(a_2+4b_2+c_2\right) \end{aligned} \tag{5}$$

Two important operators the addition and the multiplication operations on triangular fuzzy numbers can be used to obtain the PIS and the NIS. The use of graded mean integration representation method is to transform a triangular fuzzy number into a crisp number which can reduce the required computation under fuzzy environment. For more detailed information, it can be found in [12].

In evaluation processes, human temps to use natural languages to express their opinions rather than exact numbers. Linguistic variables can be defined to represent evaluations [7]. Then each linguistic variable can be parameterized into a fuzzy set. For example, the importance weights of various criteria and the ratings of the criteria can be expressed as linguistic variables which can be modeled as triangular fuzzy numbers as shown in Table 3 and Table 4, respectively.

Table 3 Linguistic variables for the importance weight of each criterion

Linguistic variables	**Importance weight of each criterion**
Very low (VL)	(0.0, 0.1, 0.3)
Low (L)	(0.1, 0.3, 0.5)
Medium (M)	(0.3, 0.5, 0.7)
High (H)	(0.5, 0.7, 0.9)
Very high (VH)	(0.7, 0.9, 1.0)

Table 4 Linguistic variables for the rating of each alternative

Linguistic variables	**Importance weight of each alternative**
Very poor (VP)	(1, 1, 3)
Poor (P)	(1, 3, 5)
Fair (F)	(3, 5, 7)
Good (G)	(5, 7, 9)
Very good (VG)	(7, 9, 9)

Once the users express their opinions based on the above tables, Eq. (2, 3) can be applied to obtain the graded mean integration representation of the importance weight of each criterion and ratings shown in Table 5 and Table 6 to form the importance weight of each criterion and each alternative rating.

Table 5 Graded mean integration representation for the importance weight of each criterion

Linguistic variables	**Importance weight of each criterion**
Very low (VL)	0.1167
Low (L)	0.3000
Medium (M)	0.5000
High (H)	0.7000
Very high (VH)	0.8833

Table 6 Linguistic variables for the rating of each alternative

Linguistic variables	**Importance weight of each alternative**
Very poor (VP)	1.3333
Poor (P)	3.0000
Fair (F)	5.0000
Good (G)	7.0000
Very good (VG)	8.6667

3.2. A Fuzzy TOPSIS Method for Web Service Selection

Assume that a group of k users $(D_1, D_2, ..., D_k)$ is formed for ranking m alternatives of web service $(A_1, A_2, ..., A_m)$ with respect to n criteria $(C_1, C_2, ..., C_n)$. Then the decision matrix, R_t, given by decision maker, $d_t, t = 1, 2, ..., k$, is as follows.

$$R_t = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} r_{11t} & r_{12t} & \cdots & r_{1nt} \\ r_{21t} & r_{22t} & \cdots & r_{2nt} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1t} & r_{m2t} & \cdots & r_{mnt} \end{bmatrix} \end{array} \quad (7)$$

We use $r_{ijt} = (o_{ijt}, p_{ijt}, q_{ijt}), r_{ijt} \in \Re^+, i = 1, 2, ..., m;\ j = 1, 2, ..., n;\ t = 1, 2, ..., k;$ to denote the rating of alternative a_i with respect to criterion C_j given by the user d_t.

The procedure of the fuzzy TOPSIS method is stated as follows.

Step 1. aggregate the importance weights. Let $w_{jt} = (a_{jt}, b_{jt}, c_{jt})$, $j = 1, 2, ..., n;$ $t = 1, 2, ..., k;$ be the importance weight of criterion C_j given by the user d_t. Then we can calculate the aggregated crisp weight W_j of criterion C_j by the following formula:

$$W_j = \frac{\sum_{t=1}^{k} w'_{jt}}{k}, \quad (8)$$

, where w'_{jt} is the weight derived from the graded mean integration representation of fuzzy numbers, as illustrated in Equation (2).

Step 2. aggregate rating of alternatives. The following formula is used to obtain the aggregated crisp rating of alternatives R_{ij}.

$$R_{ij} = \frac{\sum_{t=1}^{k} r'_{ijt}}{k}, \qquad (9)$$

, where r'_{ijt} is obtained by the graded mean integration representation of fuzzy numbers, as illustrated in Equation (2).

Step 3. construct the normalized and weighted decision matrix. Let $S = \left[s_{ij} \right]_{m \times n}$ be the normalized decision matrix. We can calculate the normalized value s_{ij} via the following formula.

$$s_{ij} = \frac{R_{ij}}{\sqrt{\sum_{i=1}^{m} \left(R_{ij} \right)^2}}. \qquad (10)$$

Let $V = \left[v_{ij} \right]_{m \times n}$ be the weighted decision matrix. The weighted value v_{ij} is derived from the product of elements in the normalized decision matrix and crisp weights.

$$v_{ij} = W_j \cdot s_{ij} \qquad (11)$$

Step 4. determine the Positive Ideal Solution (PIS) and the Negative Ideal Solution (NIS). Let I and J be the index sets associated with the alternative set and the criterion set, respectively. We can gain the PIS, A^+, and the NIS, A^-, from the following methods.

$$A^+ = \left\{ v_1^+, v_2^+, \cdots, v_n^+ \right\} = \left\{ \max_{i \in I} v_{ij} \mid j \in J \right\} \qquad (12)$$

$$A^- = \left\{ v_1^-, v_2^-, \cdots, v_n^- \right\} = \left\{ \min_{i \in I} v_{ij} \mid j \in J \right\} \qquad (13)$$

Step 5. measure the distance of each alternative from the PIS and the NIS respectively. Traditionally, the Euclidean distance is used to measure the distance of each alternative from A^+ and A^- as follows.

$$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2}, i = 1, 2, \ldots, m, \qquad (14)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^-\right)^2}, i = 1, 2, \ldots, m. \qquad (15)$$

However, the use of the Euclidean distance may have the problem associated with weight having been calculated twice. This problem can be resolved by introducing Eq. (10) or Eq. (11) as follows.

From Eq. (14), we can easily observe that the decision results overly controlled by weighting.

$$d_i^+ = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j^+\right)^2} = \sqrt{\sum_{j=1}^{n}\left(W_j s_{ij} - W_j s_j^+\right)^2} = \sqrt{\sum_{j=1}^{n} W_j^2\left(s_{ij} - s_j^+\right)^2}. \quad (16)$$

Therefore, this problem can be overcome by means of Minkowski distance [39][40], L_p^w, as follows.

$$L_p^w\left(x, y\right) = \left[\sum_{j=1}^{n} w_j \left|x_j - y_j\right|^p\right]^{1/p} \qquad (17)$$

, where w_j is the weight of importance with respect to the j-th criterion and $p \geq 1$.

Note that L_p^w with $p = 2$ is known as the weighted Euclidean distance.

Based on the weighted Euclidean distance, A^+ and A^- can be redefined as follows.

Recall that $S=[s_{ij}]$ is the normalized decision matrix. Define

$$A^+ = \left\{ s_1^+, s_2^+, \ldots, s_n^+ \right\} = \left\{ \left(\max_{i \in I} s_{ij} \mid j \in J \right) \right\} \quad (18)$$

$$A^- = \left\{ s_1^-, s_2^-, \ldots, s_n^- \right\} = \left\{ \left(\min_{i \in I} s_{ij} \mid j \in J \right) \right\} \quad (19)$$

, and then the distance of each alternative from A^+ and A^- based on the weighted Euclidean distance is computed as

$$d_i^+ = \sqrt{\sum_{j=1}^{n} W_j \left| s_{ij} - s_j^+ \right|^2}, i = 1, 2, \ldots, m, \quad (20)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} W_j \left| s_{ij} - s_j^- \right|^2}, i = 1, 2, \ldots, m \quad (21)$$

Step 6. Calculate the relative closeness coefficient and rank the preference order. The relative closeness coefficient of the i-th alternative, RCC_i, can be computed by

$$RCC_i = \frac{d_i^-}{d_i^+ + d_i^-} \quad (22)$$

Consequently, the alternatives can be ranked according to RCC_i.

In this research, we employ the fuzzy TOPSIS method to evaluate web services for selection. It helps this research to identify an idea solution across a set of service QoS criteria by maximizing their acceptable preferences, while satisfying the QoS constraints given by a group of consumers.

3.3. Design Principle of Service Oriented Modeling

System development from analysis to implementation needs to conquer many problems which might come from end-user, computer, or designer. For example, in the phase of analysis, a designer needs to find out the users' requirement. The requirements can be separated into two types: functional requirement, and comfort requirement. Functional requirement defines scale, quantity, and function of all hardware and software. For example, the number of lights, air-condition units, dehumidifier or heater, etc. The comfort requirement is related to users' preferences which are about QoS.

The requirements collected from the previous phase lay the foundation for modeling the required services. An analyst can use any modeling language such as UML to model the requirements. Because some of the service-oriented features cannot be satisfied with UML, it requires another modeling language to specify service flows, service relations, and service capabilities.

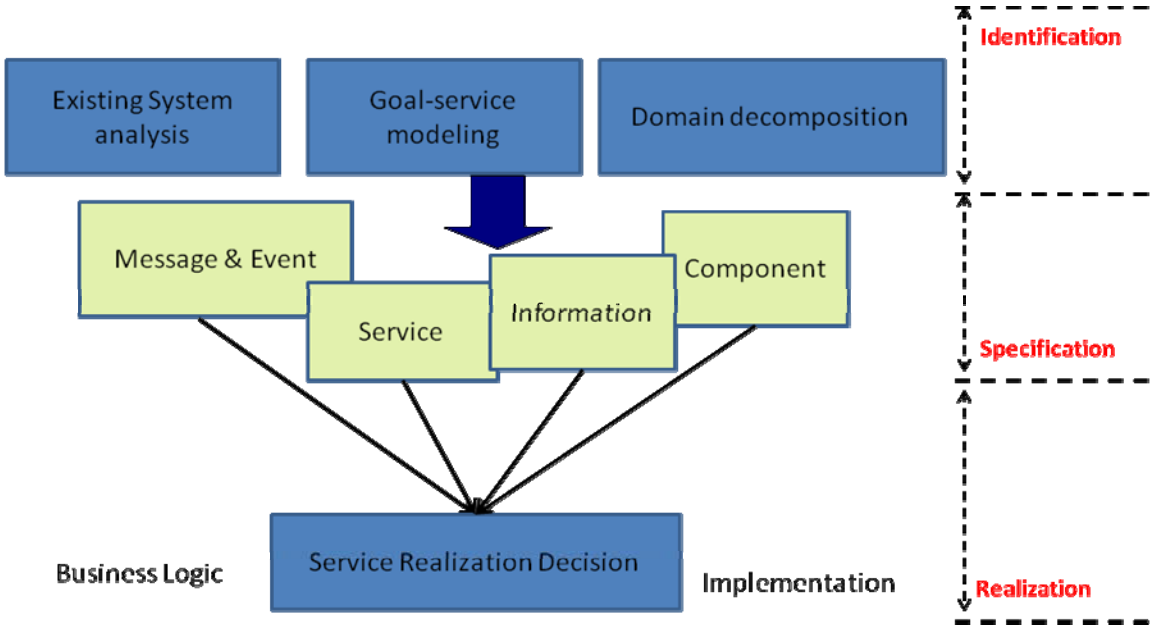


Figure 11 Three phase of Service Modeling Architecture

In our propose framework, we distinguish two types of requirements which are functional requirement and comfort requirement in initial phase. After analysis phase, the users can use any tools or modeling language which they are familiar with to model the system. Here, we adopt the service-oriented modeling framework (SMOF) as a modeling framework. In PIM to PSM phases, we use Service Component Architecture (SCA) as transforming methodology. Also in PSM phase, we use the Service Data Object (SDO) to manipulate the connection between application and the database. Our proposed framework is based on MDA that includes SPEF and MOF. The overall architecture is shown in Figure 12.

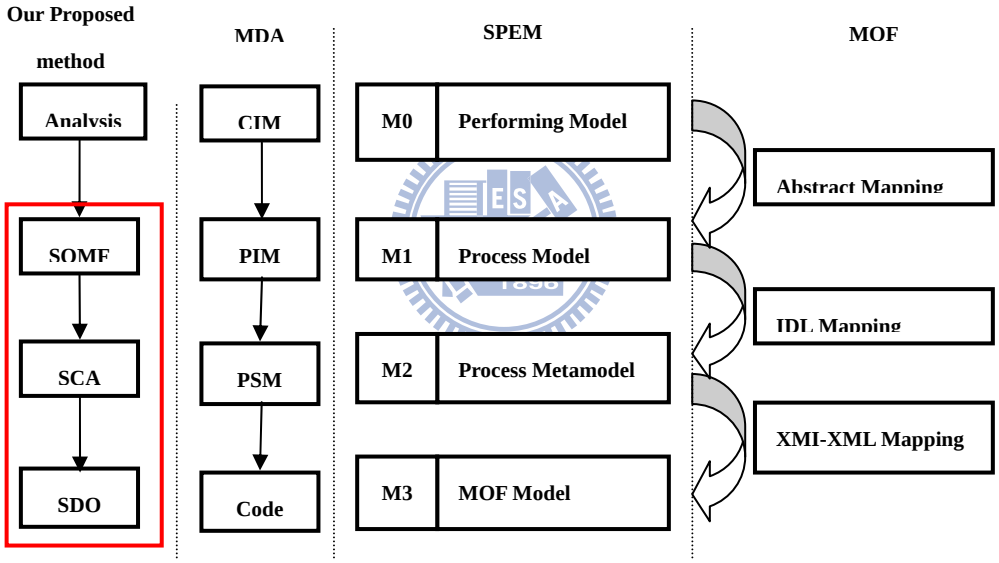


Figure 12 Service-Oriented Modeling Approach architecture

Our proposed User Centric Service-Oriented Approach provides a top-down modeling analysis method. As mentioned above, we combine MDA concepts in the software design and system implementation with web services. The requirements can be separated into two types: functional requirement, and comfort requirement. Functional requirement defines scale, quantity, and function of all hardware and software. For example, the number of lights, air-condition units, dehumidifier or heater. The comfort requirement is related to users' preferences which are about QoS.

The requirements collected from the previous CIM phase lay the foundation for modeling the required services. An analyst can use any modeling language such as UML to model the requirements. Because some of the service-oriented features cannot be satisfied with UML, it requires another modeling language to specify service flows, service relations, and service capabilities. Hence, we adopt Service-Oriented Modeling Framework (SOMF) in the PIM phase. SOMF is a discipline of modeling business functions and system behaviors based on services.

In PSM phase, the main task is to draw SCA diagram and obtain a system meta-model. After that, the SDO (Service Data Object) and ESB (Enterprise Service Bus) can connect to database and bind services together. SDO aims to provide a consistent means of handling data within applications, regardless of its source and format. It provides a unified way of handling data of databases and services. ESB is used to integrate applications, coordinate resources, and manipulate information. The proposed architecture is depicted in Figure 13.

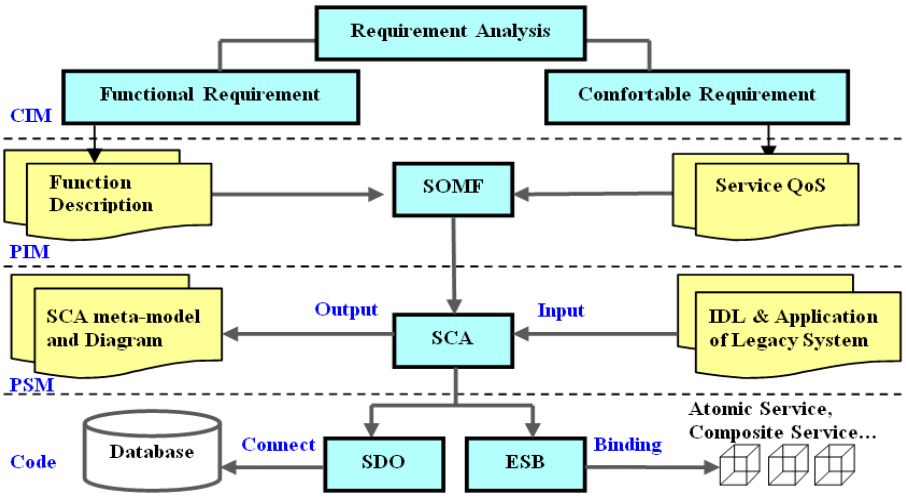


Figure 13 Life-cycle of our proposed service-oriented approach

The limitation of our proposed method is the services need to be given in advance without generating automatically. Our proposed method can be applies in any specific domain where service selection is made based on the independent feedback which represent the quality rating of the service content (QoS). The user centric service-oriented modeling framework (see Figure 14) and procedure (see Figure 15) presented as following.

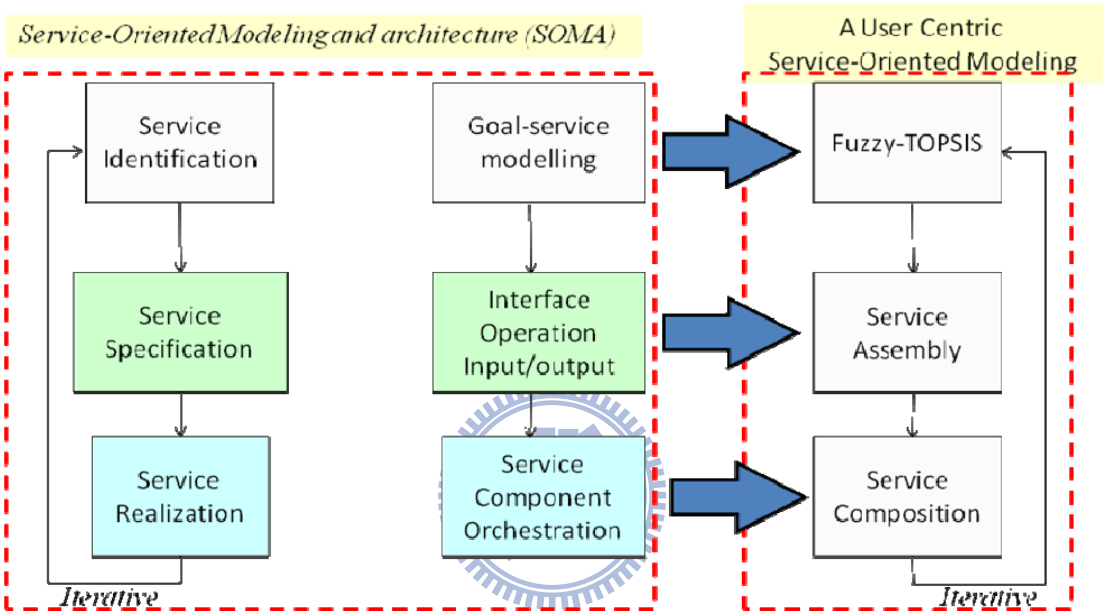


Figure 14 User Centric Service-Oriented Modeling

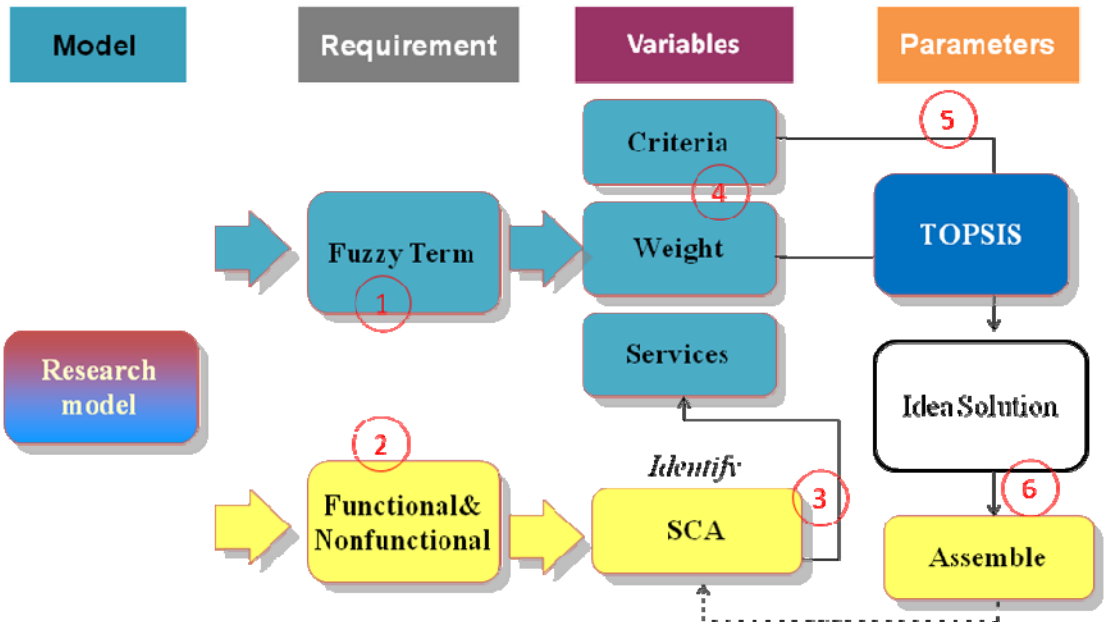


Figure 15 Procedure of our proposed method

In the end, we summarize the design principle and guideline that concern about user centric and service-oriented modeling as following.

(1) Services-Oriented Modeling:

It can reduce the deficiency of object-oriented modeling in service-oriented applications, as UML meta-model cannot provide the necessary support. Designer could adopt Service-Oriented Modeling Framework (SOMF) which is a discipline of modeling business functions and system behaviors based on services. Designer needs to identify service, define the specification of service, and implementation service.

Identify service:

In service-oriented environment, software and hardware can be represented as services. Services are more transparent and loose coupled, which contain a collection of independent functions or operations as compared to objects. Objects heavily reply on their interdependencies and their internal states to operate.

Define the specification of service:

Regarding to the existence application or new services from the business domain and the atomic business activity. Constructing service component or referencing external service can be achieved by drawing SCA diagram and obtain a system meta-model.

Implementation service:

SDO (Service Data Object) and ESB (Enterprise Service Bus) can connect to database and bind services together. SDO aims to provide a consistent means of handling data within applications, regardless of its source and format. It provides a unified way of handling data of databases and services. ESB is used to integrate applications, coordinate resources, and manipulate information.

(2) User Behavior:

A ICT system based on SOA possesses abilities such as autonomous adjustment,

autonomous management, and autonomous deployment to satisfy diverse requirements from multi-user. The group consensus approach collects the preferences from the users and reason over them to provide a basis for system self-adjustment in order to meet the majority of users' requirements. The alternatives and criteria should be given by such system that could offer the ability of group consensus computation.

(3) Annotating sensor data with semantics:

Sensor data could be value of temperature, humidity or an expression representing other conditions, but this data could imply a condition such as light brightness or weather. The sensor devices and their sensed data can be grouped together to become services and annotated with semantics for reasoning.

(4) Information Streams Fusion and resource description:

The resource including data, services, computation resource, and device profile will be described explicitly with their location and characteristics. This can benefit locating, allocating and re-deploying resources.

Chaprt 4. Proposed User Centric Service-Oriented Modeling

This research is to propose a service-oriented modeling approach including the aforementioned SCA principles and TOPSIS method to form an architecture that enables system developers to model hardware and software components as services and to work together seamlessly. The approach is able to efficiently satisfy a group of participating service consumers' subjective requirements and preferences in a dynamic environment and it can also effectively facilitate service development. The proposed system architecture shown in Figure 16 comprises of a number components, including Enterprise Server Bus (ESB), TOPSIS evaluation service, data adapter service, collection service, Tuscany server, Web Service registry, group preference database. Furthermore, the overall architecture can be classified as Service Providers (the right side) and Service Consumers (the left side), and a middleware. The following subsections will offer more details on these components. Prior to that, the flow of the overall architecture will be introduced.

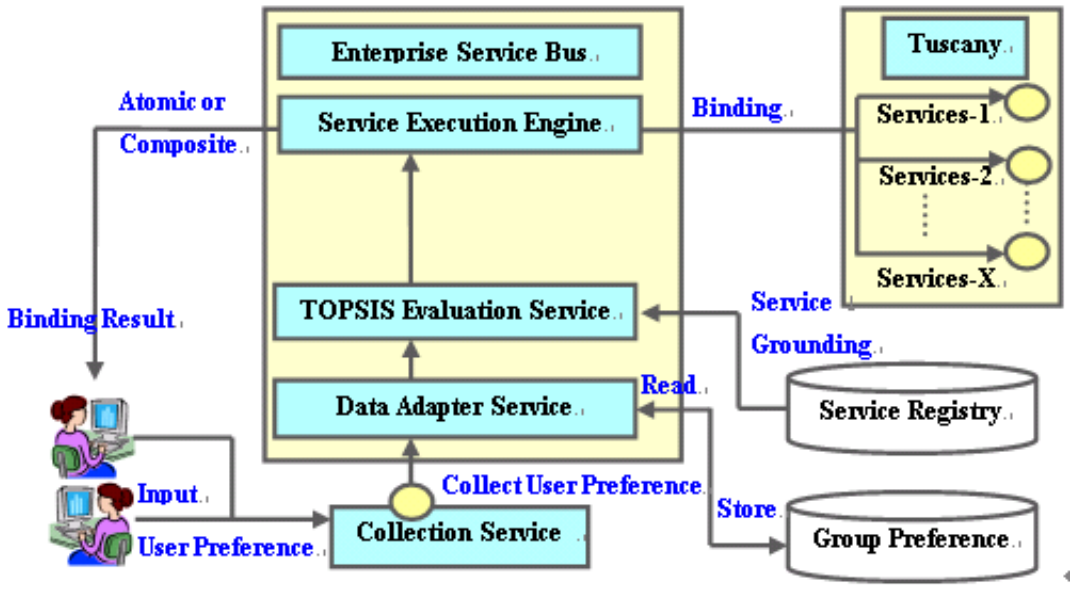


Figure 16 Prototype system architecture

4.1. General description and basic scenario

The proposed approach is illustrated in the system throughout the study. It can be applied in any specific domain where service composition is made based on the users' feedback which represent the quality rate of the service content. The proposed approaches are helpful to form the values objectively based on the consensus, and it can be iteratively applied for reaching a consensus to interactive environment. To answer questions concerning interaction between the services and users, the number of services and number of users might be cause the limitations. One large source of inefficiency in SOAP is the use of multiple system calls to send one logical message. Another source of inefficiency in SOAP is the XML parsing and formatting time. ESB can bind the proper service from different web server. Hence, it can reduce the effort on one server. Furthermore, SCA is designed for the XML parsing and formatting on SOAP. ESB and SCA can offer a good scalability in our proposed approach.

However, this prototype system architecture has its own constrains. First, the proposed method is based on pre-defined criteria such as convenience, comfortable, and power saving to evaluate a service. Therefore, dynamically evaluation to each service is supported in order to get better users' interaction between human with environment. Second, we only use one embedded board to simulate the hardware as services. Arduino offers multiple transmission interface such as wired and wireless to communicate each other. The hardware and software used to implement the prototype system are listed in following. (See Table 7)

Table 7 Implementation suggestion

Hardware	**CPU**	Xeon 2.33 GHz
	L2 cache	2MB
	RAM	8GB
Arduino		Duemilano (connect with USB cable)
LED Matrix		8 * 8 LED
Operation System		Windows 2008
UDDI Server		jUDDI v0.9 rc4
HTTP Server		Tomcat 5.5 with Axis2 1.5
ESB Server		Synapse 1.1
Database System		MySQL 5.5
Main Program Language		J2SDK 1.6

In this study, we assume that there is only one consensus formation method in these services. This TOPSIS evaluation service was located on a AXIS web service container which could be triggered by data adapter service. The evaluation process can be perform iterative by each user, and user can evaluate each service in each time. Once any user get into the space, user can express their opinions according to their preferences. The evaluation process can be also trigger by the other service. For example, if there is another service for timekeeping, the collection service can get the correct time given by the timekeeping service. The service execution engine can also automatically turn on the lighting in the evening. Any other better inference result by a novel algorithm than TOPSIS can bind the proper services by service execution engine.

We use a sequence diagram to help readers understand how services are activated and adjusted to meet users' requirements. The basic scenario for this architecture is divided into 7 steps which are illustrated as follows:

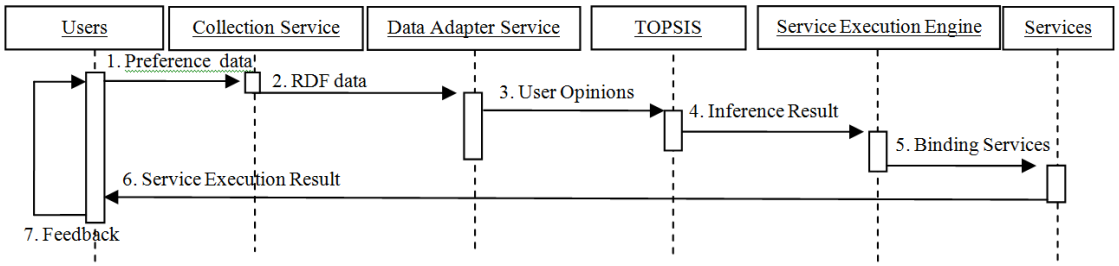


Figure 17 Sequence Diagram of service support the consensus-adjusting between ESB and users

Step 1:

Users prescribe their functional requirements and their QoS preferences. Users use linguistic variables to rate all possible alternatives and give a weight to each criterion based on their importance.

Step 2:

Collection service gathers the users' preferences in fuzzy terms, transforms them into RDFs and sends them to a data adapter service.

Step 3:

The Data adapter service stores users' preferences send by the collection service into database. Then, the data adapter service is responsible for maintaining the existing users' preferences consistently as well as new ones. In addition, the adapter service makes sure that the data can be accessible coherently regardless their locations and physical database structures. In the end, the data adapter service makes the data available to the TOPSIS evaluation service to reason.

Step 4:

The weight corresponding to importance of a criterion is represented by linguistic variables which are defined as triangle fuzzy numbers. Then, we transform a triangular fuzzy number into a crisp number through a graded mean integration method by equation (4) and equation (5). The TOPSIS is able to reason over the values relating to QoS criteria and alternatives to identify the possible group

consensus by recommending appropriate services. The recommended services must be able to satisfy most users' requirements. If not, it means that the group cannot reach a consensus.

Step 5:

In the previous step, the recommended services are abstract services. Enterprise Service Bus (ESB) can bind these abstract services to the physical ones. In ESB, the Service Execution Engine (SEE) locates the designated services which can be a collection of atomic and composite services.

Step 6:

The service is located, invoked, and shows the result to users. The service normally runs on a web container which provides essential library for a runtime environment.

Step7:

Once users received the service, they can assess the results according to functional and nonfunctional requirements. If the services cannot satisfy the requirements, the user can give their opinions and preferences again. These feedbacks will be included in the system as inputs for the next round of group consensus. The above steps will be carried out again in order to reflect new group requirements.

In our development, we adopted an open source project which is Synapse to support the required enterprise service bus. We also used Tuscany to realize SCA development environment. With these enabling technologies and middleware along with other modules, the services can be advertised, discovered, selected, composed, and executed according to the requirements.

4.2. Module Design

There are several modules in our proposed architecture that depicts in the above figure. The system functionality and key modules are described as follows.

4.2.1. Service Execution Engine

We use an open source system, Synapse, which is an open source based on Apache web server to be our Enterprise Service Bus (ESB). ESB is not only a web server container but also can forward the message to other web services accordingly which are deployed on the other server. Synapse provides a simple, lightweight and fully open source SOA infrastructure to assemble and manage composite applications as well as route message. Synapse supports HTTP, SOAP, SMTP, JMS, FTP and file system transport for message exchange using XSLS, XPath and XQuery to bind the web services and to relate each other. Figure 18 shows the ESB architecture.

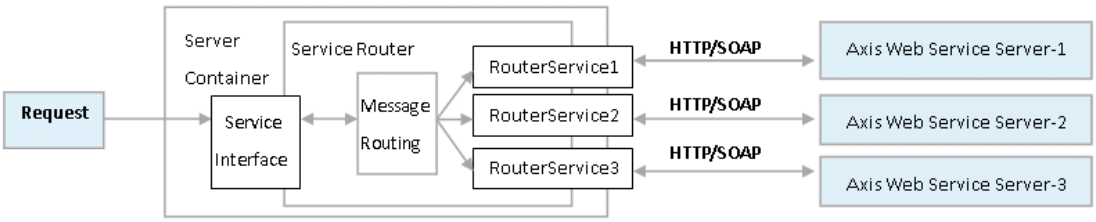


Figure 18 Architecture of Enterprise Service Bus architecture

4.2.2. Data Adapter Service

The purpose of data adapter service module is to output Service Data Object (SDO) in XML format so that web service can manipulate data between database and application. Service data objects (SDO) that represent XSLT data output include all data content (e.g., attribute values). Those objects later serve as input parameters for the TOPSIS evaluation service. Moreover, user preference received from collection service can store into group preference database. The SDO is a technology which is a language-independent representation of a data entity that can be passed between

services. Within the SCA, the SDO provides common and simple APIs which manipulate data from heterogeneous sources including relational databases, XML data, or web services, etc.

SDO is the input/output of data adapter service. Here, we use Service Data Objects (SDO) to be our implementation foundation. There are three key elements inside the SDO which are data object, data graph, and data access service (DAS). The source of data graph can be XML file, web service, or Enterprise Java Bean et.al.

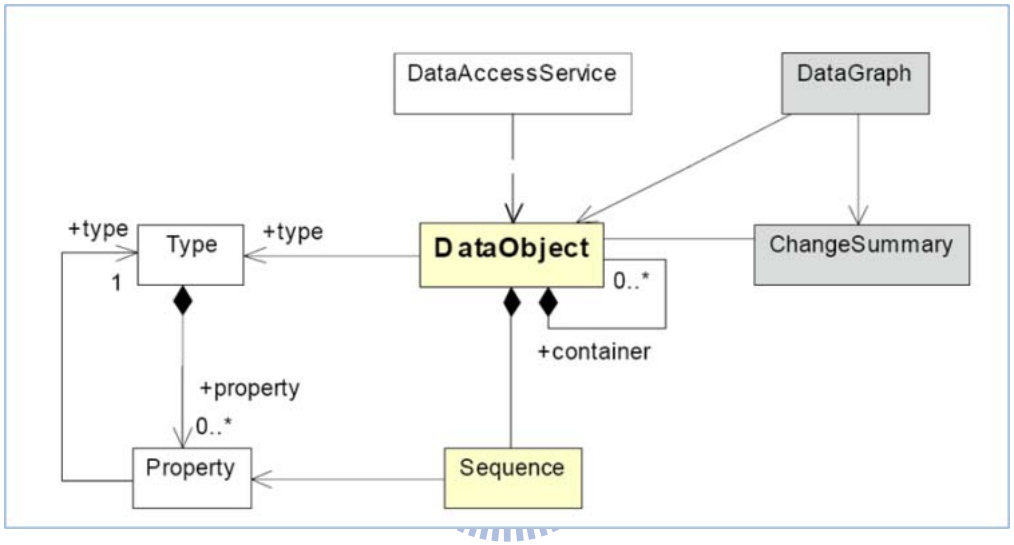


Figure 19 SDO API meta-diagram

The SDO mediator reads data from difference sources (database, flat file or proprietary data APIs) for conversion into data graph. Data graph that represent SDO data adapter input include all data content (e.g., attribute values). Those objects later serve as input parameter for the SDO query engine and XML generator. The service router can forward and send the query string to one or another web service. Moreover, the result of invoked web service could also be another data source, and then, the difference web service can invoked synchronous at the same time for one purpose or asynchronous for service composition. The operation concept is shown as Figure 20.

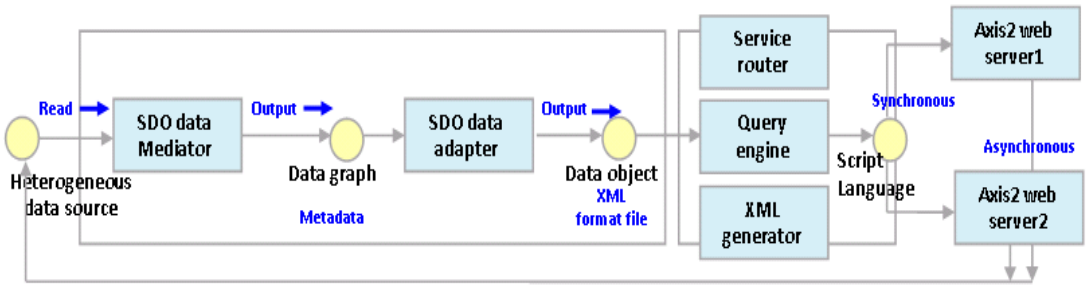


Figure 20 Data adapter service operation flow

4.2.3. Collection Service

Since users need to express their preferences over their required services, there is a GUI for them to input their opinions. A collection service would gather these inputs and send them to a data adapter service.

4.2.4. Service Registry

The aim of service registry is to store service profiles based on the functionalities provided by the web services. These services are registered in a service repository which is UDDI. JUDDI, an open source tool, is adopted to support UDDI. It allows the services to represent their business details by providing a number of facilities such as Business Entities, Service Entities, Binding Templates, and tModels. Services registered with in JUDDI can be searched by name, location, business, bindings or tModels. However, the JUDDI or UDDI specification does not offer any facility to characterize service QoS profile. Therefore, we enhanced JUDDI by introducing a QoS tModel to model service QoS profile in details. So, the services can be searched according to QoS requirement.

4.2.5. Group Preference Database

The group preference database stores the users' preferences (e.g., Very Cold, Normal, Warm, Hot, Very Hot) and the corresponding user profile in a relational database. The data can only be accessible to the data adapter service to ensure the data

consistency. When a new user opinion occurs and needs to be included in the system, all the data in the group preference database will be retrieved by the DAS and be conveyed to the evaluation service to carry out the reasoning process in order to derive a new group consensus, if there is any.

4.2.6. Consensus Evaluation Service-Fuzzy TOSIS Method

We design a consensus evaluation service which is based on the Fuzzy TOPSIS method to reason over a group of users' preferences to identify their potential agreements. These preferences can be very subjective and inconsistent and they could be represented in different ways. The preferences can be associated with uncertainty, fuzziness, and incompleteness. The consensus evaluation service, which obtains the data from the DAS, is able to identify common requests from the majority of users and made recommendations to the users or other services for them to dispose.

Chaprt 5. Case Study

In this section, we offer an example to demonstrate how the proposed user centric service-oriented modeling approach functions. It includes a TOPSIS method in a consensus evaluation service to resolve potential conflicting opinions from the users. Then, we describe how the proposed approach can model physical devices (components) as services to be composed dynamically in order to meet the consumers' requirements.

5.1. Senario I - An Application of Group User Consensus formation

Section 3.2 shows how the TOPSIS process is applied to assist in reaching the group consensus on a number of alternatives. This section presents the overall architecture and system flows to illustrate how the proposed approach is able to model and compose services according to users' requirements. In this case study, 30 services have been designed to control different devices and the UDDI Registry has these service profiles for search and selection. There are 26 services corresponding to different lighting devices in an office, two services control two air-condition appliances and two dehumidifier services control the humidity level in the office. In this experiment, we only allow these services to be composed in 10 different composite services. In other words, one of these alternatives can be selected to provide services. There are 10 staffs in the office and they are service consumers who can express their preferences and opinions in order to control settings on these devices. Each alternative in our case refers to a composite service, as each device is independent and is regarded as a service. The required components and the overall simulation process are shown in Figure 21.

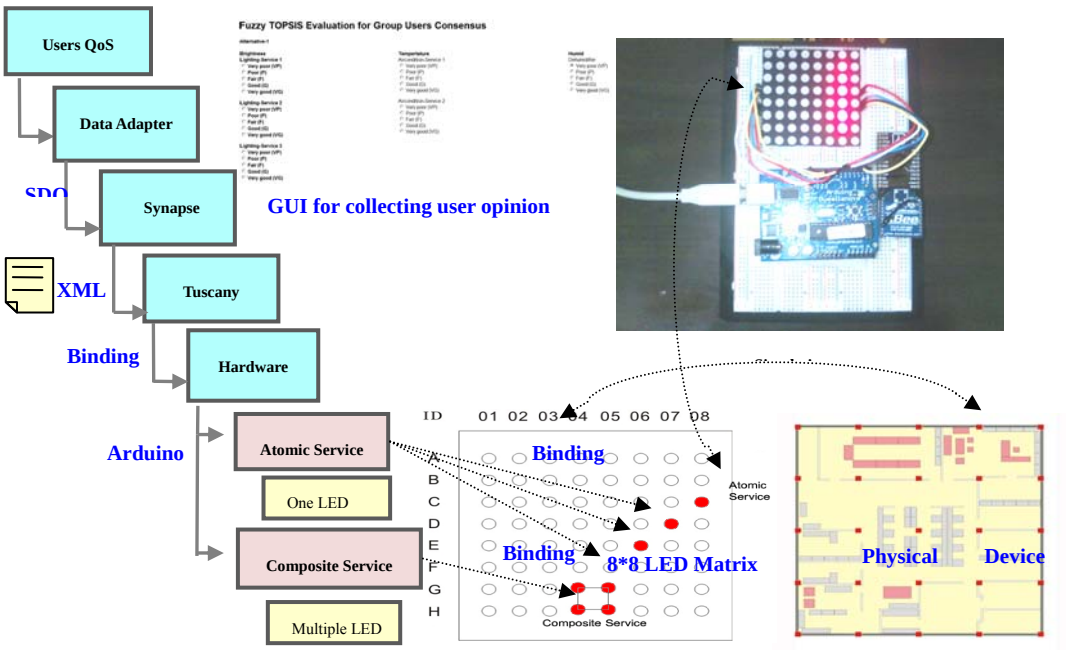


Figure 21 LED matrix and Simulation Device

We designed a prototype system to demonstrate and evaluate the proposed user-centric service-oriented modeling approach. In the system, these 10 composite services (alternatives) can be classified into three different types which are LightingComposite, AirconditionComposite, and DehumidifierComposite services. The LightingComposite service is designed for controlling the brightness. Here, we view one LED as an atomic service, and one LED receives the command from the corresponding web service to switch it on/off. Similarly, AirconditionComposite service is associated with Air Condition device (component) and is designed to control it for setting the office temperature. DehumidifierComposite service works with the dehumidifier to manage the humid level in a space. The communication protocol, which allows the interactions between services and devices to take place, is represented in XML. We model these composite services by using SCA diagram which is shown in Figure 22.

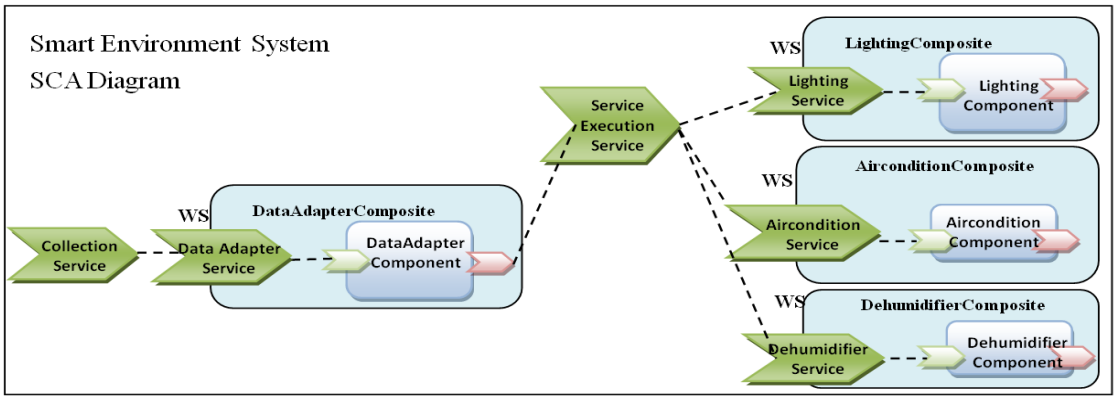


Figure 22 Smart environment system based on SCA designed-principle

Once all of the components have been transformed to services, the system is ready to get the service consumers involved. The system starts with the collection service by gathering the consumers' preferences, ranking alternatives accordingly, composing services, and executing them. The process involves these steps which are carried out in a linear style. The whole process iterates when the new inputs (opinions) emerge. The rest of this section illustrates the whole process in the context of the case study.

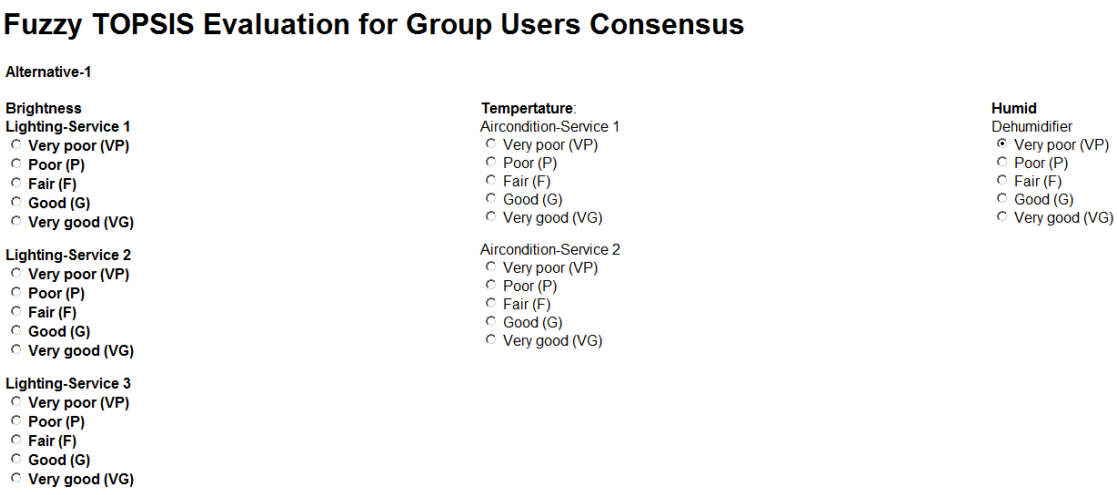


Figure 23 GUI for user's preference collection

Step 2: The Collection service transforms the users' preferences in fuzzy terms and their profiles into RDFs. For example, we can store the user name and the linguistic ratings on the alternatives for each criterion. The following RDF sample shows a user giving two preference values (good and very good) to two different criteria (brightness and temperature).

```
<RDF
   xmlns="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
   xmlns:n="http://www.nist.gov/units/">
   <rdf:Description about="userPreference">
      <rdf:Description aboutEach="#C01"
         pics:by="Jane Doe"
         pics:rating="VG"
         pics:alternative="1"/>

      <rdf:Description aboutEach="#C02"
         pics:by=" Jane Doe"
         pics:rating="VG"
         pics:alternative="1"/>
         ...
   </Description>
</RDF>
```

Figure 24 RDF sample

Step 3: Once the collection service has completed the transformation, the RDF will pass on to the data adapter service. The key task for the data service adapter is to store the information into the preference database consistently. It adopts SDO objects to alleviate the barriers that could be caused by heterogeneous database systems. It represents the information into graphs. Figure 25 shows the code to allow the SDO to retrieve user preferences from a relational database via a SQL statement and store them in a graph for the consensus evaluation service.

```
DataGraph graph = db.executeQuery( select * from user_preference);
DataObject root = graph.getRootObject();
// use xpath to get the name of the first customer
String userName = root.getString(user_preference [0]/name );
// iterate through all customers
Iterator iter = root.getList( customer ).iterator();
while (iter.hasNext()) {
   DataObject dataObject = (DataObject) iter.next();
   String userName = dataObject.getString( name );
   Double userRating = dataObject.getString( Rating );
   …
}
```

Figure 25 SDO object sample

Step 4: We design a consensus evaluation service which is based on the Fuzzy TOPSIS method to reason over a group of users' preferences to identify their potential agreements. The general description and calculation process describe as follows. Assume that ten alternatives of web services $A_i, i = 1,2,3,...,10$ are chosen for evaluation. A group of ten users, $D_k, k = 1,2,3,...,10$ have been formed to conduct the assessment based on three QoS criteria, denoted by $C_l, l = 1,2,3$. The hierarchical structure of these criteria is shown in Figure 26.

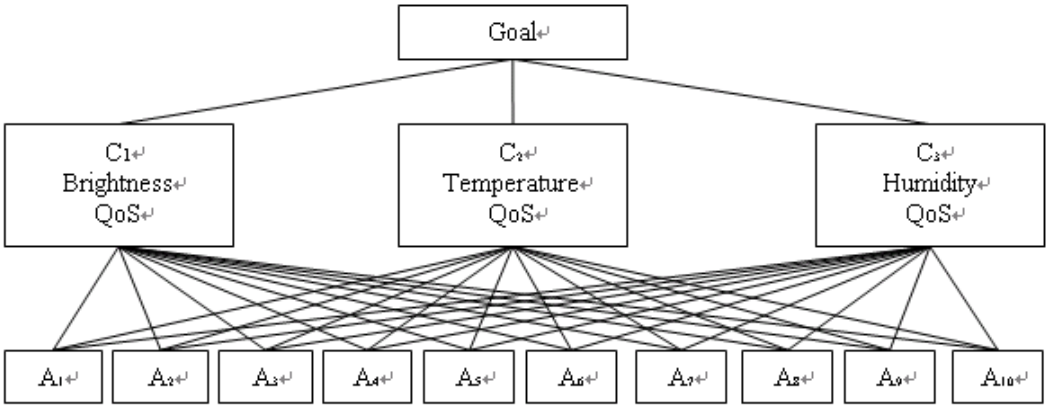


Figure 26 A hierarchical structure for the web service selection problem

The details for these criteria are listed as follows: (1) **Brightness Related QoS** (c_1). (2) **Temperature QoS** (c_2). (3) **Humidity QoS** (c_3).

The fuzzy TOPSIS method is then applied to solve this problem according to the following procedures step 4-1 to step 4-7:

Step 4-1 The users use the linguistic variables to evaluate the importance of each criterion. Without using the linguistic variables, we applied the entropy method to obtain fuzzy weights of criteria [58] as follows.

$w_1 = (0.090, 0.200, 0.208)$; $w_2 = (0.129, 0.206, 0.216)$; $w_3 = (0.041, 0.141, 0.477)$;

In this step, we use the above fuzzy weights of criteria and apply Eq. (2) to calculate the weights of criteria as follows.

$w_1 = 0.183$; $w_2 = 0.1948$; $w_3 = 0.1803$;

Step 4-2 For each web service, the users use the linguistic variables to produce fuzzy or crisp performance ratings against each criterion.

Table 8 Ratings by users with respect to criteria

Criteria	**Candidates**	**Users**				
		D_1	D_2	D_3	…	D_{10}
C_1	A_1	F	VG	G	…	G
	A_2	G	F	VG	…	VG
	…	…	…	…	…	VG
	A_{10}	G	G	F	…	F
C_2	A_1	G	F	G	…	G
	…	…	…	…	…	G
	A_{10}	P	G	F	…	F
C_3	A_1	F	G	G	…	G
	…	…	…	…	…	…
	A_{10}	P	F	G	…	G

The graded mean integration representation of each linguistic variable is listed in Table 6.

Step 4-3 By applying Eq. (4), the aggregated ratings of web services with respect to the three criteria can be computed.

Step 4-4 Construct the normalized decision matrix. The normalized decision matrix can be calculated by applying Eq. (5) as follows.

Table 9 The normalized decision matrix

	Criteria		
Candidates	C_1	C_2	C_3
A_1	*0.3273*	*0.2917*	*0.2500*
A_2	*0.3470*	*0.2999*	*0.2749*
…	…	…	…
A_{10}	*0.4101*	*0.4213*	*0.4333*

Step 4-5 Determine the positive ideal solution, A^+, and the negative ideal solution, A^- as follows.

$A^+ = (0.4101, 0.4213, 0.4333)$ $A^- = (0.2839, 0.2917, 0.2500)$

Step 4-6 Calculate the weighted Euclidean distance of each web service from A^+ and A^- as follows.

Table 10 The distance measure

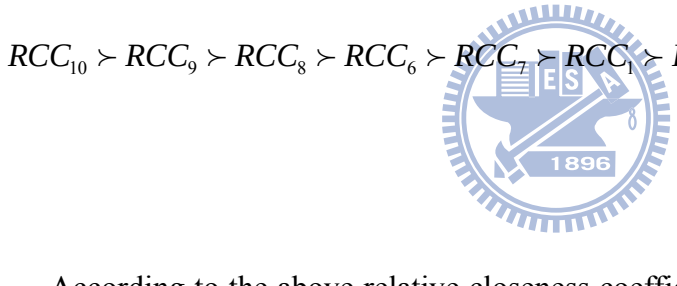
Candidates	The distance measure	
	d^+	d^-
A_1	*0.089119*	*0.038192*
A_2	*0.076057*	*0.052212*
…	…	…
A_{10}	*0*	*0.164882*

Step 4-7 Obtain the relative closeness coefficient and rank the order of web services.

$$RCC_1 = 0.3000,\ RCC_2 = 0.4070,\ RCC_3 = 0.2694,\ RCC_4 = 0.2436,\ RCC_5 = 0.1286,$$

$$RCC_6 = 0.2755,\ RCC_7 = 0.3800,\ RCC_8 = 0.5830,\ RCC_9 = 0.6774,\ RCC_{10} = 1$$

$$RCC_{10} \succ RCC_9 \succ RCC_8 \succ RCC_6 \succ RCC_7 \succ RCC_1 \succ RCC_6 \succ RCC_3 \succ RCC_5 \succ RCC_4$$



According to the above relative closeness coefficient, the ranking order of the ten alternative web services is A_{10}, A_9, A_8, A_6,…, and A_4. From Eq. (12) and Eq. (13), our method is capable of revealing the positive and negative preference degree associated with Users' alternative and assisting the users to make a decision based on the group consensus. We can use the alternative A_{10} to bind the web services that simulates the other scenario on a LED matrix on the Figure 27.

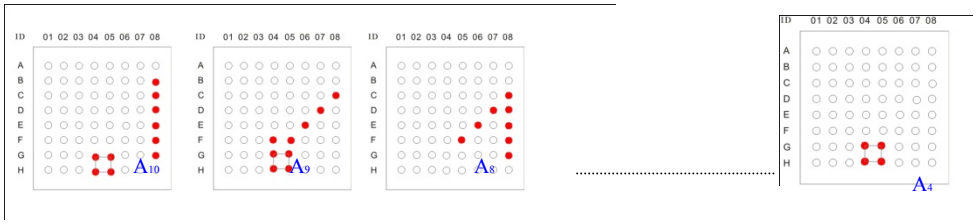


Figure 27 Alternatives presents on a LED matrix

Step 5: The previous step determine which services will be selected. In this step, Synapse is introduced to bind the physical service. Synapse is vehicle to enable services can be located and designated. Synapse is driven by a set of simple XML configuration, so it is easy to deploy and bind services. Part of XML for configuring light services is illustrated as follows.

```
<definitions xmlns="http://ws.apache.org/ns/synapse">
    <!-- filtering of messages with XPath and regex matches -->
    <filter source="get-property('To')" regex=".*/LightingService.*">
        <send>
            <endpoint>
                <address uri="http://localhost:9000/soap/LightingService"/>
            </endpoint>
        </send>          <drop/>
    </filter>
    <send/>
</definitions>
```

Figure 28 Sample XML of Synapse configuration

Step 6: The corresponding web service would be executed after the previous step. The following XML code shows that LightingService SOAP message. Later, the SOAP message will be sent to our simulated circuit board. There are three main elements “Type”, “Duration”, and “Blank”. The first element “Type” means the output signal. The signal could be digital or analog. The second element “Duration” stands for the execution time. The third element “Blink” stands for the lighting twinkle.

```
<?xml version='1.0' encoding='UTF-8'?>
    <soapenv:Envelope      xmlns:xenc="http://www.w3.org/2001/04/xmlenc#"
xmlns:wsa="http://www.w3.org/2005/08/addressing".>
          <soapenv:Header>
          </soapenv:Header>
          <soapenv:Body
xmlns:wsu="http://docs.oasis-open.org/wss/2004/01/oasis-200401-wss-wssecu
rity-utility-1.0. xsd">
             <Device ID=”01”>
           <Command Type="Digital">On</Command>
           <Command Duration="Loop">Yes</Command>
           <Command Blink="NO">0</Command>
            </Device>
         </soapenv:Body>
    </soapenv:Envelope>
```

Figure 29 Sample LightingService of SOAP message

We implement a XML parser to receive SOAP message and convert the XML to be the command on Arduino. The simulation device can receive data from wired or wireless network. The LED matrix on the circuit board stands for different services, that is, we simulate these services in our system. We design and implement the hardware plugged with multiple input and output channels. It can also extend the storage by adding extra memory card such as SD-Card. A circuit board, which runs on 2.7-5.5 V and comprises of an ATmega168V microcontroller, a reset switch, an indicator LED. It also includes a 5 V power supply and an RGB LED Matrix. The hardware architecture of simulation device is shown in Figure 30.

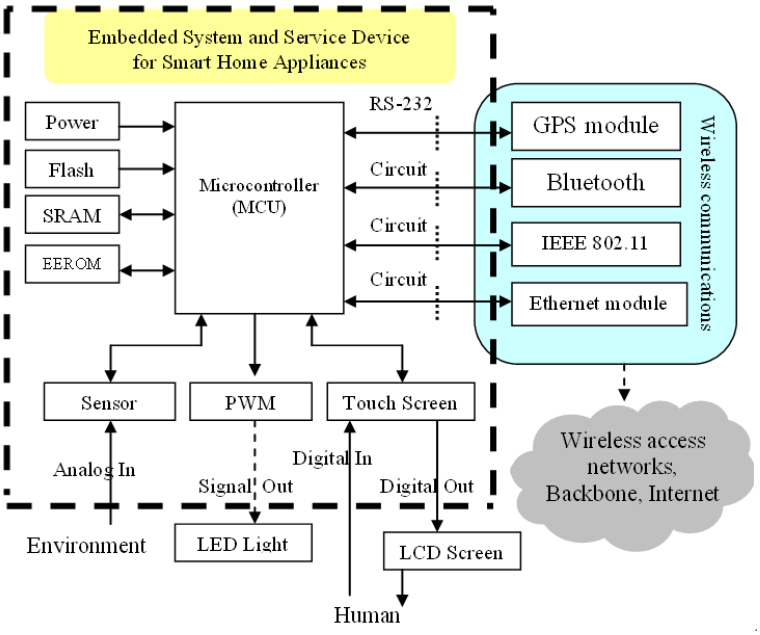


Figure 30 Implementation of Microcontroller Hardware

Step7: Users can revise their preference after they receive the binding results. On the other hand, if a new staff enters the office, he/she can provide his/her opinion to the system. Similarly, these feedbacks will be included in the system as inputs for the next round of calculating group consensus. If the alternative changes from one to another, the service binding would change accordingly (see Figure 31).

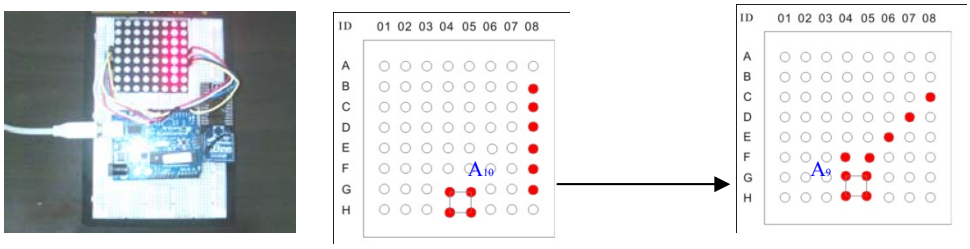


Figure 31 Group users change alternative from A10 to A9

5.2. Senario II -An Application of ICT for Energy Efficiency

In order to justify our proposed Fuzzy-TOPSIS method is feasible, we give a further description by an extend application which is a research project. The research project is named "ICT for Energy Efficiency". This research project is cooperated with Department of the Computing and the Digital Environments, Faculty of Engineering and Computing at Coventry University in United Kingdom. The main purposes of this project are reducing the power consumption and presenting good suggestions for inhabitants. There are 300 homes in Coventry City to be our subjects in this project. In this experiment, we constructed a system called DEHENS to be a test bed that consists of a database system, a application server, and an expert system. The database system is response for storing the users' data and home device profile. Furthermore, all the power usage would be store in the database system. The application server can offer users to connect for viewing the real-time analysis report though web browser. An expert system is composed of Protégé and JESS(Java Expert Shell System). The connection bridge between Protégé and JESS is JessTab which could plug-in Protégé. Protégé is a free open-source Java tool providing an extensible architecture for the creation of customized knowledge-based applications. Protégé is also an OWL editor supported by the National Library of Medicine. JESS is a rule engine and scripting environment written entirely in Sun's Java language. JESS has the capacity to "reason" using knowledge you supply in the form of declarative rules. Hence, we can reason using knowledge from the huge electric current of appliances database.

In order to analyze the power consumption according to different home inhabitants, we use a power-sensors device which is called "plug-wise" to collect the electric current of appliance. Each appliance needs to plug to socket though plug-wise

device. The plug-wise can log the electronic current every specify time interval. Time interval could be configure as 1 second, 10 second or otherwise. For example, the washing machine plugs to socket though plug-wise device such that we can monitor the electronic current from the washing start to end. The log can transmit into a home gateway though Zigbee protocol. The plug-wise can help inhabitants realize quick results in their efforts to make their homes more sustainable. From the function of my appliances, user can review the electronic current of appliances which connect plug-wise. User can on-line check the total amount of energy consumptions. Also, user can query the history of the usage from the function of my energy history. In this investigation we carried out two kinds of data collection. One is the electronic current collecting by sensors, and transmitting to data center to offer the source of knowledge discovery. Another is the users' feedback which could not only provide the comments for adjusting and system-improving also form the consensus for all users. The primary research questions to be address in the project are as follows:

1. How to use ICT for Energy Efficiency?
2. What is useful guideline for users to be the instructions according to home appliances?
3. What kind of home appliances is the reason which caused the useless of power-consumption?
4. How to dig the potential knowledge from enormous database which stored all the appliances' electronic current and users' profile.

From the function of "My Experience" in the DEHENS system, users can see the tips automatically given by system. We offer the tips about power-saving suggestion to users. There are three criteria of these tips which are *effective, saving, and convenience*. Also, user can comment on tips if users have something to add or think the system have made a mistake. The data collection session each lasted one hour and were conduct after user reviewing the tips. The tips are designed for the users in order to give some guidelines which could offer instructions for appliance usage. We apply the Fuzzy-TOPSIS method to the tips which user can rate the importance and availability according to three criteria which are convenience, importance and money-saving.

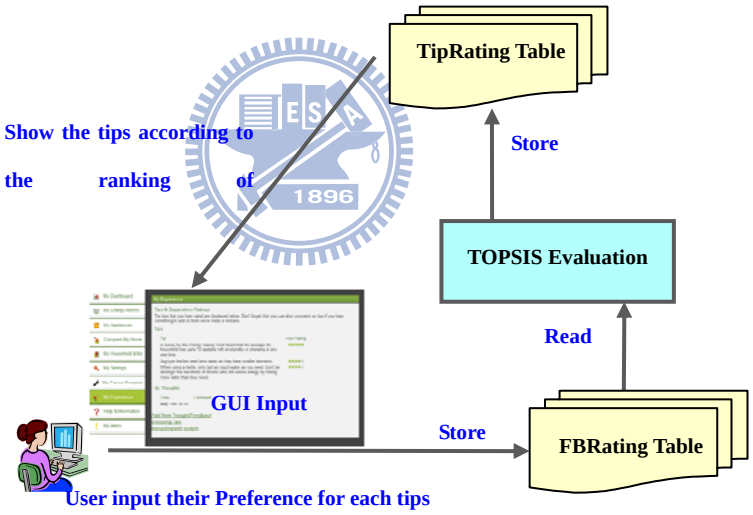


Figure 32 Fuzzy-TOPSIS Cooperated with DEHEMS System

We introduce the steps of proposed method in the DEHEMS System:

Step 1: Users would review the tips which are given by system. Users could check these tips from the function of "My Experience".

Step 2: Users would offer their opinion according these tips (alternative) regarding to three criteria (effective, saving, and convenience). The row data would store in table of FBRating.

Step 3: While new opinions come into system, system can calculate the ranking of tips by Fuzzy-TOPSIS Service.

Step 4: Storing the results to the table of TipRating in mySQL database, the new ranking would take effect and offer to users next time.

We give the structure of FBRating and TipRating table as following.

Table 11 Table of FBRating

Field Name	**Data Type**	**Length**	**Mark**
id	Numeric	(Not null)	Identity for each rating
user_id	Numeric		Identity for each users
tip_id	Varchar	45	Identity for each tips
Rating	Varchar	10	The number of stars
Rating_C1	Double	10	The number of stars on Criteria 1
Rating_C2	Double	10	The number of stars on Criteria 2
Rating_C3	Double	10	The number of stars on Criteria 3
Rating_W1	Double	10	The importance weight of Criteria
Rating_W2	Double		The importance weight of Criteria
Rating_W3	Double	10	The importance weight of Criteria

Note:
FBRating store the feedback rating from users' feedback.
Example:

Id	user_id	tip_id	rating	suggestion
1	Abel	3	3	null
2	Bill	3	4	null
3	Chars	3	2	null
…				

Table 12 Table of FBRating

Field Name	Data Type	Length	Mark
tip_id	Numeric	(Not null)	Identity for each tips
TOPSIS_value	Double		Calculate result of TOPSIS

Note:
Table of TipRating would calculate the ranking value by TOPSIS ,and store the results.
Column of tip_id is primary key
Column of tip_type and tip_content should be consistent with Ontology
Example:

tip_Id	TOPSIS_VALUE
1	3.2
2	2.2
3	4.2
…	

From the tips and suggestions ratings, we can find out the result of consensus on using appliances from group users which could be from one family such that the principle of using appliances might reduce the power-consumption. We give three examples of tips as following:

1. A survey by the Energy Saving Trust found that the average UK household has up to 12 gadgets left on standby or charging at any one time.

2. Jug-type kettles need less water as they have smaller elements.

3. When using a kettle, only boil as much water as you need. Don't be amongst the two-thirds of Britons who still waste energy by boiling more water than they need.

The GUI of DEHENS system for user browsing showed as following (see Figure 33).

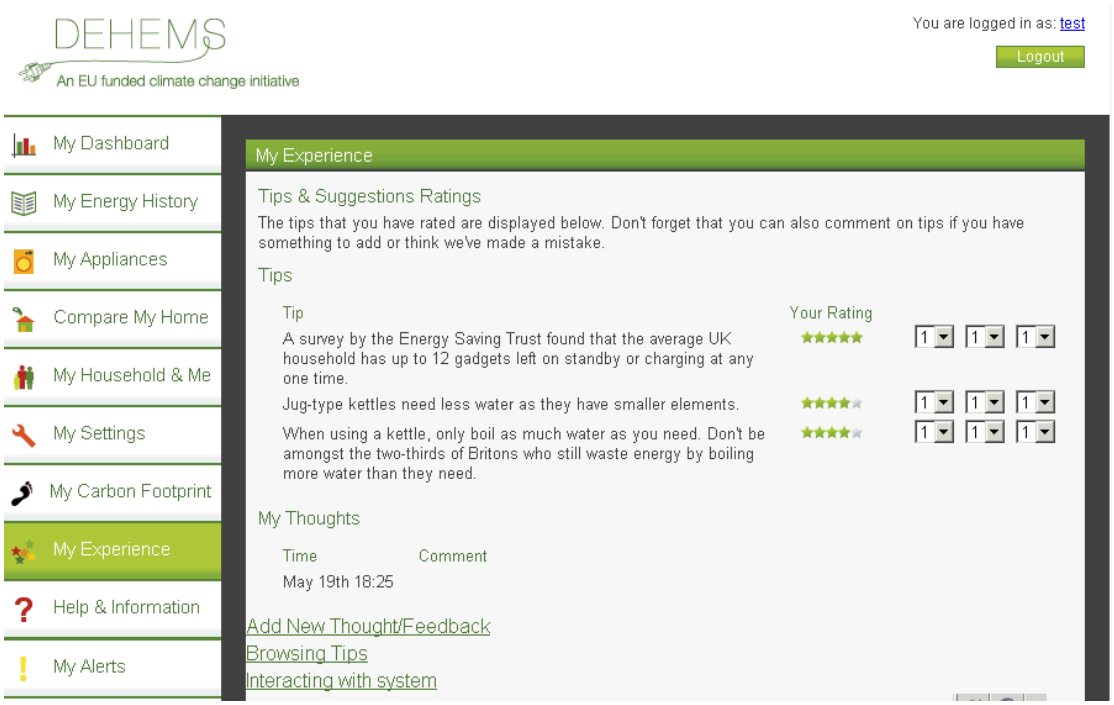


Figure 33 GUI of DEHENS system for user browsing

Chaprt 6. Discussion

In this previous section, the proposed user centric service-oriented modeling approach has been applied to a smart environment which includes a number of appliance services and 10 staffs in an open office. Since we designed a simulated environment using LED lights instead of control system to instruct appliances in order to demonstrate the system feasibility, the evaluation on service consumers' subjective opinions and preferences on these composite services presents a difficulty. The adjustments on the appliances, however, were carried out manually according to predefined configurations and questionnaire was used to collect their feedbacks. In addition, we have evaluated the system effectiveness by examining whether the LED lights have behaved consistently according to the user requirements. In other words, composite services should be selected in line with the group consensus. We have varied the values in the preference database, so different composite services are selected in response to the changes. The experimental results given by the previous sections shows composite service 10 having been selected initially and LED lights have been switched on accordingly. The composite service 9 was chosen later, as the users have changed their preferences. This demonstrates the system coherence and SCA can be used to model software and hardware components as services.

The system performance and complexity are important criteria for evaluating the system. The system cannot be scaled up, if it required huge computational resources when the number of services and QoS criteria increases. We have evaluated TOPSIS method performance and complexity, as it is a critical task in the system. We also compare it with other existing approaches to express the distinct features of the proposed approach.

In addition to evaluation SAM in terms of discovered alias pairs, it is important to investigate the computational complexity that would determine or even limit their actual real-world applications. Opinion similarity measure is the most computational resource demanding step in the proposed approach. The opinions collected from the users are fuzzy terms. The traditional methods [22] would calculate the maximum and minimum intersection area of two membership functions given by the users. For example, the triangle membership function is composed of four piecewise linear segments.

The first segment function given by the user 1 would check the point of intersection in respect to the four piecewise linear segments from the user 2. After that, the second segment function would check others until all the four segments have been done. Computing similarity measures and constructing an agreement matrix would be done in exponential time $O\left(m^n\right)$.

Similarly, the Ordered Weighted Averaging (OWA) aggregation method to generation all pair-wise similarity value is $O\left(m^2 n^2\right)$. In contrast, the Fuzzy-TOSIS is rather merely to the SAM as it begins with aggregating all users using the graded mean integration representation method. The crisp values can be derived from the graded mean integration representation method. So, the required computation on the crisp number significantly reduces the complexity compared with fuzzy values. It can be complete in linear time $O(m \cdot n)$.

According to the complexity of computing users' evaluation, we also used the TOPSIS method to eliminate the problem associated with the duplicated calculation on weightings by introducing the Minkowski distance function. This can increase the accuracy in measurement. Moreover, our approach can significantly reduce computation complexity in similarity measure, so the proposed approach can be

scaled up. Figure 34 (left) shows the system performance of our proposed TOPSIS method against Huang's work-SAM with 2 criteria. Figure 34 (right) shows the system performance with 3 criteria. The computational time of SAM would increase exponentially as the number of user opinions and criteria grow. On contrast, the computational time of TOPSIS method only increases slightly when the number of criteria rises to 16. The computational time does not exceed 10 seconds (see Figure 35). Overall, the TOPSIS is very efficient in the cases where the large number of users involves. Hence, the approach is suitable for on-line applications which often involve large amount of data.

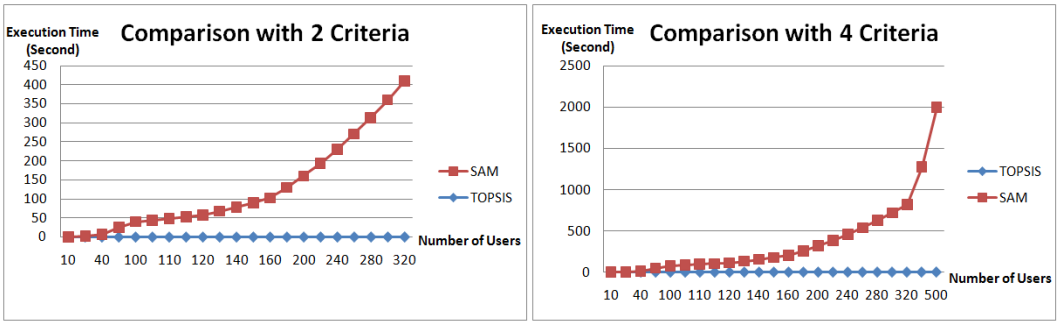


Figure 34 Performance analysis under difference users

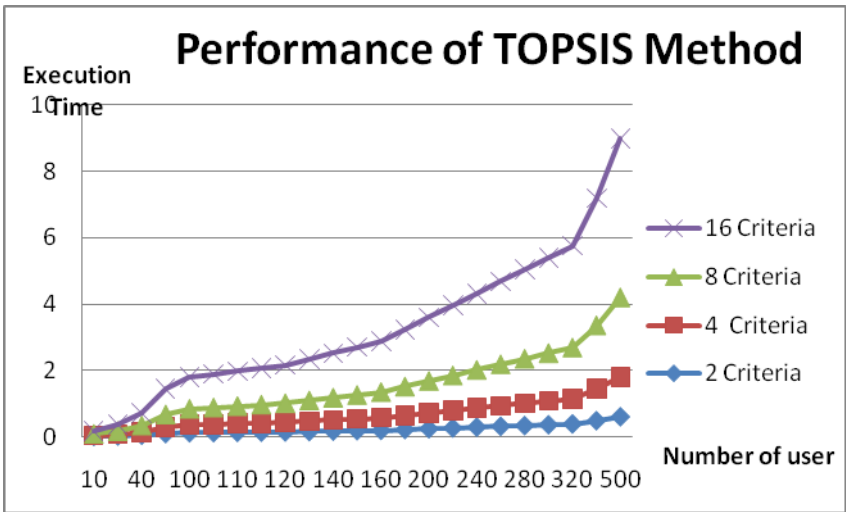


Figure 35 Performance Analysis of different criteria

From the above case study, we can get the ranking order of the three alternative web services is A_{10}, A_9, A_8, A_6,…, and A_4. The resulting order of these preferences is derived from 10 users. While the number of users increases significantly, the proposed approach still outperforms Huang's work [21].

We setup the system within an open office in a research lab. We designed an experiment in which 10 users had to rank the alternatives and choose them according to the predefined criteria. Three different types of services such as air-condition, dehumidifiers and lighting are included for service provision, but with 10 different combinations (10 composited services). Before the system is introduced to the users, the average satisfaction rate from 10 users was just under 43.75%. After the system reasoned over their opinions and preferences, a new service composition was selected to reflect most users' requirements by changing office appliance configuration. As a result, the average satisfaction rate increases to 68.75%. This evidences usability of the system.

The performance of TOPSIS is analyzed by varying numbers of criteria and users, so we can conclude that the method is very efficient when the number of users is under 320 and the number of criteria does not exceed 16 (see Figure 35). The number of services that can be supported or executed depends on the capacity of web container. We deploy all the services to one server in this experiment, as we only 10 composite services. In this case, we have run the tests on an Apache Axis2 server with various numbers of services. The total volume of data relating to users' preferences and opinions which has been used for reasoning is around 40K. The results in Table 13 show that the system is scalable. When the number of services increases two folds, it did not require twice execution time. This is due to Apache Axis2 server managing concurrent processes with great efficiency. The total execution time of the whole platform is around 6000ms in the above experiment without taking into account of

time for manual operations on appliances.

Table 13 Service execution time on axis2

Number of services	***Execution Time***
2 services	5187 ms
4 services	5357 ms
10 services	5398 ms
16 services	5448 ms

Taking into account the fact that the experiment was carried out under two conditions. After the new setting of the air-conditioner, lighting, and dehumidifiers, the satisfaction rate from users is increased. Overall, the result of users' satisfaction have been very positive. The results reflected in Figure 36 indicate that the satisfaction rate for the regulation setting is lower. A more detailed understanding of the usability can be gained from the "after-rate".

Figure 36 Usability analysis of satisfaction rate

We observed the whole data volume increment in different period. The collected data are composed of users' opinion and commend. Furthermore, the sensor services can collect the vary from environment. The data volume increment will increase with time.

We estimated the whole data volume increment in different period. The collected data are composed of 32 users' opinion and commend. The data volume increment will increase with time. Furthermore, the sensor services can collect the vary from environment.

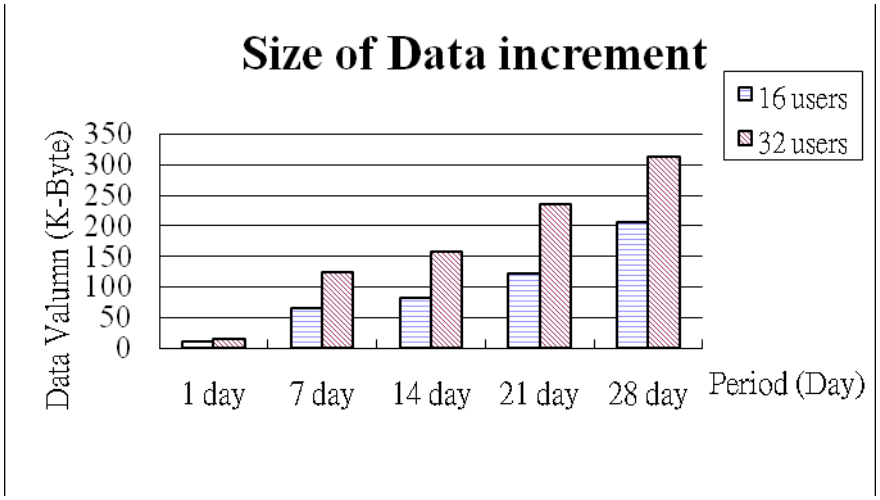


Figure 37 Data volume increment

Chaprt 7. Conclusion and Future Works

In this paper, we proposed a new user centric service-oriented modeling approach which is featured by integrating fuzzy TOPSIS method and SCA to facilitate web service development and to effectively satisfy a group of service consumers' subjective requirements and preferences. The overall architecture including a number of modules and procedures provides a systematic approach for service developers to model hardware and software components as services, so they can be composed on the fly to meet changeable user requirements. We adopt various open source tools for the system to manage and maintain services to ensure that they can perform consistently.

Since the proposed architecture is a user centric approach, so incorporating users' subjective preferences and opinions into service selection and composition process becomes important. The fuzzy TOPSIS method is employed to solve the web service selection problem when a group of users have different opinions on evaluation. In this approach, due to crisp number having been used for canonical representation rather than a triangular fuzzy number, the complicated calculations involving triangular fuzzy numbers can be avoided in the fuzzy TOPSIS. This feature reduces the computational resources and complexity significantly.

We also applied Minkowski distance function to measure the distance of each alternative from the PIS and the NIS to overcome the drawback of duplication calculation on weighting. Consequently, the preference order over the alternatives according to the relative closeness coefficients can be identified more precisely. In this study, the proposed model is generic and systematic, so system architecture and service abstract level APIs can be extended to accommodate new appliances and comfort criteria. New opinions and users can be included in the process of reaching a new group consensus by re-calculating them.

We carried out a number of experiments on a simulated environment which includes a 8*8 LED matrix representing 30 different services to form 10 composite services for selection. These services can be invoked according to the group preference and the users' feedbacks. The experimental results show that the system can stratify users' requirements. As a result, the proposed approach is effective and efficient.

The future work of this research will include different types of sensors such as environmental and biological sensors, so room temperature, humility, and brightness etc can be collected automatically along with sensors to measure body temperature, heart beat and blood pressure etc in order to draw a complete picture of users' conform levels in relation to their environment. So, the system can intelligently and automatically interact with users and environment accordingly. The manual inputs required from users can be reduced.

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