Systematic Review of Applying Service Oriented Architecture in Networking

Duen-Kai Chen

Department of Innovative Information and Technology
Tamkang University
I-Lan, Taiwan
dkchen@mail.tku.edu.tw

Abstract—**Networking is the practice of communicating and data sharing among devices, through wired or wireless network, and it is playing a pivotal role in our daily life. In other words, Networking is essential for information exchange. However, along with all the benefits from networking technologies, comes various of new challenges, such as network management, network discovery and selection, etc. Due to the increasing demand of more efficient network management system, the concept of Service Oriented Architecture (SOA) has attracted networking professionals' attention. SOA provides patterns for architecture, design, implementation of loosely coupled, distributed services regardless of underlying platform or implementation, thus, it is believed to be appropriate to be applied to build a more efficient network management system. This study is motivated by the increasingly popularity of SOA in the networking discipline. In this study, a systematic review of academic papers from IEEE Explore regarding this topic is presented; current state of the application of SOA for networking is highlighted, research efforts in related area are discussed. The study concludes with a suggested future research agenda.**

Keywords: Service Oriented Architecture, SOA, Networking, Web Services.

I. INTRODUCTION

Networking is essential for information exchange and the last decade have seen a tremendous burst in technology for the field of it. From traditional LAN (local area network) to wireless network, Networking covers a wide range of technologies and played a very important role in our daily lives. However, with the rapid development of network technologies and communication needs, there are some issues arise. These issues include how to connect heterogeneous access networks, how to make the information available for network discovery and selection, how to update the network state information in a real-time manner for wireless network, and how to select the appropriate network that meets application performance requirements. In other words, the main challenge faced by today's networking technologies lies in the heterogeneity of the coexisting access networks and the wide variety of networking applications. An independent, standard architecture that enables flexible and effective interactions among various heterogeneous access networks, various applications, and user equipments is needed.

The key feature of "loose-coupling" interactions in SOA makes it an effective architecture for coordinating heterogeneous systems to support various application requirements, which is essentially the same challenge faced by Networking, especially in the ad-hoc, wireless, mobile networks. That is, it is believed that SOA demonstrated satisfactory results when dealing with problems faced by networking nowadays. SOA enables software components including application functions, objects and processes from different systems to be exposed as services, which can be distributed over a network and can be combined and reused to create business applications. The most essential benefits of this approach are modularity, flexibility, loose-coupling and interoperability. Due to the advantages promised by SOA, there are several attempts to introduce the concept of SOA to Networking. In this study, nine papers from IEEE Explore (IEEE electronic database) regarding applying SOA/Web service to Networking are reviewed. These paper can be further divided into two categories, one regards to apply SOA/Web service to achieve more efficient Network Management Systems, the other is about apply SOA/Web service to achieve network discovery and selection. It is believed that by review these critical attempts, it would be easier to identify future research directions.

The subsequent sections of this paper are organized as follows. Section 2 introduces the basic concepts of SOA and Web Services. Section 3 is the main body of this study which reviews nine paper from IEEE regarding apply SOA in Networking. Discussion over the issues of SOA in Networking is also presented in this section. Finally, conclusion and directions for future work are highlighted in the last section.

II. IMPLEMENT SOA STANDARD FOR NETWORKING

A. Service-Oriented Architecture

SOA rooted in the need for communication among, and efficient use of heterogeneous, geographically distributed resources. It facilitates interaction and communication among services. The basic operation of SOA [1] is that service requestors query the registry using a wide variety of search criteria, including category-based searches, to find the service they need. Having identified the service, determined the interface requirements, such as port, protocol, and data location of the service, then they bind to the service to invoke it. This process flow of publish-discover-bind forms the basic service management capabilities of an SOA [2]. SOA-compliant architectures exhibit the following four

properties, Modularity, Loose Coupling, Technology neutrality, Location transparency.

B. *Web Services*

From implementation perspective, there have been varying technologies to realize SOA, such as DCOM (Distributed Component Object Model), CORBA (Common Object Request Broker Architecture), but as of today, Web Service seems to be the most promising technology to implement SOA. One of the strongest reasons to support Web Services is due to its use of the Internet and related open standards as the communication medium. W3C [3] defines web service as "…a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using Simple Object Access Protocol (SOAP) messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards." As described in the author's previous work [4], Web services technologies is based on providing common protocols with which clients can discover and contact the services through the World Wide Web. A Web service is an accessible application that other applications and humans can discover and invoke. Web services are nowadays emerging as a major technology for deploying automated interactions between distributed and heterogeneous applications.

III. REVIEW OF LITERATURE

As mentioned before in the Introduction, study, nine papers from IEEE Explore (IEEE electronic database) regarding applying SOA/Web service to Networking are reviewed. These paper can be further divided into two categories, one regards to apply SOA/Web service to achieve more efficient Network Management Systems, the other is about apply SOA/Web service to achieve network discovery and selection. .To sum up, by applying the principles of SOA in the field of networking, the different networking resources can be encapsulated into "network services." The capabilities of the network systems and the approach to accessing the networking resources in these systems are described in form of service descriptions, which are published at a network service registry. When a network service user, which could be a networking application or user equipment, needs to utilize the services, it sends a request to a service brokering mechanism. The service broker discovers and selects the network service that meets the user's requirements and optimizes networking performance as well. Such a service-oriented network control mechanism supports effective and flexible interactions among heterogeneous network systems and applications, thus greatly enhancing the network intelligence and provides more efficient Network Management System. Below are the reviews of the abovementioned nine articles.

An efficient service oriented architecture for heterogeneous and dynamic wireless sensor networks [5]

In this article, the authors pointed out the essential role played by SOA in bridging the gap between wireless sensor network and resource limited networked devices. Wireless sensor networks can be applied to variety of applications, ranging from monitoring to controlling. Problems of current wireless sensor networks were highlighted in this paper. For example, since most of the sensors are resource constrained due to its batteries, communication bandwidth and processing speed, sensor network architectures are designed for specific applications in order to optimize the scarce resources, and inevitably resulted in prevent the reuse of software components and interoperability between different wireless sensor networks. The authors proposed a multi-level SOA architecture for heterogeneous and dynamic wireless sensor networks in belief that same issues mentioned above have been tackled in the past few years in the field of enterprise information systems by SOA. To achieve the aforementioned advantages, authors of this article extended SOA capabilities to device with limited resources and facilitated deployment of network entities by providing auto configuration functionality both at the service and the network level. A surveillance scenario to detect intruders was studied as the proof of concept. Wireless sensor networks is essential for ubiquitous computing, for example, smart homes, therefore, the effort to apply SOA for the consolidation of heterogeneous dynamic wireless sensor networks is crucial.

Applying the Service-Oriented Architecture for Network Discovery and Selection in the Next Generation Wireless Mobile Networks [6]

As described by the authors, the next generation wireless mobile network will be a heterogeneous networking environment consisting of various networks with heterogeneous implementations. Within the abovementioned network environment, discovering and selecting optimal networks for delivering networking services will seriously affect the service quality offered to networking applications. This means that how to discover the available access networks and select the optimal access network for each user to meet the application requirements becomes a significant research problem. To efficiently discover and select optimal networks, flexible and effective interactions among the heterogeneous networks and various user equipments are crucial. SOA attracts attentions of academic and practitioners owing to its ability for coordinating heterogeneous systems for supporting various application requirements, thus, ideal to facilitating network discovery and selection in wireless mobile networks. In this study, authors investigated on applying the SOA principles in wireless networking environments, particularly for network discovery and selection, since the authors believed network independent architecture that enables flexible and effective interactions among various heterogeneous access networks and various user equipments, coordinating heterogeneous systems to support various application requirements, would be the key to such problem. Moreover, the authors discussed

the technologies that can be used in SOA for updating network state information in a real-time manner without causing heavy overhead load. Service (in this case, network services) discovery and selection is the key issue in SOA, the authors depicted network discovery and selection problem in the next generation wireless mobile networks and tackled this problem with SOA.

Event-Driven Service-Oriented Architecture for an Agile and Scalable Network Management System [7]

This study present an agile and scalable network management system (NMS) based on event-driven SOA. The functionalities of NMS defined by ISO (International Organization for Standardization) include configuration management, performance management, fault management, security management and accounting management. The limitations of traditional NMS, as described in this study, can conclude to the complex information flow, interoperability and scalability issues. The need of agile and scalable NMS is driven by fast changing business requirement, the increasing demand on interoperability with various network devices, protocols, and platforms, as well as the need to support new network technologies and products. SOA-based framework for NMS provides significant advantages through well-defined, easy-to-plug-in interfaces. The advantages can be summarized as ease of integration, scalability and reusability. The aforementioned advantages are due to network components and devices treated as services and can be used by different NMS through standard interfaces.

Network management system using web services and service oriented architecture: A case study[8]

Similar to the precede study; this work presented an effort to apply Web Services and SOA for network devices management. The authors argued that SOA implemented through Web Services is suitable for building network management system. Again, the authors pointed out the complexity of managing large amount of network devices increases drastically. And the management of geographically distributed devices makes it even more complicated for NMS. Therefore, a scalable NMS framework which could present consistent interface, unified configuration control is the cornerstone to facilitate building of next generation NMS. SOA and Web Services were chosen by the in this study after evaluated several possible frameworks since the abovementioned technologies highlighted advantages such as open standards, interoperability across different platforms. This study could serve as a case study for building complex NMS with SOA and Web Services. The authors reported successful implementation but performance issue had not yet been discussed in this study.

Provisioning and Management of Interdomain Connections in Optical Networks: A Service Oriented Architecture-based Approach [9]

Interdomain connections have poses serious challenges for network service providers. In this study, a SOA-based

approach, implemented via Web Service technology, is proposed to assist in establishment and management of end to end connections in optical networks. It is described by the authors that the main problem when considering interdomain connections is related to how traffic engineering (TE) is performed and how local domain constraints are respected. The use of Web services can act as a facilitator to define how different administrative domains can interact to each other. The idea of having services that operate according to the business and goals of the network provider is also easily addressed by the Web services technology. The solution suggested in this study also adopted the idea of having a virtual topology over the physical one. The authors had reported their preliminary implementation results, which indicated the feasibility of the proposed approach and the time needed to establish the interdomain connections. This study also demonstrated a scenario where SOA-based approach could be appropriate, even necessary.

Service Oriented Architecture for Context Perception Based on Heterogeneous Sensors Network [10]

Sensor networks are essential for the concept of Smart Home, the reason for that is because Smart Home needs sensors to provide services adapted to the needs of its residents. In other words, Smart Home needs sensor network to provide variety of information of its residents, in order to provide appropriate services to them. In this study, SOA is introduced to achieve context perception for Smart Home. The concept of context can be described by Dey as "…all information which can be used to characterize an entity". The service oriented approach mentioned in this study is focused on the description and the organization of the services to support services dynamic discovery during execution time. This dynamic availability makes it possible to build applications being able to adapt to various situations, such as the one refer to as the context awareness. The key to successfully apply SOA to Smart Home is to transmit context data observed by sensor, and to make inference on those data to trigger appropriate services for Smart Home residents. The inference aforementioned is achieved by using ontology.

Service-Oriented Management Architecture of Optical Virtual Private Networks [11]

A management architecture based on SOA is presented for Optical Virtual Private Networks in this study. The authors in this study claim the SOA is appropriate for management tasks among network provider, service provider and user. It is due to SOA can provide more flexibility in service composition and ease to integration. To demonstrate the applicability of SOA, an SOA-based integrated management system was build. The basic process described in this study is that network providers allocate resources to service providers, service providers compose OVPNs by aggregating resources received from different sources, end users configure OVPN topology and activate operational OVPNs. This study also pointed out an interesting

viewpoint, that is, via the adoption of SOA, new business model such as physical network resource brokerage is possible. Once again, the flexibility, modularity of the software architecture is praised in this study.

Service-oriented mobility management architecture for seamless handover in ubiquitous networks [12]

A service oriented mobility management scheme was proposed in this study to achieve seamless handover for mobile nodes. In this study, authors first investigated several handover decision criteria then described a service oriented management scheme based on the criterion chosen. Here in this study, seamless handover refers to avoid degradation in communication quality. To achieve aforementioned seamless handover, three requirements should be fulfilled. First of all, reliable detection of change in wireless link condition, second, elimination of interruption in communication, and finally, selection of optimal WLAN. And number of frame retransmission is chosen as handover decision criterion. The authors further pointed out that in traditional layered architecture, information can not pass in between layers, and in the proposed service-oriented based scheme support cross-layer approach and allow information flow in between different layers. The proposed handover management scheme then tested in both FTP and VoIP applications and according to the authors, confirmed feasibility of the scheme. However, through out the paper, how SOA support the proposed handover management scheme is not explained in detail.

Using web services to realize service oriented architecture in military communication networks [13]

The authors in this study first state that networking facilitates information exchange then highlighted that service oriented architecture served as one of the key enabler to today's networking. Also, the authors recognized Web Services had become standard solution to implement SOA. But when a very different scenario, in this study the military tactical network, comes into discussion, new issues and concerns arises. The major difference between military tactical network and traditional network is data rates, while military tactic network usually got to cope with limited bandwidth capacity (low data rate, high delay, and frequent disconnections). Possible solutions and remaining challenges on the way toward also realizing service oriented architecture on the military network was presented in this study. There are several attempts to introduce SOA into military organizations. In order to benefit the military tactic network with full advantages of SOA/Web Service, several techniques and mechanisms were mentioned in this study, including data compression, optimized data representation, data exchange, service registry, proxy server, and communication solutions. The authors also pointed out in this study that the issue of automatically configuring applications based on resource availability and user requirements should be further investigated.

IV. CONCLUSION

Some of the problems faced by the Networking might be solved by introducing the concept of SOA because SOA demonstrated fulfilling results while dealing with similar problems in enterprise level information system building and information exchange. In this study, several previous attempts were reviewed and it is found that SOA be appropriate to deal with two kinds of Networking issues, namely building efficient Network Management System and efficient network discovery and selection. Basic concepts of SOA were also presented in this study, along with Web service, the most promising implementation method of SOA.

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