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Integration of SME, Industry and Government Through Public Infrastructure of SOA and Cloud Computing

W.H. Utomo
Department of Information System, Satya Wacana Christian University, Jalan Diponegoro 52-60, Salatiga, 50711, Jawa Tengah, Indonesia

Abstract: Service Oriented Architecture based integration is a solution to the problem of the complexity of the integration of point-to-point, the integration hub-and-spoke as well as the integration of enterprise message bus. The aim of the research was to use service-oriented architecture (SOA) based integration method and technology through open-source that can integrate various information systems in a company or inter-companies without disturbing daily business operation. The outcome of this research can be used for integrating Information Technology and Communication (ITC) based infrastructure and services, especially for Small Medium Enterprise (SME) and various nonprofit institutions that cannot afford to buy the expensive licensed integration software. Aside from that, it can also be used as a basis in building industrial networking that connect SME, Industry and Government into Cloud Computing public infrastructure.

Key words: Integration, service oriented architecture, small medium enterprise, open source, cloud computing

INTRODUCTION

Application integration in enterprise (intra-enterprise integration) and inter-enterprise (B2B) becomes more important. The need of up-to-date information that can be accessed from any places and the development of e-business solution (especially B2B) requires a solution to integrate various, heterogenic applications that are built from various architecture, programming language and platform. Therefore, integration is a very difficult task (Juric *et al*., 2007).

Most companies use old application (legacy), which is built using various architecture and technology that are not designed for integration. Companies cannot afford the cost to change this application in a short time, because this application is still used and run, also because the companies are not able to build the whole information system in the current business environment. Companies need to introduce this new application and system from time to time. New solution is usually based on modern architecture that is significantly different from the existing architecture application (legacy). This new application (if built) must be integrated to the existing application and the existing application must be integrated to the others to fulfill the purpose of availability and accessibility (Juric *et al*., 2007).

Integration will be the most important strategy priority, because the innovative, new business solution requires integration from various business units that include data integration, application and business system. Integrated information system will improve competitive excellence by the availability of wholly and efficient information access. Integrated application will result in easier access and more coordinated information from various sources (Juric *et al*., 2007).

Particular companies that have just existed for the last couple of years rarely possess integrated information system. These companies are presented with the mixture of separated and heterogenic systems. Those applications are built in different platforms, using different technology and language programming. Because the application is built in different times, different application will use different programming model that is usually separated in not related information islands. Each island is built by different and heterogenic technology. Some of the common technology used to develop the application are: Remote Procedure Call (RPC), Common Object Request Broker Architecture (CORBA), Distributed Component Object Model (DCOM), .NET remoting, Enterprise Java Bean (EJB) and Java Remote Method Invocation (RMI) (Binildas, 2008).

The applications built in the past are usually not designed for integration. This is the cause of the limited or almost no inter-operability of one old application and the others. The problems related to inter-operability are standard proprietary and tightly coupling (Pulier and Taylor, 2006).

The integration usually does not bring much result because of two things; (1) complexity of information technology architecture from heterogenic application that is built from different architecture, language programming and platform, as well as (2) the existing application must keep running when it is improved (Juric *et al*., 2010).

SOA based integration is one of integration architectures to develop service based software application. It allows the re-use of existing services and the production of easy and fast to build and change applications. In SOA integration, ESB (Enterprise Service Bus) is middleware infrastructure for service connection and message exchange. The use of ESB in this integration method can overcome the complexity of Information Technology (IT) architecture that is from heterogenic application, built from different architecture, language programming and platform. Next, SOA-ESB will be used to refer to SOA based integration with ESB middleware.

Some major vendor has developed some expensive SOA-ESB integrator commercially. Because of this reason, the focus of this research is a wholly open-source SOA-ESB integration architecture, such as Java EE, with IDE NetBeans and middleware OPEN-ESB. The reason of the use of open-source technology is that the technology produced can be implemented to non profit institution and SME.

The purposes of the research were to:

- Carry out SOA based inter-enterprise integration (B2B) using ESB middleware technology that involve Amazon.com, eBay.com, Yahoo.com and Paypal.com
- Carry out SOA based intra-enterprise integration with ESB middleware technology in Graduation Business Process in Satya Wacana Christian University (SWCU) case study

In this research, Yin *et al.* (2009) stated that service integration is an important issue in service oriented computing. SOA generally and WS especially support service composition and application evolution. ESB framework support service integration dynamically and intelligently in heterogenic distributed environment. Similar to bus concept in computer hardware, ESB also route inter-services message and provide function such as data format transformation, reliable message route and service management. However, middleware tool such as ESB requires application programmer to guarantee the dependency of end-to-end application. ESB focuses on service integration, service route, message transformation and orchestration and other software development techniques. In this research Yin *et al.* (2009) stated that ESB framework is a flexible distributed architecture and that ESB needs re-improvement method to improve the robustness in services integration. Yin *et al.* (2009) then stated that JTangSynergy is an ESB framework developed to ease service integration for big scale distributed applications. This JTangSynergy framework is then implemented in Chinese Healthcare Service Integration (CHSI) project. CHSI is the development of software system and tool to integrate distributed health information system for Yangzi River Delta area that allows each system to work together. The Scenario of Chinese National Healthcare Service Integration can be seen in Fig. 1.

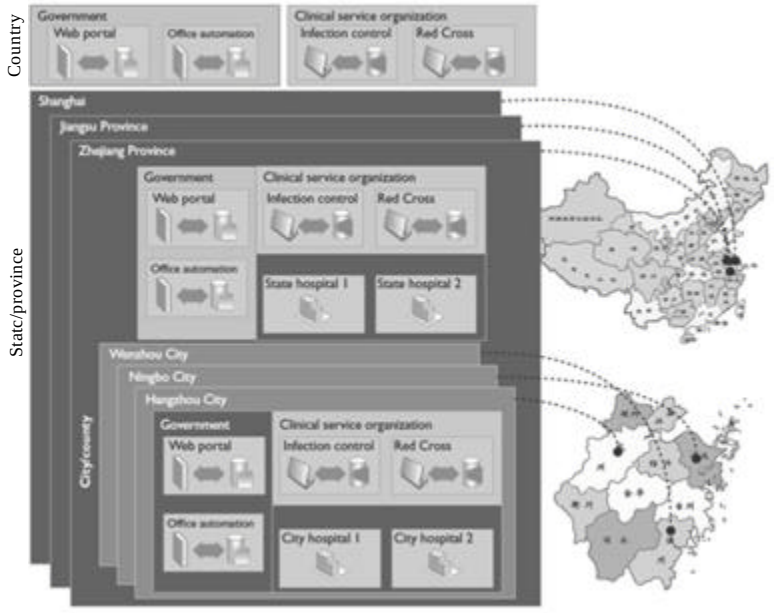

Fig. 1: The Scenario of Chinese national healthcare service integration (Yin *et al.*, 2009)

Table 1: Previous research related to SOA based integration

References	Support to this research	Contradiction to this research
Kumari *et al.* (2008)	This research discusses an open standards based reengineered solution employing SOA principles and deployed on a SOA infrastructure for service provisioning business process of a major telecom provider	The integration platform was implemented on ALSB (AquaLogic Service Bus-an ESB provided by BEA) Focus on intra-enterprise integration
Hu *et al.* (2008)	This study presents a new SOA-based Enterprise Application Integration Environment which clarifies the status and function of ESB SOA in constructing Web services-based application supporting platform	The integration platform was implemented on INOA XML BuS Focus on intra-enterprise integration
Gu and Zhang (2010)	This research present how the process services, atomic services and composite services are used to model the business process of the enterprise and identify process blocks using SOA methods and design styles, through an example of traveling agency	The integration platform was implemented on Service Component Architecture (SCA) Focus on intra-enterprise integration
Al-Otaibi and Noaman (2011)	This research suggests the use of Service Oriented Architecture (SOA) to integrate biological data from different data sources. This work shows SOA will solve the problems that facing integration process and if the biologist scientists can access the biological data in easier way	The Microsoft. Net Framework used to implement integration architecture
Dahman *et al.* (2010)	This study presented a model-driven development methodology for inter-organizational systems that are based on a SOA. The approach advocates a service oriented IT infrastructure provision from a business process specification while tackling with their architectural alignment issues	The integration platform was implemented on Service Component Architecture (SCA) for Travel Booker Case
Kart *et al.* (2008)	This article describes a distributed e-healthcare system that uses the service-oriented architecture as a means of designing, implementing and managing healthcare services	The prototype e-healthcare system was implemented in Plain Old Java Objects (POJO) based on the Spring framework
Vos and van Waveren (2011)	This article aims to examine the ability of SOA to satisfy the requirements and concerns posed by financial trading systems and to present a SOA framework for building an automated trading application The framework supports interoperability and integration with other trading, risk management, or other financial applications and it supports flexibility in terms of adding and configuring existing functionality, as well as the dynamic addition of new and modification of existing trading algorithms	The integration platform was implemented on Enterprise Message Bus (Microsoft Message Queuing /MSMQ)
Mohamed *et al.* (2010)	This study proposed an integrated multi-layered framework for building a generic B2B e-Commerce hub platform based on dynamic SOA. It provided a comprehensive business services model and capitalizes on Web services as well as business process management and orchestration	The paper uses the EDI Reference model, which is provided by the ISO organization to analyze the challenges of the architectures of B2B e-Commerce hubs
Eze *et al.* (2010)	This study extend the traditional SOA framework to define a flexible policy-based approach for defining and monitoring streaming event data based on a general publish/subscribe model in a business-to-business (B2B) healthcare network	The integration platform was implemented on Java Message Service (the publish-subscribe technology for J2EE applications)
He *et al.* (2009)	This study introduces the integration of enterprise application, then analyzing the architectures and key technologies of SOA, propose a SOA-based solution to the integration of enterprise application realized	The integration platform was implemented on Java Enterprise Edition (Java EE)

SOA has gained a lot of attention for several research, whose contributions have been published in a significant number of new journals and conferences that have appeared within the scope of SOA systems. There is much previous research about the supporting or contradicting to this research. This previous research can be seen in Table 1.

INTEGRATION ARCHITECTURE

According to Juric *et al.* (2007), there are four integration architecture, (1) point-to-point, (2) hub-and-spoke, (3) enterprise message bus (JMS) and (4) SOA (Service Oriented Architecture).

Point-to-point architecture is a group of independent system connected through a network. The weakness of point-to-point integration model is that it cannot be widened and it requires complicated maintenance. It is related to the complexity in integrating it point-to-point. In point-to-point integration model, the integration of N application to other N application need N(N-1)/2 interface. If there are six integration applications, 15 interfaces are needed, therefore, to integrate 150 application, 11.175 interfaces are needed. The more application to be integrated point-to-point, the more difficult the application modification and the maintenance of application will be. This also applies in application maintenance. (Manouvrier and Menard, 2007).

Hub-and-spoke integration model is similar to point-to-point integration model. The difference is one additional hub that connects all applications. Message transformation and routing take place in the hub. This integration model is the improvement of point-to-point solution by reducing the number of connections needed for integration. Because the application is not directly connected to other applications, this application can be eliminated from integration topology by eliminating it from hub. This will reduce the chaos in integration management. However, hub-and-spoke weakness lies on the centralized character of hub. If hub experiences failure, the integration as a whole will experience the failure. Moreover, the problem of hub and spoke integration model is that its integration technology is locked by vendor.

While the hub-and-spoke architecture makes use of lightweight connectors for applications to integrate together through a central hub, many a times the integrating applications need to interact in a decoupled fashion, so that they can be easily added or removed without affecting the others. An enterprise message bus provides a common communication infrastructure, which acts as a platform-neutral and language-neutral adapter between applications. This communication infrastructure may include a message router and/or Publish-Subscribe channels. So applications interact with each other through the message bus with the help of request-response queues (Binildas, 2008).

SOA-ESB based integration uses services transferred through a middleware known as ESB. SOA based integration application concept is formerly present as a solution toward the problem of point-to-point integration complexity and hub-and-spoke integration. SOA is architectural service based software application development; therefore, there will be a light-binding in services integration. It allows the re-use of the existing services and production of easy and fast to build and change applications.

ESB is an infrastructure for SOA service connection and message exchange. The main functionality of ESB is to carry out route, protocol transformation, as well as message or data transformation. The presence of protocol transformation function and message in this ESB can overcome protocol and data discrepancy. ESB also eases connection and mediation, simplifies integration and ease the service components re-use, that it results in high integration scalability (Schmutz *et al*., 2010).

ESB is one of SOA pillars, other pillars are WS and BPEL. WS provides only point-to-point integration that is no longer appropriate to integrate application in large quantities. The solution over this problem is through indirect connection among applications through ESB that provides the facilities to carry out content or context based message routing.

In addition, there are two main problems of heterogeneity, the first is the incompatibility among communication protocols used between service users and service providers. This incompatibility does not allow service users to do service request provided by service providers. ESB can solve the problem by providing facilities to convert a transport/communication protocol into other protocols needed. This facility will transform HTTP protocol into SMTP protocol, for example. Through this facility, applications can communicate even though the protocol of service users and service providers are different.

The second problem of heterogeneity related to the incompatibility of the message format used by service users and service providers. This problem is solved by ESB that provides the facility to carry out message format transformation used by both service provider and service users. For example, this facility can transform SOAP message into other XML based formats.

THE COMBINATION METHOD OF SOA AND MDA

The research uses the combination method of SOA and MDA (Utomo, 2011). The combination of these two methods is based on the thinking that each method in itself will not be optimum in integrating services. SOA itself can only provide services analysis and identification, but it does not provide guideline to implement services found. MDA method possess superiority in the transformation of high level Business Process Model to low level model (code) which is platform free but without guideline in term of finding services. By combining MDA and SOA methods, two completing each other advantages will be gained. SOA provides an infrastructure that reduces complexity in the services reuse and integrates all kinds of technology, protocol and application whereas MDA is used in High Level Business Process Model transformation to platform independent low level one (programming code). The combination of SOA and MDA methods will be a complete method for enterprise integration.

This method provides a series of concepts required for modeling of the two perspectives. All concepts can be seen in Fig. 2 that represents the two methods, SOA and MDA. The concepts related to business perspective explain the attached elements in business and are represented in CIM Model through Business Process Model. The concepts related to system perspective are elements used to describe system functionality and

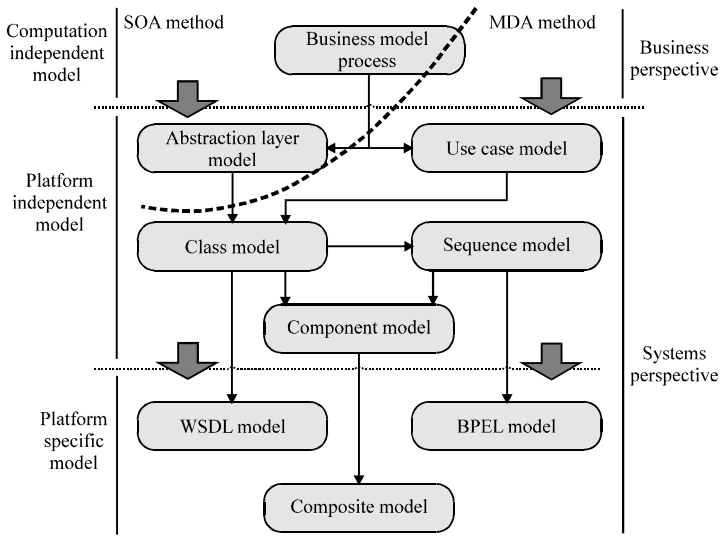

Fig. 2: The combination method of SOA and MDA (Utomo, 2011)

process and are represented in PIM and PSM Model, with Use Case Model, Class Model, Sequence Model, Component Model, WSDL Model, BPEL Model and Composite Model Fig. 2.

RESULTS AND DISCUSSION

This integration application is an application that integrates some services. These services can be obtained in three ways: building new services, building from legacy application and services from a third party.

In this research, two kinds of integration as proofs of integration implementation concept with SOA architecture and ESB technology will be carried out. The two kinds of integrations consist of: (1) B2B integration (inter-EAI) or inter-companies integration and (2) Intra EAI integration (integration in the company).

B2B integration will use the services provided by the third party in the form of web services provided by Amazon.com, eBay.com, Yahoo!Shopping.com and Paypal.com. On the other hand, the second integration (intra-company) will use web services originates from legacy application and will be built a new web service.

B2B Integration: B2B integration is integration from some companies that provide their own services (in the form of web service) such as from Amazon.com, eBay.com, Yahoo!Shopping.com and Paypal.com. The architecture of B2B Integration can be seen in Fig. 3.

The functionality of this integration application is that users can carry out parallel search for a product from Amazon, eBay and Yahoo, put it into shopping cart, do payment via Paypal, receive purchasing notification, as well as register (user registry). The strength of this application is that users do not need to move from one website to another to do online purchasing transaction and that users can compare the prices of goods in a website only. However, the main strength of this application is as a proof (proof of concept) of integration inter-companies by using the web services provided by each company. The implementation of the integration can be seen in Fig. 4.

Intra-enterprise Integration: Intra-enterprise integration or integration inside the company is carried out by integrating graduation business process that consists of six applications, (1) SIASAT-Sistem Akademik Satya Wacana-(Satya Wacana Academic System), is an application used by faculties to check the students' academic transcripts, (2) SIKASA-Sistem Informasi Keuangan Satya Wacana-Satya Wacana Finance Information System, is an application used by the finance department to check students' financial, (3) Library (application to check students' obligation related to the library), (4) Student Service Department, (5) Dormitory and (6) Faculty Laboratory. The six applications will be connected using web service for data exchange using ESB middleware Fig. 5.

This integration system is used by Academic Administration Bureau to handle the process of managing graduation requirements involving library, finance,

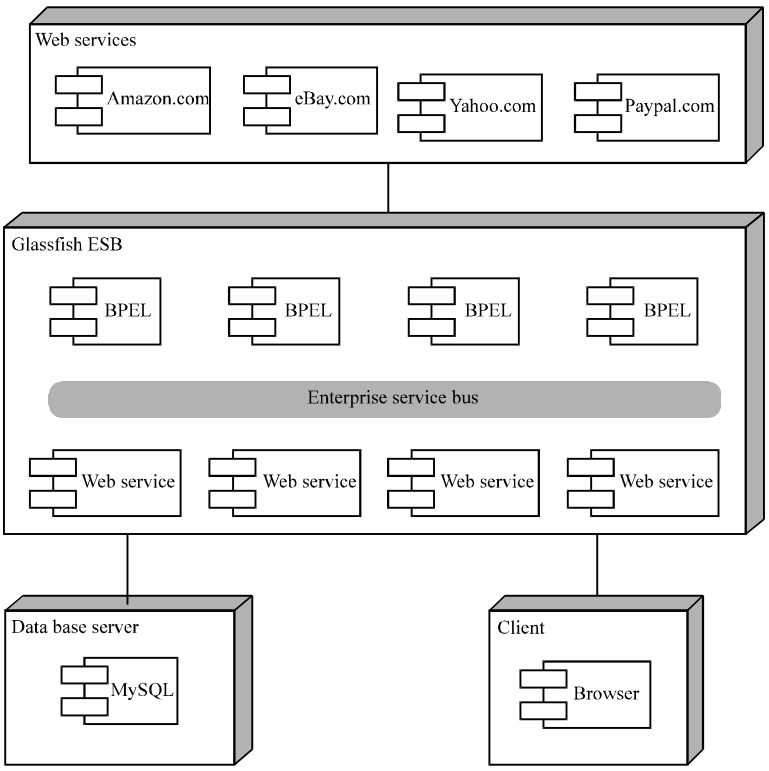

Fig. 3: B2B integration architecture that involved Amazon, eBay, Yahoo and Paypal

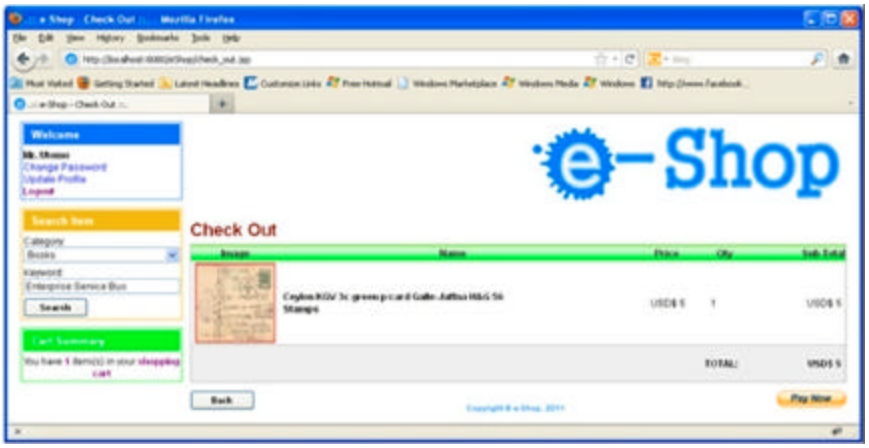

Fig. 4: One of the interfaces of B2B integration application

academic, dormitory, laboratory and faculty units. The business process of managing graduation requirements can be seen in Fig. 6. The integration application of the system can be seen in the following Fig. 7.

For the successful implementation of a SOA-based system, the composition of the services is essential and service identification and modeling is the essential starting point of successful implementation of SOA systems. On the other hand, it is a fact that there are neither any standards nor standardized methods for business service modeling. Thus this study proposes a service identification and modeling method for deducting services that fit system purposes and deducts actual services for agent-based purchase management systems.

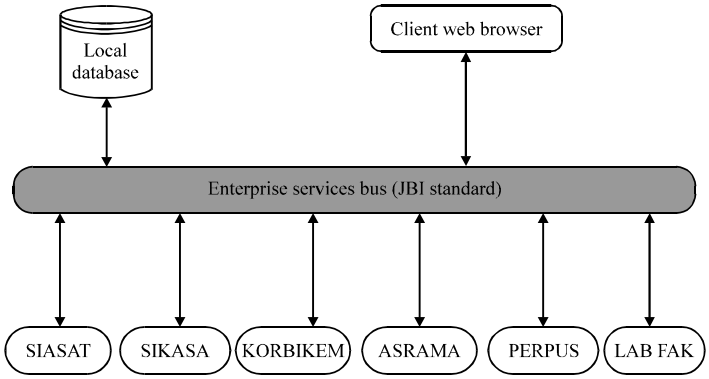

Fig. 5: Integration application architecture of graduation process

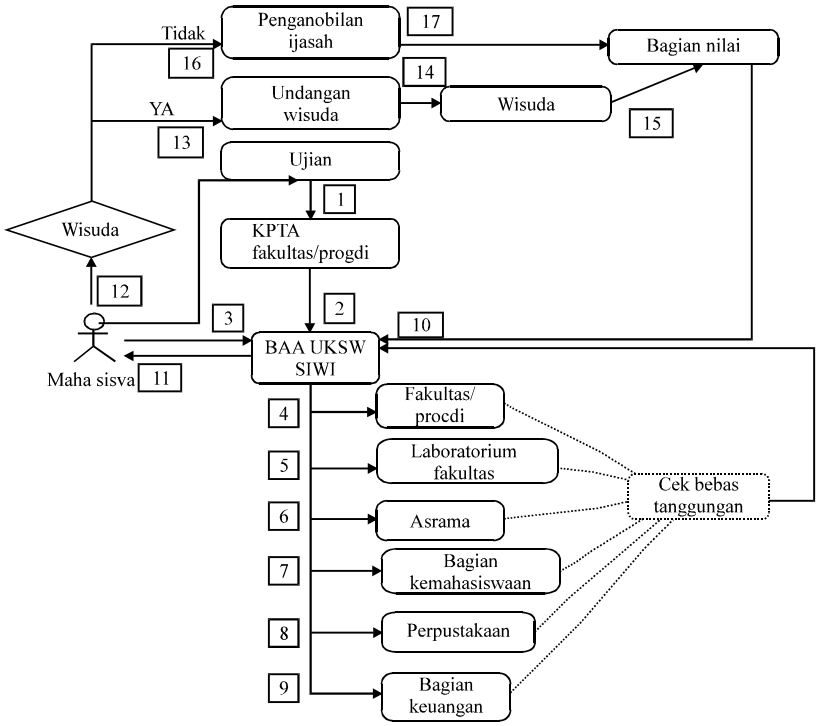

Fig. 6: The process of graduation business in SWCU

Research contribution and future plan: In a previous research, Yin *et al.* (2009) using only two types of services are new services and services from legacy applications. However, in this research used three types of services: new services and services from legacy applications and services from third parties. However, both studies are similar in terms of the use of ESB as integration middleware. The use of ESB in integration method can also help in dealing with complexity of IT architecture from heterogeneous applications, constructed from different architectures and programming languages as well as different platform.

In addition, this research can be used to synchronize company business process and company information system. Company will be more flexible in adapting to its business environment. This flexibility takes place because the services, both services of the existing applications and new services, are easily developed and because new process can be developed from services. Model layering will ease the synchronization between information system and business process or company strategy. With the fast changing business process, this layering process enables a fast process or services reconfiguration without interfering on going operational activity.

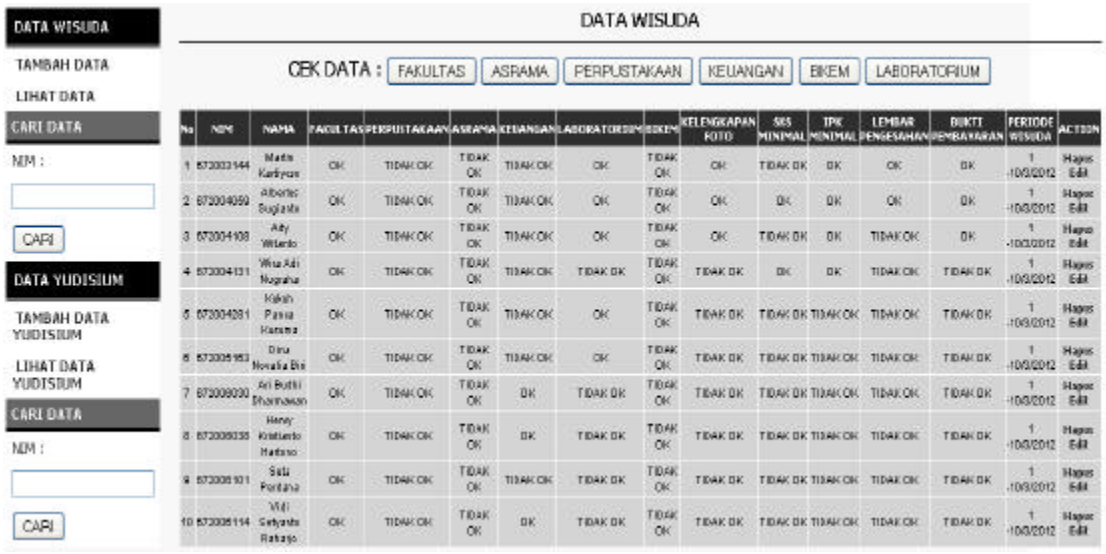

Fig. 7: One of the interfaces of integration application of graduation process

The two kinds of integration mentioned above are the proofs (proof of concept) of SOA based integration by using web services provided by the third party, web services from legacy application and new self-built web services. The findings can be implemented to integrate other applications, such as intra as well as inter-SME integration, intra as well as inter-industry integration, intra as well as inter-government integration and inter-business, government, as well as SME integration. In that way, it can be said that the research findings can be used to integrate Business to Business (B2B), Business to Government (B2G) and Government to Government (G2G).

In the future, the findings of this SOA research can be continued by involving new technology in web sector, that is, Cloud Computing. SOA and Cloud Computing can be integrated because both use services in their developments. With cloud computing, companies can access services put in the third party's server. With SOA, companies can integrate services more "light-weighted" compared to traditional application integration.

SOA is about the process to define IT architecture solution where cloud computing is the alternative architectural. It can be said that SOA cannot be replaced by Cloud computing. Most cloud computing solutions are defined through SOA; therefore, both complement each other. Adopting SOA can prepare enterprises to use cloud computing.

Both cloud computing and SOA set some main components that can be re-used and set the appropriate long-term technology. The companies that implemented SOA modularly achieve better positions in heading toward the use of cloud computing.

Cloud computing is defined as a technology that uses internet as computing resources that can be requested by the users. From corporate business view, cloud computing will trigger changes in how Information Technology system in an organization works. Virtual, standardization and other basic features of cloud computing can reduce the cost of IT, simplify IT management service and accelerate service delivery (Rosenberg and Mateos, 2010).

The main idea behind cloud computing is that it is easier to improve IT resources as service by paying according to usage and need rather than to buy a hardware or software to build a data center. Cloud computing is per-usage payment model to enable availability, satisfaction and on-demand network access that can be quickly installed and uninstalled with minimum management effort or little interaction with service providers.

Cloud computing provides new solution to the provision of public computing infrastructure. The services given through cloud computing posses three main purposes: cheaper, easier and faster. Cheaper because the users do not need installation, complicated settings and high specification hardware, moreover, providers do not need to visit users. It is easier because the users use mainly internet and browser to access services. Faster because it can be accessed anywhere and anytime as long

as the users have member and internet access. These three things make cloud computing an important public infrastructure (Marks and Lozano, 2010).

The number of problems and challenges in public services in Indonesia gives an interesting chance to implement cloud computing technology to solve the problems. Some examples of the problems are: synchronization, system integration and over budget information technology implementation that puts burden on government and private organizations in providing public service such as educational services and SME.

Research in cloud computing implementation in public service information system will provide a solution in answering public service problems. The aim of cloud computing technology implementation in public service information system is to produce an integrated and on-demand system. Moreover, it is expected that this activity will produce cloud computing based public service system application used for integrating useful information in order to support appropriate decision making in an organization that improves the services to community.

Through public infrastructure, connectivity development can be carried out to strengthen SME sector. By using this public infrastructure, the expected impact is to enhance society's economic growth, among them are more efficient market promotion, effective public service delivery, new business opportunity generation and comprehensive social economy transformation.

CONCLUSION

The research has proven inter-enterprise and intra-enterprise integration by using web services provided by the third party, legacy application web services and self-built web services by using open source technology. In addition, the findings of this research can be used as a basis in building industrial network that connects SME, Industry and Government into public infrastructure of cloud computing.

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