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Service Component Architecture for Smart Store System in Cloud Computing Infrastructure

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ABSTRACT : *This paper proposes service component architecture with cloud computing infrastructure in the vending industry for Smart Store system. We use the software integration model to rapidly integrate related services, substantially reduce development costs, and establish innovative services. We expand the concepts of SCA-based service into a large scale as Smart Store system. The system services about the Smart Store can be separated into four components of system modules. These modules include: System Management Module, Financial Management Module, Logistics Management Module and Smart Store Module. We apply cloud computing technology to solve the problem of service overloading in a distributed environment. Finally, this paper gives services as an example to be implemented in the vending industry. The case illustrates how to rapidly integrate the Machine Management ServiceComponent and the Business Intelligent Service Component by cloudbased integration model of SCA, and how to decrease system overloading.*
Keywords: *Service Component Architecture, Vending Industry, Smart Store System, Innovative Services, Virtual Integration, Cloud Computing*

I. INTRODUCTION

The service-oriented machine is a trend in the business world, such as ATM machines, photo kiosk machines, self-service ticket machines, and vending machines. Over the past few decades, there has been a dramatic increase in the breadth of development in the vending machine industry. The vending industry has a revenueof $US 22.05 billion in 2008 in the United States according to the 2009 Automatic Merchandiser State of the Vending Industry Report (Elliot, 2009). In Europe, the industry's yearly turnover was over €13 billion in 2008, according to European Vending Association. Figure 1 shows a statistics report which involves the amount of vending machines and annual sales in the vending machine industry in Japan which showed by Japan Vending Machine Manufacturers Association. Unlike most shops, automatic vending machines operate 24 hours a day and provide consumers with the convenience of being able to purchase products with self-service. Following requirements of customers, vending machines have offered a multiplicity of products, such as food, beverages, CDs, newspapers, sanitary utensils, postage stamps, toys and et al (Bessman, 1994, Guenette, 1995). With more and more respect given to the demand for customer convenience, vending machines have gradually developed to become one of the most important product channels in life. It can offer consumers with various products, like food, beverages, papers, sanitary utensils, postage stamps or toys. The vending industry is very competitive and challenging, to say the least. We see some very exciting new entries in the market place every month. Glow necklace vending, Camera vending, Digital film developing, Custom post card vending, Cartoon video kiddie trains, Soft serve ice cream vending, Dressing bears, Hydraulic gold digger kiddie ride, DVD vending and Internet kiosks are capable of many new options. The potential rewards are high and too enticing to refuse, but machine owners must take care in stocking individual machines to ensure that products stocked are appropriate to the location and will maximize revenue. Many integrated system firms develop some principle methodologies for machine connection in a manner that integrates back-end and front-end environment.

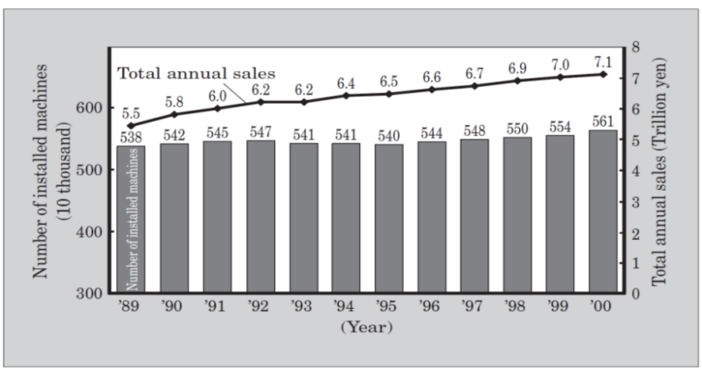

Figure 1: Transition of the number of installed vending machines and annual sales of merchandise(Japan Vending Machine Manufacturers Association, 2012)

Due to the development and advancement of technology, more and more information systems are applied on vending machines to supply personal and customization services. A host of technologies has emerged to provide vending machines new benefits in recent years (Elliot, 2007). Machines offer services such as cashless purchasing, remote machine monitoring, electronic security, data-based menu planning, and more (DemirkanandSpohrer, 2014). Some of the common problems that retailers face while evaluating alternative technology solutions are overviewed and presented a survey of available analytical tools (Bharat, 2000). Related technologies and services are combined in the retail industry such as Smart Store that is a technology-enabled innovation shown in Figure 2.

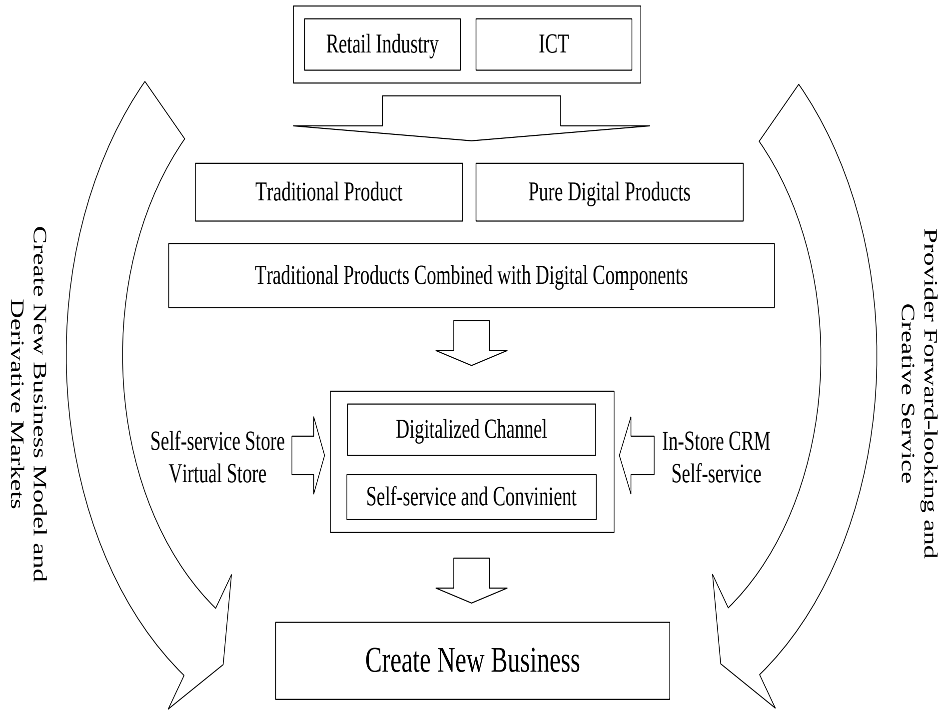

Figure 2: The Concept of Smart Store(Tseng and Yao,2007)

How to use information and communication technologies (ICT) in intelligent shops are discussed and listed 6 big problems : location decisions, human resources, limited space, the advent of the e-commerce era, development of innovative business models, and balance between energy saving and industrial value that the current convenience stores will face (Tseng and Yao, 2007). Smart Store integrates the information and communication technologies (ICT) and innovation of related services. Smart Store is based on a technological platform that offers support for some attractive and efficient services for customers and administrative staff. Customers can obtain a new brand new experimental shopping environment from Smart Store which differs from traditional and drives customer-valued innovation through deeper insight, so innovation has become the most successful factor for business survival.

Markets are changing quickly and the ability of marketers to respond to these changes in both a timely and economical manner is critical to every company's success. Business environments are full of complexities in terms of managing the value adding (Shamsuzzoha andHelo,2012). An innovative platforms offer great benefits to companies developing new dominant position in highly competitive markets (Mortensen et al., 2013).Smart Store enables large corporations, mid to small businesses, and even non-profit organizations to respond to market dynamics with unprecedented speed and accuracy, and makes critical improvements to in-store efficiency. An innovative solution is presented in retail activities based on a technological platform that offers support for some attractive and efficient services for customers and administrative staff (Stan et al., 2008).

Smart Store is such a creative and innovative conception which offers customers value-added services through information technologies. Smart Stores are similar to retail or convenience stores; however, they can be combined with features such as innovative service, more convenient avant-garde customer service, advanced electronic control, and refrigeration monitoring of your stores. Now, there are conceptions of Smart Stores offering advanced services on vending machines with self-service everywhere in Japan, USA and Europe (Lo and Yang, 2007). Although the setup cost of the store was about the same as opening a convenience store, it can offer lower labor costs in business operation. There will be more and more businesses investing in this industry to offer customers value-added services and turn it into a new niche market. Smart Store uses information and communication technology to establish an innovative platform and service to provide customers a new shopping environment and experience.

With the growth and improvement of Smart Store, more and more enterprises pay attention and put effort into Smart Stores. There have been advances and diversification in technology with System and operating platform, however, software components are developed by different programming language, like Java, C++, C, .NET etc. How to easily integrate as a set of software components working together is a problem that needs to be addressed these days.

Following the development of Smart Store system, many industries apply customer services combined with Smart Store apparatus to satisfy diversification of customer requirement. And then, service over loading became hard to deal with. To solve these issues, we propose a software integration model of service component architecture in a vending industry. We use this architecture to rapidly integrate related services, substantially reduce development costs, and establish innovative services and provide consumers with a brand new experiential shopping environment in retail domain. Meanwhile, we apply a cloud computing technology to solve the following problem: service over loading in a distributed environment. We also discover many issues that will be happened with system scaling up, such as virtual integration, LBS combined shopping services, personal services, and product optimization. Therefore we use cloud computing as a solution to prevent these discussed issues.

II. RELATED WORKS

First, it is necessary to illustrate the content and describe the state of SCA. And then, the application for retailer industry by SCA-Based service is built to process management application. Finally, we will introduce cloud computing and how we use it.

Service Oriented Architecture (SOA) is an architectural design pattern. It provides software application functionalities as services to other applications via a protocol (Dhara et al., 2015). In the recent years, Service Oriented Architecture (SOA) has been a popular model of system architecture. Many industries increasingly focus on SOA and make efforts to standardize SOA. About seventeen companies develop SOA technology and persist in renovating the draft and specifications. SOA is a business-centric IT architectural approach that supports integrating your business as linked, repeatable business tasks, or services. With the Smart SOA approach, you can find value at every stage of the SOA continuum, from departmental projects to enterprise-wide initiatives. Service Component Architecture (SCA) is a set of specifications which describe a model for building applications and systems using a SOA. SCA extends and complements prior approaches to implementing services, and SCA builds on open standards such as Web services. Now, these industry partners established one of the standards is Service Component Architecture.

SCA focus on simplifying the creation and integration of business applications built using SOA. In SOA, relatively coarse-grained business components are exposed as services, with well-defined interfaces and contracts. OASIS Open Composite Services Architecture defines that SCA is a set of specifications for building SOA applications, how to create components and how to combine those components into complete applications and provides a programming model for building applications and solutions based on SOA. SCA defines a general approach to do both of these things. SCA allows developers to write business logic. However, SCA complies with existing standards "under the covers" to preserve existing investment in standards, middleware and tools. This approach is exemplified by a number of existing projects.

A SCA application is even more dynamic; the application knows the details of the component's interface at build time and does not access the component's implementation at build time; the component is invoked by the SCA invocation framework and does not know the details of the component's access method at build time; this is also handled by the SCA invocation framework. SCA moves the implementation and access method details out of your application and into the middleware, so SCA makes the work of the designer simpler.

SCA is built on four concepts: services, components, composites, and the domain. In SCA, applications are organized into a set of services that perform particular tasks. The basic construction blocks are the components, which require and provide services. Components are configured using a configuration file called a composite. Composites are deployed into an environment running SCA middleware termed a domain. SCA supports the creation and reuse of service components using a wide variety of implementation technologies.

Alves et al. (2007) describe that components can be built with programming languages such as Java, C++, PHP, COBOL, and BPEL. SCA is designed to be language independent. The model is also neutral regarding the communication protocols used between remote components. In the same way, services can be described using different service description languages. With SCA it is possible to combine components which were built with different technologies. Furthermore, components behavior and interaction can be configured to different contexts, using the policy frameworks defined by SCA.

A property has a type and a value. Properties define the ways in which a component can be configured and handle the difference between the interfaces. Properties are manifested differently depending in the implementation language used for components. A service component has one or more services with which it is associated. Service is a set of operations defined by an interface that can be used by other components. Each service component can access other services in their implementation. A service component definition can include zero or more than one reference to other service components or imports included in the current module.

Components are the basic elements of business function in a SCA assembly, which are combined into complete business solutions by SCA composites. Components are configured instances of implementations. Components provide and consume services. A client connects to a service via an address and invokes operations on it. More than one component can use and configure the same implementation, where each component configures the implementation differently. A service or a reference has an interface and a binding. The interface might be a Java interface, a WSDL port type, a BPEL partner link, a C++ class, etc. The binding defines the access method, could be SOAP/HTTP, JMS, ATOM, JSON, RMI-IIOP, SCA, etc. In SCA, bindings are used by services and references. References use bindings to describe the access mechanism used to call a service (which can be a service provided by another SCA composite). Services use bindings to describe the access mechanism that clients (which can be a client from another SCA composite) have to use to call the service. Although SCA is an emerging technology, there are several companies devoted on developing, so several open source implementations are available. Marino and Rowley (2009) indicated that two of the most well-known are Fabric3 and Apache Tuscany.

III. SCA-BASED SERVICE FOR THE RETAILER INDUSTRY

SCA is a technology for creating, assembling, and managing distributed applications. SCA aims to support a wide range of technologies for the implementation of service components and gives your developers a single programming model for using services. This includes not only specific programming languages but also frameworks and other extensions built using those programming languages.

Each component typically implements some business logic, exposed as one or more services. A service provides some number of operations that can be accessed by the component's client. How services are described depends on the technology that's used to implement the component. Services and references allow a component to communicate with other software.

In smart store systems, there are many service components including transaction data service, transaction analysis, business intelligence, commodity data management, machine slot management, inventory monitoring, fault notification, E-mail message and so on.

The Service Component Architecture provides the ability to represent business logic as a reusable component which can be easily integrated when assembling an application or solution. When a maintain service application is implemented, fault notification and E-mail message components together build a composite application. Other applications are the same. Figure 3 shows the Service Assembly for Smart Store Platform.

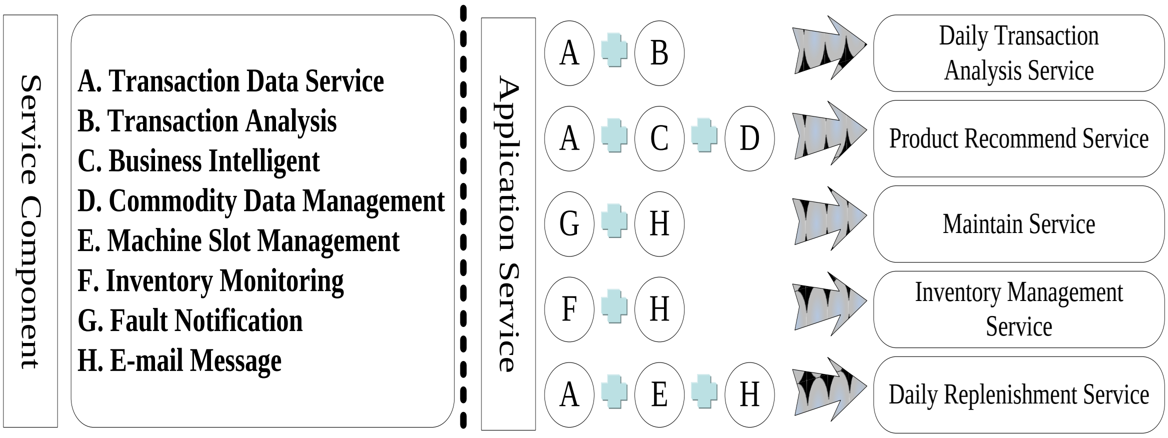

Figure 3: Service Assembly for Smart Store Platform

In Figure 4, we use a retailer system to construct an enterprise-class SCA application. This application offers a front-end web site, lets operators process retailer management such as inventory management, product recommend and daily replenishment. Using business logic presented by SCA, every composite contains several components, of which interact to provide a service to operators. All data and information are stored in the back-end database which is a data warehouse.

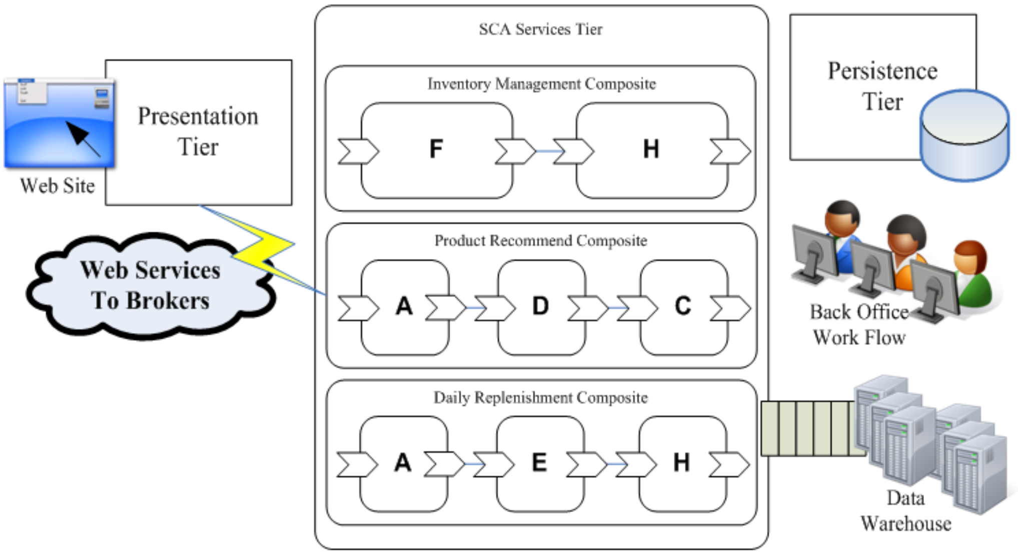

Figure 4: Retailer Management System Application Architecture

IV. CLOUD COMPUTING

Cloud computing is a conceptual refinement of pervasive virtualization (Fernandoet al., 2013). Therefore, the cloud model is an inevitable consequence of pervasive virtualization. Even though Cloud Computing is not a new conception or technology, but it has become more popular since the financial of 2008 in every industry. The cloud computing marketing is expected to surpass 95 billion dollars. More and more researchers survey on cloud computing (Zhang et al., 2010,Jing et al., 2013,Mehta et al.,2013).

Many computing researchers and practitioners have attempted to define Clouds in various ways. Buyya et al. (2008) give the definition that a Cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers. Cloud Computing is associated with a new paradigm for the provision of computing infrastructure. Hayes (2008) states that this paradigm shifts the location of this infrastructure to the network to reduce the costs associated with the management of hardware and software resources. Thereafter, Vaquero et al. (2009) attempts to offer a more comprehensive analysis of all the features of Cloud Computing and reach a definition that encompass them. Cloud computing is massively scalable and allows connecting and provisioning the proliferating array of the end-user. It can rapidly develop & deploy new innovative applications & services to be delivered over the network.

Lin et al. (2009) indicate different meanings for different people to describe the application concept of Cloud Computing. (1) For application and IT users, it's IT as a service (ITaaS) delivery of computing, storage, and applications over the Internet from centralized data centers. (2) For Internet application developers, it's an Internet-scale software development platform and runtime environment. (3) For infrastructure providers and administrators, it's the massive, distributed data center infrastructure connected by IP networks.

McFedries (2008) indicate that Cloud Computing, in which we let not just data but even software reside within the Cloud and access everything not only through our PCs but also Cloud-friendly devices, such as smart phones, PDAs et al, are the mega computers enabled by virtualization and software as a service. This is utility computing powered by massive utility data centers.

Cloud computing is any IT resource, including storage, database, application development, application services, and so on, that exists outside of the firewall that may be leveraged by enterprise ITs over the Internet. As cloud computing emerges there is a lot of discussion about how to define cloud computing as a computing model. Maturity models have been published and debated, and providers clearly have a model for their own products.

However, Cloud computing is a concept and represents the use of the Internet to enable the computer to cooperate with each other or make services more far-reaching. In the realization of concept of the process, it will produce a corresponding technology. Lin (2009) divides it into three kinds of goods via demand-driven analysis of market segmentation for Cloud computing, Infrastructure-as-a-Service, Platform-as-a-Service and Software-as-a-Service. Of the three commodities in the cloud computing model, Software-as-a-Service is the most well-known as PeopleSoft, it could be the largest number of instances of the current model. Infrastructure-as-a-Service, Platform-as-a-Service and Software-as-a-Service can be said that the bottom-up three levels of cloud computing (layer), each level has a corresponding current product/service.

In this paper, we will apply architecture of Platform-as-a-Service (PaaS) to integrate our system to solve derivative problems which follow the development of smart store systems.

SCA is a great technology for defining components and assembling them. SCA makes your applications easier to write and maintain and lets the administrator change the infrastructure of your application without changing the application itself. Cloud computing is a great technology for virtualization. The cloud lets you create and manage VMs and storage cheaply, quickly, efficiently, and without any knowledge of the actual network. Combining SCA and cloud computing is an extremely powerful combination. SCA and cloud computing make your applications more flexible and robust.

V. INTERGRATION MODEL OF SERVICE COMPONENT ARCHITECTURE

We expand the concepts of SCA-based service into a large scale as smart store system. Figure 5 presents that system services applied with Smart Store. The system can be separated into four components of system modules which include System Management Module, Financial Management Module, Logistics Management Module and Smart Store Module. System Management Module handles system related tasks which deal with network and management tasks and harmonizes the dynamic behavior overall system.Financial Management Module includes features that support creation of ad hoc reporting, generate financial reports, manage cash and fixed assets and execute payment and receivable transactions.Logistics Management Moduleprocesses supply chain of products or business process. Smart Store Moduleoffers related deals the control of the vending mechanism and improves the ability of machines to interact with customers and its operational efficiency. These modules can accomplish services by service components which operate themselves and users can access them by application. Next, we describe briefly each service component:

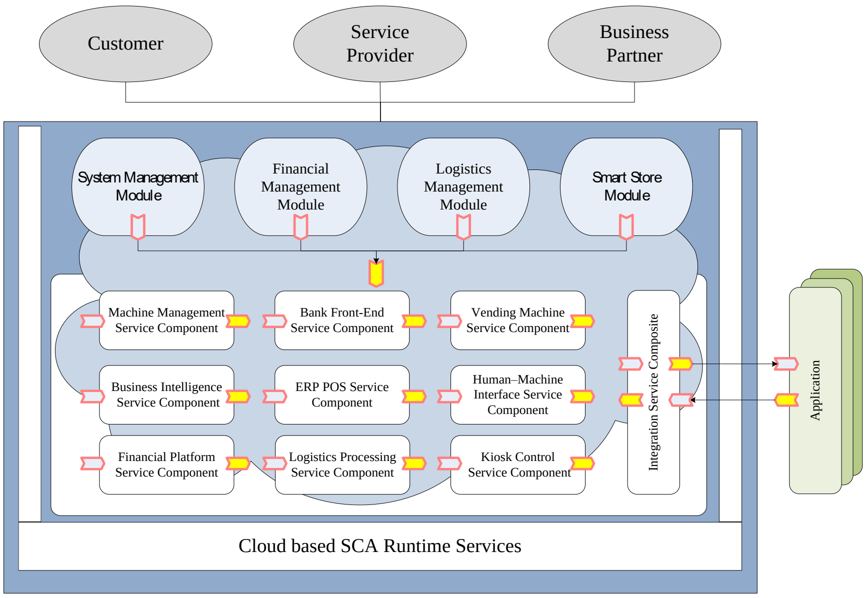

Figure 5: SCA Assembly Diagram of a Smart Store System

1). Machine Management Service Component

Machine management service component is a backstage service platform of all machine management. The platform can monitor every status of each product, the complete information of replenished products, transaction data, and error messages of vending machines via network connection.

2). Business Intelligence Service Component

Business intelligence service component offers related business analysis collected by machine information. When sales data is available after operating for a period of time, this service inducts the attributes of good selling products. Finally, this component replaces bad selling products with those having attributes of good selling products. This decision approach can promote customer satisfaction and total sales. In addition, Kiosk device can collect the questionnaire from users' interaction and analyze the results by Business intelligence service component.

3). Financial Platform Service Component

Financial platform service component provides various types of financial processing services, such as receiving and recording the amount of the transaction data to carry out statistical operations in financial-related services. In addition, front-end and back-end service component of vending machines and banks can be communicated and processed through this service component.

4). Bank Front-End Service Component

Bank front-end service component is a financial payment system in a vending machine via payment cards. It operates this service with the Smart Card Alliance, and contactless payment technology that follows the near field communication standards which enables improved customer self-service and speed of transaction with a reader device.

5). ERP POS Service Component

ERP POS Service Component analyzes transaction data as it is received from machines and stocks with goods by ERP services. This service also monitors customer requirements to achieve “customer-centric” capabilities that offer better merchandise to local customers and emphasize desired customer segments.

6). Logistics Processing Service Component

Logistics processing service component is about all services of logistics, like process improvement service which concerns the process of supplying vending machine products or uses the Barcode Reader scanning to do some services like supply reminding or supply amount. This service will affect the vending machine business process.

7). Vending Machine Service Component

Vending machine service component offers related services which control the vending mechanism of vending machines. This service will improve the ability of machines to interact with customers and its operational efficiency.

8). Human–Machine Interface Service Component

Human-machine interface service component offers services on rich-media front-end interaction machines to directly serve users and records interactive information between users and machine. Digital Signage is one of the infrastructures and applications that disseminate dynamic media content to display and improve promotion effectiveness and communications.

9). Kiosk Control Service Component

Kiosk control service component offers users to control and interact with a vending machine which affects and relates to users such as product/service ordering.

The above services can be integrated by cloud based SCA. Each service operates other services and accesses them by application.We can easily integrate and use the Network-Attached Memory mechanism to decrease over loading and increase system efficiency through cloud based SCA. Next, we describe briefly each cloud based SCA runtime service:

10). Distributed Shared Memory

Distributed Shared Memory (DSM) is a technique to make multi-computers easier to program by simulating a shared address space on them and refer to a wide class of software and hardware implementations. DSM systems represent a successful hybrid of two parallel computer classes: shared-memory multiprocessors and distributed computer systems. They provide the shared memory abstraction in systems with physically distributed memories and consequently combine the advantages of both approaches (e.g., Scott (2005)).

DSM systems provide shared memory abstraction over physically distributed memory of clusters and can be implemented within an operating system, or as a programming library. In addition, they are also implemented in the operating system and be the extensions of the underlying virtual memory architecture.

Shared memory architecture may involve separating memory into shared parts distributed amongst nodes and the main memory; or distributing all memory between nodes. A coherence protocol, chosen in accordance with a consistency model, maintains memory coherence.

We want to implement the concept of DSM to cluster Java Virtual Machines (JVMs) directly underneath applications, and prove the runtime approach that can provide Java applications with both high availability and scalability through managing mission critical data. It can improve disk durability and runs at in-memory speeds, which means it's faster and more scalable than databases, distributed caches, spaces, or message-oriented replications.

11). Cloud-Based Integration Model of Service Component Architecture

As shown in Figure 6, based on DSM, we proposed a cloud-based integration model of service component architecture that includes the following parts:

- Load Balancer – When users send a service request, Load Balancer will invoke the service composite and send the composite information to SCA Wiring & Promoting Executor. It manages the request queues to reduce heavy load from the front-end of vending systems.
- SCA Wiring & Promoting Executor – SCA Wiring & Promoting Executor is responsible for building the link between a user client, servicecomponents related to user vending request and Service Clustering environment.
- Service Component Index – When a service is deployed to the In-Memory Shared Service Component Heap, it will generate an index about the service. The position information about the deployed services will be kept by the Service Component Index.

- In-Memory Shared Service Component Heap – In-Memory Shared Service Component Heap stores lots of service components and data; it uses Distributed Shared Memory to reduce the system overloading.
- Server Register – Each server registers itself as a member in the Service Clustering environment. Through Server Registry, Service Crawler has the capability to know each server status and any information about services which exist in it.
- Service Crawler – The Service Crawler allocates resources for In-Memory Shared Service Component Heap. It has two main functions: one is to deploy services and data of each server to the Heap; the other is to dispatch service execution information to different servers.
- Service Pumper – The Service Pumper is a server interface which communicates with the Server Register; it notifies of the server status and transmits server-owned services to the Service Crawler.

12). Services Operation in Cloud-Based Integration Model of Service Component Architecture

When the user generates the request of services, the SCA Wiring & Promoting Executor will build the link between the user client and Service Clustering, and then the Service Clustering will compute and provide integration services. Service Clustering is a kind of cloud clustering which collects various service components through the sharing mechanism in the Memory level. Service clustering is constructed on the basis of service array that provides high availability and massive scalability at the service layer.

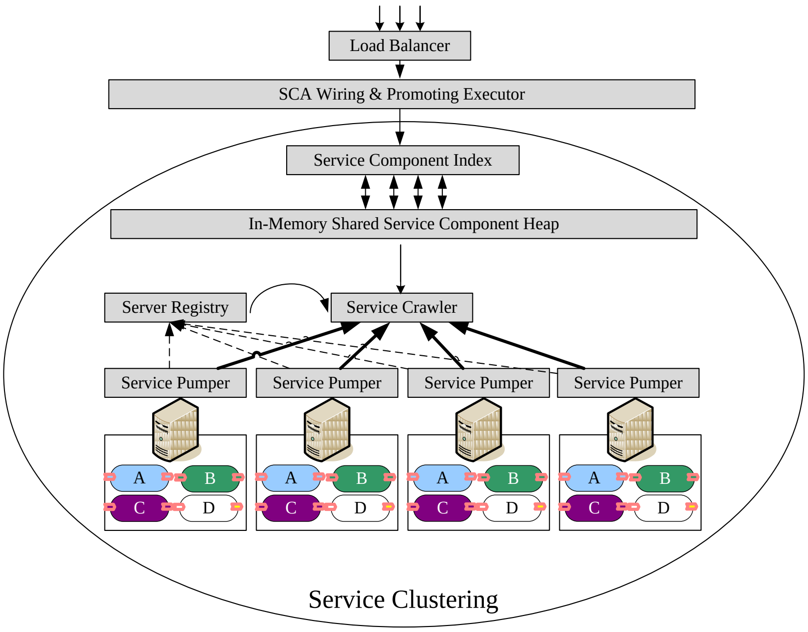

Figure 6: Cloud-Based Integration Model of Service Component Architecture

In the system-initial phase, each server is registered to the Server Registry, which gives the server information to the Service Crawler, and deploys the service to the In-Memory Shared Service Component Heap through the Service Crawler. When the service is called again, Service Clustering will search for the service in the Memory-Shared Service Component Heap. Therefore, we can reduce the service loading time, decrease overloading, and increase system efficiency. In addition, the Service Crawler will gather services from different servers by accidental request or bu the perodic gathering policy to avoid overloading in the Service Clustering environment. Thus, it can be viewd as a distributed intelligent service allocating mechanism in the cloud-based integration model of SCA. It has the following benefits:

- Data cache – The information of each server, like service metadata and transaction data, is transmitted to the In-Memory Shared Component Heap by the Service Crawler. The heap can keep critical data for vending request processing. Unlike the traditional way of storing data in the database, we regard the memory as a persistent layer to accelerate data access.
- Decrease server overloading and achieve a fault-tolerance service provision system

The crawler can dynamically dispatch the execution command to any server according to the service information on the heap. Through the shared-memory, all of the servers in the Service Clustering environment can observe the same information about services and transaction data, take the execution command delegated by the crawler, and replace other unavailable servers to process continuing vending requests.

VI. EXPERIMENT CASE

This section illustrates how to rapidly integrate the Machine Management Service Component and the Business Intelligent Service Component by cloud based integration model of SCA, and how to decrease system overloading.

When users want to comprehend all the statistical information of transaction data from vending machines, the information has to be calculated from the Machine Management Service Component and the Business Intelligent Service Component. The execution steps in Figure 7 are described as follows:

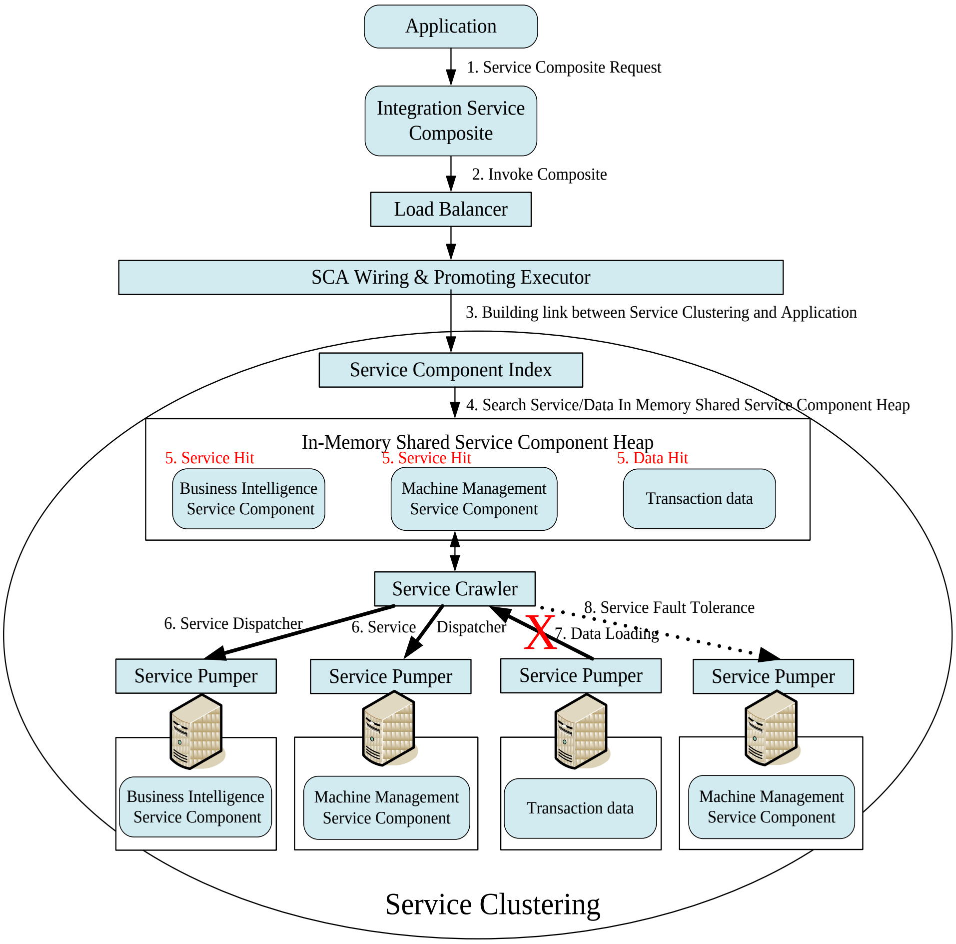

Figure 7: Service Operation in Cloud Based Integration Model of Service Component Architecture

At step 1, the user will send a service composite request to the integration service composite. The system will invoke composites though the Load Balancer as in step 2 and the SCA Wiring & Promoting Executor will build the link between the user client and the Service Clustering as in step 3. At step 4, the system will search for the related service and data in the In-Memory Shared Service Component Heap. If the services or data are kept in this heap as in step 5, which means the services hit or the data hit, we can reduce the service loading time and data loading time. Therefore, step 7 isn't executed. After finding related services information on this heap, the Service Crawler will dispatch each service to different servers as in step 6, which can avoid system overloading and increase its efficiency. When the Service Crawler detects any problem from one of these servers, the Service Crawler will dispatch the service execution to other servers as in step 8 to achieve fault tolerances.

VII. CONCLUSION

In this paper, we propose a cloud based integration model of SCA to solve the problem regarding service integration and service overloading in the retail domain. The Cloud based integration model of SCA is based on distributed shares memory; it shared memory between every service server which is registered to Service Crawler. In addition, Cloud-Based Integration Model of SCA can be applied to any service in different domain field. Therefore, if we need to integrate related services, we can utilize the Cloud-Based Integration Model of SCA to achieve such services. It helps us decrease server overloading and increase system efficiency.

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