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클라우드 컴퓨팅 기술을 활용한 적응형 연구개발 프로젝트 관리 프로세스 설계 프레임워크

Adaptive Framework for Designing R&D Project Management Process Using Cloud Computing Technology

신광섭(Kwang-Sup Shin)*

초 록

최근 글로벌 시장의 변화를 대표할만한 주요 키워드는 초연결(Hyper-Connection)과 지역적 세계화(Glocalization)으로 요약될 수 있다. 이러한 변화에 대응하고 경쟁 우위를 확보하기 위해서는 서비스 관리를 위한 표준화된 조직, 정책, 프로세스를 구축하는 것이 필요하다. 또한 서비스 관리 시스템은 연구개발 프로젝트 관리를 효과적으로 지원할 수 있어야만 한다. 본 연구에서는 클라우드 컴퓨팅 기술을 이용한 연구개발 프로젝트 관리 프로세스 설계를 위한 적응형 프레임워크와 시스템 구조를 제안한다. 이를 통해 전통적인 서비스 관리 기법이 가지는 한계점을 극복하고 시장의 요구에 빠르게 대응할 수 있을 것이다. 이와 함께 본 연구에서 제안하는 시스템을 통해서 국제 시장에서 경쟁우위를 확보함과 동시에 고객이 원하는 것 이상의 가치를 제공할 수 있을 것이다.

ABSTRACT

Two of the most important changes in the global market can be represented with Hyper-connection and Glocalization. To cope with these changes and secure the competitive advantages, it is essential to develop the standard organization, policy, processes and criteria for service management. In addition, the service management system is required to effectively support the R&D project management. In this research, an adaptive framework and system architecture for designing R&D project management process using cloud computing has been introduced. With the proposed system, it is able to overcome the limitations of traditional service management and treat the demand from the market in agility. Moreover, it may be possible to present more value than customers want and secure the competitive advantages in the global market with the proposed system.

키워드 : 연구개발 프로젝트 관리, 개방형 혁신, 클라우드 컴퓨팅, 적응형 프로세스
R&D Project Management, Open Innovation, Cloud Computing, Adaptive Process

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1. Introduction

During the past few decades, the most important changes in the global market can be represented with Hyper-connection and Glocalization accompanied by an acceleration of innovation cycle. These ongoing transformation of market structures and situations competitive has been observable in many service and product markets [4]. Getting through these changes, because introducing successful new products or services is essential for every general organization, the product and service innovation become one of the most important way to adapt to the changes in markets, technologies, and competition [5].

As Yelkur and Herbig [8] have pointed-out, a new approach for the globalized market becomes required because the traditional new product or service development process cannot work in the globalized market [18]. Like the case of globalization, for the era of glocalization, more flexible, agile and collaborative approach to manage the process of new product or service development should be defined to secure the sustainable competitive advantages.

Although a lot of prior research has been conducted, there is no generally approved and accepted standard process and model for innovating service and product for the glocalization. And it has been known that mostorganizations still have difficulties with sustained product innovation, or managing a number of product innovations over time [2]. The major reason for this problem can be found in the diverse of services, products, markets and corporates. In addition, in the increasingly dynamic competitive environment, cost, quality and technology leadership are no longer sufficient for service enterprises to secure crucial advantages. Instead, growing importance is nowadays attached to more subtle differentiations in the form of innovative services, which in many branches are rapidly developing into the unique selling propositions of each firm [4].

Since the competitive advantage with the glocalization strategy may not be achieved through the traditional closed innovation activities, a concept of “Open Innovation” may be adopted to overcome the limitations of closed innovation [8]. However, the most corporates are aware of the open innovation but do not know how to proactively utilize it as the tool of innovation [13, 14]. In general, innovation is not given the support from top managers because a few experts or a certain small part of entire organization participate in the innovation process. Additionally, the most of organizations are not organized to facilitate innovation: occasionally innovation did occur, but it occurred in spite of the system, not because of it. Also, innovation is a fragile and vulnerable activity [5]. The few scientific models that have so far taken up the chal-

lenge of service development only seldom cater for the needs of practical users. Weak po- ints are observed such as insufficient level of detail, lack of configurability, lack of practical collaboration, lack of Information Communication Technology (ICT) system [4].

Therefore, efficient ICT system should be developed in order to secure successfully introducing and operating the open innovation. Meanwhile, it can be beneficial to proactively utilize hyper-connecting technologies represented by cloud computing, social network service, and web 2.0 technologies. It is the reason that hyperconnection, which means that all users are always connected and can share information and collaborate, is the most important and essential component to achieve the ultimate goal of open innovation because open innovation gather innovative idea from internal or external resources and develop them. Also, the traditional R&D ma- nagement process has some problems such as ambiguous process, insufficient flexibility, delay in localization, one-way communication, and closed innovation, which make it hard to adapt the concept and strategy of open innovation.

In order to overcome the weak points which are insufficient for the sustained innovation and take advantage of collective intelligence going beyond the collaboration, an open innovative ICT system based on cloud computing as well as an adaptive framework for process design has been proposed, which can fully support organization wide innovation activities in this research. And the standard process, organization structureand R&R(role and responsibility) of each component to innovate product and service are also to be defined. With this ICT system including several functions such as process modeling, project management, groupware and knowledge management [4], it is possible to monitor and manage the service innovation process and share the knowledge related to the service. For this system, we propose the way to utilize the paradigm of cloud computing technology that are the most popular and known to be well-suited for the distributed computing and web-based service delivery. With the proposed approach for designing R&D management processes and developing ICT system to support the pro- cesses, it may be possible to reduce the total cost for ICT systems as well as enhance the flexibility and reduce the lead time by eliminating the unnecessary activities which cannot make additional values such as converting or migrating data and interpreting the results from other branches.

The paper is organized as follows. In the next section, the concepts of glocalization and open innovation and their relationship are explained at first. In section 3, the standard process, organization structure, and

R&R of each participant for the open innovative R&D management are described. In section 4, after describing the definition of cloud computing and the way to integrate it into the innovation supporting system, the overall system architecture and detailed descriptions of each component are presented. In section 5, this paper is concluded with contributions of this research and future works.

2. Background and Related Work

In this section, the definition and meaning of several key concepts such as glocalization, open innovation, and hyper-connection and their relationships are explained. And some limitations of prior research are pointed out together.

2.1 Glocalization and Open Innovation

In general, because users' needs cannot be globally unified, both globalization and localization strategies should be applied simultaneously to secure the competitive advantages in each local market. This discriminative strategy is referred as "Glocalization." In the glocalization strategy, the core components which can be differentiated with competitor's service and create the most values are defined as the global standard modules, and are applied to the global market without exception. Other components are to be freely developed to secure the competitive advantages in each local market within the scope of not affecting to the global standard modules.

The competitive advantage with the glocalization strategy may not be achieved through the traditional closed innovation activities due to the some limitations of cost, lead-time and impacts on overall organization. Thus, a concept of "Open Innovation" which utilizes the external idea, resource, and technology innovation as the input of internal innovation has been introduced [8, 9]. The open innovation concept has been regarded as relevant primarily to 'high-technology' industries, but they are already in use in a wide range of industries [10]. The competitive advantage often comes from inbound open innovation, which is the practice of leveraging the discoveries of others: companies need not and indeed should not rely exclusively on their own R&D. In addition outbound open innovation suggests that rather than relying entirely on internal paths to market, companies can look for external organizations with business models that are better suited to commercialize a given technology [8].

Here, the external ideas can be obtained from customers or service users. These ideas can be the input to a design process in which they are made feasible. Also, they

can be used as a learning tool in order to understand users better and as a source of inspiration [15]. In practice, people in or out of organizations were perceived as the resources like machines, but nowadays, it has changed to source of innovation and improvement of productivity [4]. Therefore, it can be said that involving users has the importance and positive effect in product/service innovation, although it is open to dispute. For example, collaboration between suppliers and users can lead to a mutual understanding of users' needs and wishes, as well as an understanding of the technological opportunities. And it has also been recognized that development times can be shortened if continuous acceptance testing is used during development by users [1, 3, 16, 17].

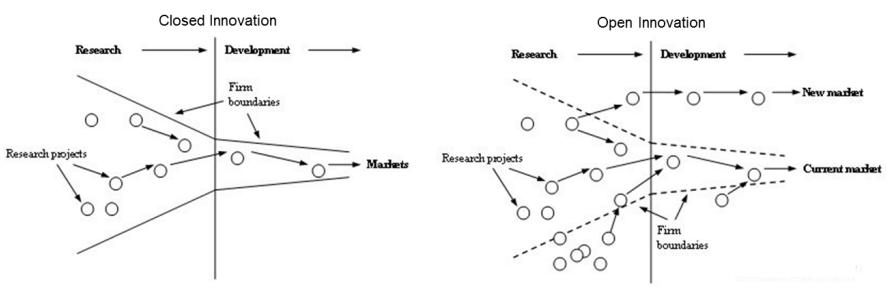
Dougherty and Hardy [8] defined fundamental capacities for sustained innovation to successfully make innovation- to-organization connections with following three key areas [5].

- make resources available for new product
- provide collaborative structures and processes to solve problems creatively and connect innovations with existing businesses
- incorporate innovation as a meaningful component of the organization's strategies

In addition, innovations initiated by users are being accelerated because of the hyper-connection among users enabled by the advanced wireless communication and development of social network. Then, the hyper-connection reinforces the unification of markets and users' impacts on the market.

2.2 Open Innovation and R&D Project Management

As described in section 2.1, the meaning and positive effects of the open innovation concepts have been described in lots of prior research. With the open innovation con-



〈Figure 1〉 Differences Between Closed Innovation and Open Innovation

cept, corporates can save the cost and increase the possibility and maximize the value of the successful innovation through opening the process of innovation and utilizing external resources. Major differences between open innovation and traditional closed innovation are described in the <Figure. 1> [8, 9].

Additionally, differences between traditional closed innovation and open innovation lie not on simply transferring external technology to internal one, but on the paradigm shift that a corporate develops strategies to survive in the current ecology where corporates take part in. Open innovation let corporates secure the view point of synthetically considering to utilize resources, throwing away dividinginternal and external resources. With adopting open innovation, corporates can expect following effects: reduction of cost and time, diversification and enhancement of profit source, and object evaluation of market oriented business model [9].

Opening the innovation process is enabled by diversifying the source of innovation through proactive utilizing the external ideas and resources, creating new market by exporting internally developed technology and accelerating internal innovation simultaneously, and elevating the value of technology [11]. Because open innovation activities are conducted individually according to the technology development roadmap, it may be impossible to apprehend the overall status of innovation, not to discover or analyze certain cases.

According to the survey conducted by the Korea government agency, Korea Industrial Technology Association (KOITA) in 2008, only 20 percent of corporates chose the open innovation as the most interested subject of current technology management trends. So to speak, the most corporates are aware of the open innovation but do not know how to proactively utilize it as the tool of innovation [14]. Enkel et al. [7] analyzed the reason which open innovation does not have great impacts on R&D management in the various point of view with practical cases [7]. The common fundamental reason is because there is not detailed guide to develop practical strategies both to adapt open innovation, and to devise or operate actual management system although corporates fully understand the concept of open innovation.

Therefore, to overcome the limitations, it has been introduced the strategy to accomplish the essential objectives of open innovation and secure the sustainable competitive advantages inthe glocalized market environment. Especially, process design framework for the R&D management is proposed to apply the requirements gathered from the various local markets to the R&D phase to new product/service development or innovation. Also, the architecture of the

cloud based system is presented, which support the whole procedure of process design and operation.

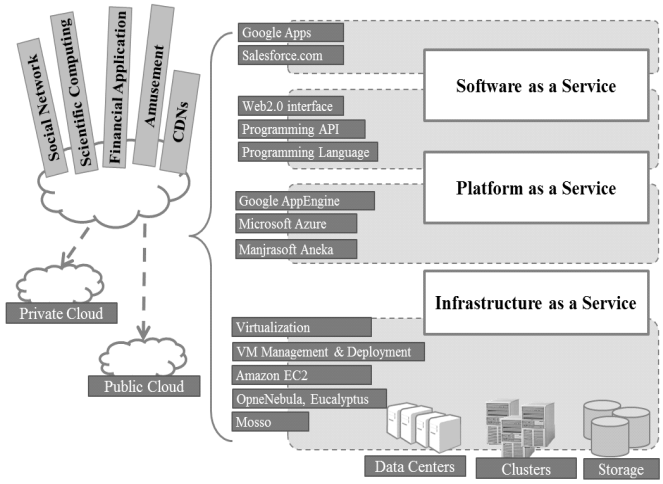
2.3 Cloud Computing

Although there is no widely accepted definition, cloud computing can be generally defined as "A set of network enabled services, providing scalable, QoS guaranteed, normally personalized, inexpensive computing platforms on demand, which could be accessed in a simple and pervasive way," Especially, the cloud computing is characterized by the set of services which are accessible through the network, QoS (quality of service) guaranteed, scalable and flexible. It is the most important function that the cloud computing can present users with platform-independent services. Thus, users can access and take advantage of services at anytime and in anywhere.

In order to enable these cloud-based services, the architecture of the system should be composed with several new technologies such as server virtualization, SaaS (Software as a Service), IaaS (Infrastructure as a Service) and PaaS (Platform as a Service) which are depicted in <Figure 2> [6].

Since various services, applications and data can be accessible from anywhere and at anytime, the cloud computing may be adequate for the distributed computing environment that finds and evaluates users' needs in local market [12]. In the following subsection, the way to design and manage the open innovative service management system with the cloud computing technology in distributes environment is described.

As explained in section 1, cloud computing is the most representative and important technology to implement hyper-



〈Figure 2〉 General Service Architecture of Cloud Computing

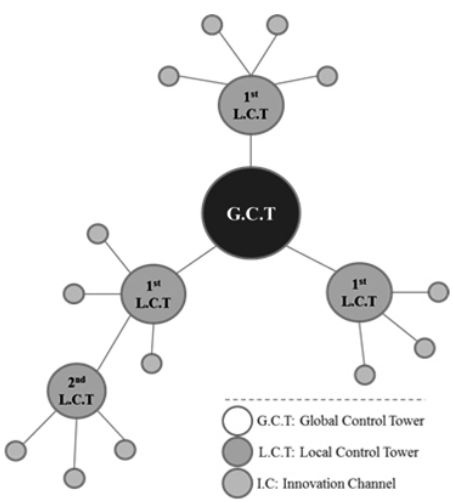
connect system. In other words, it can be said that cloud computing enables us to successfully introduce open innovation. Especially, in the case of developing R&D project management system based on cloud computing, it is possible to reduce the lead time of entire R&D project since all global market managers can access and utilize the system function at anytime through Web. In addition, because additional systems for a certain local office are not necessary any more, the total cost for system development and operation can be saved.

3. Open Innovative R&D Project Management

In this section, it has been presented the organization structure and detailed role and responsibilities of its participants to plan, evaluate, design, develop, launch and manage new services to secure competitive advantages.

3.1 Organization Structure and R&R

The proposed R&D management system has the ultimate objective same with one of the open innovation. It is to develop and to innovate products or services as soon as possible by efficiently utilizing the both internaland external resources. In order to accomplish the ultimate goal, the transparent management process, clear rules and definite target should be defined. Before defining the management process, the structure of organization and R&R of each participant is explained at first. The organization structure depicted in the <Figure 3>



〈Figure 3〉 Structure of R&D Management Organization

〈Table 1〉 R&R of Each Part Consisting Global R&D Management Organization

Parts	Role & Responsibility
Global Control Tower	• evaluating R&D projects and Innovation ideas • developing global standard action items • executing R&D projects applied to global market
Local Control Tower	• gathering ideas from ICs • evaluating the practical applicability and competencies • executing R&D project
Innovation Channel	• the major role of the practical innovation • discover, evaluate and the innovative idea

is composed with Global Control Tower (GCT), Local Control Tower (LCT) and Innovation Channel(IC). The ICs take the major role of the practical innovation, to discover and evaluate the innovative idea. Thus, ICs should be located in the place which is more close to customers. This structure of organization and role of each component are designed based on the interview with the global R&D manager of a domestic global manufacturing company, which has global network, local research and development centers, and regional offices. In addition, the practical build-up possibility and effectiveness are also verified.

Following <Table 1> explains the R&R of each part which consists of the whole R&D management organizations.

New or innovative ideas detected or developed by the ICs are gathered and integrated by the LCT. The integrated innovative ideas are transformed into R&D projects for developing or innovating practical product or services after evaluating the practical possibility of implementation and competitiveness, and revising processes. After the R&D projects developed in each LCT are gathered in GCT, the lead-lag relationships and priorities among them are evaluated based on the efficiency. The GCT plays the most important role in the R&D management process, evaluating projects as well as developing global standard modules for the management process and executing projects applied to global market.

3.2 Objectives and Requirements of Open Innovative R&D Project Management

Before explaining the process design framework and supporting system, the ultimate objectives and requirements should be defined. The proposed process design framework and its supporting system should present following functions to accomplish the ultimate goal of this research.

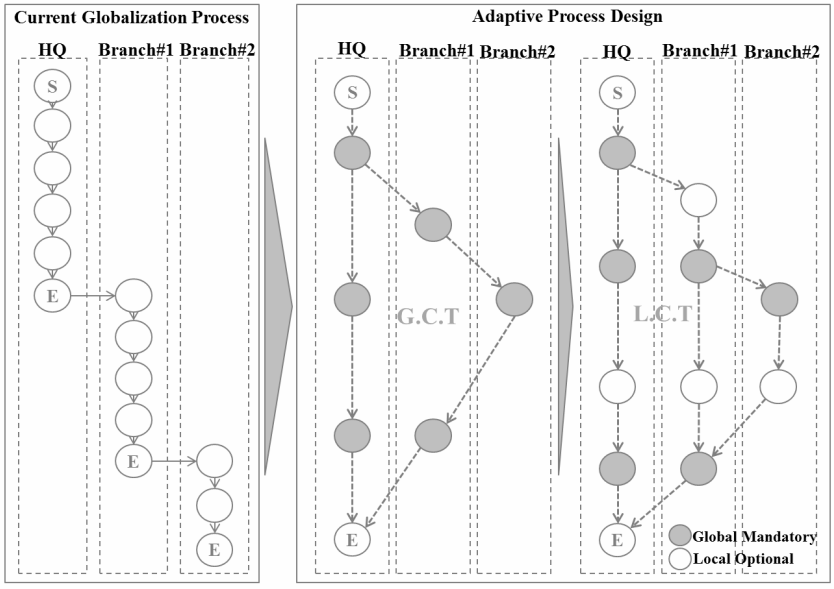
• Bottom-up innovation : All customers

request and innovative proposals proposed by an IC should be evaluated whether they can be applied to global market, and can be integrated with those from other ICs.

- Availability of global resources : All resources needed to develop or innovate products/services such as systems, solution packages, infrastructures, R&D history and related knowledge should be presented as an on-demand service. This means that all resources do not have to be installed or stored in the each local system, but users should be able to utilize them at the moment that they want.
- Balance between globalization and localization : While the proposed R&D management system should support the glocalized environment, the system should be able to keep the consistency of service and resolve the conflicts among LCTs and ICs. Thus, core applications or system functions for R&D management should follow the global standard to prevent over-localization.
- Reusability : The applications or system functions dedicated to a certain R&D management process should be reused in the other R&D management process as much as possible, not discarded.

3.3 Adaptive Framework for Designing Management Process

Here, the procedure and basic rules for designing the R&D management process using cloud computing are presented. Ge-



〈Figure 4〉 The Procedure for Designing Adaptive Processes

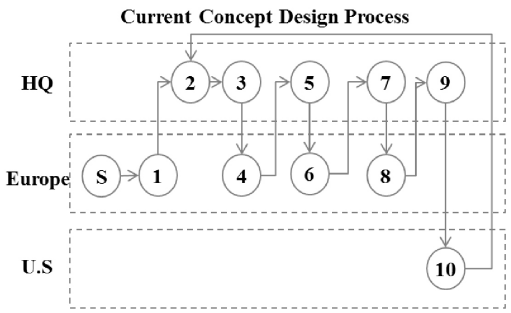
nerally, cloud computing system presents the internal resource as an independent service. This independent service can be defined as the unit cloud service, and it can be assumed that the R&D project management processes are composed with structurally connected unit cloud services. Here, this unit service is defined as an activity which composes the process. Theseactivities can be categorized into two groups, global mandatory activities and local optional activities. The global mandatory activities are commonly applied to global market with no exceptions, and utilized to present the core functions. The local optional activitiesare defined to presents discriminated services specialized to the local market.

After defining the ultimate goal of a R&D project management process, the sequence of activitiesand business rules are devised to achieve the business goal. The GCT first completes the abstract frame for the process by assigning and connecting global mandatory activities. Then, the LCT completes the detailed processes based on the global mandatory activities by adding local optional activities as needed. All activities should be composed with a cloud service as a unit, and meet the prerequisites to establish the relationship between services. In addition, each service should include criteria or check list with which should be complied. This procedure is depicted in the <Figure 4>.

By applying this framework, the current global R&D project management processes which the activities are executed sequentially starting from headquarter, terminating to the local branches can be improved to make headquarter and local branches able to effectively collaborate.

3.4 Illustrative Example

In this subsection, an illustrative example to redesign the simplified concept design process is explained in order to show how to utilize the proposed framework. First of



〈Figure 5〉 Example of Concept Design Process

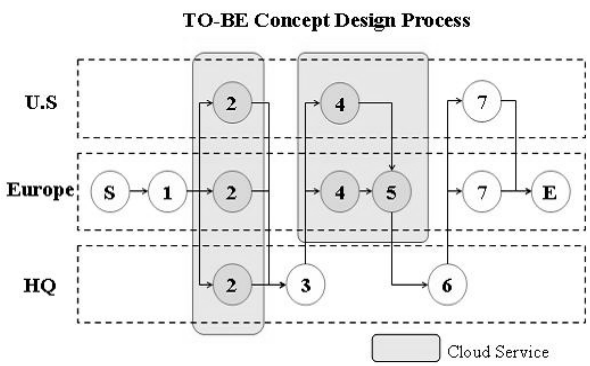
〈Table 2〉 List of Activities Compose Current Concept Design Process

No.	Organization (Performer)	Activities	No.	Organization (Performer)	Activities
1	Local	Proposal of new product concept	6	Local	Proposal of local specification
2	HQ+Local	Workshop for concept validation	7	HQ	Proposal of product design
3	HQ	Proposal of concept development	8	Local	Review the design specification
4	Local	Simulation and evaluation of product concept	9	HQ	Proposal for new product development
5	HQ	Proposal of objectives for concept development	10	Local	Review proposal for new product development

all, <Figure 5> shows the current procedure to define the new product concept, and <Table 2> does the list of activities.

This process includes several problems, and the most important one is that Branch U.S cannot participate in the middle ofconcept design process, and it can make the entire process be reworked. In addition, there are too much and complicated procedure of communication to hand over and review information. Also, each local branch should develop and operate its own ICT system to simulate or validate product concepts.

Following <Figure 6> and <Table 3> show the improved process by applying the proposed adaptive process design framework to resolve these problems. In this improved TO-BE process, each local branch can initiate the entire concept design process by proposing a new product concept. This new idea is reviewed in the concept design workshop which all branches participate in. This workshop will be held on the



〈Figure 6〉 Improved TO-BE Concept Design Process

〈Table 3〉 List of Activities Compose TO-BE Concept Design Process

No.	Organization (Performer)	Activities	No.	Organization (Performer)	Activities
1	Local	Proposal of new product concept	5	Local	Proposal of design specification
2	HQ+Local	Conference for reviewing the result of concept validation	6	HQ	Proposal for new product development
3	HQ	Proposal of objectives and product design	7	Local	Review proposal for new product development
4	Local	Simulation and evaluation of product design			

remote conference system that can share result of validating the proposed product concept. Before participating in the remote workshop, each local branch should validate the new product concept whether it is possible to produce or sell in the local branch by utilizing the validation tool presented by HQ. Here, the validation tool should be developed as a cloud service in order to prevent each develop its own procedure or criteria for validation. With the cloud service, it is possible to guarantee the standardized procedure and results.

Based on the result ofworkshop, HQ develops a detailed objective and design of the new product concept, and then each branch tests whether the new concept coincideswith requirements from local market or not using simulation tools presented as a cloud service. The result of tests is transmitted to the branch that initiated the process, and the detailed specification for new product concept is defined based on the result. The tools for defining specification also should be presented through Web as a cloud service. If the tools for simulation and defining specifications were not presented as cloud services, it may cause additional costs to buy or develop and operate software packages specialized to each branch, as well as complications among branches which take part in the process due to the lack of compatibility among the results from the different systems.

After the local branch submitting the design proposal, HQ reviews the design proposal and completes the proposals for new product development through integrating the result ofprior activities. Finally, each branch reviews the proposals for new product development. If there is no claim or requests for modification, the process can be terminated.

As seen from the example, a new product concept being requested, HQ can flexibly define this TO-BE process as needed except the mandatory activities. This approach can enhance the flexibility of R&D

project management. Since all branches can participate in the middle of concept design process even though they are not initiators, the lead time of entire process can be reduced by eliminating the unnecessary reworkwhich arise from other relevant branches' not involving in the very first steps of the process. In addition, each branch can replace its own ICT systems with the cloud services which are presented by HQ. It can enhance the quality of output of the processand reduce the total cost for ICT system development and operation. Without the cloud based ICT system, it may be impossible to avoid the additional cost to launch and operate systems customized to the each local branch and complications due to the lack of compatibility among systems.Besides the beneficial aspects due to the redesigned process and the standardized ICT systems, it is also possible to support the glocalization strategy with the system customized to the local branch by combining the unit cloud services, which can be categorized into mandatory and optional services.

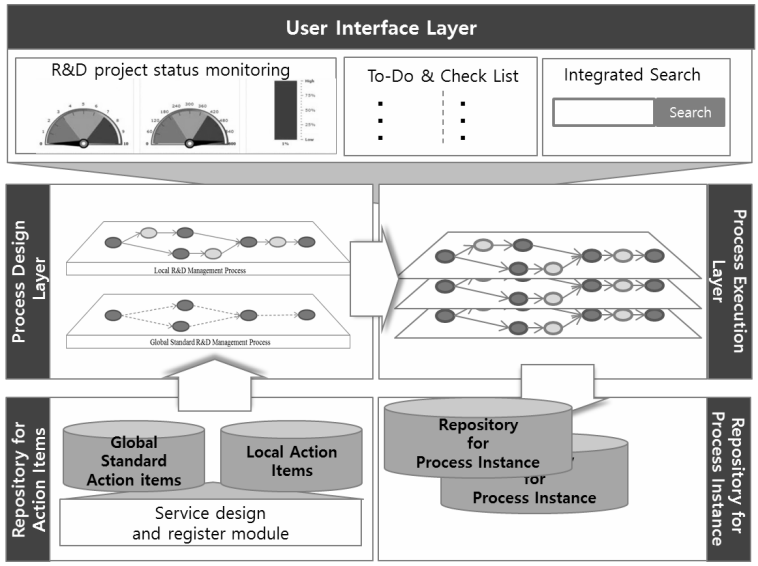
4. Cloud based System Architecture

In this section, the architecture of the cloud based R&D management system to support the organization, process and criteria will be presented by explaining meaning, characteristics and utilization of each component. <Figure 7> shows the detailed structure and relationship among components.

- *Types of unit service(action items)* : The proposed system is designed based on the cloud computing. Thus, all action items are developed with an independent unit services. Some kind of processes, criteria, check list and even testing platform can be developed as a service. For example, a simulation package including application, data, configuration and even computing resource can be developed and presented to users in local branches when to install new key components. Since it is general that local branches do not have enough specialized labor forces and sophisticated system, instrument, or facilities, this proposed cloud based system may save the total cost of system development and maintenance.
- *Repository for action items* : A developed unit service should be stored in and these services are categorized into global and local action items and stored in the global service repositoryafter GCT's evaluation. These stored action items can be searched and reused to design and launch the other R&D management processes. Also, since the action items are presented as a service, itcan be instantiated and utilized in the several different processes

simultaneously.

- ***Process Design Layer*** : Local R&D management processes adequate to the local market or environment are designed by adding the local action items to the global mandatory action items which are assigned by the GCTand establishing the lead-lag relationship. The local action items may include ones developed by the other LCT. This can make it possible that a new product or service developed by the certain LCT can be evaluated whether it can be launched into the global market or not.
- ***Process execution Layer*** : Local R&D management processes can be executed on the Process execution layer. All resources for the R&D management are always available and all participants always do their job in the same environment due to the cloud computing technology.
- **Repository for R&D management process instances** : The result of R&D process execution should be kept in the separated storage. These accumulated records are utilized as the references when the LCT develops new ideas, review the result of prior R&D projects, and check whether same R&D projects were executed or not. And cases or lessons learned related to the R&D project are pushed to the person in charge.
- ***User Interface Layer*** : At last, user



〈Figure 7〉 System Architecture for Open Innovative R&D Management

interface layer is composed with modules for the practical users who participate in the R&D projects. And it includes the real-time monitoring module, To-Do and Check List module that presents tasks at a certain time, and search module to retrieve information related to the R&D projects.

In addition, the additional components which can enhance the effect of adopting the cloud computing technology such as cross browsing independent to the service providing and platform as wellas core component should be developed in order to achieve the ultimate goal of the proposed system.

5. Conclusion

In this paper, the open innovative R&D project management framework and its supporting system based on the cloud computing are presented. For accomplishing the ultimate goal and enhancing the practical applicability of open innovation approach in R&D management, the process design framework, structure of organization, and R&R of each party have been proposed to adapt the innovative ideas from several local markets. Also, it has been presented the system architecture that fully supports the open innovative R&D management strategy, which is utilized the advantageous properties of the cloud computing. The corporates may overcome the limitations of the traditional R&D management and cope with the changes of market and customers' requests. Moreover, it can secure the competitive advantages in the glocalized market by proposing beforehand higher level of values than users want.

Still, there remain some limitations. In this research, it has been assumed that only the internal organization including HQ and local branches may take part in the open innovative processes. At the beginning, it may be better to limit the scope of participants as the internal organizations considering several risks such as security and infringement of copyright. However, if it is possible to guarantee the stability and security of the system, the open innovative process can be extended to the outer stakeholders such as cooperative companies, investors and customers, at the end. In addition, only an adaptive process design framework and the way of designing R&D project management system using cloud computing is presented. Thus, pilot tests are required to validate the practical effect of introducing the proposed framework and cloud based R&D project management system. In addition, it cannot be said that the ultimate goal of R&D management is accomplished by simply developing the system according to the proposed framework. The political supports are also es-

sential to make the best use of the external resources and overcome the physical limits of communication. Therefore, it is required to develop a plan for internal change management and revise the long term strategies.

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