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KNOWLEDGE BASE CLOUD FRAMEWORK FOR EFFECTIVE KNOWLEDGE RETENTION IN SOFTWARE SUPPLY CHAIN

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Abstract— **Most researches focus and suggest Database and Data Warehouses to manage and manipulate organizational knowledge, although both are more suited for running data and information. Hence, they lack the basic constructs required to manipulate knowledge. This research introduces a framework for a new type of Knowledge Base (KB), which refers to as a Software Service Supply Chain Knowledge Base CLOUD (SSSC KB CLOUD) framework. SSSC KB CLOUD framework provides and explores the infrastructure for manipulating knowledge during the developmental process of Software Service Supply Chain (SSSC). Also, it explores the main technical components of the SSSC KB CLOUD and shows how these components integrate and work together to achieve the main aims of SSSC KB CLOUD. The proposed framework shows the life cycle of knowledge in SSSC. It highlights the source of knowledge in SSSC and how it passes the SSSC KM process for sorting and refining. Then, it suggests a SSSC KB CLOUD framework to store and manipulate this knowledge. Finally, it provides the SSSC experts with an interface to access and retrieve knowledge from the SSSC KB CLOUD. The SSSC KB CLOUD consists of four components: Knowledge Cloud Management System (KCMS), Prior Projects Knowledge Marts (PPKM), Experts' Base (EB), and SSSC Group Formation CLOUD. KCMS provides a management system of SSSC KB CLOUD, while, PPKM is considered a knowledge repository of the knowledge captured during the development of projects, it also stores and holds all the retained SSSC knowledge. Moreover, EB stores and holds the SSSC experts' details, including the area of expertise, experience, education, etc. Thus, SSSC KB CLOUD holds the experts' details and records in its EB. Given the previously mentioned components, the SSSC KB CLOUD framework suggests SSSC group formation CLOUD, a new functionality of forming a new SSSC experts' group to work and complete the new client project.**

Keywords— **Supply Chain, Knowledge Base, Software Service Supply Chain, Knowledge CLOUD, Knowledge Warehouse, Database, Data Warehouse**

I. INTRODUCTION

During the developmental phases of SC, information and data knowledge is harvested as a result of its participants' quest to fulfill the clients' requirements. This is due to a high level of interactions and communications among the participants involved in the SC's developmental process [1, 2]. For example, a banker who deals with his customers daily will accumulate and gain insights on the daily entries of customers' records. Furthermore, a software expert involved in developing and fulfilling clients' projects requirements will accumulate and gain knowledge on how-to-do tasks and diverse skills. Similarly, in the SSSC life cycle, knowledge is created during the completion of every task and process [3]. Thus, to ensure efficiency in SSSC, this knowledge must be captured and retained for future use. The latter could only be possible if, on the one hand, the organization adopts and introduces incentives for its employees to release, create and retain knowledge. On the other hand, it provides the technological infrastructure to capture and retain knowledge. Therefore, the captured knowledge can be employed and embedded back in future SSSC operations. Most academics emphasize the importance of knowledge in business operations [4, 5]. In this context, Baydoun and El-Den [3] proposed that during the SSSC development, experts have to identify knowledge to be captured, the knowledge that would later influence critical decisions, and SSSC's performance and productivity. They added that knowledge is essential for the software company's benefit, providing competitive advantages. This knowledge reflects the employees' practical experience accumulated from real-world experiences and challenges [3]. Additionally, Dymond [6] stated that knowledge is an asset and should be retained, refreshed, and transferred to preserve its values. Furthermore, North and Kumta [7] speculated that knowledge is a source of long-lasting competitive advantage; however, once captured, knowledge must be effectively transferred and stored to generate future and present needs solutions. So, how do we

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manage and store this vital asset in the SSSC? This question is answered by Baydoun and El-Den [3], who introduced a new Knowledge Management (KM) process, called SSSC KM, to store and manage knowledge in the SSSC effectively. SSSC KM provides a solution to capture, release and retain knowledge effectively. Baydoun and El-Den [3] defined SSSC KM as a process of identifying and capturing the SSSC knowledge; this knowledge would be retained and then retrieved later by the SSSC experts to enhance and facilitate the SSSC development process. Therefore, the result of the SSSC KM process is a generation of knowledge. Thus, in this case, the main research question is: how do we capture and retain knowledge in the SSSC? In other words, what is the structure of the SSSC Knowledge Base? To address this question, this research paper proposes the SSSC KB CLOUD framework as an architectural proposal for storing, managing, and facilitating knowledge during the SSSC development process.

Of note, Database and Data warehouse (DW) does not accommodate knowledge retention. It is mainly suited for manipulating data and information [8]. This necessitates the development of SSSC KB CLOUD. Firestone and ANSI [9] pointed out that the main limitations of DW include the lack of ability to store knowledge for high-capacity decision support and to comprehensively integrate and support knowledge production. Moreover, Khan [10] proposed that DW only stores data for managerial purpose, which is to store data and information used to analyze and support managerial decision-making. Moreover, he stated that the main limitation of DW is the inability of its innovative mechanism to store knowledge for high-capacity decision support. The latter is supported by Sharda [11], who re-expressed what had been stated by Firestone & Khan, highlighting the main aims of the database/DW, which are to support managerial decision-making throughout the organization and to store data of potential interest for managers. Therefore, Database and DW are only effective in retaining data for analyzing and managerial purposes, and they do not support the organization's KM retention process. Unfortunately, the existing literature lacks studies to illustrate and propose a framework for organizational knowledge transfer and retention [12, 13]. Interestingly, this research paper explores the main possible components needed to manage and retain SSSC knowledge. It suggests a new framework called SSSC KB CLOUD. It discusses and explains the main components of the proposed framework, including Knowledge Cloud Management System (KCMS), Prior Projects Knowledge Marts (PPKM), Experts' Base (EB), and SSSC Group Formation CLOUD.

II. Type of Knowledge in the SSSC

The knowledge generated during the SSSC is different among different projects. Generally, this knowledge is the experts' thoughts and their accumulated knowledge during the project's development [14]. In this context, Baydoun and El-Den [3] affirmed that different types of data, information, and knowledge are generated during the SSSC fulfillment process. They added that the SSSC knowledge consists of "know-how," lessons learned, experiences, "know-why," decision made, a new way of doing things, skills, expertise, prior experience, etc. Therefore, this diverse knowledge needs a special storage accommodation to be manipulated, as the traditional Database concepts fail to provide proper infrastructure for knowledge retention and access [15]. To strengthen this argument, Carreteiro, de Vasconcelos [16] stated that a solution for knowledge retention is needed to enhance the productivity of the software. It is integral to draw a clear distinction between data, information, and knowledge to pave the way to the argument proposed in this paper, which opts for a particular type of storage of the knowledge generated during the SSSC developmental process. [17] stated that data is a symbol that represents a property of an object, while information is descriptions of the object, the information provides answers to questions that begin with such words as "who," "what," "when" and 'how many,' whereas, knowledge is the "know-how" skills. Therefore, the SSSC should be able to store not only simple data and information but also different types of knowledge, including objects, frames, software, part of the software, processes, etc...

III. The Research Proposed Framework

It is a known fact that any problem in the adaptation and identification of knowledge retention mechanism will influence the knowledge flow in the SSSC. The following section of this paper introduces the SSSC KB CLOUD framework, the proposed solution for knowledge retention within the SSSC boundaries.

A. SSSC KB CLOUD Definition –

SSSC KB CLOUD forms the backbone of the SSSC; it is a substantial operational factor of SSSC. Thus, it is essential to mention here that the application of the SSSC KM process depends mainly on the functionality of the SSSC KB CLOUD and the ways SSSC KB CLOUD effectively facilitates and supports the retention, sharing, and transformation of knowledge in the SSSC. Academically, Schultze [18] defined KB as electronic documents that knowledge experts have written to explain and outline some potential areas of their accumulated experiences: "know-how" and "know-why" skills. Interestingly, SSSC KB CLOUD is defined as a CLOUD of knowledge where all the necessary SSSC captured knowledge resides.

B. SSSC KB CLOUD Functions –

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SSSC KB CLOUD has two main functions: 1) knowledge retention and provider, 2) group formation. The SSSC KB CLOUD can be simultaneously accessed by all experts (individuals or groups) who participate in the SSSC project's developmental activities. The experts generate/create knowledge during the process and save that knowledge in the SSSC KB CLOUD, which can be disseminated and shared by all SSSC experts involved in developing a project. However, upon the completion of the project, every participant in SSSC will be granted 'read only' access to the entire contents of the SSSC. The SSSC experts do not directly put knowledge into the SSSC KB CLOUD. However, they only have an access/ retrieval right. Hosseinioun, Shakeri [19] stated that the primary goal of the KB is to provide the knowledge experts with an intelligent analysis platform that improves all the phases of the KM process.

C. SSSC KB CLOUD Contents –

The content of the SSSC KB CLOUD includes all the 'know-how' skills, experiences, programs, processes, rules, frames, objects, algorithms, problem-solving, decisions made, past experiences, a record of discussions among the project's participants the entire software system or part of it. In addition, all the SSSC KB CLOUD knowledge is associated and combined with the details (such as contacts, skills, promotions, education, etc.) of the SSSC experts who participated in creating knowledge during the process. On this point, Mir Sajjad Hussain, Chandio [20] affirmed that KB is composed of objects, frames, rules, cases, data, information, procedures, algorithms, manuals, experience, and lessons learned. [16] posited that KB composes business processes, decision-making, rules, objects, and case studies to strengthen this argument. The content of SSSC KB CLOUD must be frequently reviewed and maintained to ensure its knowledge's validity. Baldassarre, Caballero [21] stated that the KB must be continually refreshed and kept up to date; otherwise, the KB will not provide effective results and support. Sawaneh, Cole [22] warned that outdated information/ data and knowledge in the repository system would lead to data redundancy, ineffective data, and integrity/ security issues. Furthermore, Eppler [23] stated that the SC knowledge managers must continuously ensure the current state of the KB content. They have to manage the quality of its content to ensure that their KM applications, starting from best practice repository to lessons learned database, remain relevant and valid. Moreover, according to Hu, Huang [24], the content of KB must get frequent refreshment and maintenance to ensure business intelligence. Based on Huang, Lee [25], the main problems of the organizational KB are outdated entries, contradicting, inconsistent formats, incomplete descriptions, and ambiguous conclusions or duplicate entries. In this context, some questions and concerns are raised and need to be addressed to achieve a functional, productive, and accessible SSSC KB CLOUD. The questions are:

1. How to structure and store knowledge in the SSSC KB CLOUD?
2. How to maintain and update the content of SSSC KB CLOUD?
3. How can the experts retrieve knowledge from the SSSC KB CLOUD?

To address the above questions and resolve the SSSC KB CLOUD expected issues, the following section suggests and develops a framework to retain, handle, organize, maintain, and facilitate knowledge retrieval during the SSSC developmental process.

D. SSSC KB CLOUD Architecture –

SSSC KB CLOUD consists of four parts: Knowledge CLOUD Management System (KCMS), Prior Projects' Knowledge Marts (PPKM), Experts' Base (EB), and SSSC Group Formation CLOUD. Figure 1 represents the framework of the research's SSSC KB CLOUD structure. It shows the main components of phases of the SSSC KB CLOUD. The following example simplifies the understanding of the SSSC KB CLOUD and helps the reader to understand how the authors of this paper developed and concluded the proposed framework.

Example

Before we proceed, let us explore and understand the architecture of the SSSC KB CLOUD from a real-life example, which is the system of the university's library. The library consists of thousands of books, references, software, audio and visual media, journals, guides, magazines, legal sources, papers, etc.; all these are cataloged, organized, and categorized on shelves, based on subject matter or domain. For example, there are all the catalogs on one shelf related to the ICT domain, and on the other shelf, these related to law and legal domain, etc. So, when a new catalog is released, the librarians register this catalog in the system and place it on its subject-related shelf. Hence, to manage and organize the library's content, the librarians have to get access to software called Library Management System [26]. The latter has metadata on all the library's catalogs, including codes, location, shelf number, publisher, author, area, status, etc. [27]. This software is also used to enter/register a new catalog, index and classify, check the status of the catalogs, analyze the library's contents, and provide statistical information about all the contents [28].

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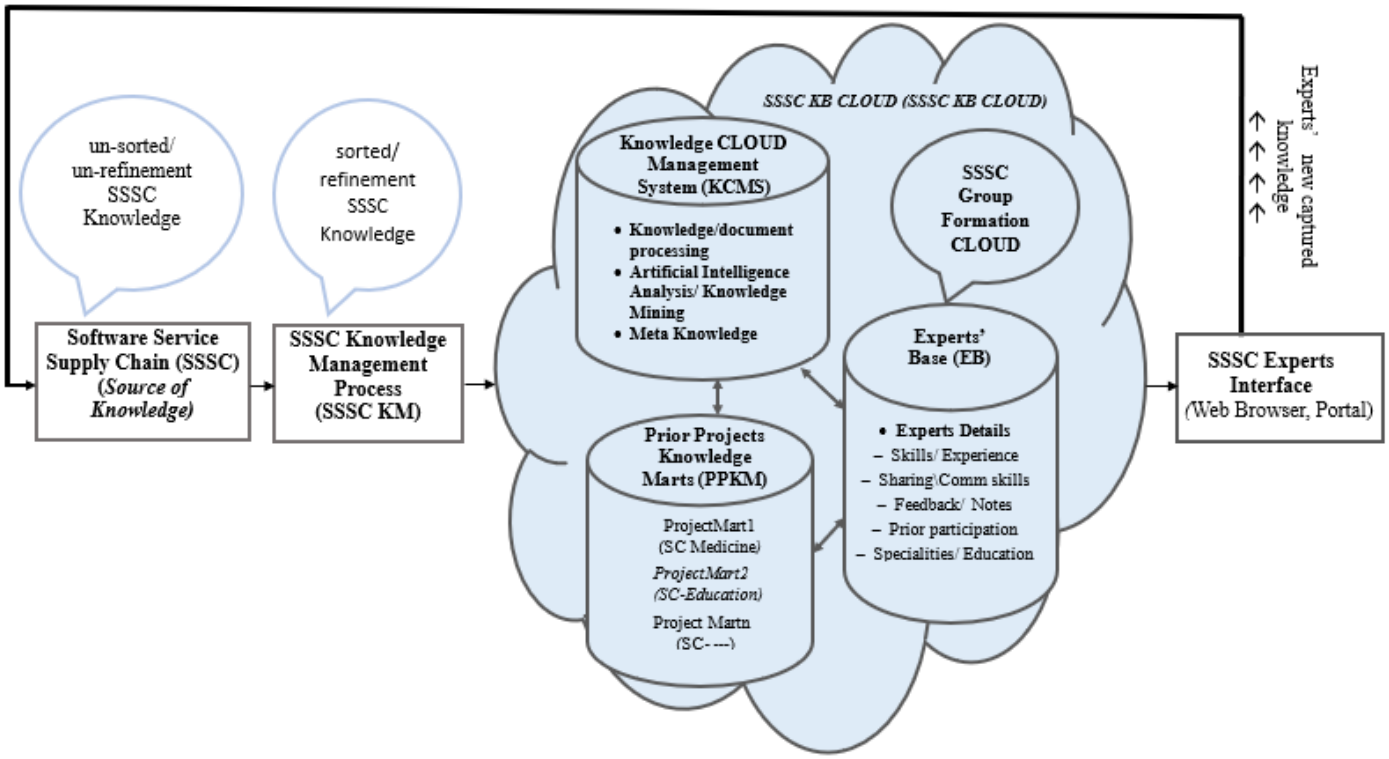

Fig. 1. SSSC KB CLOUD Framework

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The university students have web browser access to the Library Management System to search for a specific catalog or material. The below suggested SSSC KB CLOUD architecture is designed and developed based on the university's library system's structure, where the library's contents are taken as that of the SSSC KB CLOUD's contents. In the same way, this system consists of different forms of catalogs, the SSSC KB CLOUD, also, consists of different forms of knowledge, including manuals, objects, rules, processes, etc. In addition, the shelves in the library are quite similar to the functions of the suggested knowledge marts in the SSSC KB CLOUD. KBMS is very similar to the Library Management System, and the students are paralleled with the SSSC experts who retrieve knowledge from the SSSC KB CLOUD.

E. Knowledge CLOUD Management System (KCMS) –

This is a crucial part of the SSSC KB CLOUD. It represents the management system of the SSSC KB CLOUD. This research proposes that KCMS is a computer software similar to the Library Management System and Database Management System (DBMS) in DW. It provides all the management functionalities of the SSSC KB CLOUD, including group formation, experts' assignments, knowledge/ documents' processing, experts' identifications' details, analysis and data mining functionality, access permission and security functionality, knowledge maps, reports, as well as s description of all the contents of the SSSC KB CLOUD. Bellomarini, Gottlob [29] postulated that Knowledge Base Management System (KBMS) performs complex reasoning tasks on a large amount of data and provides methods and tools for knowledge analysis and machine learning. In addition, Elwakil and Zayed [30] speculated that the main component of KBMS is the knowledge discovery stage, where the patterns are extracted, and they/it? Implicitly represents the knowledge that is stored or captured in large KBs. Furthermore, KBMS provides management functionality, not only for data and information but also for all the knowledge and content of the KB [31]. Of interest, KCMS is responsible for performing the following three functionalities: Knowledge/ Document Processing, Artificial Intelligence Analysis (Knowledge Mining), and Meta Knowledge.

1. Knowledge and documents' processing

Knowledge and documents processing is one of SSSC KB CLOUD functions. It supports the experts' routine access to knowledge and information during the project's development. It provides the SSSC experts with the ability to access and search the SSSC KB CLOUD and retrieve the required knowledge, including previously developed software or documents that support their daily tasks and facilitate the SSSC production process.

2. Artificial intelligence/ SSSC KB knowledge mining

It is a business analytics process that allows data mining to support knowledge extraction. It is responsible for exploring, updating, maintaining, and analyzing the contents of the SSSC KB CLOUD. In this context, Hamad and Qader [32] argued that data mining should have been called "knowledge mining" because it is used not only for discovering data in the database but also for discovering and extracting hidden knowledge and objects in the KB. To this, Rosli, Salamon [33] added that data mining is a process that uses statistical, mathematical, artificial, and machine learning techniques to extract and identify useful information and knowledge. Furthermore, Sjarif, Lim [34] stated that the objective of data mining is to use discovered patterns to help explain various behaviors or to predict future outcomes. Therefore, in this research, we define SSSC KB CLOUD knowledge mining as a process of identifying and exploring the contents of SSSC KB CLOUD for maintenance, decision making, project process tracking, clarification, and verification purposes.

3. Meta knowledge

In this research, Meta Knowledge is defined as a storage location in the SSSC KB CLOUD where all the description of knowledge is retained; that is, Meta knowledge consists of knowledge that explains and describes all contents of the SSSC KB CLOUD system. This concept is taken from the traditional metadata, which holds all the documentation that describes the data and the processes that created it. Meta knowledge contains knowledge about itself, including explanations of the KB's contents [31].

F. Prior Projects' Knowledge Marts (PPKM) –

The PPKM is a knowledge repository of the knowledge captured during the development of projects. It is the backbone of the overall SSSC process and holds experts' experiences, chatting, explanations, frames, objects, or the fully developed software for the specific project. The PPKM is organized and categorized based on the projects' topics and the client's SC specialty. Therefore, Knowledge Mart is defined as a subset of the SSSC KB CLOUD used to categorize the content of the CLOUD based on the SC project's area. This categorization of knowledge enhances the retention, maintenance, update, security, and search throughout the content of the SSSC KB CLOUD. The proposed SSSC KB CLOUD framework in Figure 1 shows few Knowledge Marts are categorized based on the client's SCs specialty. For example, a Knowledge Mart holds the knowledge gained from developing software for clients specializing in medicine. Another Knowledge Mart is for clients that are specializing in education, etc. Traditional Data Marts store data for managerial decision making [35, 36], whereas the proposed Knowledge Mart stores data and all sorts of knowledge contents, including objects, rules, frames, cases, problem-solving, 'know how' skills, experience, processes, and

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manuals. Figure 2 shows the contents of the Prior Projects' Knowledge Marts (PPKM).

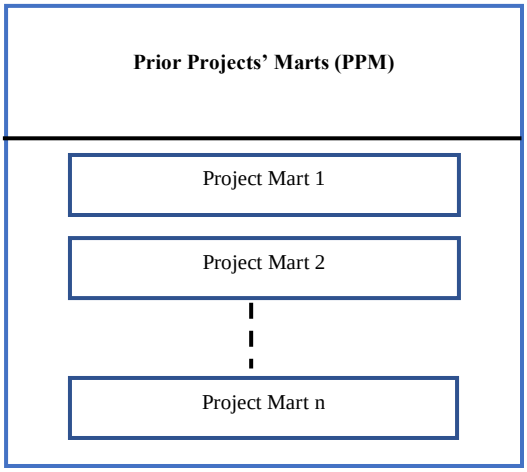

Fig. 2. SSSC Prior Projects' Knowledge Marts (PPKM)

G. Experts' Base (EB) –

The EB holds information about experts in the SSSC organization in different areas of expertise, as well as their prior developed knowledge and knowledge contribution. It is a repository of detailed information about the experts. EB stores information about each knowledge content in the Knowledge Marts and states who of SSSC experts created a specific knowledge entry. Accordingly, the SSSC experts can identify and question the right expert(s) for a specific SSSC complicity of a project. Also, EB holds all the details of SSSC experts' contacts, specialties, areas of interest, education, experiences, etc. It provides SSSC experts with the ability to retrieve contacts and details of the best supportive expert who has the right specialty to solve or help on a particular case or project. Figure 3 illustrates the contents of Experts' Base (EB).

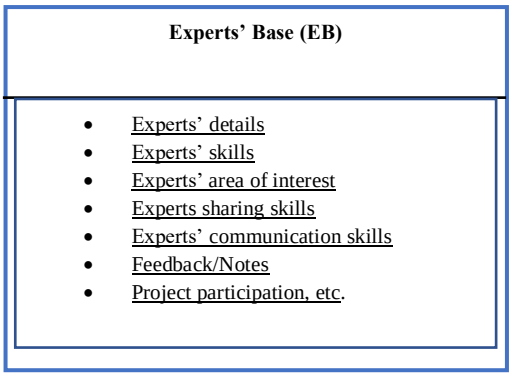

Fig. 3. SSSC Experts' Base (EB)

H. SSSC Experts' Workspace Interface –

SSSC Experts' Workspace Interface is an interface used by SSSC experts to search the KB's contents and then display and retrieve the required knowledge. It consists of tools that display knowledge in a user-friendly format. Zhang and Liang [37] pointed out that knowledge in the KB can be accessed, retrieved and utilized simultaneously by different experts, regardless of their physical location. It only requires logon authentication, and it enables group members to communicate, discuss, retrieve and share knowledge.

I. Process of forming the SSSC group –

It is a must that the SSSC formed group is the most suitable/specialized group with the required skills, which can successfully develop and complete the new project's requirements, considering the SSSC group's performance, productivity, speed, and efficiency. The questions arise here: how are the groups in SSSC formed? What mechanism must be followed to ensure a professional SSSC group formation process? It is essential to keep in mind that when forming SSSC group, there is a repository (EB) in the SSSC KB, which consists of all SSSC details of the experts, including their skills, feedback on their performance, participation in the project, communication, collaboration activities, and promotion. In addition, the SSSC KB CLOUD system contains all the prior projects' knowledge captured from previously completed clients' projects. Therefore, the SSSC KB CLOUD must be the starting point of the SSSC group formation process. In this paper, in order to make and suggest a sustainable/ effective group formation process, it is proposed that the SSSC group formation process is automated, whereby the SSSC KB CLOUD suggests and generates knowledge of the most matching experts who are suitable to accomplish the new project's requirements. To put it simply, the SSSC KB CLOUD will generate and form the group for the new project. For instance, think about it to be like a Microsoft CLOUD technology where someone logs on by sending his/her credentials and then downloads his/her profile on his/her local machine; it is almost the same scenario here Once the inquiry for the new project's requirements is sent to the SSSC KB CLOUD, the CLOUD forms the group based on its retained knowledge. In this paper, the SSSC Group CLOUD is defined as a place to where the new projects' requirements are sent, and then the SSSC Group CLOUD returns and forms the SSSC group who is eligible to effectively commence the developmental process of the new project. Figure 4 represents the proposed SSSC Group CLOUD.

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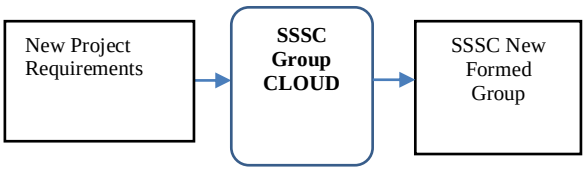

Fig. 4. SSSC Group CLOUD illustration

It is expected that the SSSC Group CLOUD formation process facilitates and stimulates the formation and accurately assigns a group of experts based on their skills, experience, previous participation in projects, and incurred feedback. In addition, the SSSC Group CLOUD formation process is proposed to save considerable time, preventing a long process of formation that includes meetings, searching, and discussion. It is also expected that such a system would minimize human errors by considering friendship ties and personal perceptions. Table 1 summarises the main benefits of the SSSC Group CLOUD's formation process:

Table -1 Benefits of the SSSC Group CLOUD 's formation process

Benefits of the SSSC group CLOUD formation system
- Facilitate and stimulate the SSSC group formation process
- Assign the most suitable group based on skills, previous experience, and project participation
- Save time going through the long formation process
- Avoiding human mistakes, including friendship consideration and personal perceptions

As mentioned previously, the SSSC KB is constituted of two parts:

1. Experts Base (EB) is composed of the repository of experts' details, including their skills, areas of experience, and previous projects' participation.
2. Prior Projects' Knowledge Marts (PPKM) consists of all the retained knowledge captured from prior, completed projects.

Therefore, the EB retained knowledge must be utilized and employed in the SSSC group formation process where all the required experts' knowledge for the group formation is "there" in the SSSC KB system. Thus, 'this is the right time to utilize this knowledge and employ the SSSC KB CLOUD to identify experts and form the 'new group'. That is, the EB system automatically forms, generates, and identifies the most suitable/ competent experts for the new group.

IV.CONCLUSION

The SSSC captured knowledge is the main performance and productivity factors of its developmental phases. Therefore, the SSSC captured knowledge must be effectively retained and organized to keep its value and achieve its purpose. Academics still refer to KB and Database interchangeably. The research argued that adapting a database/ DW solution to retain knowledge in SSSC is considered a waste of resources and efforts because the well-known database/ DW does not have the capability and ability to retain knowledge. Therefore, the research introduced the SSSC KB CLOUD framework as a new integral mechanism of retaining knowledge in SSSC. In addition, the research explored and defined SSSC KB CLOUD and then identified the main components of the proposed SSSC KC services.

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