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Reference Model of Cloud Computing Based Decision Support Hospital Management System

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Abstract: With the development of computer technology, the use of information systems is spreading with data and database structure. In emergencies and daily life necessities to the process of operations is very important to implement in a short period of in daily life for the distributed and dynamic environment. This study proposes the reference model of the cloud computing hospital management system. It provides how the evaluation and analysis of large information sources containing especially indistinct and incomplete data for quick and efficient decision making. In this study, all data types in the hospital environment consider to evaluate and analyze in reference model which includes the hospital management, logistics, and human resources, patient treatment and orientation, and hospital capacity situation management sub-modules.

1. Introduction

The use of information systems is spreading with the development of computer technology, It is very important to perform operations in a short time in emergencies in daily life for distributed and dynamic environments. Suggested hospital management reference model established in the targeted decision support system (DSS) structure. It is aimed to process, evaluate and analyze large information sources containing uncertain and incomplete data together with cloud cognitive structure.

Monitoring errors occurring on the network and eliminating the problems connected to the network, and studies that extend the network life realized with monitoring the network. Since all data types in the hospital environment included in the system and the structure focused on the hospital management system after that the system extended from hospital management to logistics and human resources, patient treatment and orientation and hospital capacity status management, patient status analysis. The algorithm structure is applied to all data.

Cloud cognitive architecture consists of three basic components: infrastructure, platform, and software services. IAAS (Infrastructure as a Service) is based on algorithmic structure, the missing information in the scope of analysis by keeping the system that is intended to perform the analysis process with the dynamic structure. The architectural structure of the platform to be installed (PAAS - Platform as a Service) and the operation methods are given in detail and the performance

and behaviour of the system with this architectural structure are examined. Within the scope of this study, it is aimed to establish a cloud cognitive-based decision support structure that takes into account the hospital information structure, event type and process, time dimension, and system dynamics in the real environment, and to create cluster-based algorithms and computer software and to run programs. In this study, firstly, the algorithm analyzed the big and dynamic data set then developed the mathematical model which established the algorithm to perform the effective analysis process. After the validity analysis of the algorithm is performed, the software operation can be performed. Two main objectives covered the study; firstly developed a new clustering algorithm that used large data in a dynamic environment. Secondly, a decision support model with a cloud computing application was developed. Since the proposed decision support model is flexible and intelligent, can easily be adapted to the relevant data structures and enable to obtaining of the relevant rules. Independent decision-making processes can be used to solve dynamic and big system problems. This study tries to establish a factor-based decision support structure that takes into account hospital information structure, event type and process, time dimension, and system dynamics in a real environment, and to create cluster-based algorithms.

The remainder of the paper is structured as follows: firstly, some concerning notions of cloud computing and hospital management system reviewed. Then, the proposed cloud computing-based hospital management system is demonstrated. Next, the proposed reference model steps are given. Finally, discussion and some concluding remarks are discussed.

2. Literature Survey

For distributed and dynamic environments, it is very important to operate in a short time in emergencies in daily life. The study is aimed to process, evaluate and analyze large sources of information containing uncertain and incomplete data together with cloud cognitive structure in the DSS. It covers some of the modules which include some of the parts that can be able to solve big data structures and related problems in a shorter time and more efficiently with the data integration provided with data access, pass module, adaptation, and flexibility features in the decision support system. These operations were realized with the clustering approach and applied the specific and uncertain data structure with a normal data structure.

The main component is a user interface in DSS. Also, the DSS database can be in the form of a database small enough to be placed in a personal computer or a very large data store. DSS includes the data; model and dialogue modules. The DSS database consists of a combination of past and present data from many applications or groups. This system consists of a variety of online analytical processing tools, data mining tools, or a combination of mathematical and analytical models that are easily accessible to the DSS user.

The DSS includes the incomplete information of the system which is processed and the system is aimed to work more effectively and faster. Using these data in the databases and evaluating them in the managerial decisions stage has made it necessary to emerge the area.

Cloud Computing (Common Location-independent Online Utility provisioned On-Demand Computing) provides the ability to provide computing services requested on the Internet to desktops, laptops, and mobile devices. Briefly, it provides services such as processing power and storage among provider applications over the web with the offering from a remote location [1-5]. At the same time, the availability of Industry 4.0 and Big Data has made it necessary for the development of cloud computing technology.

The basic elements of cloud computing are optional self-service; wide network access; common resource pool; promptness and flexibility; measurable service. In positioning models, it can be expressed as private cloud, community cloud, public cloud, and hybrid cloud[6,7,8,9,10].

It is aimed to develop a hospital management system with a strong infrastructure realized over the Internet thanks to wireless communication and sensor networks along with cloud information technology. The development of health service platforms, preventive medicine practices, the development of patient-hospital relationship structures, and the development of hospital management system discussed.

There is an increasing number of studies addressing the health platform structure along with cloud computing technologies, and studies on personalized health management to improve preventive medicine effectiveness. Integrating mobile devices and network structure developed with healthcare platforms. The widespread the developing technology and the use of online technology and social media become widespread with developing programming. Personal health management, making treatment decisions for the patient, and the hospital management module together with cloud information technology are integrated. However, information about the patient's concern is often disseminated through information has acquired through many different websites. Therefore, the more information the patient can be accessed and visited the website, the more reliable the health information. As a result, according to mobile health research, young people are more inclined to mobile information devices thanks to the widespread use of mobile phones [11,12]. Wang et al. (2016) proposed a cloud-based mobile health information suggestion system and established a collaborative suggestion structure but did not take into account the uncertain and incomplete data structure situation [13]. This study contributes to cloud cognitive architecture with platform and software structure to eliminate the deficiency. Particularly, in the structure of the cluster-based cloud computing architecture modelled with considering the system with the hybrid model. It includes the PaaS (Platform as Service) structure and the architecture designed in the private and public platforms. The hospital management system uses servers and virtual servers with hospital and internet-oriented structure and server structure. It causes the program to lock and fail to reach the user and perform the desired function, especially if the number of patients is high and the server cannot respond to a large number of users. A chain of rules for system behaviour is obtained and the decision mechanism of the system is established with the rule structure. The data obtained and applied to a wide range of data from the health field such as production and customer satisfaction analysis and necessary analysis and validity tests are provided.

3. Cloud Computing Architecture

Technologically has become the target of institutions and organizations for minimize purchasing, maintenance, operations, air conditioning, energy, security service, and related personnel expenses in information services with the developing computer technology since the 2000s. The distributed computing (grid computing); outsourcing, utility computing, and hosting developed and started for the application fields. The basic cloud computing components are showed in below (Figure 1)[14,15].

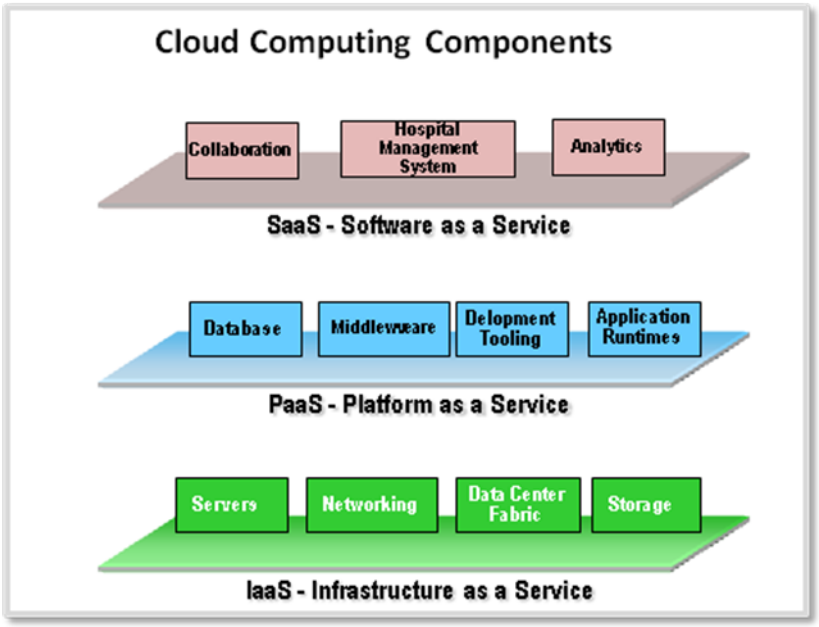

Figure 1. Basic components of cloud computing

a) **Software as a Service (SaaS):** Cloud computing software service enables the user to use software running on cloud computing infrastructure. This software is e-mail service accounting, finance, and office applications, including the needed web-based corporate or end-user versions, are available as a service model. As a result, the user does not need to acquire the applications or obtain any license for the later application. Google Docs is also one of the best examples of SaaS. The user only needs tools such as Mozilla Firefox or Internet Explorer in a web browser to use applications [16][Taylor, 2011].

b) **Platform as a Service (PaaS):** It can create its application running on the infrastructure of the cloud service provider and service users from the enterprise's servers. In short, the platform provides services such as operating and development platforms for the user. The user can use a platform as a service with the support of cloud computing infrastructure to develop and run his / her applications. The user not be able to manage or control infrastructures running under the cloud (network, server, operating system, and storage space), but deployed applications can be controlled and environment configuration hosting the applications can be provided [17]. By utilizing web-based cloud computing facilities, the software can be developed. At the same time, practitioners not need to buy expensive platforms and be able to develop functional, comprehensive applications [16,17].

c) **Infrastructure as a Service (IaaS):** In this model, the service provider provides processor power, memory, storage, and network services that the user can fully utilize and install operating systems and other software on. In short, IaaS provides computer infrastructure to the user as a service [18,19]. The user now use the IaaS agent as a service instead of receiving infrastructures such as server, network, and repository, and pay as many services as he can. Amazon and Rackspace Cloud are the best examples for IaaS [18,20,21,23][Skúlason, 2011]. The main factors that make up IaaS is hardware; network; Internet connection; virtualization environment; service level agreements and usage bill [22,24][Rittinghouse and Ransome, 2010].

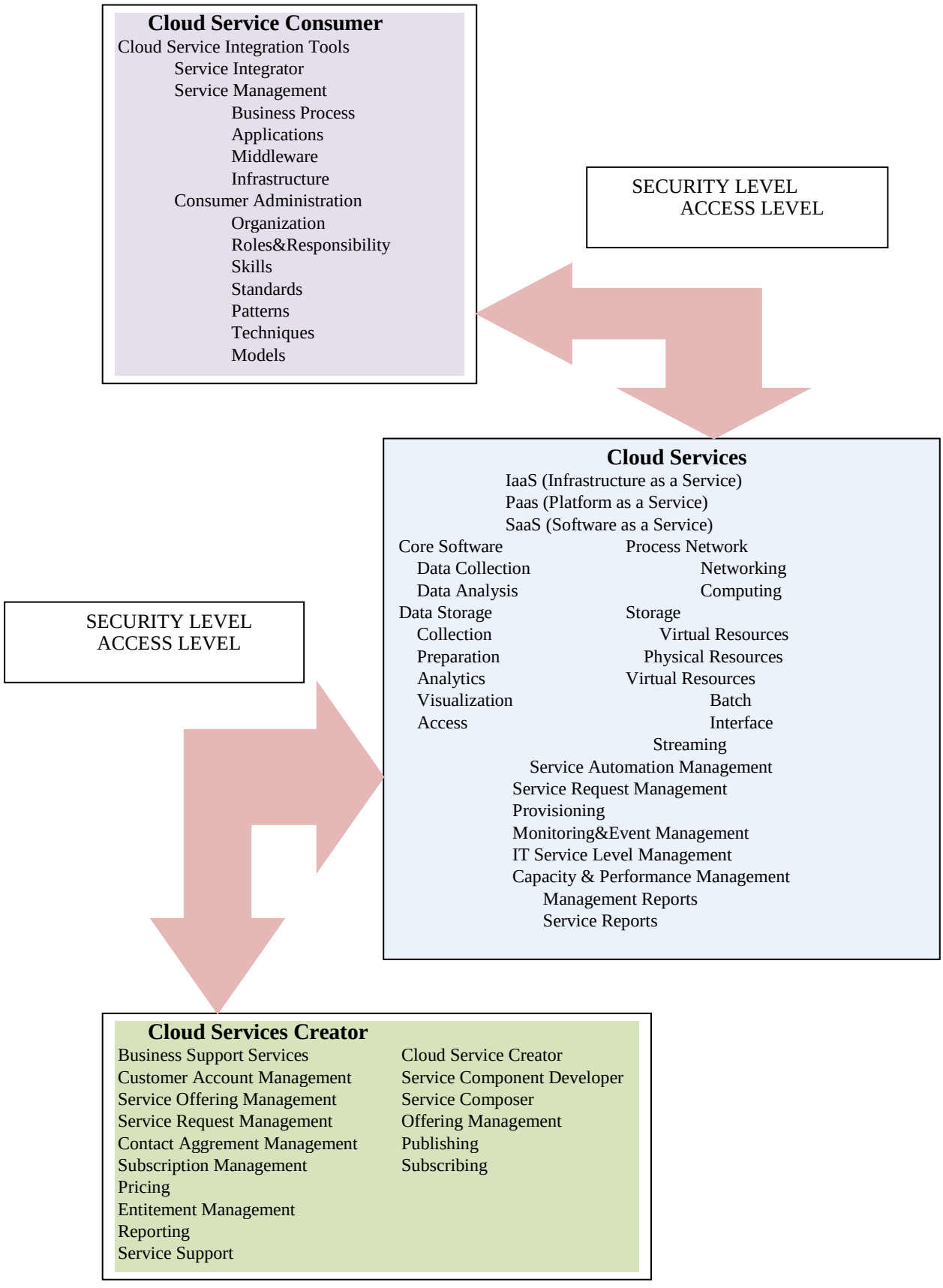

Figure 2. Cloud Computing Reference Model

The cloud computing architecture includes the two basic components which are user and service provider. With the service provider and access layers, the system meets with the user and the provider, and the basic management functions of the system are combined with the Cloud Services for reporting, service support, capacity, planning, metering, provisioning, monitoring, billing, subscription management functions to the service process (Figure 2). Wang et al. proposed a cloud-based mobile health information suggestion system and formed a collaborative suggestion structure [3, 25, 26].

Clustering-based cloud cognitive architecture consists of three basic components: service infrastructure, platform, and software parts. IAAS (Infrastructure as a Service) service infrastructure that is based on cluster-based algorithmic structure, the missing information in the scope of analysis by keeping the system is intended to perform the analysis process with the dynamic structure. The architectural structure of the platform to be installed (PAAS - Platform as a Service) and the operation method is given in detail and the performance and behaviour of the system with this architectural structure examined. This study aims to establish a cloud cognitive-based decision support structure that takes into account the hospital information structure, event type and process, time dimension, and system dynamics in the real environment.

4. Cloud Computing Based Reference Model

The developed cloud architecture provides advantages in the analysis of data and the field of mobile use by providing a faster and more accurate evaluation of data with the help of cognitive architecture in this study. In addition, the proposed reference model is based on the following three processes.

1: The cloud cognitive service structure determined, designing the architectural structure of the platform to be installed, grouping the data and data types use the system during the design and grouping the data with the clustering-based algorithm, and determining the decision rule structure, dynamic structure of Platform as a Service (PaaS) with the proposed algorithm. With these operations, the structure of the hospital management system is realized with the modelled algorithm and the data structures and the behaviour types in the dynamic environment that can be realized by object-based modelling (UML structure, Case-Based Diagrams). It is aimed to determine the factors affecting the system behaviour structure and to rank them according to the importance level and create the rating matrix.

2: Hospital management system software is developed based on the platform SaaS (SaaS - Software as a Service) and the cluster-based data analysis and classification algorithm. It is defined on the platform of the basic database management module, which enables data transfer with the created data types and related database structures, extraction of the data, modification, and deletion when necessary on the data. Mobile cloud computing software and patient and hospital management modules created. The modelling, analysis, and new network management policies of hospital application software determined by moving cloud data to cloud servers, virtualization, networking of cloud servers, and changing network load.

3: For each activity belonging to the developed hospital management system, determining the alternative status types by taking the hospital operational grading matrix into consideration and testing the system operation performance, and testing the generated scenarios at the local scale. Testing is performed using the validation and validation methods of the performance of the developed cloud cognitive-based decision support system.

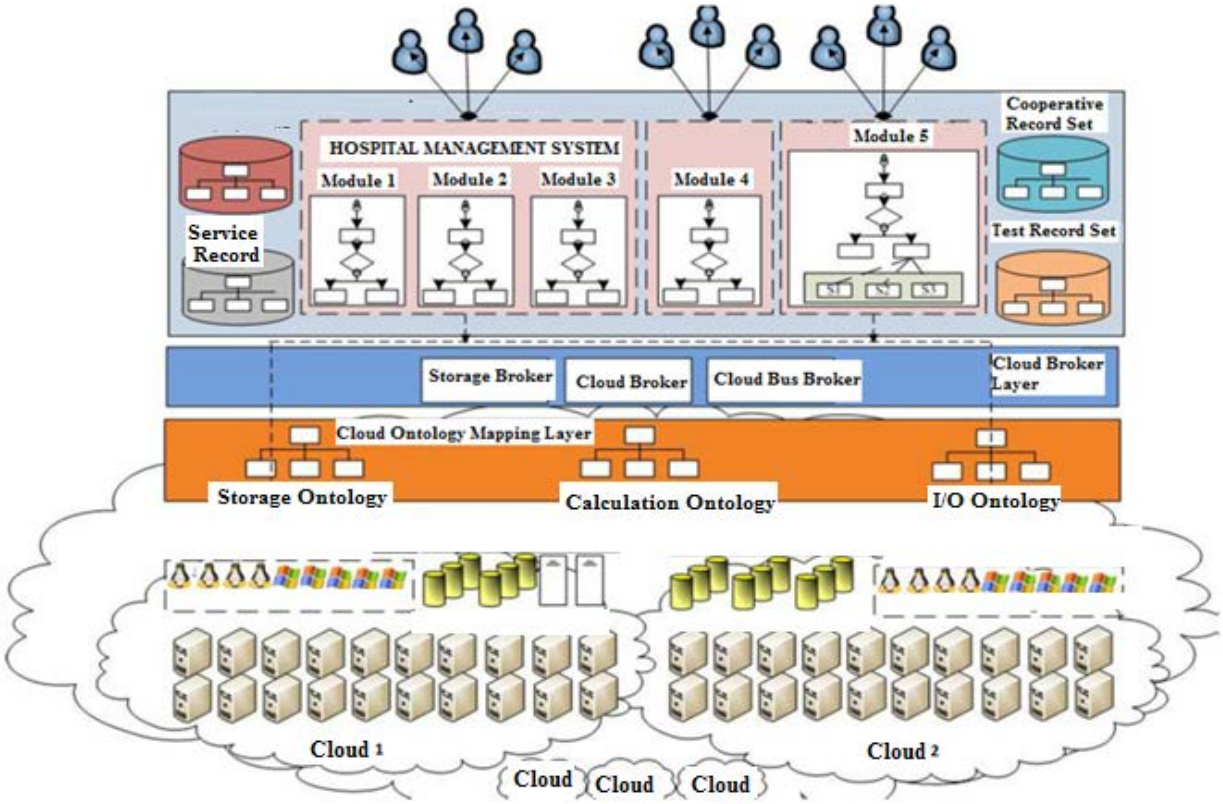

Figure 3. Cluster Based Cloud Hospital Information Architecture Structure

By integrating the proposed model with the hospital management system, it is aimed to operate the system with the cluster-based cloud cognitive architecture. The process of analyzing and evaluating the data appropriately and action is realized by including all modules of the hospital management system within the cloud cognitive architecture structure.

Cloud Hospital management system composed of three basic structures: cloud-based structure, clinical structure, and administrative structure. The intermediate layer structure and reliable web service structure that take place in the proposed cloud computing architecture can be established between the client and the server in the internet environment. In short, a communicating and networking task able to perform.

With the Hospital Information System, it is aimed that the patient receives the hospital services in the fastest and easiest manner in the chain process such as hospitalization, treatment, surgery, discharge, and referral, which starts with the application of the patient to the hospital. While performing these procedures, it is done by the cloud cognitive-based modules that are developed by the hospital staff to transfer patient services, observations, and medical requirements to automation. At the same time, it aims to provide the most effective and fast interactions between patient-doctor-hospital with its integrated modular structure and cluster-based cloud computing architecture. The hospital management system ensures that information is obtained and followed by the needs with the modules it contains. At the same time, it is a system that enables data to be obtained very fast and accurately by providing integration with all devices in the health institution and organization, minimizing the application, waiting, the result time of the individuals who received health service, increasing the satisfaction to the institution and receiving instant information. It aims to provide easy management of drug and material stocks of pharmacies with stock level alarm solutions.

As can be seen in Figure 3, the software application layer constitutes the most important part of the system in the cluster base cloud hospital information architecture structure. With the structure in this section, the system performs cloud analysis and evaluation processes with the cloud ontology mapping layer.

4.1 Resources layer

The resource layer contains three basic functions:
(1) identify components and resources of the hospital management system,
(2) virtualization and
(3) Real-time monitoring status. measuring system performance, the process of standardizing services determined with user satisfaction considered as performance parameters.

4.2 Service layer

The service layer is responsible for initially evaluating patient requests through request collection, request rollback, and request allocation. The demand evaluation process in this layer is primarily responsible for evaluating patient requests and converting patient and hospital information into information related to the patient management process. By reusing historical data, it helps to identify the health problems that the patient has experienced in the past and to distribute relevant resources, thereby increasing system efficiency and guaranteeing service quality. The optional allocation function allows the patient to meet the appropriate service, doctor, and treatment process by successfully performing patient and hospital management functions after comparing patient and physician requests to the spatial capabilities of service providers. Also, the cooperative suggestion module structure and the health data suggestion module function perform with the coarse cluster-based computation matrix, while contributing to the cloud cognitive computation structure. Together with the developed architectural structure, it also contributes to the classified health information query module. The service layer structure also includes the patient treatment module, the patient treatment planning module, the service management module, and the hospital logistics management module. Patient status analysis, disease severity ratio, and patient-hospital status map are included as a new approach to the patient treatment planning module.

(1) Cloud-based database - The system uses VMware virtualization and cloud to create a cloud server. All patient and hospital management system data of the hospital is taken and analyzed within the cloud cognitive architecture to be developed and the patient and hospital management system used with a wide usage network structure. Therefore, together with the data to be taken from the hospital, suggestion system user profile, matrix table generated by cluster-based estimation and an indicator database showing health status created. The matrix profile generated by the user profile and the cluster-based prediction often support the common proponent calculation process.

(3) Web-based user interface – It can be able to access the hospital management system both to receive personal patient information and to be informed about hospital appointments and general health information. They can obtain health outcomes more easily through cooperative advice and the suggestion system based on health-related indicators.

The study also includes personalized health information and the necessary infrastructure for expert knowledge to make recommendations. Users are expected to provide health information services under different conditions. The suggestion system with the collaborative structure uses the cluster-based algorithm by evaluating the health information of the users.

(2) Patient Class. Expresses service demand expectations and after-service evaluations of patients. The Patient Class acquires patient information and captures patient relationships by the Patient Status Class and allocates patient relationships intelligently, appropriately through the

Service Class. Also, the Patient Assessment Class records examinations and recommendations for design concepts.

(3) Patient Management Class. It indicates the service providers' service to patients. Patient Management System, system administrators, analysts, re-coding, design, and conceptual structure of the system process is undertaken by undertaking the system design.

Considering the mathematical model of cloud cognitive architecture, the system's performance evaluated. At the same time, the information in the system grouped and the suggestion system formed by taking into account certain or uncertain data with the coarse cluster-based algorithm below. In the software to be developed, the algorithm below used to be used in the SaaS layer of cloud computing.

4.3 Model Analysis

The algorithm is then challenged within the cloud machine that is not used to implement the algorithms within the clouds, data centers, and metering unit brochures. Considering the mathematical model developed by Shahdi-Pashaki et al. (2015)[27],

Indexes:

J Task (j = 1,…, J)
İ Subtask (i = 1,…, I)
p Virtual Machine Type (p = 1,…, P)
k Server (k =1,…, K)
M Large positive ınteger number

Variables:

T_{ijp} Process time where the task j is performed on machine p

A_{ijp} 1 if the machine p type i is required for sub-task i in task j;
0, otherwise

L_p QoS standard provided by p type machine (Quality of Service)
C_k QoS standard provided by k server
DS_j Position of the requested j task in the Service Level Agreement
A_p Cost of VM creation
B_t t task transfer unit cost

$\alpha,\beta,\gamma,\delta$ Defined user properties

Decision Variables:

X_{ijpk} 1 if the sub-task i of task j to the server k has been performed on a machine of type p;
0, otherwise

N_{pk} the number of machines of type k assigned to server k;

Y_{ijk} 1 if sub-task i for task j on server k is assigned;
0, otherwise,

H_k Number of tasks assigned to server k

V_k 1 if server k is active, H k > 0;
0, otherwise

Y_j 1 if the j request is not met;
0, otherwise

D_j The amount of task j provided by the server provider

S_j 1 if task j cannot be performed
0 otherwise,

$$F = \alpha \sum_{1}^{I} \sum_{j}^{J} \sum_{p}^{P} \sum_{k}^{K} D_j B_i \left[Y_{ijk} \left(1 - Y_{i+1,j,k} \right) \right] + \beta \sum_{k}^{K} P_k V_k + \gamma \sum_{p}^{P} \sum_{k}^{K} N_{pk} A_p + \delta \sum \left(DS_j - D_j \right) . Y_j P_j \quad (1)$$

$$X_{ijpk} = a_{ijp} . Y_{ijk} \qquad \forall i,j,p,k \quad (2)$$

$$X_{ijpk} \leq N_{pk} \qquad \forall i,j,p,k \quad (3)$$

$$\sum_{p}^{P} \sum_{k}^{K} X_{ijpk} \qquad \forall i,j,p,k \quad (4)$$

$$\sum_{i}^{I} \sum_{j}^{J} D_j t_{ijp} X_{ijpk} \leq L_p \qquad \forall p,k \quad (5)$$

$$\sum_{i}^{I} \sum_{j}^{J} D_j t_{ijpk} X_{ijpk} = \qquad \forall p,k \quad (6)$$

$$\sum_{p}^{P} L_p N_{pk} \leq C \qquad \forall p,k \quad (7)$$

$$M(S_j - 1) < DS_j - D_j \qquad \forall j \quad (8)$$

$$M \times S_j \geq DS_j - D_j \qquad \forall j \quad (9)$$

$$\sum_{i}^{I} \sum_{j}^{J} Y_{ijk} = \qquad \forall i,j,k \quad (10)$$

$$M(V_k - 1) \leq H_k - 1 \qquad \forall k \quad (11)$$

$$M \times V_k > H_k - 1 \qquad \forall k \quad (12)$$

$$X_{ijpk}, Y_{ijk}, V_k, Y_j, N_{pk} \in \{0,1\} \qquad \forall i,j,p,k \quad (13)$$

$$D_j, N_{pk} : \text{integer} \qquad \forall i,j,k \quad (14)$$

The objective function consists of four components. The first component refers to the transfer function (Y_{ijk} = 1 and Y_{i+1jk} = 0) in the case of sequential sub-tasks from different servers. Secondly, the fourth component represents the cost of the servers, the creation of the VM, and the total penalty cost. (DS_j-Dj≥0) refers to unmet demand. Constraint (2) shows the relationship between X_{ijk} and Y_{ijk} variables, that is, from task i to task j, from the VM to server k (X_{ijk} = 1) if (Y_{ijk} = 1) and (a_{ijk} = 1). Constraint (3) and Constraint (4) indicate each sub-task assigned from a server to a virtual machine if the desired virtual machines are present. Constraint (5) and Constraint (6) refer to the condition that virtual machines and servers not exceed capacity. In Constraint (7) and Constraint (8), if S_j = 1, it means missing data state, and if S_j = 0, it means lost data state. Constraint (9), Constraint (10), and Constraint (11) indicate the usage status of the virtual machines in the servers. (V_k = 1) indicates usage, while (V_k = 0) indicates that it is not used. H_k>0 indicates

that at least one task is assigned to the server. Constraint (12) and Constraint (13) represent two and non-negative integer variables Constraint (14).

Considering the mathematical model of cloud cognitive architecture, the system's performance evaluated. At the same time, the information in the system grouped and the suggestion system formed by taking into account certain or uncertain data with the coarse cluster-based algorithm below. In the software to be developed, the algorithm below used in the SaaS layer of cloud computing.

The steps of the suggested study include the below items:

1: Determination of cloud cognitive service structure

2: Designing the architectural structure of the platform to be installed

3: Grouping of data and data types to be used in the system during the design

4: Determination of decision rule structure by grouping the data with a set algorithm

5: Integration of PAAS (Platform as Service) event types with the proposed algorithm with the dynamic structure,

6: Integration of hospital management system structure with model version algorithm and data structures

7: Object-oriented modeling of data behavior types in a dynamic environment

8: Integrate PAAS (Platform as Service) event types with the dynamic structure and proposed algorithm

9: Determination of data structures of Hospital Management System

10: Obtaining dynamic models of files and variables belonging to the hospital management system

11: Using UML and Case-Based Diagrams in the system analysis of the Hospital Management System

12: Sorting the factors affecting the system behaviour structure according to their importance

13: Design the software platform

14: Development of coarse cluster-based data analysis and classification algorithm

15: Identify all components of the hospital management system software module

16: Define the data, database structures of each module

17: Transferring data to the database, withdrawing data, making necessary changes and deletions on the data,

18: Development and implementation of the basic database management module on the platform

19: Development of a cluster-based mobile cloud computing algorithm and software

20: Establishment of hospital management modules

21: Transferring the data of the Hospital Management System to the cloud servers, virtualization

22: Modelling changing network loads by connecting cloud servers to the network

23: Perform the analysis and determine the network management policy

24: Establishing the hospital operational rating matrix for each activity in the developed hospital management system,

25: Identify alternative case types

26: Test system operating performance

27: Locally testing the generated scenarios

28: Perform the validation and validation analyzes of the performance of each platform of the cluster-based cloud cognitive architecture

Suggested decision support system modules are:

Data pre-processing - The main task at this stage is to analyze the processes collected from different system users. Each process consists of multiple contents and a degree divided into three tables: a user profile table; An item profile table; And a user matrix. The item profile table consists of the

characteristics of the easily discovered information item (eg. drug name, disease type). The user matrix encodes users' preferences for items in the collection. The next step is to explore the relationship rules (U-I-R) from user data, item content, and scoring score by analyzing data in a specific structure using a cluster-based approach.

Users clustering - At this stage, the data grouped with a cluster to provide the decision rules by clustering the basic variables that make up the system according to various groups by using the Correlation Coefficient method. The main purpose of the cluster is to reduce the cost of computation. The rules discovered in Phase 1 and the clustered user-item matrices are stored in the database. In the correlation, formula ui represents the target user and u_j represents the relative user relative to the target user. k represents evaluation items, m represents the total number of items. Ii represents the total number of users closest to the target, m is the closest user to the target in the current assessment, relative to the target relative status, k, and l, i is closest to the user target.

Estimating the target information - The estimation function is a structure that tries to analyze the health of the system, taking into account health information. The developed algorithm performs clustering according to the desired variable state, considering that users with similar features/views always create similar item options. By combining the cluster-based estimation and average category rating calculation, the target health information (items) in the matrix found also form the suggestion rules required for the suggestion system. First, a new user must sign up to use the services.

Simulation of the developed model - Simulation of the sensors used in the system; Simulation performed during the testing of operational performance of the proposed virtual networks within the system; Simulation testing of the performance of patients using the system; Simulation analyzes that measure the performance of each personnel, doctor, nurse, nurse, administrative and technical personnel of the hospital management system using the system can be tested in terms of the operational status of the architectural and hospital management modules developed within this study.

5. Conclusion

With the clustering algorithm structure to be developed and aimed to evaluate and analyze the data in fast data traffic, even in the dynamic structure, based on the effective use of big data structures. Clusters include the process of organizing incomplete, stand-alone, and uncertain information and performing appropriate data analysis. It helps to make effective decisions with the most effective rules chain together with the decision support structure to be formed with the computer software program, together with the large volume and incomplete, uncertain information structure. Providing the necessary logistic support according to the scenarios created.

1. Determination of cloud cognitive service structure

a. Defining the basic data types and database structures that make up the service structure

b. Collection of necessary data

c. Development of cluster-based algorithms required for the process of identification, grouping, and classification of data in the system

d. Grouping of data

This study, it is aimed to develop cluster-based algorithms for big data analysis in cloud computing platforms and hospital applications of developed models.

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