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Ambient Intelligence Healthcare Monitoring Information Architecture (AIHMIA)

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Abstract**:** In this paper we have used the concepts of an enterprise view to Ambient Intelligence (AmI) healthcare monitoring (HCM) information management towards understanding the whole and making sense out of it to develop AmI Health care monitoring Information Architecture (AmIHCMIA). In the effort of assisted HCM and reduce the problem of traditional HCM. Under the umbrella of an information architecture research for AmIHCM, the objective of this paper is to develop novel intelligent ensemble healthcare decision support and monitoring system to classify the situation of an emergency hospital based on the Vital Signs from simulation wearable sensors and to construct AmIHCM Information Architecture (IA) based on existing enterprise frameworks. Zachman Enterprise Framework was used to guide the development of the AmIHCMIA. The paper also employed classification techniques using ensemble-voting model combining with J48, Random Forest, Random Tree classifiers. Results showed that the architectural representation guided by the selected framework could provide a holistic view to the management of AmI healthcare monitoring data. Moreover the novel intelligent ensemble health care decision support and monitoring system experiments with promising performance. .

Keywords**:** AmI healthcare monitoring, Data Mining, Ensemble models, Voting model, Information Architecture, Zachman Framework.

I. Introduction

IA is defined as high level information requirements of an organization. It is applied in areas such as information systems development, enterprise architecture and organizational change management. Healthcare organization is always seen as information intensive organization, IA hence plays an important role in information provisioning within the context of AmI healthcare monitoring in order to support decision and communication between clinician and patients. Moreover [1]. AmI for healthcare monitoring and personalized healthcare is a promising solution to provide efficient medical services, which could significantly lower down the healthcare cost [2]. AmI proposes new ways of interaction between people and technology, making it suited to the needs of individuals and the environment that surrounds those. AmI healthcare monitoring aims to provide healthcare services to anyone, anywhere and anytime by incorporating mobile devices and wireless network. Proper handling and management of the healthcare issues hinge on full understanding of the patient's situation from the existing cumulated data. Defining well-structured information architecture for the collection and analysis of HCM data is a major challenge in order to create assisted environment for understanding AmIHCM situations and take appropriate measures. AmIHCM vital signs and analysis is one of the major areas in healthcare researches. In such type of researches classification related to data monitoring, environment, and patient's situation behavior are being investigated. So as to achievement assisted decision support system. As a continuation of previous experiments of related researches this paper extends in explaining the AmI healthcare assisted decision support and monitoring. Under the umbrella of an information architecture research for healthcare monitoring, in this paper the main objective focus on define and developing enterprise IA based on existing enterprise frameworks at Khartoum state (Sudan) hospitals for constructing and representing AmIHCM based on Zachman framework [3]. To assist decision support using data mining methods, as an approach to the management of AmIHCM information and explaining an aspect of HCM situation. Thus result of this paper adds on the effort of understanding the HCM situation in Khartoum state in Sudan and to evaluate the existing HCM data system or design a new one. The paper followed a Design Science research paradigm and Zachman Enterprise Framework was used to guide the development of the AmIHCMIA. The remaining part of the paper is organized as follows. In Section two, the background presented while the third Section provides methods and materials, used. Section four is dedicated to the presentation of results and Section five discussion followed by a conclusion.

II. Background

In this paper we focus on explaining HCM situations using data mining methods and developing integrated architectural models for AmIHCM data collection and analysis. Thus this paper reports a result of data mining experiment from [4].previous experiments and presents architectural model of AmIHCMIA. The results of previous and experiments exhibited the magnitude of data quality problems like attributes selection.

• Information Architecture

The term information architecture (IA) is coined by Richard Saul Wurman to describe the need to transform data into meaningful information for people to use. [5]. IA is later defined by [6], as a high level map of information requirements of an organization or a process of architecting information in order to achieve organizational benefit. [6],[7]. There are many definitions, views and conceptualizations of IA depending on its application. In [8], it is defined , as a professional practice and field of studies focused on solving the basic problems of accessing and using, the big amounts of information available today. In [9], have explained IA, as represents a higher level of abstraction, emphasizing an awareness of systems in terms of how critical subcomponents interacts according to semantic aspects of processes, designs, and metrics. In [10], IA have been defined as supporting business processes by using methods, techniques and software to design, control and analyze operational processes involving humans, organizations, applications, documents and other sources of information[10]. Also explained in [9], it is generally, represents a higher level of abstraction, emphasizing an awareness of systems in terms of how critical subcomponents interact according to semantic aspects of processes, designs, and metrics. In [11] IA is used to organize information about a topic in order to manage it in a structured way.

• Enterprise architecture framework

The term Enterprise Architecture Framework (EAF) is mostly used to specify a list of important abstraction mechanisms such as perspectives, viewpoints, and dimensions. Thus an Enterprise Architecture Framework is a documentation structure for Enterprise Architectures. In [12], define EAF as a kind of implicit conceptual meta model of the architecture of their IT systems. It describes the architecture of a business and its information technology (IT), and their alignment. The term EAF is mostly used to specify a list of important abstraction mechanisms such as perspectives, viewpoints, and dimensions. Thus an Enterprise Architecture Framework is a documentation structure for Enterprise Architectures. There are a number of reference architectural frameworks including; The Open Group Architectural Framework (TOGAF), Department of Defense Architecture Framework (DoDAF), Federal Enterprise Architecture Framework (FEAF), Treasury Enterprise Architecture Framework (TEAF), Zachman Framework. The TEAF creating a matrix of four view (columns) and four perspectives (rows) describe four views (columns), comparable to the one suggested by Zachman). [12]. TOGAF is a high level and holistic approach to the design of enterprise architecture. It covers four architectural domains; Business, Application, Data, and Technology, which can be seen as views. [13]. FEAF was developed to promote interoperability. Its dimensions are entities (what), activities (how) and locations (where). With respect to the views it provides five level perspectives for more details.[12]. DoDAF builds on three sets of views; operational, system and technical standards Operational view describes the operational elements, and tasks. Systems view describes systems and interconnections to support the Operational View. Technical Standards describes rules governing the arrangement, interdependence of system components to augment the Systems View. [14]. In study conducted by [13]. The purpose of their study was to present a direct comparison of the frameworks, based on their views and aspects. According to the authors they studied several existing enterprise architecture frameworks, which helped them to establish a common ground for the framework comparison. Comparison was made based on the perspectives of their stakeholders and abstractions. Finally the research concluded, that Zachman framework appears to be the most comprehensive using a number of viewpoints (dimensions and perspectives) relate to different aspects. "Zachman framework is a generic reference model, which serves as the basis for numerous other models eg, TOGAF, FEAF and TEAF" [15].

• Zachman Framework of Architecture

Zachman, who is recognized as an expert on Enterprise Architecture, introduced a well-defined framework of architecture having strong and logical connection between business processes, organization strategies and enterprise architectures. This is considered to be one of the major origins of the field of Enterprise Architecture.[16]. Zachman describes the aim of this framework as an architecture that represents the information systems' artifacts, providing a means of ensuring that standards for creating the information environment exist and they are approximately integrated. [17]. This framework was first introduced by Zachman in 1987 and was called Information Systems Architecture Framework which then was extended in [18]. Originally the Information Systems Architecture Framework proposed by Zachman had only three aspects Data, Function, and Network. In the extended framework which was then named the Enterprise Architecture Framework by Zachman and Sowa, three more columns or aspects of the enterprise were added namely People, Time, and Motivation which represented the business aspects of the enterprise. According to the authors the Zachman Framework can also be defined as a conceptual methodology, which shows how all of the specific architectures that an organization might define can be integrated into a comprehensive and coherent environment for enterprise systems. It is an analytical model that organizes various representations of architecture. The Zachman Framework is a two-dimensional classification schema, a normalized schema. It is the intersection between two historical classifications that have been in use for literally thousands of years, the universal linguistic communications classification of primitive interrogatives: What, How, Where, Who, When, and Why; and the classification of audience perspectives: Owner, Designer, Builder, bounded by the

Scoping perspective, and the Implementation perspective. [19]. Zachman Framework is typically depicted as a 6 x 6 matrix in which the architecture is described using two independent aspects, rows represent the different audience perspective used to view a business, and the columns represent the various communication interrogatives, which apply to each perspective of the business.

III. Methods and Materials

Qualitative Data Collection and Analysis Approaches

The research is based on seven private hospitals and eighteen public hospitals were selected randomly in Khartoum state (Sudan). The detail of the process is presented in the following subsections.

- **Study Population and Sampling**

The unit of analysis is the healthcare monitoring of inquiry data system with patients monitoring data reporting, analysis and dissemination practice and activities being the phenomenon. Accordingly, the population research has been based on HCM in Twenty-five selected hospitals in Khartoum state (Sudan). Seven private and eighteen public hospitals were selected randomly, also at the ministry of health in Khartoum State. This makes the research more comprehensive and representative; the majority of the registered patients are concentrated at the capital Khartoum State. The sampling frame comprises all stakeholder organizations working in the departments of healthcare monitoring data in hospitals. This also includes experts in healthcare monitoring, head of information system in these hospitals and in the Ministry of health in Khartoum state. With recognizable variations, literature in the qualitative research area suggests sample sizes ranging from 3 to 30. [20],[21],[22].

- **Data Collection Techniques**

Qualitative data sources include observation and participant observation, interviews and questionnaires, documents and texts, and the researcher's impressions and reactions [23]. In qualitative study, use of different data collection technique is highly recommended in order to get a full picture of the subject at hand, which is HCM in the context of this paper. Accordingly, the preferred data collection techniques for this specific research are interviews, observation, focused group discussion, and document analysis. Particularly, interview and focused group discussion were used to collect the required data from healthcare monitoring experts in selected hospitals, while observation and document analysis helps for closer understanding of the case.

- **Data Analysis procedures**

The analysis in this paper is based on the principle of the hermeneutic circle, which suggests that a deeper understanding of a text or text-analogue (HCM information management) in relation to its context can only take place through a back and forth movement of renewed understandings [24]. In doing so, the interview sessions, repeated observation and focused group discussions helped a lot. As stated by [25], the three concurrent activities in data analysis, namely data reduction, data display and conclusion drawing /verification were employed. Data reduction refers to the process of selecting, simplifying, abstracting and transforming raw case data. Data display refers to the organized assembly of information using techniques like narratives, tables, matrices etc, to enable drawing of conclusions. Conclusion drawing /verification involves drawing meaning from data and building logical chain of evidence. Cross-analysis of the healthcare monitoring data collection and analysis practices in the organizations was mapped against the Zachman Framework to determine the dimensions and elements of the architecture. With its variety of modeling profiles. The Unified Modeling Language (UML) is chosen as a modeling tool to document architectural artifacts. [26]. UML and its business profile could be freely used for EA modeling based on the Zachman framework as discussed in [16], and [27]. Literature providing conceptual frameworks and review of internal practices are also part of the effort and approaches in the process of the study.

- **Evaluation of Survey Results**

The evaluation method involved supplying a copy of the architectural descriptions and explanation of AmI concept and each concept in the IA to the participants, who are actually experts in healthcare vital signs monitoring data collection and analysis. Twenty-five healthcare vital signs monitoring experts whose work is directly related to vital signs monitoring data management have participated in the evaluation process. As discussed in the previous section, to confirm the validity of the AmIHCMIA, 30 questionnaires containing 24 likert type items and 5 open-ended questions were distributed among experts in healthcare vital signs monitoring departments in both private and public hospitals at Khartoum state. Finally, 25 completed questionnaires were returned and used for analysis. The questionnaire's reliability was analyzed using one of the reliability analysis features of SPSS 16.0 tool.

IV. Results and Discussions

A. Decision Support Experiments and Results

This section presents experimental findings and architectural model in responding to the objectives mentioned in the introduction section. We simulated the environment of Baraha Medical City in Shambat, Khartoum North, in Sudan using the framework reported in [28],[29]. In our simulation, we allocated chronic 6 ill patients in each floor (total 30 patients) as we focused only on the monitoring and providing medical service for patients with chronic or terminally ill diseases,[4]. Depending on the critical condition of the patent, each patient was attached with several sensors. For thirty patients, there were a total of 300 readings at any measuring instant. Depending on the criticality of the patient's condition, when a sensor finds values that fall in the danger zone an automated alarm is triggered notifying the nurses and doctors through mobile network or Wifi systems [28].[29]. In this project, our main task is to develop novel intelligent ensemble health care decision support and monitoring system that could assist the hospital management to assess the situation of the hospital as Normal or Abnormal (too many medical emergencies) so that more medical help could be sorted. We apply attribute selection method to reduce the number of the attributes to only

6 attributes. We investigated the Decision Tree algorithm J48, Logistic Model Trees (LMT), Random Tree, Random Forest, PART and the lazy IBk classifiers using WEKA [30]. We found that cross-validation give the best classification with 10 Fold. Then the overall accuracy for all classifiers was done. Second we tested various Meta Classifiers and have chosen the following classifiers for a series of complete tests with outcomes presented in this paper. In the third stage we constructed novel ensemble methods using Voting Meta Classifier that combine the base models built in the previous step into the final ensemble model. Table 1 dipicts the classification performance of each combing voting model in term of recall, precision, f- measure and Roc Area for Normal and Abnormal class, while Table 2 dipicts The classification performance of each Ensemble model in term of Sensitivity and Specificity. Voting Classifiers combining with various single Meta classifiers. Voting combining: J48, LMT, Random Forest, Random Tree, PART (Voting + 5 classifiers), Voting combining: J48, Random Forest, Random Tree (Voting + 3 classifiers), and Voting combining: Random Forest, Random Tree (Voting + 2 classifiers),[4].

Ensmble	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area	Class
Voting + 5 classifiers	0.977	0.069	0.927	0.977	0.951	0.987	Normal
	0.931	0.023	0.979	0.931	0.954	0.987	Abnormal
Voting + 3 classifiers	0.974	0.063	0.932	0.974	0.953	0.982	Normal
	0.937	0.026	0.976	0.937	0.956	0.982	Abnormal
Voting + 2 classifiers	0.954	0.056	0.938	0.954	0.946	0.981	Normal
	0.944	0.046	0.959	0.944	0.951	0.981	Abnormal

Table 1: The classification performance of each Ensemble model in term of recall, precision, f- measure and Roc Area for Normal and Abnormal class.

Combined Classifiers	Sensitivity	Specificity	Accuracy
Voting + 5 classifiers	0.92702	0.93147	0.95302
Voting + 3 classifiers	0.93188	0.93654	0.95436
Voting + 2 classifiers	0.93837	0.94416	0.94899

Table 2: The classification performance of each Ensemble model in term of Sensitivity and Specificity

B. The AmIHCMIA

From literature review and existing practices in a local context and result of our successive data mining experiments conducted by salih and Abrham [4], exhibited a need for an integrated approach to the AmIHCM data collection and analysis which will be addressed by an enterprise view. Therefore, in order to define IA model, two dimensions of human and operative perspectives are mentioned based on the Zachman framework, [3]. The first dimension the viewpoint of the people, who are the actors of AmIHCM data collection and analysis process. The second one, operative perspectives, defines the several requirements, constraints and operations that should be created or mentioned to architect the AmIHCM data collection and analysis. In the process of the proposed architecture, the essence of these dimensions is described. The content of each cell that is deduced from the crossover of columns and rows is also defined, as described in. [17].

VIEW POINTS	Description
SCOPE (CONTEXT)	Describes the strategies, content and constraints of the AmI health care monitoring, data collection and analysis.
BUSINESS (CONCEPT)	Define goals, structure and processes that are used to support mission of AmI healthcare monitoring organizations with respect to healthcare monitoring information as an enterprise.
SYSTEM (LOGICAL)	Describes system requirements, objects, activities and functions, network that implements the business model. The system model states how the system is to perform its functions.

Table 3: Rows of the AmIHCM IA Model

Dimensions	Descriptions
WHY (MOTIVATION)	It translates AmI health care monitoring strategies and objectives into specific meaning.
WHO (ENTITIES)	It defines who is related to AmI health care monitoring data and information management.
WHAT (DATA)	It is data to define and understand AmI healthcare monitoring
HOW (PROCESSES)	Processes to translate AmI healthcare monitoring requirements into more detailed implementation and operation definitions.
WHERE (PLACE)	It is related to physical distribution of places where AmbI healthcare monitoring data collection and analysis will be implemented and operated.
WHEN (TIME)	It describes how time influences AmI assisted health care monitoring information management.

Table 4: Dimensions of the AmIHCM IA Model

Since Zachman framework is more general, including different views and dimensions at different levels, it is relevant to delimit its use as per the research scope under consideration. It is essential to get a clear definition of the contents of every cell. The Zachman framework is simply a framework. It is not a process, a method, a notation or a tool [31]. Accordingly, computation (row 1 and 2) and platform independent (row 3) representations are selected because of the scope of the reserch and to keep the flexibility of the implementation of the architecture. Similarly, based on their relevance to the domain and scope of the reserch, the six dimensions or columns of the Zachman Framework are emphasized [31],[32]. [15],[33] suggested four dimensions namely, the **what, why, who and how** as the minimum set of descriptions for each representation, though, it may be necessary to add more descriptions depending on the business domain under study. Thus, reconsidering the idea given in [3],[15],[33] for our case AmI healthcare monitoring data collection and analysis, information management could be represented in a 3 by 6 matrix containing the top three viewpoints (rows) and six dimensions (columns). The rows of this architectural model describe different viewpoints to approach the subject at different layers. They are described in table 3. Similarly, the columns of this architectural model describe several dimensions of the model, which are referred to as abstractions. They are explained in Table 4.

	Why (Motivation)	**Who (People)**	**What (Content)**
Scope (Contextual)	Service care delivery in healthcare monitoring and impact to personal and public health	Essential Healthcare monitoring service organizations and their functions.	Description of important healthcare monitoring service and care delivery information.
Enterprise and Environment(Conceptual)	Personal HCM benefit and care monitoring delivery business objectives.	Healthcare monitoring information system workflow	Semantic description of health care monitoring processes
AmIHCM System (Logical Design)	System functional requirements.	Healthcare monitoring information system human system interface architecture.	Logical data model for healthcare monitoring information.

Table 5:AmIHCMIA based on Zachman Approach

According to the above discussions, a 3X6 grid representation of the architecture is presented in Table 5 and Table 6, by identifying relevant dimensions and user views for AmI healthcare monitoring data collection and analysis practice. Accordingly, a higher level AmI healthcare monitoring Information Architecture is offered based on the Zachman's architectural framework. As indicated on the architecture (Tables 3 and 4), contextual or the first row, defines higher-level view of the data, people, function, time, place and motivation of AmI healthcare monitoring data collection and analysis. This creates an umbrella under which the conceptual and logical design of the AmI healthcare monitoring data collection and analysis is to be implemented. Returning to the columns, the "Why" enables to clearly state the motivations at the three levels (rows), the 'what" will describe, what to collect, analyze and disseminate, the "how" help in defining how to collect, analysis and disseminate, the "When" will guide the timing, the "where" depict the geographical distribution of activities and lastly the "Who" depict who should collect, analyze, use and disseminate. The next level of architecture produces various drawings, checklists, diagrams appropriate in representing the above-mentioned content with in their context for their respective users.

	Where (Network)	**How (Function)**	**When (Time)**
Scope (Contextual)	Identification And description of organization and individual locations.	Important healthcare monitoring and monitoring care delivery services.	Identification of significant health care monitoring and care monitoring delivery events.
Enterprise and Environment (Conceptual)	Structure and interrelationship of health care monitoring facilities.	Conceptual activity model of health care monitoring delivery.	Sequence and timelines of healthcare monitoring services.
AmI healthcare monitoring System (Logical Design)	Connectivity and distributed system architecture	Application architecture with function and user views.	Healthcare monitoring event phases and process components

Table 6: (Continued) AmI healthcare monitoring Information Architecture based on Zachman Approach

Given the high level architectural representation, the detail description follows. Accordingly, based on the empirical results, literature review practice and a method to define an enterprise architecture using Zachman framework proposed in [17], a description of an architectural model for AmI healthcare monitoring data collection and analysis is presented by views/perspectives.

- **Contextual View- Scope/Planners Perspective**

This perspective can be seen as a means of defining the scope of the proposed system. According to [17],[33], there is no dependency among cells' concepts. So, the order of fulfilling for this row is totally free. Drawing from interview results and analysis of a AmIHCM strategic plan was also used to define the content of cells at this viewpoint. Accordingly, the first cell (Context-Motivation) Address public and individual health monitoring and the business of healthcare monitoring delivery across enterprise boundaries. The content is presented in Table 5. Similarly the next cell (Context-People) Identify the essential components of the health care delivery system. Essential healthcare monitoring entities or organizations identified, while the third cell (Context-Content) Identify and describe the important global healthcare monitoring service and healthcare monitoring delivery information. Data hierarchy can be extracted based on data analysis of enterprise strategic plan, [34]. The fourth cell (Context-Network) Identify and describe the global entities involved in delivering healthcare monitoring services. Individual and organizational participants in the organization. Addresses the location of an enterprise [34].

	Why Motivation	**Who People**	**What Content**
Scope (Contextual) AmI healthcare monitoring	Develop Efficient AmI Assisted HCM, decision support and monitoring in a form of goals	Essential AmI assisted HCM organizatios AmI healthcare Manager Coordination Office. Patients with wearable sensors Doctors Office Nurses Office Relatives	Monitoring Patients (with wearable sensors). Medical services. Doctors with PAD treats patients, receives Alarm and messages Nurse with PAD Medical services. Alarm and messages Manager Manages the DB With computer work station, decision support, send Alarm and messages Environment
	Why	**Who**	**What**

Table 7:Contextual View- Scope/Planners Perspective

The fifth cell (Context-Functions). Identify, describe, and regulate important business operates and delivery services. The sixth cell (Context-time) Identify and describe the fundamental organization delivery events independent of profession, specialty or services delivery environment. [16],[35]. As recommended in literatures strategic documents and experience are analyzed in the process of populating the first row of the model as presented in Table 7 and 8. Motivations of design and deplopment of the AmIHCMIA, people, entities who participating in AMIHCMIA and AMIHCM data content are presented in Table 7 . While the network, the place, for example patients room, doctors office and nurse station. Function of each entities in AMIHCMIA process and duties of each entity in AMIHCMIA and timing and events aspect of monitoring and recording wearable sensors patients healthcare monitoring data are exhibited in Table 8.

	Network	**Function**	**Time**
Scope (Contextual) **AmI healthcare monitoring**	Locations of patients data collection and analysis system Patients wearable sensors RoomsNurses offices Doctors Office ManagerOffice Relatives.	Patients sensors data collection and reporting FRID and Access Points Quality and completeness checking,Updatig monitoring data Sending Alarm and Messages Machine learning and data mining analysis(Descriptive analysis, Exploratory analysis.Decision support assisted	Monitoring events Monitoring recording Data Quality check Monitoring analysis Alarm and messages Decision support. Dissemination
	Where	How	When

Table 8: Contextual View- Scope/Planners Perspective

- **ConceptualView-Enterprise/Environment Perspective**

The second important users view considered was conceptual view which is from the enterprise and environment aspect. Based on the recommendation [36], cell contents at this level are derived from the above contextual perspectives. This perspective models the motivation, people, content, network, time and functions of a AmI healthcare monitoring data collection and analysis system from the viewpoint of business owners. Accordingly, in the first cell (Conceptual-motivation). Identify and describe the means to quantify individual healthfulness and the business objectives of a healthcare monitoring delivery organization. The major reason for this specific system from enterprise point of view is presented in terms of objectives. The second cell (Conceptual-People) Identify and define the roles of individuals participating in healthcare monitoring delivery in an organization. As shown in Table 9 allows exhibiting the general work flow in between and within AmI healthcare monitoring organizations. As explained in [17], Organization chart or Processes vs. Organization Matrix can be used to model the content of this cell.

	HCMDC	QCU	DA	PA	Al	ISD	TR	MS
Manager	X	X	X	X	X	X		
Patients	X					X		
Doctor							X	X
Nurse							X	X
Relatives					X	X		

Table 9: Conceptual-People using Process Vs. Organization matrix

Key: *HCMDC: Healthcare monitoring data collection (reporting and referencing), QCU: Quality Checking and Update, DA: Descriptive analysis (interpretation), PA: Predictive & exploratory analysis (interpretation), AL: Alarm, TR: Treat patients, MS: Medical Service ISD: Information Sharing and dissemination*.

The third Cell (Conceptual-Content) presents Define and describes the essential types of information required for operation of a care delivery organization. Semantic description of the AmI healthcare monitoring data, the business content, including business entities, their attributes and relationship. Entity dictionary can be used to represent this cell [35]. The fourth cell (Conceptual-Network). Specify and describe the layout of health care monitoring facilities and their interconnection. The location of business nodes, where the system is used [34]. It is also mentioned in [35] that, the focus of this cell is to represent the conceptual model of “Where”, which includes the location of and place, where stakeholders, use from the system and also the operations that they can do related to this. As described in [35],[16], organizational units within location stereotypes of UML packages associated using dependency relationship is a preferred modeling to represent this cell. The content of this cell is represented accordingly as shown in Figure 1. As can be seen from the figure 1, five important AmI healthcare monitoring information management locations are represented with their dependency relationship. It also agrees with the proposed approach in [17], that considers the content of conceptual-function and contextual-network cells to populate this cell.

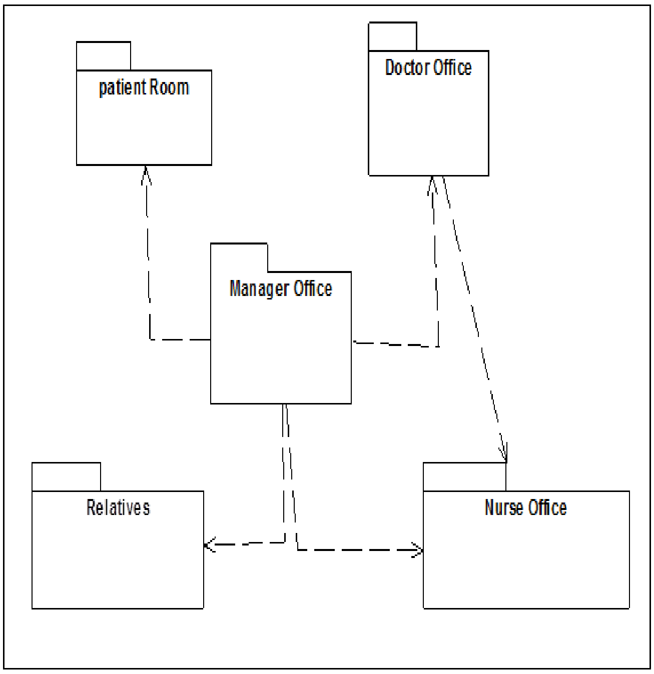


Figure 1: UML package representing conceptual-network cell.

The fifth cell within this perspective, (Conceptual- Function) Identify and describe the fundamental health care monitoring, management and support activities in a care monitoring delivery organization. Models the business workflow of the stakeholders interacting with the business. Flowchart, activity diagram, UML use case diagram and sequence diagrams are common tools for process modeling at this layer [35]. Accordingly, activity diagram is used to represent the content of this cell as depicts in figure 2. It clearly explicates the work flow in between the locations identified earlier. Its content is derived from the cell in the above row, contextual-function.

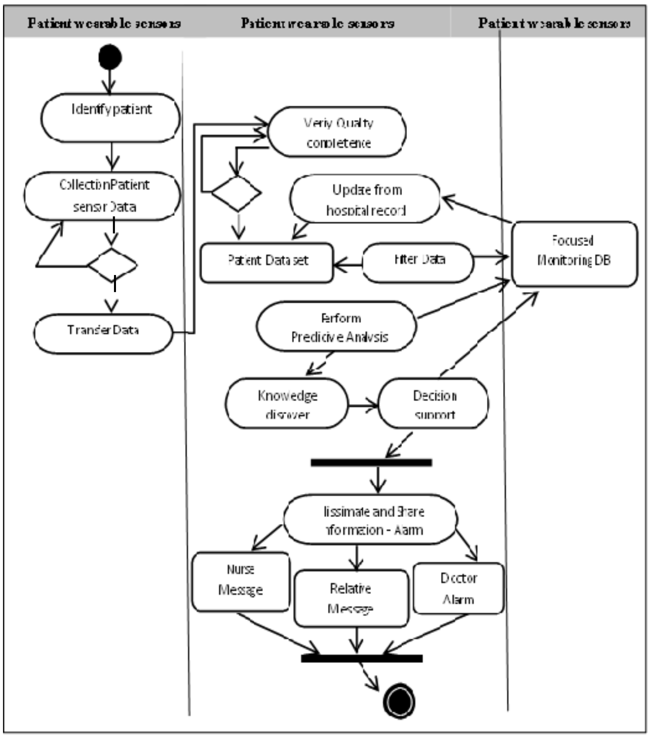


Figure 2: Activity Diagram representing conceptual – function cell .

Finally, the sixth cell (Conceptual-Time) focuses on Determine the order and timing for the processes of fundamental healthcare monitoring services in a care delivery organization. sequencing of the timing of process, events and flows significant to the business, the healthcare monitoring data collection and analysis. According to [34], time dimension may be of two forms. One of the forms represents the snapshot of a point in time and the other defines a period. There is a number of representations like Business execution plan, GANTT , PERT charts and sequence diagram using business actors, were proposed in the literature. [16],[35]. Hence, a list of events with their suggested period is a preferred approach for its understandability to represent this cell. Thus the populated architectural description of the second row of the AmI healthcare monitoring information management system is presented in Table 10 and 11. The conceptual level representations of motivation, people and content are shown in Table 10 while Table 11 contains models and description for the network, function and time dimensions.

Logical View- AmI healthcare monitoring Data Collection and Analysis System Perspective

This perspective models the requirements, participation, business content, and process of the AmI healthcare monitoring data collection and analysis system from the viewpoint of a system. It helps to give specific functional requirements view of the system, human-system interface issue, logical data model, geographical location, timing and layered architectural design of the data collection and analysis system with functions and users views. Architectural artifacts of this perspective are presented in Table 12 and 13. Accordingly, the first cell (Logical-Motivation) Relate to the functional requirements and the test and acceptance criteria for a healthcare monitoring information system. Presents the reason of the system in terms of functional requirements. Using data from the interviews and review of existing healthcare monitoring initiatives, it was possible to develop functional requirement of the AmI healthcare monitoring data collection and analysis system expressed as behavioral objectives to populate the Motivation (Why) component of this perspective. In [35], it is recommended to consider the analysis of the cells above and the content of logical-function cell in defining the content of this cell i.e Logical-Motivation. The second cell (Logical-People) Detail the methods used for the description of the functioning architecture for the interaction of individuals with the healthcare monitoring information system. Describes the structure and contents of user interactions with the system. It can be modeled using Systems vs. Roles Matrix or UML Use Case diagram [17]. Accordingly, Use Case model as depicts in figure 3 is used to represent the proposed user interaction in a AmI healthcare monitoring information management scenario. The inclusion of relatives in the process of AmI healthcare monitoring information management is worth mentioning. Its content is derived from the above cell and analysis of the function perspective of the systems view.

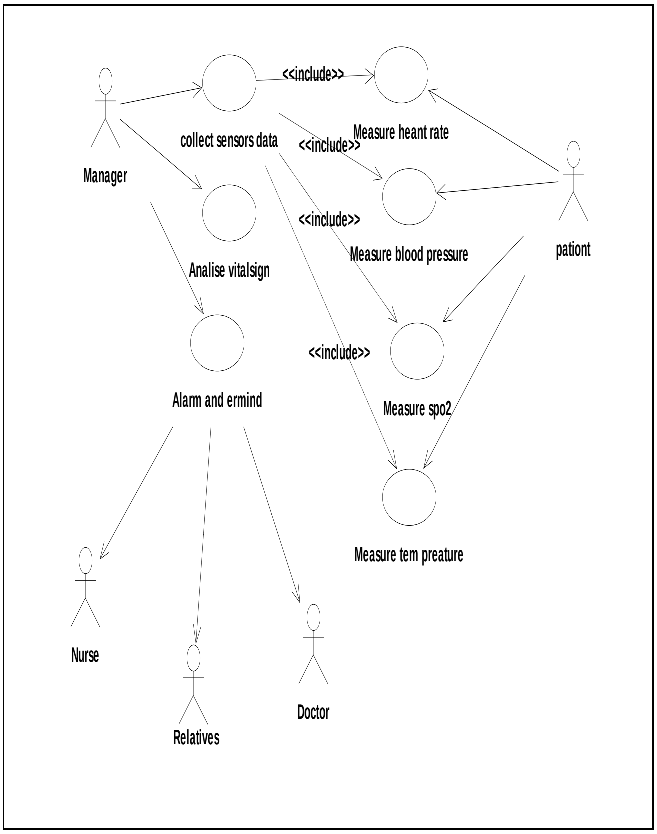


Figure 3: Use case Model representing Logical-People cell

The third cell (Logical-Content) Detail the methods used to prepare a logical data model, or the non-technological description of the data used for healthcare monitoring delivery in an organization. Describes the business structure including business entities and their relationship. Example model of this cell could be a business entity-relationship diagram (ERD) that models the business concepts, entities and attributes. The content of this cell could be extracted from owner's perspective output [17],[36]. It is depicted in Figure 4.

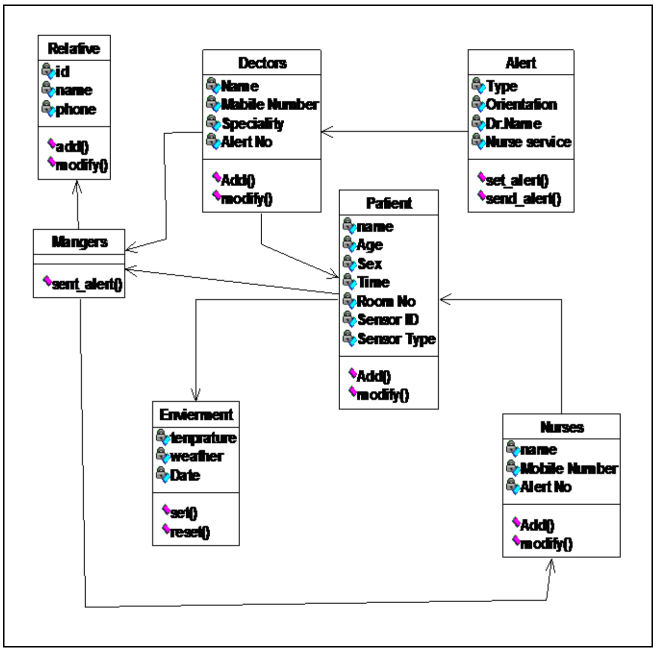


Figure 4: ER Model representing logical-Content cell

The forth cell in this perspective (Logical-Network) Describes the communication architecture supporting healthcare monitoring and care monitoring delivery. Represents the available nodes of a whole system and logical links in between them. In the healthcare monitoring domain the Patients Sensors, Relatives, Doctors office, nurse office and Manager Office are modeled with their respective modules are modeled. This cell has the conceptual-network and logical-function artifacts as its base [17]. Though, system diagram and UML component are also proposed, Deployment diagram, as shown in Figure 5, using location stereotype of packages is a preferred modeling techniques to represent this cell.[16].

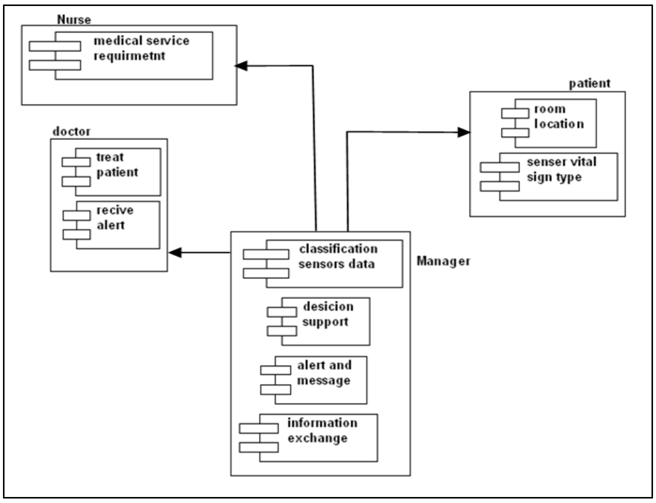


Figure 5: Deployment diagram representing logical –network

The fifth cell (Logical-function). Describe the structure of software to support healthcare monitoring and care monitoring delivery processes. Represents a layered architectural design of AmI healthcare monitoring data collection and analysis system with function and user views . Its content can be derived from the cell immediately above. Thus, it specifies the structure, the responsibilities and the relationships of the design elements of a healthcare monitoring data collection and analysis system. As can be seen from the diagram depicts in Figure 6 the system is represented in three layers where the bottom layer represents the data storage while the upper two layers illustrate the business logic and the presentation or end users view respectively.

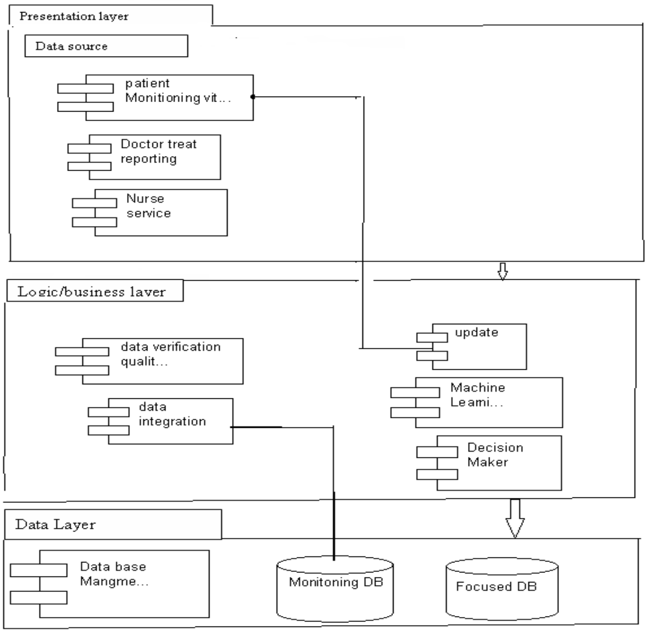


Figure 6: Layer Architecture representing Logical – Function cell

Finally, the sixth cell (Logical-Time) Detail the methods used to describe or descriptions of processes and event sequences within a care delivery organization. is used to represent events with their sequence and period in a more detail. State diagrams and sequence diagrams are recommended in the literature to define the content of this cell [17]. Sequence diagram depicted in Figure 7 using UML notes for periods is a suggested diagram to represent timing in AmI healthcare monitoring information management. [16],[35]. The diagram explicates the process of AmI healthcare monitoring data collection and analysis practices emphasizing on time sequencing of the events.

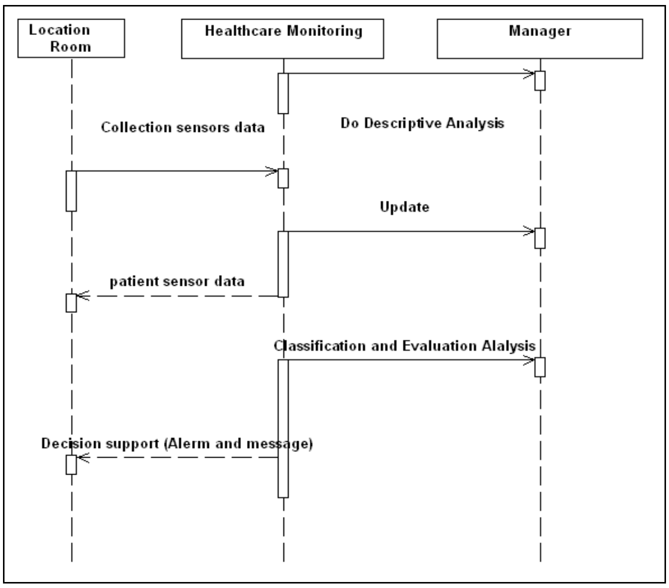


Figure 7: Sequence Diagram Representing Logical– Function cell

From system (logical) view point as minions above. The aarchitecture describes system requirements, objects, activities and functions, network that implements the business model. The system model states how the system is to perform its functions..

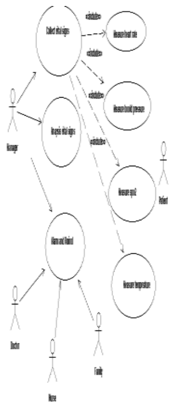
	Motivation	**People**	**Content**
AmI HCM Data Collection and Analysis System (Logical Design)	1. Functional requirements of AmI data collection and monitoring analysis system. 2. Quality and Accurate Information. 3. Provide AmI assisted healthcare and monitoring platform for decision support in real-time. 4. Information sharing 5. Enable periodic data mining and machine learning analysis and techniques. 6.Enable exploratory and Decision support.	 **Figure 3: Use case Model representing Logical-People cell**	 **Figure4:E-R Model representing logical-Content cell**
	Why	**Who**	**What**

Table 12: Logical View- Healthcare monitoring data collection and analysis system perspective.

The logical view of the AmI healthcare monitoring data system is shown in an integrated manner in Table 12 dipicts logical view- healthcare monitoring data collection and analysis system perspective. The first column motivation was filled according to data collection and analysis, the second column reprents the Use case Model representing Logical-People cell in AMIHCMIA, while the third column represent the logical content cell reprented in E-R model as depicts in table 12. The integration is expressed in terms of coherence in between the contents of each cell. while the the first column in table 13 is related to physical distribution of places where AmbI healthcare monitoring data collection and analysis will be implemented and operated, is representing in deployment diagram which representing logical –network, the second column of the table describes the processes to translate AmI healthcare monitoring requirements into more detailed implementation and operation definitions, it represented in layer architecture representing logical – function cell. While the third column the table describes how time influences AmI assisted health care monitoring information management, it represented by Sequence Diagram Representing Logical– Function cell.

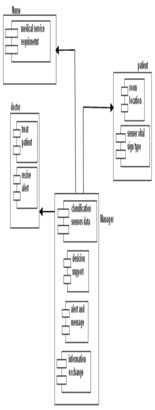
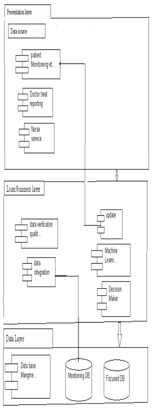
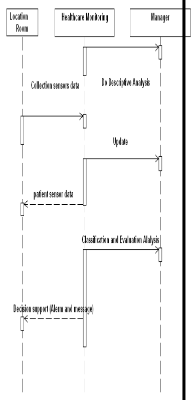
	Network	Function	Time
AmI HCM Data Collection and Analysis System (Logical Design)	 **Figure 5: Deployment diagram representing logical –network.**	 **Figure 6: Layer Architecture representing Logical – Function cell.**	 **Figure 7: Sequence Diagram Representing Logical– Function cell.** -
	Where	**How**	**When**

Table 13: (continued) Logical View- healthcare monitoring data collection and analysis system perspective.

- ## Evaluation of Survey Results

The questionnaire's reliability was analyzed using one of the reliability analysis features of SPSS 16.0 tool. Accordingly, the Cronbach's Alpha (α = 0.813) was calculated (see Annex B) which confirms its reliability. Regarding the analysis of experts' response for Likert type items, standard deviation and mean of descriptive statistics were used. In view of that the standard deviation was calculated for each item of the survey based on the gathered data. As evident from the table in Annex A, it is easy to deduce that the healthcare monitoring IA is acceptable as the survey exhibits standard deviation less than 1 (0.569 – 0.935) for each item.Another parameter used in the analysis of the experts' response on the acceptability of the IA is comparing the mean score results of completed questionnaire with the questionnaire's average. Hence, the mean score of the 25 completed questionnaires was 83.33, which is by far more than the questionnaires average score, 75. Respondents rate most of the questions in the survey above average, which indicates that the IA defined in this research in the opinion of healthcare monitoring experts is desirable.

RELIABILITY
/VARIABLES=Qus1 Qus2 Qus3 Qus4 Qus5 Qus6 Qus7 Qu s8 Qus9 Qus10 Qus11 Qus12 Qus13 Qus14 Qus15 Qus16 Q us17 Qus18 Qus19 Qus20 Qus21 Qu s22 Qus23 Qus24

/SCALE('ALL VARIABLES') ALL

/MODEL=ALPHA.

Reliability

[DataSet1] C:\Users\AFAF-PC\Desktop\evaluation resul t.sav
Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	25	100.0
	Excluded[a]	0	.0
	Total	25	100.0

[a]Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.813	24

Figure 8: Relability

V. Discussion

This section discusses key attributes of the proposed AmI healthcare monitoring IA. The architecture serves as a mechanism to facilitate communication regarding healthcare monitoring data by which it satisfies one of the major purposes of architecture. Based on the generic Zachman Framework, the AmI health monitoring IA is represented by the integration of rows and columns. Each row at each column point presents a unique perspective. We noted here that each perspective could be applied to both development of new systems and maintenance of existing systems. Without an integrated perspective, all architectural models and strategies will be inflexible and will remain unused. As stated in [37], such type of architectural guidelines portrays the real life situation and thus considered robust. By applying the top three levels of the Zachman hierarchy, it was possible to develop descriptive AmI health monitoring IA. Major procedures includes; determining the dimensions and perspectives required and applicable for the purpose under study, determining the information requirements of the domain through qualitative data collection and data mining experiments, classifying and structuring the information based on the dimensions identified keeping the integrity, representing the information in a required level of detail for the perspective under consideration, evaluating both the process and the content using recommended metrics and methods. Analyzing the framework's perspectives, In [17]. According to the authors, an anchor cell is a cell that on any framework's perspective has an aggregate function relative to the other cells. In line with this, it is easy to learn that two cells representing the intersection of the conceptual and logical perspectives under the function or process dimension are more of aggregate and core, which entails they deserve more discussions and attention. In the context of this specific research, the description of content, process and people at a conceptual and logical level satisfy the 'anchor cell' concept. This is mainly because these cells represent the major issues in an healthcare monitoring information management practice under study. Information Architecture core representations; content, context and users. AmI healthcare monitoring IA is developed based on empirical data where infrastructure related to healthcare monitoring management is limited which will influence mainly the content and process aspects of healthcare monitoring information management. Main distinguishing feature of AmI healthcare IA is simplicity. Partly, the simplicity emanates from the nature of the guiding framework selected. The overarching purpose of the AmI healthcare monitoring IA is to assist in evaluating and/or developing healthcare monitoring data collection and analysis systems and promoting informed decision support by healthcare monitoring organizations. The research result can also be generalize into a general architecture that can be applied in whole Sudan and other development countries with similar context in the area of healthcare monitoring data collection and analysis.

VI. Conclusions

In this paper we extend data mining experiments in explaining healthcare monitoring situations and investigate application of enterprise information architecture concepts. Evaluate Ensembles design and Combining different algorithms to develop Novel Intelligent Ensemble Health Care Decision Support and Monitoring System to classify the situation of an emergency hospital based on the Vital Signs from Wearable Sensors. Our Novel Intelligent Ensemble Health Care Decision Support and Monitoring can optimize the results and improve assisted health care monitoring. Survey of the literature enabled to create understanding and attempts in a healthcare monitoring data quality and data analysis domain. the major issues in explaining healthcare monitoring situation are the role of patient factors, which is identified to be the major factor, on the risk of a patient with critical situation related factors. With respect to patient related factors it is found that factors like sensor Id, sensor type, room No. These optimal attributes are used as an input in the design of content demission of the architecture. In addition the major contribution of this research work includes comparison of analytical ensembles models for the domain, highlighting data quality issues, proposing ensemble technique to improve accuracy and trend analysis regarding factors for healthcare monitoring severity, which also informs the function dimension of the architecture. However, provides an advantage that with a reduced feature set a better classification performance and it is able to offer a better decision support system. Another major aspect of this paper is the definition of AmI healthcare monitoring IA. Extensive survey of literature in the area has been made to provide evidence for the applicability of enterprise information architecture in other areas. According, a review of literature also enabled us to create a good understanding of international practices and attempts in improving healthcare monitoring data collection and analysis in a healthcare monitoring domain. The defined architecture is based on Zachman's framework. By applying the top three rows of Zachman hierarchy, it was possible to develop descriptive AmI healthcare monitoring IA that can facilitate communication. The development of AmI healthcare monitoring in this paper and design of a healthcare monitoring information management is an original contribution which improves and expands the conceptual framework of the research in both healthcare monitoring domain and IA field. AmI healthcare monitoring IA can serve as a strategic guide to the review and development of the healthcare monitoring data collection and analysis systems. It can also be used as a tool for analysis and of existing healthcare monitoring data systems. The result of the research helps healthcare monitoring organizations to revisit their focus of attention in implementing measures to reduce healthcare monitoring problems. The research result can also be generalize into a general architecture that can be applied in whole Sudan and in other development countries with similar context in the area of healthcare monitoring data collection and analysis.

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