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A Proposed Software Development Methodology for the Hospital Management Information Systems

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Abstract:
Information System design and development needs to consider systematic and disciplined software development methodology in today's revolutionary world. Each of the system development methodologies has its own characteristics, specific interest, coverage etc. Digitalization in the hospital management information systems and processes is essential in the era of globalization and modernization. The hospital management Information system is widely expected to increase patient safety and reduce medical errors. Designing and developing software project needs careful and appropriate software development methodology which helps the developers as a guiding tool to design and develop new systems. In this paper a software development methodology for the hospital management information system has been proposed. It is helpful to solve the challenges of the designing and development of healthcare applications in the modern world of Artificial Intelligence.

Keywords: Information System, Hospital Management Information Systems ((HMIS), Software Development Methodology, Agile approach, Modular approach.

Introduction:

In this era of globalization throughout the world all the businesses implementing information system to enhance their business processes, to provide efficient information flow for effective decision making for the business activities. Health sector is also started using information systems for the availability and accessibility of information and also enhanced decision making processes for providing better services and care to the patients in the hospital. No, healthcare facility works and manage without the efficient information systems. Information in healthcare facility can be organized and managed efficiently by implementing health information systems. Information Systems (IS) is one of the tool of information and communication technology. IS generally referred as set of interrelated components in computer system which store, process, retrieve, distribute an appropriate information which helps the users of healthcare sector. The information system in healthcare is usually known as Hospital Management Information System (HMIS). Adopting and implementation of HMIS in hospital is a complex task compare to other fields. HMIS is helpful to the hospitals from administrative, financial, clinical etc. point of view. [2][3][19][20]

SDM is a process of handling and managing the activities during the development of different stages of software project. Software Development Life Cycle (SDLC) is extremely vast and full of various development and testing activities, methodologies, techniques, tools, and more. It engages strong planning as well as management, computation, plan, and preparation. Software Development Life Cycle has mainly eight phases Requirement Collection and Analysis, Feasibility Study, Design, Coding, Testing, Implementation and Maintenance. SDM works as a framework or model for the software developers and

designers for developing or building the software or the information systems for the community of users. It gives the insight on requirement and need for the design of software and information systems. Information System development projects needs careful planning, hardworking dedicated and knowledgeable team and also client involvements. Software development organizations have many challenges to stand in market and to prove their position with their real goal. Software development industries help them to manage low-cost budget by providing good quality software. Good quality software development has different attributes like reliability, usability, cost, efficiency, maintainability etc. it's hard to define and difficult to measures and manage all attributes. A systematic development of information system leads it to the qualitative balanced successful implementation and use of information systems.[2][3]

Different software development methodologies are available for the development and maintenance of the software. Each one of them have their own characteristics, benefits and weaknesses. The software development model explains the sequence of activities which are followed in the development by the software engineers, software developers, IT experts etc. The various different software development methodologies available for developing software are Waterfall model, Prototype model, Iterative method, V-Shaped model, Scrum Model, Spiral model, Agile model etc. Design and development of HMIS requires an appropriate software development methodology. [ ][6[16][17]

Common Software development process models:

Waterfall Model: It is a traditional, linear and sequential approach for the development of software. It is one of the oldest planned linear-sequential approach for the development of large size software. It has six different phases. In this model as development process is sequential in nature so one phase starts after the completion of previous phase and hence there is no overlapping of phases. Output of one phase becomes the input of another phase. In the model documentation is very essential as next phase starts after the completion of the previous phase. The phases include in this models are feasibility study, requirement analysis, design, coding, testing and maintenance.

Prototype Model: Prototyping is defined as the developing a working solution of a product or a system. It is one of the popularly used software development methodology for the small system and when the requirements are not give completely at the beginning of the project. Preliminary version of the software is developed, tested and then necessary revision has been made until the desired required prototype is not developed. It works best in the situation when requirements are not known in detail in advance. It is iterative in nature. No. of versions will be developed till the customers requirement will not satisfied. It includes the different phases as requirement gathering and analysis, design, building a prototype, initial user evaluation, revising prototype, implementation and maintenance.

Iterative Model: First version with the some software specifications will be designed and developed in this model. After the release of the first version if here is a need to change in the software then a related changes can be done and new version of the software is developed with a new iteration. Each version of this model finishes in fixed given period is called an iteration. The final version of the project renewed at the end of the SDLC. After completing all the iterations as per need and specifications, the software gets developed successfully. This approach divides the large software development process into smaller parts. The

iterative model comprises repeating the below-mentioned four stages as a sequence. These are: Requirement analysis, design, implementation and review.
V-Shaped Model: It refers as Verification and Validation Model. In this model, each phase must complete before the second phase begins. It follows sequential process model same as waterfall model. Testing has been done throughout the each stage of the development process. The development of each step is associated with the testing phase. For each development process testing activity can be done. It is based on the idea of V-shaped design. Verification and Validation process is joined by coding phase in V-shaped model.

Agile Model: It is one of the simplest and effective processes to develop software as per the need and vision of the business. Agile means swift or versatile. Agile Software development model supports improvement, flexibility, evolutionary, team work, faster, continuous planning. It works with iterative development of the software. This approach divides the task into smaller iterations rather than planning for long term. The requirements are decided at the beginning of the development process. And planning regarding the number of iterations, the duration and the scope of each iteration are defined in advance. Each iteration is for short time duration usually for one to four weeks. As in this approach entire project is divided into smaller iterations which minimize the risk and makes project delivery faster. The phases of agile model are Requirements gathering, Design the requirements, Construction/ iteration, Testing/ Quality assurance, Deployment, Feedback. The major drawbacks of agile model is lack of proper documentation and accommodate the changes in requirement as it works with number of iterations. [2][4][5][7][9]

Literature Review:
Information system designing and development needs the systematic framework for the structuring, planning and controlling the activities of building the information system. There are the various different software development models have been used since many years. Each of them have their own strength and weaknesses. It is not necessary that each of the methodology is suitable for all the type of system developments. Designing of hospital management information system requires specific development methodology for designing and development of the system. Here some of the reviewed research work has been presented.

- Nesma EI, Walla & Nagy (2021) have discussed that the healthcare software development has emerged from paper-based system to digitalized systems. They have discussed that healthcare software requires greater safety, stability, less errors, high performance and availability. So, it should not release poor quality software and continuous improvement in it. In this paper they have discussed the commonly used software development methodologies with their benefits and drawbacks of each. They have also proposed the hybrid development methodology named as hybrid scrum fall methodology for the healthcare software development. In this model they have combined the features of agile model and waterfall methodology both.
- Desislava Ivanova and Vladimir Kadurin (March 2021) discussed about different key significant software development methodologies with their characteristics, benefits, drawbacks in different situations. They also performed comparison between the software models with their characteristics. They also discussed the complexity and problems of healthcare software developments and also suggest the proposed model for the healthcare software development.

- A.K.M Zahidul Islam & Dr. Alex Ferworn (2020) focuses on traditional and agile software development methodology. They have talked about software development life cycle role, responsibilities and technical practices. They have performed the comparison between both practices. They have collected data via questionnaire from the experts of IT industry of Bangladesh.. They performed the comparison between their survey result and Ambler survey.
- Lalband & Kavitha (2019) focused have discussed that software engineering principles are used by software developers and vendors. Since last a decade for many industries software development methodologies are evolved. Healthcare sector is lacking on focus for systematic development process which affects the quality of software, increase the flaws, cost and time. They have analysed the existing software development models and proposed the best model for developing smart healthcare applications.
- Mohammed Abubakar (2019) discussed that developing software without a proper software development methodologies may lead to poor software project developments and may not sustainable. He aimed at designing a software development methodology framework for implementing MIS and integrating e-learning in educational institutes. He conducted the survey for different higher education institutes and also used modelling approach, unified modeling language (UML) for use case diagram, activity diagram etc. to design the framework for the educational information system for higher education institutes.
- Sampada Chaudhari, Prateeksha Chouksey, Priyanka Lonkar (2018) have focused on selecting the right software development approach has many factors like quality, cost, schedule etc. They discussed about the traditional and agile approach along with their characteristics. They have bring out the difference between agile and traditional methodology. They have also said that apart from the appropriate methodology testing and validation also plays the important role. They said client should also know that the system has developed as per their specification.
- Yu, Jiujiu (2018) highlighted that software development model can affect the quality of of software development. Software development models are helpful for management and organization of overall software development. He first analyzed and summarized different thirteen types of software development models with their characteristics and also suggested certain improved software development models according to certain application fields.
- Rayan Dasoriya (2017) discussed that variety of software development models can be selected based on the factors as per the requirement of software project. He also mention that there is no perfect software development model is exist but selection of appropriate model can give better result and also increase the chances of success. In certain software development different models can be combined and software will be designed and developed.
- Priyanka, Shweta and A. Hemlata (2017) have performed the comparison between traditional software development process and agile software development process. They have discussed the benefits and issues with the different software development methodologies. Their research objective is to gain insight into agile methods and practices, finding the issues in using agile methods, understanding the transition from traditional to agile method. They have performed the case study on two companies to check about the agile method on organizations.
- Jorge Gomes & Mario Romao (2016) discussed that in order to improve business practices and internal procedures healthcare organizations must invest heavily in information systems or information technology which helps them to improve the management of information and patient's demand. They conducted research on how organisational maturity,

enhanced by investments in IS/IT, project management and best practices which leads to successful projects in public healthcare organisations.

- Farzandipur, Mehrdad Jeddi, Fatemeh Rangraz Azimi, Esmaeil (2016) discussed about the use of information systems in health environment is as important and necessary as other fields. They highlighted on inability of design and implementation of these systems by developers and users can lead to the problems in the use of healthcare information systems. By strengthening the human and technological factors at the time of development and implementation leads to the better development and management of healthcare information systems.
- Astuti, Hanim Maria Herdiyanti, Anisah Iriandani, Nurul (2015) evaluated the Hospital Management Information System (HMIS) of a hospital in Indonesia and proposed Information Systems Success Model (ISSM) for the finding the factors which influence the successful implementation of HMIS in the hospital. They constructed the model based on several variable like information quality, service quality, systems quality etc.
- Merhi, Mohammad I. (2015) focused on the implementation of Electronic health record (EHR) systems has several difficult challenges for practitioners. They proposes a process model of the factors leading to the successful implementation of EHR systems. They explained the model as three stages pre-implementation, implementation and post-implementation. He analysed based on quantitative tool to assess model and demonstrate its best practices. He has discussed from both researchers and practitioner point of view.
- Nikitana and Mattsson (2014) suggested a process model for the selection and adoption of software method and list the contextual factors for guiding the deployment of software development methods. A process model has included the activities in five different phases. They evaluated the software method adoption model and contextual factors in six different industrial projects and it has been proven to be helpful to the industry for the selection and adoption of the software method.
- Mihai Liviu DESPA (2014) stared explaining his paper with specific characteristics in software development. He defined and described basic four stages of software development process. He explained current software development methodologies with highlighting their strength and weaknesses from stack-holder point of view. He concluded by dividing software development methodologies as heavy weight and light weight approach and one should consider it project owner profile, developer's technical expertise, project complexity, budget, deadlines etc.
- Abdullah Al-Dahmash, Samir El-Masri (2013) highlighted that design and implementation of healthcare information system needs software engineering methodologies. They discussed the common software engineering methodologies along with their uses. They proposed new software engineering model with four phases for the healthcare applications. They also performed the comparison between common software development methodologies and proposed model.
- Abdullah, Zainatul Shima (2013) discussed that to provide high quality health services HIS development, adoption and implementation has to be there. Based on the evidence they showed that implementing HIS is not easy, To implement successfully certain implementation factors play a crucial role. it requires Based on critical success factors and Delone and McLean's information system success model they developed an implementation framework comprised of essential elements to guide for the HIS implementation.

- According to Hotchkiss, Aqil, Lippeveld & Mukooyo (2010), healthcare sector requires timely information from the routine healthcare information system for day to day activities, management decisions, resource allocation etc. They observed that in low and middle income countries RHIS is not able to providing quality data and timely information for the better performance of the healthcare services. They evaluated the usefulness of the newly developed performance of routine information system management (PRISM) framework. It is a conceptual framework. They have collected data from the different healthcare facilities in Uganda. Their analysis and result suggested that PRISM approach can be used by the RHIS policy makers and practitioners to assess and evaluate the RHIS.
- Triantafyllia Doumpa (2009) tried to develop an instrument for the evaluation of the Greek hospital information systems. He tried to find out the factors which affect the IS user satisfaction. He performed the study based on the DeLone and McLeans model of IS success and also validated user satisfaction models. He considered system quality, information quality, service quality and user background to measure the user satisfaction. He prepared the model and based on that questionnaire was generated.

Proposed Software Development Methodology For Hospital Management Information System

HMIS plays an important role in managing and handling the activities of hospitals. Activities of hospital management in terms of handling patient data and other related information is very dynamic and needs the help of technologies into the handling of these processes effectively and efficiently and also to provide better quality services, to save time and cost, to enhance performance and reliability, to provide confidentiality of data. Hospital Management Information System deals with the different variety of users and several modules are interacting with one another to deliver and maintain the better services to the users of the system. And it is essential for the hospital system developers that for diverse users the system should be user-friendly. The developers need to keep mainly following points in their mind as:

- choose appropriate processes
- design of software
- provide better quality of software
- save time and cost
- enhance performance
- maintenance of software

Traditional development models have certain risks like add into the requirements, re-organize the strategy and design, which takes additional time to deal re-organize this changing needs. The further u find the changes or issues in the development process, it becomes harder, costlier and time-consuming to accommodate or to fix them. Sometimes developers and other team members can not show up certain complexity and issues of the system. And because of that those needs couldn't be accommodated. So to accommodate those changes into the systems takes more time and efforts and certain time it increased the complexity of the system also. So, agile software development methodology gives you the great benefit by iterative development of system. As agile iterations are smaller than traditional development cycles, it minimizes the risk in terms of cost, time and complexity.

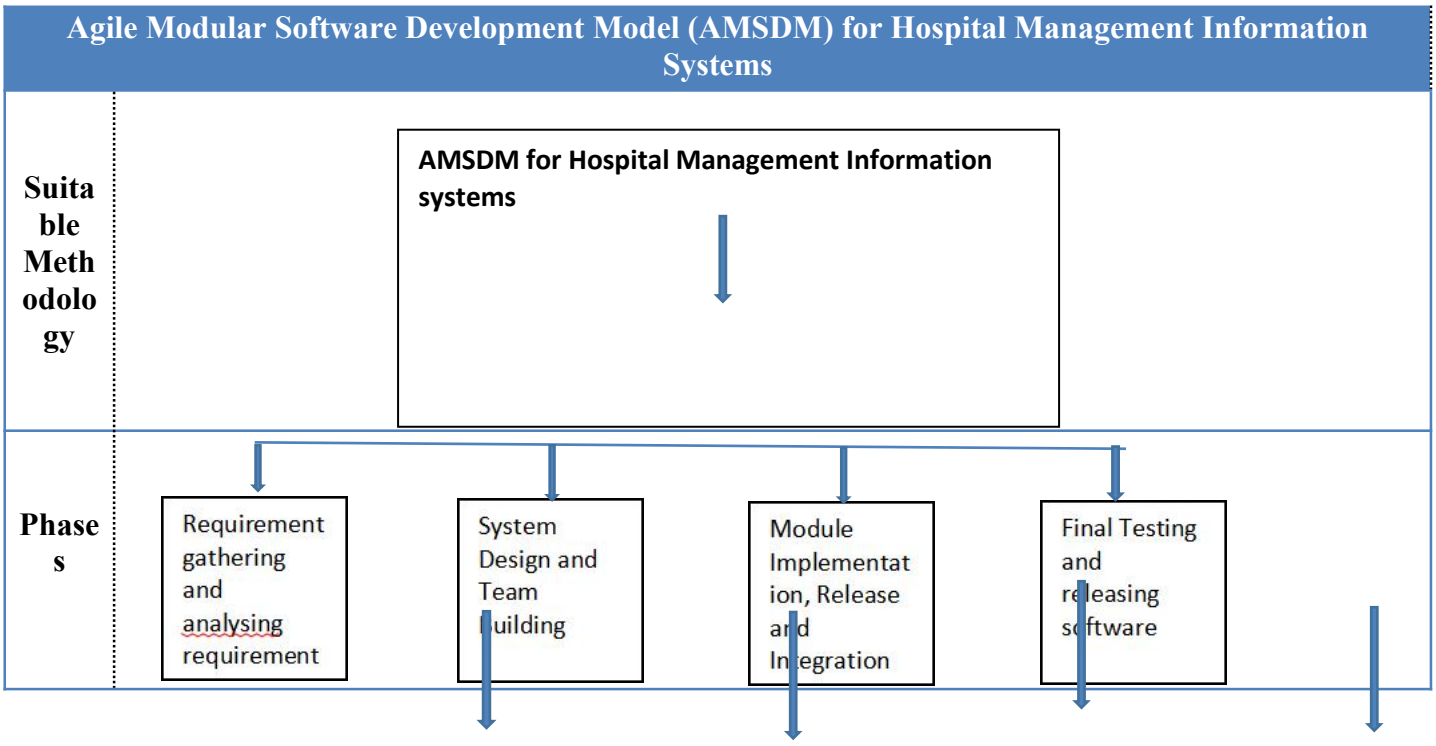
Agile software development method allows rapid development of software which given enhance result and user centric development of the software. Agile gives the benefit of including rapid changes in the development of hospital management software. It tries to accommodate new advanced changes in the area of healthcare management. It means that it

leads to the development of small frequent releases with smaller set of requirements which meets the hospital management and its user requirements. The advantage of agile method is that different features can be added as development is going on or may be re-organized as per the changing need. These changes don't require complete re-design or re-organization of software development processes to accommodate new developments. This Agile development model for hospital management settles in for the rapid and changing needs of the hospitals.

Agile software development methodology quickly divides the designed features into smaller iterations unlike a large software release is in testing to identify the problem or issue. When developing a software for the hospital management system, it is important that the software must be meet all the need of hospitals, user-friendly, error-free, robust and regulations which are require for the hospital management. The agile methodology helps in dealing the above challenging need of the healthcare development as a part of proven methodology.

As development of HMIS is complex task and requires planning and insight. It also has several modules for performing variety of tasks. Here, an integrated agile modular approach can be proposed to design and development of Hospital Management Information Systems. Modularization process can be done for large complex hospital management information system. Here entire system divides into different modules and each module has relationship with another module. Each module will be treated as separate small system. And for each of the module along with the detailed requirement analysis documentation will also be done. Which will helpful for overcoming the drawback of agile methodology. Developer is also involved during the meeting and discussion with the client. Client involvement is also there throughout the development of the system. So, changes in the requirement can be accommodate instantly in the system.[1][4][7][8][10][11][13][12][14][18][22]

Framework of the proposed model:



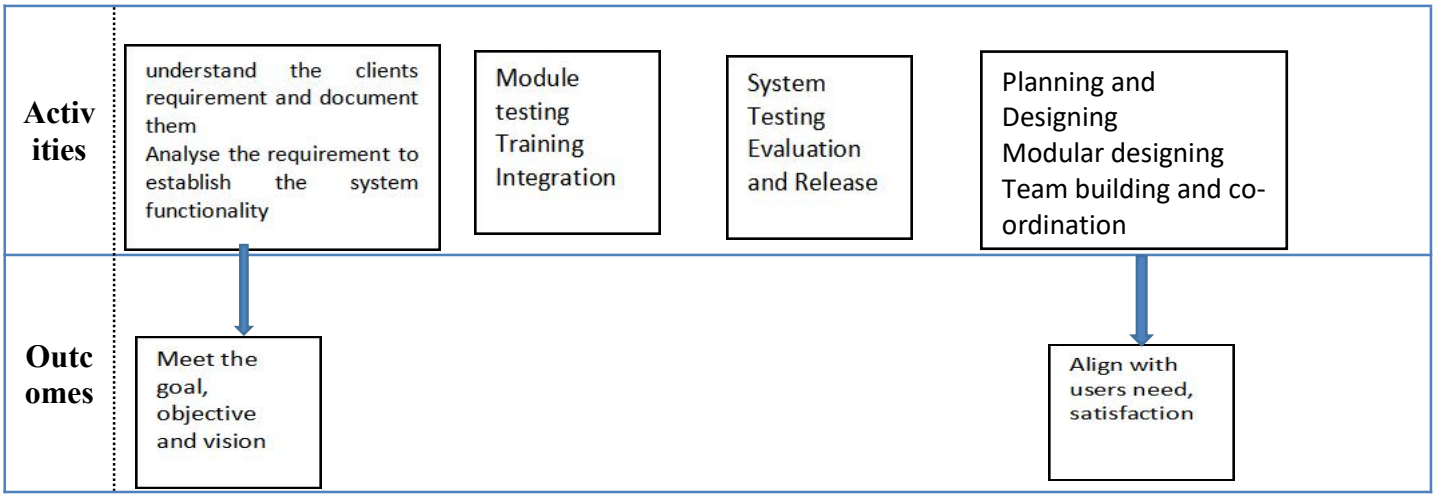


Fig.1: Framework of the Suggested Model

Stages of the proposed model:

Requirement gathering and analysis, Research and Plan:

This is the most important and challenging phase as a system plan should be created to bridge the gap between hospital specific requirement and technical solution to deliver end product. It also emphasizes to set proper communication between healthcare personnel, stack holders and developer team. Developer team and health care personnel and others need to communicate and work in a team to prepare a robust project management structure which deals with all the different issues which may appear. Requirement will be gathered in document story form. They need to prepare a detailed document which includes all the requirements and need which is clearly and easily understand by all team-members. This makes sure that all the requirements and functionality is included in the system. Requirement analysis is an important aspect for the successful development of the system. This phase may include internal iterations until all requirements are included and no discrepancies will appear.

Design and Build:

The requirement analysis and plan should be documented well before the starting of designing phase. Based on the requirements from the previous phase different designs are considered and evaluated. The most suitable is considered with components, elements, interfaces and other characteristics of hospital management system. As system has been designed as per the modularity concept so processes and tasks are divided into the different modules. Different modules will be designed independently as per the need and will be altered as per the need in different iterations. And at the end all the modules are integrated as whole. Once the design which meets all the requirements at a given time and the standards for the product then the design is considered as final. And design document should be prepared along with the technical details about the system.

This method involves the customer and their feedback throughout the development process. Customer involvement and communication is vital. Customer involvement and communication may be a one of the effective way to know requirement and expectation while developing the system. For the synchronization, communication and smooth functionalities in the development process activities are distributed among the different teams like developer team, specialist team, integration team, communication team etc.

Developer Team: they are responsible for developing the individual module or the program which has been assigned to them. The development of the module is completed once then it will be given for testing.

Specialist Team: this team is responsible for building and maintaining a part of the system that depends highly on specialised expert knowledge.
Integration Team: this team closely work with developer team and specialist team. They work for the module integration and also perform the testing. They required the knowledge of the different modules. They need to have complete understanding about the system.
Communication Team: this team is responsible for providing correct requirement and validate it with the other teams. They are also responsible for the testing of the system. They work with the other teams which helps them to deliver the final system with less time as per the users need and with less maintenance.

Development, Implementation and Integration:
In this stage developer and team members develops the system as it defines in the previous two stages. Here if system is large and it is developing from the scratch then the development of large system should be done in modules. System development project should divide into the modules by making logical relationship between and within the modules. Each module is considered as a small individual system and detailed analysis will be done. Here modules are developed in parallel. Here management of activities of this stage is very important to ensure that all details are exactly added as required or mentioned in the previous two stages. It includes several iterations as end product delivered in small increments that allow the end customer to start testing before the final product is finished. Testing of the individual module will also be done. Flow of data is also checked from one module to another module. System performance, reliability, security, availability will be taken care during this stage. Training will also be provided to users.

Testing, Validation and release:
As healthcare is the different type of domain with its specific needs and requirements, so it needs to have special team for the validation of the system. The teams should include developers, system designers, medical professionals and other hospital staff members. So it helps in to make certain whether all the needed requirements and specifications have included from both healthcare and technical point of view.
Once the development process is over as per the requirement, unit testing and individual module wise testing is completed and module integration is completed then the whole system is tested. If no error or defects found in the system then the system is delivered to the client with all detailed required documentation of the system.

Comparison between different Software Development Methodologies:
The following table represents the comparison between traditional, agile and proposed integrated agile modular approach. [4][10][14][15][21]

Sr no	Characteristics	Traditional Methodologies	Agile Methodologies	Proposed – Integrated Agile Modular method
1	Development Approach	Predictive	Adaptive	Adaptive and modular
2	flexibility	Low	High	Very high
3	Team size	Large	Small	Small with more number of teams
4	Project size	Large	Small and medium	Large
5	Communication	Usual	Causal	Client is a part of team
6	Documentation	High	Low	High

7	User requirement	Clearly defined	Interactive	Dynamic
8	Time period	More	Less	Less
9	Implementation	Fixed	Flexible can change	Module wise implementation
10	Testing	At the end of the development	Can be done at the end of each phase	End of each phase for between and within modules
11	Restructuring	less flexible	Flexible	Highly flexible
12	modularity	Low	moderate	High
13	Development models	Lifecycle	Evolutionary	Evolutionary and modularized
14	Scope	Plan oriented	Value oriented	Customer oriented
15	Reliability	Low	High	High
16	Performance	Moderate	High	High
17	MVP	No	limited	Yes
18	Maintenance	Harder	Moderate	Easier

Table 1: Comparison between existing and proposed software development methodology

Conclusion:

In this paper, a brief discussion about different software development methodologies used in the development of information system is given. Although there are many different development models are available but few models which are commonly used were discussed. However, for development of hospital management system a new methodology has been suggested with four different stages. The stages include – Requirement gathering and analysis and Planning, Design and build, Development, Implementation and Integration, Testing, Validation and Release. So, developers will add the benefits of both agile and modular approaches in the development activity. It is suitable for the various issues for the hospital management software development such as complexity, performance, reliability, time, flexibility, documentation, maintenance etc. In future can concentrate on nature of the hospital management system and the working together with healthcare specialists and software developers and their team for the development of the healthcare sector information systems.

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