Impact of Pipe and Filter Style on Medical Process Re-engineering

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Abstract: *The architecture style helps to determine the relationship of components and connectors that can be used with a set of constraints at any instance of architectural descriptions. With increase in size of software systems the software Architecture style presents a new set of design problems for systems to serve the needs of specific domains with integration of components. It has been recognized both by Academia and software industries as the most promising approach to tackle the problems in the era of Finance, Communications, Medical, Run-time applications etc. Different style has different system characteristics. In this paper we propose to model the architecture of medical process Re-engineering based on Pipe and Filter Architectural style. Medical process re-engineering model provides clinical staff, patients, and other individuals with knowledge and person – specific information, intelligently filtered and presented at appropriate times to enhance health and health care with the concept of using software re-engineering, which helped to improve understanding about the processes and led to the conclusions with deletion of subsequent improvements to those processes. We discuss the properties that are interesting to be analyzed with the process of design and reengineering.*

Index Terms: *Architecture style, MPR model, Reengineering, Reusability, Software architecture.*

I. Introduction

Architecture Styles

An architectural style is a set of principles, which improves partitioning and promotes design reuse by providing solutions to frequently recurring problems [3, 4]. "…a family of systems in terms of a pattern of structural organization. More specifically, it determines the vocabulary of components and connectors that can be used in instances of that style, together with a set of constraints on how they can be combined, for an instance, can include topological constraints on architectural descriptions (e.g., no cycles)". The major benefit of using this, is that they provide a way to have a conversation that is technology agnostic with common Language. This allows us to facilitate a higher level of conversation that is inclusive of patterns and principles, without getting into the specifics.

Process modeling approach

Process modeling is a method that helps to understand the actions, work flow, and tasks of an organization, and how the tasks are executed. Process modeling captures the process flow, the actors in the process, and the tasks performed by these actors. The focus in process modeling is on the functional processes which are entities that start with a certain event and end with a certain result. A process has always an input that triggers the process and process results in an output [5, 6].

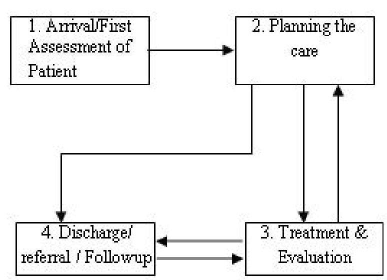

Fig. 1. Medical Process Modeling Approach

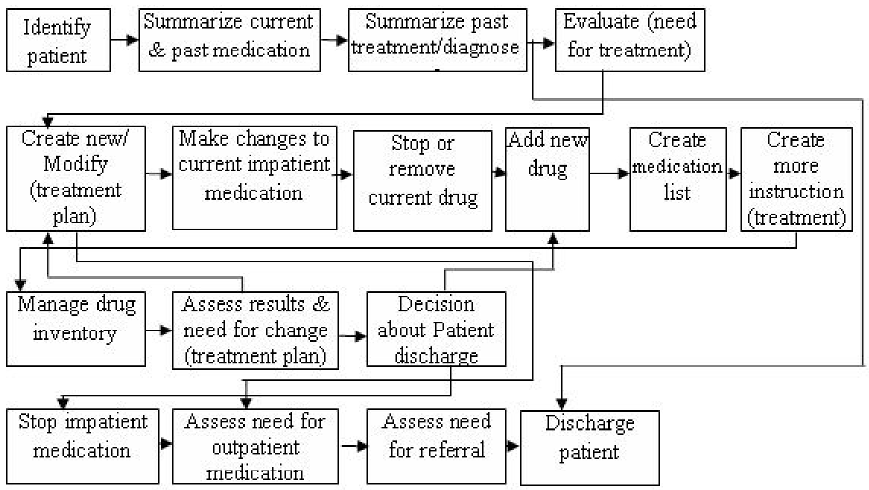

Fig. 2. Detailed steps of modeling approach

The medical process consists of four steps (Fig.1) in the highest abstraction level. Each of the steps and the relations between them are depicted in more detail in Fig. 2. Process begins when the patient arrives to the reception of a therapeutic centre. It ends when the patient is discharged. The actor of the processes is a doctor unless mentioned otherwise [1, 7].

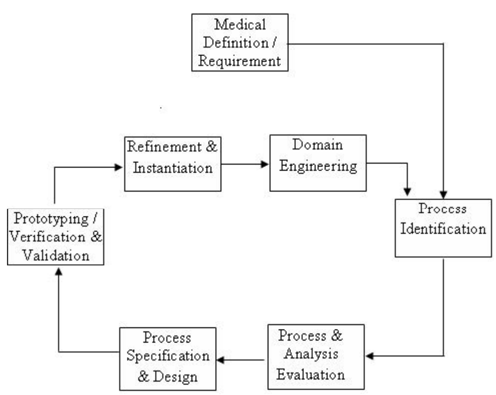

Fig. 3. A MPR Model

Medical process re-engineering (MPR) model

A medical process is "a set of logically related tasks performed to achieve a defined outcome", as shown in Fig. 3. The model defines seven activities: [2, 11]

Medical Definition: Medical Goals are identified within the context of the promotion and maintenance of health, saving and extending of life. This can be done in the context of cost reduction, time reduction, quality improvement, personnel development, and empowerment. Goals may be defined at the initial level or for a specific stage of the medical process.

Process Identification: Processes that are critical to achieve the goals defined in medical definition are identified. They may then be prioritized by importance, need for change, or in any other way that is more appropriate for the re-engineering activity in view of MPR.

Process Evaluation: The existing process is thoroughly analyzed and measured. Process tasks that are identified are evaluated in terms of the costs, times consumed by process tasks and quality/performance problems are isolated.

Process specification and design: Based on information obtained during the first three MPR activities, use cases are prepared for each process which contains the specification of the process, a new set of tasks, which are obtained from medical design control [8]. The Medical design control includes project verification & validation plans, creation of input &design output documents, requirements specification with descriptions and many more.

Prototyping: A redesigned medical process must be prototyped before it is fully integrated into the medical domain. This activity "tests" the processes so that refinements can be made with precision and time. The tests covers validation and verification at the following levels – planning, system level, Mechanical, electrical process validation and field or/and clinical level.

Refinement and instantiation: Based on feedback from the prototype, the medical process is refined and then instantiated within a medical system.

Domain Engineering: The outcomes possible in form of specific development, embedded system, electro-mechanical systems, critical system design technique for safety, reliability &compliance, fault free analysis, failure mode effects analysis, risk analysis of all considerable factors, reliability analysis, decision making/design, trade-off analysis, engineering tool & product selection, design for standards & regulatory compliance.[10]

II. Pipe and Filter Architecture Style

In a pipe and filter style each component has a set of inputs and outputs. A component reads streams of data on its inputs and produces streams of data on its outputs, delivering a complete instance of the result in a standard order. This is usually accomplished by applying a local transformation to the input streams and computing incrementally so output begins before input is consumed. Hence components are termed “filters”. The connectors of this style serve as conduits for the streams, transmitting outputs of one filter to inputs of another. Hence the connectors are termed “pipes”.

Filters must be independent entities, i.e., they should not share state with other filters with important invariant is that filters do not know the identity of their upstream and downstream filters. Their specifications might restrict what appears on the input pipes or make guarantees about what appears on the output pipes, but they may not identify the components at the end of those pipes.

Pipe and filter systems have numerous properties. They allow the designer to understand the behavior of a system in terms of the individual filters’ behavior, support reusability concept, it can be easily maintained and enhanced, permit certain kinds of specialized analysis, such as throughput and deadlock analysis and support concurrent execution. Each filter can be implemented as a separate task and potentially executed in parallel with other filters

The best known examples of pipe and filter architectures are programs written in the Unix shell. As another well-known example, traditionally compilers have been viewed as a pipeline system (though the phases are often not incremental). The stages in the pipeline include lexical analysis, parsing, semantic analysis, and code generation. (We return to this example in the case studies.) Other examples of pipes and filters occur in signal processing domains, functional programming, and distributed systems.[12]

III. Modeling and Analysis

The Pipe-and-Filter style (P&F) shown in fig. 4 emphasizes the incremental transformation of data by successive components. Pipes are stateless and simply exist to move data between filters. Both pipes and Filters are run non-deterministically until no more computations or transmissions are possible. Constraints on the pipe-and-filter style indicate the ways in which pipes and filters can be joined [9].

Modeling of architectural style is presented with the UML & transformation rules; model includes a static and dynamic model. The static part defines the set of possible medical process components, connectors and constrains the way in which these elements can be combined together. The dynamic part specifies how a given medical process re-engineering architecture can evolve in reaction to planned reconfigurations or unanticipated changes of the medical process environment.

Pipe and filter Architecture style of medical processing reengineering

The Pipe and filter architecture style uses the Process modelling approach and Detailed steps of modelling approach which is discussed in previous sections and represented in fig.2 and fig.3. The process modelling of Medical process reengineering contains four steps (1) Arrival or First assessment of the patient, (2) Planning the care of Patients, (3) Training and evaluation and (4) Discharge referral or follow-up.

The source of Medical information for the corresponding filter for medical processes is a pipe. The patient is essential source for providing information in model. The first step checks the arrival of patient new or old, who already took the services of medical process, and found authentic process of arrival then stored information in database of the system. Second step include the patients caring regarding medication after identify the symptoms of the patients with the output as diseases of patient. Third step provides the treatment and evaluate the condition of the patients for which the medication is provided by the experts or consulting doctors. If the diseases are properly cured then discharge the patient or follow-up the system for future consultation. All the steps are reengineered to filtered information as shown in fig.4.

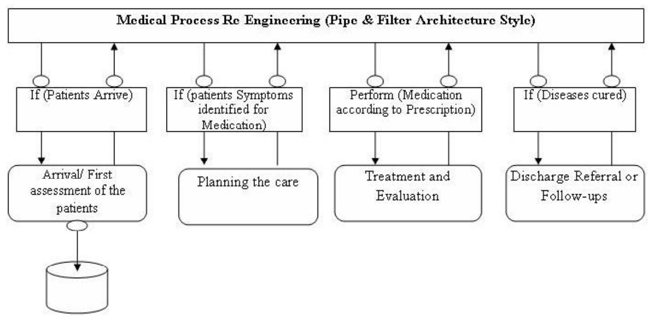

Fig. 4. Pipe and Filter architecture of Medical Processing Reengineering

Arrival assessment of patient Pipe & Filter Architecture style

The first step of the MPR is the arrival assessment of the patient which contains four phases (1) Identify the validity of patient, (2) Summarize the past & current medication, (3) Analyze past treatment and diagnosis and (4) Evaluate the need for treatments. The out comes of each phases have depends on their corresponding filters. This step mainly deals with the process identification and evaluation and overview of the Medical process as shown in Fig. 5.

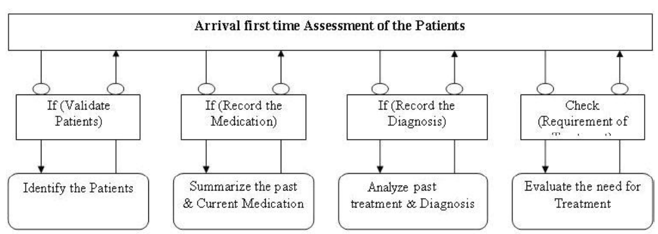

Fig. 5. Pipe and Filter architecture of Arrival assessment of patient for Medical Process reengineering

Planning the care of patient Pipe & Filter Architecture style

The next step of Process modelling approach is planning the care of patients which gives the emphasis on the process specification & design with the use of prototyping concept. The major focus is on medication, diseases and precautions. as shown in the Fig.6 the entire step is get divided into 6 phases, which deals with either to create or modify the previous prescription with the help of filter, make changes to current impatient medication after filter the medication requirement, modify the medication if not suited to patient conditions at the planning level. This step is based on information obtained from medical design control. This includes verification & validation of the treatments with the creation of new requirement specifications with descriptions. It focuses on redesigned medical process which must be prototyped before it is fully integrated into the medical domain. This step tests the processes so that refinements can be made with precision and time.

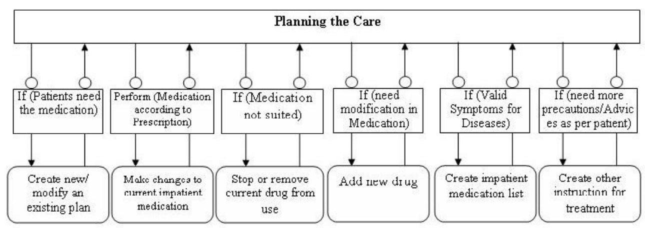

Fig. 6. Pipe and Filter architecture of planning the care of patient for Medical Process reengineering

Treatment and evaluation of patient Pipe & Filter Architecture style

This is important step because in the previous step, focus is on planning with specification, design and prototyping that how to care the patients, whereas this step consists of the refinement, instantiation and domain engineering. As the fig. 7 shows that the step is divided into three phases and emphasis on the refinement in the treatment with the evaluation of the patients' health and recovery. The out comes of each phase passed through own corresponding filter. This step involves the major reengineering concept as a keen eye is too kept on the patients' information with the impact and effect of the treatment which then becomes the instantiation of the MPR model. The outcome of the second step plays a very important role for this step as possible outcomes is in form of specific development, embedded system, electro-mechanical systems, critical system design technique for safety, reliability &compliance, fault free analysis, failure mode effects analysis, risk analysis of all considerable factors, reliability analysis, decision making/design, trade-off analysis, engineering tool & product selection, design for standards & regulatory compliance

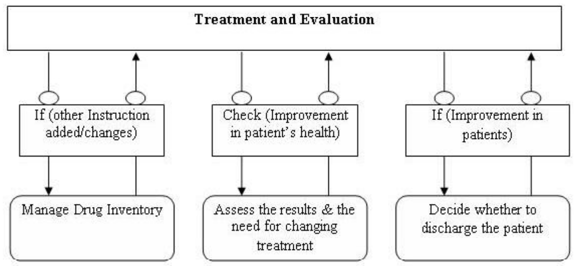

Fig. 7. Pipe and Filter architecture of treatment and Evaluation of patient for MPR

Discharge Referral or Follow-ups of patient Pipe & Filter Architecture style

This is the last step of the medical process which is divided into 4 phases as shown in the fig. 8. This step takes the final decision on the discharge referral or follow up process which is based on the status of patient for the decision taken by the experts. Each figure of pipe and filters process explanatory explains all the filters of each phase.

The analysis task is to show that the MPR model of an architecture style fulfill the formal/informal requirements with a concrete implementation of it. The filter is the set of principal, rules, and constraints. On the basis of that rules, the information provided by the pipe is check by the filters. The study explains that the pipe and filters are arranged according to the MPR model requirements. Initially pipe & filter checks the validity of patients, second step fully concentrate on planning the patients caring or strategy of patients diseases and diagnosis. Third P&F is actual step where patient treatment with all facilities is managed. The last step shows that if all reports are favourable then filter provides the output in terms of discharge the patient. The P&F maintain the hierarchical order of process steps but no feedback is possible after passing the step. We can come on to same filter in the next iteration, as intercommunication is not possible between the filters.

The main focus of P&F is system maintenance and enhances reusability for the same reasons. The filters of first step works in separate manner and generate output so reengineering is not complex task. The two filter record the medication and record the diagnosis can work in parallel manner after the identity of patients is identified. The filter concentrates on the process Identification step of MPR model.

In second step all filter process in sequential manner that means filter process the information one after the other. It is hard to process in parallel manner. The hierarchy show the package for the external world. No communication between the filters of each phase in each step. The limitation is no feedback is possible for add new drug if once we pass from this filter. It will consider in next iteration. The filters concentrate on the process analysis & evaluation steps of MPR model.

In Treatment & evaluation step two filter: other instruction and improvement in health can process in parallel as well as sequence. The step associated with the design & prototype, refinement, instantiation and specific domain of MPR model. The output of first filter maintain the medication, second specifies the need of changing in the treatment. Third phase is very important which is connect to the next step in which we decide that whether the patient is discharge or not. The Detailed steps of modeling approach show that the filters of II and III steps are highly require the communication but we can perform in sequential manner so the performance is down as compare to other architecture styles.

In last step, third filter can work parallel with first and second filter. The patient can be discharge after stop medication or expert reports. The sequential execution of process decreases the performance. In this step, the MPR model comes in iterative manner which means it includes the process identification and analysis evaluation steps of MPR model in sequential manner because we have to study the impact of patient's health in this steps of model.

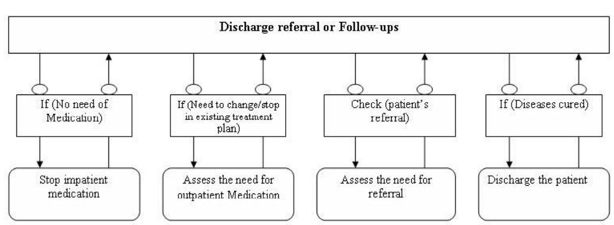

Fig. 8. Pipe and Filter architecture of Discharge referral or follow-up of patient for MPR

IV. Conclusions

The paper presents the impact of pipe and filter architecture style on the medical domain with the re-engineering concepts. The study describes that the pipe & Filter architecture style simplifies maintenance and enhance reusability of each phase of all the step of MPR model. The combination of pipe and Filter is hierarchically composed i.e. the combination of pipe and filter are in package form for the external world. If filter can process its input information in isolation from the rest of the system, a pipe and filter system can implement in parallel or distributed manner. The parallel and distributed facilities provide opportunity for enhancing the system performance. As filter works individually so no need to cooperate with other filters i.e. no dependency for their process, but if phases are in sequential manner so that the next filter must be depend on the output of previous filter. The major advantage of pipe and filter is that we can execute the same filter number of times until doesn't get the filtered output. The major area where this style is successfully executed is when the patients' give the complete information in first step with fewer modifications.

In particular, because of their Transformational character- pipe and filter systems are typically not good at handling interactive applications. This problem is most severe when incremental display updates are required, because the output pattern for incremental updates is radically different from the pattern for filter output. At initial level it's very hard to identifies how many times the process of filter is required because it process information again and again until doesn't contain the correct and consistence output information, even though it may possible that the filter process may require more lower level of filter processes. Each filter operates as a separate process or procedure call, thus incurring some overhead each time it is invoked. The major limitation of pipe and filter is that once we pass from any filter, it and reuse in next iteration. Finally Pipe and filter can specify the self-healing capabilities of MPR components which are associated with the specific ways.

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