Chapter 5

Conclusions & Future Work

In this chapter we summarize the work presented in this thesis and then conclude with a discussion of related research issues that remain open for future work. Particularly for developing countries delivering healthcare services has been difficult because poorly defined treatment process is in practice. Firstly, the process does not take all the participants (patient, medicos, non-medicos, managerial staffs and resources) into consideration. Secondly, the process of treatment is never transparent to patient and so patient often develop distrust on treatment process. This is a general feeling in India where healthcare services are provided by both public and private agencies. Thirdly, management of resources for delivering healthcare services is often inadequate in developing countries because of under specification of practicing treatment process. Fourthly, the process is ill defined to handle exigency cases. Finally the management of treatment process instances becomes an arduous task particularly for populous countries with poor healthcare record. We believe, solutions to some of these problems can be met by following a well defined treatment process and making it accessible to all the participants with the help of information technologies.

Healthcare has been a challenge for each country with aging and growing population and to meet the challenge there have been endeavors by both government as well as private enterprises. The efforts have given rise to healthcare
industry with hospital of different categories ranging from small rural healthcare center to large corporate hospitals in city centers. Currently, information technology has come to an aid to manage mostly several administrative, personal and financial activities. But, there is also a need to make use of this technology to automate treatment process particularly for patients suffering from multiple ailment or chronic diseases. In this thesis there is an attempt to automate treatment considering it as a process with well defined set of activities.

In this work we coin a concept called Treatplan that models a modular treatment at higher level and in the next level this module is detailed. Based on our specification we have defined a framework on TFMS (Treatflow Management System) to manage several Treatplan instantiation.

5.1 Summary of the Work Done

Traditionally structured method is being used for system analysis and design. The reason for its popularity is due to the pictorial presentation of a system. However, the method lacks mathematical preciseness that can be used to prove the system mathematically. Formal method in software development helps in proving the system property mathematically. The proposed work used primitives viz, linear, split and merge, parallel, supportive and cooperative and choice that are basic to represent a workflow. The uses of such primitives are shown in specifying workflow of a corporate hospital for treating patients. We use hybrid approach in the sense for, each type of primitive other than pictorial representation, system behavior is also specified mathematically. Execution of each primitive is analyzed and shown that it is possible to make unambiguous inferences on execution of each workflow primitive. The analysis is implementable as it uses assertions like Pre and Post-conditions. These assertions are used for verification and validation on workflow
primitives pertaining to an application domain.

Once a Treatflow is specified, that has to be verified in order to avoid mistakes done by non-computer science professionals. We discuss various verification issues with the help of a Treatflow verification algorithm. We present Treatflow as a graph comprising of nodes and edges and the Treatflow verification algorithm with procedures Create-Instance-Graph, Verify-Instance-Graph and Create-Next-Instance traverses the graph for the purpose of verification. We categorize the verification issues into three different types namely Structural, Behavioral and Temporal. Incompleteness, Lack of Synchronization, Deadlock issues are considered within structural disorder whereas Contextual Conflict, Retention Conflict and Expectation Conflict are studied as behavioral disorder and Delay Conflict are discussed as verification issues in case of temporal disorder.

In order to handle large and complex treatment in healthcare, chapter 3 advocates the uses of the modularization concept in healthcare domain especially in planning of treatments. We have proposed a scheme to specify a treatment module and operators to compose a treatment. It is shown that a treatment prescription can be written as an expression of modules. Sometimes it may be necessary to explore all the possibilities in executing a treatment plan, therefore we propose a method for rewriting a given expression by applying rewriting rules. We demonstrate the applicability and suitability of re-writing rules with the help of an example taken from healthcare domain. A Treatflow meant for a particular ailment can be applied to different patients suffering for the same ailment. Still, a treatment while for a patient proceeds smoothly but for another patient with the same ailment may not go well for patient specific reasons. Patient related exceptions can be either known or unknown type. In chapter 3 we also focus on exceptional behavior of healthcare workflows. We provide a comprehensive analysis on generation of such exceptions at the deviating behavior of a specified
workflow. Considering the genesis of exceptions, we categorize them into Resource, Context & Goal, Safety and Temporal perspective. In addition to these we add two more types called DefaultExcp and PatientExcp which are designed to deal with unknown situations. We discuss about processing of exception as well as define actions that can be performed with respect to exceptions. The feasibility of this concept is shown in a case study taken from healthcare domain.

In order to automate a treatment process, we propose a system architecture in chapter 4. The system architecture consists of two parts namely Treatflow-Library-Make and Treatflow-Consultation. In Treatflow-Library-Make specification of Treatflow is implemented by using Specify sub-module and verification of Treatflow is implemented by using Verify sub-module. Whereas Treatflow-Consultation composed of modules namely Authentication, Administration, Treatplan, Treat-Management, Handle-Exigencies and Role-Based-Inquiry which we discuss in detail with the help of use case diagram, activity diagram, class diagram and interaction diagram.

5.2 Future Work

In this section we point out open issues and suggestion promising directions for future work. Much work remains to be done to improve what we have achieved so far and to explore new solutions. Treatflow Management System (TFMS) can be implemented with a variety of additional requirements. We present here some plans for future works that are well out of the scope of this thesis but can be followed up for further research.

- Implementation of TFMS: To study the impact of proposed system in a hospital, the performance of a healthcare workflow management system used to analyze in a real life situation to study the efficiency like adequate
response time and managing a large number of Treatflow instances which is in fact a stark reality. The increase in number of instantiation may badly degrade system response time. For improvement in the system, the design and implementation issues may require a relook.

- **3A (Adhoc, Adapt, Adopt) Treatment:** On imitating the way a treatment takes place in reality, we can divide a span of treatment into 3 phases, namely *Adhoc, Adapt* and *Adopt*. In the initial stage i.e. Adhoc a patient is asked to take initial treatment and then the suitability of patient is studied and the treatment may possibly be refined to suit the patient i.e. Adapt phase. And finally if a treatment is found progressive, then it can be Adopted for continuation. In order to implement 3A phase in treatment process, the execution behavior of Treatflow model needs to be properly specified so that phased transition can be monitored, analyzed and traced.