Literature Review on Patient Scheduling Techniques

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Abstract

Patients need to undergo several checkups, tests, surgery and treatments according to their illness. This paper describes the challenges of patient scheduling and patient scheduling techniques. An efficient scheduling technique is needed to minimize the waiting time of patients and to improve the resource utilization. The patient treatment processes are not completely decided at the beginning of treatment. The goal of the patient scheduling is to develop a scheduling system that manages patient-focused schedules and treat the patients immediately. Patient scheduling is difficult to deal because of the complexity involved in the problem. Software agent based-scheduling system is a good option to schedule the patients efficiently in the hospital.

Keywords

Patient Scheduling; Software Agent; Multi-agent System; Distributed Computing; Coordination.

I. INTRODUCTION

In a hospital environment, the internally distributed authority makes it difficult to implement an efficient scheduling technique between different departments. Scheduling becomes more complicated when dynamic changes occur in hospital. In the past, all appointments and scheduling was done by writing in a paper by hand. Now software is designed using computerized system, specifically for the purpose of scheduling patient to the resources. There are various patient scheduling methods. The effective method for real world problem is the one that produces good patient flow and proper utilization of resources. The current patient scheduling techniques are double booking, wave scheduling, etc.

Double booking method says that two or more patients book the appointment at the same time. Doctors find difficult to treat patients at same time when both the patients came on time. This method is forcing one of the patients to wait unnecessarily. Wave scheduling method can be used effectively in health care domain. In this method patients are scheduled according to the appointment of the patient. A patient may arrive late than their appointed time and then modifications make many changes in schedule when establishing the appointments. All computerized systems provide a permanent record of patient's treatment which makes it easy to refer the old patients [1]. It can save the time for staff members who are scheduling the patients to the resources. Agents and multi-agent systems have been applied in various literatures to solve the complexity in health care domain. It responds to the dynamic changes in the health care environment. In multi-agent system coordination techniques are needed to coordinate between different agents. Each agent has its own task which needs to be exchanged with other agent to improve the health of the patients. It supports decision making in the hospital environment[2].

II. CHALLENGES

From various literatures, the challenges are identified in the patient scheduling. The challenges are identified between Emergency Medical Services (EMS) and Emergency Department(ED) teams. Same challenges found between inter-departmental coordination activities that affects the patient workflow [3], [4].

These challenges are given below:

A. Ineffectiveness of current information and communication technologies

It considers the inadequacies of current communication tools and paper as a coordination tool. Clinical/nonclinical department interaction increases the possibility of inappropriate patient transfer. Clinical/clinical department interaction increases the stay time in a department.

B. Lack of common ground

It indicates little information is shared because of dynamic nature of the problem. Then ineffective information hand offs consider lack of information sharing. Without appropriate information, inpatient access department may make inappropriate assignments as well as deal with temporary bottleneck problem in the patient flow by holding up with resources.

C. Breakdowns in information flow

It includes the potential loss of patient information, misrepresentation of patient issues, transporting patients to wrong locations, etc.

Socio technical issues are suggested to support inter-team coordination to deal with these challenges. The issues are awareness, context and workflow. Ineffectiveness of information technologies introduces the bottleneck problem when patient activities transferred late. Socio technical design issues help some of the challenges in patient transfer activities in particular departmental workflow. Socio technical design issues are mediating role of integrators, collaborative balancing of goals, collaborative resource prioritization. Mediating role of integrators uses push and pull model which can reduce the no of backlogs in clinical department. Collaborative balancing goals identify conflict goals and to mitigate the inter department coordination conflicts caused by the lack of information sharing. Collaborative resource prioritization helps to mitigate the inter department coordination related to ineffectiveness of technologies that affect patient transfer workflow.

III. SCHEDULING METHODS

There are many scheduling techniques available for the health care domain. The purpose of the scheduling method is to reduce the waiting time of the patient and to improve the resource utilization in the hospital. Some of the scheduling techniques are discussed here. Patient scheduling can be classified into dynamic patient scheduling, distributed patient scheduling and coordinated patient scheduling. This has been given in Figure 1.

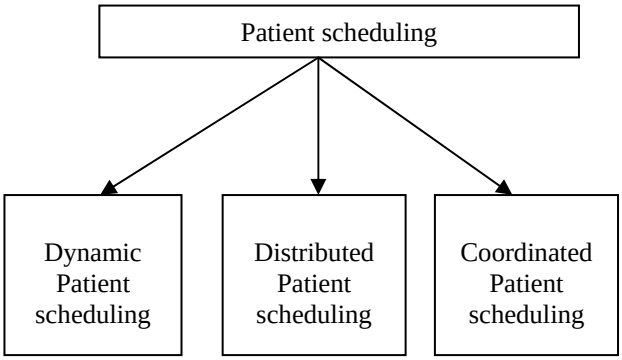

Figure 1. Classification of patient scheduling

A. Dynamic patient scheduling

Efficient scheduling should be capable of handling the dynamic changes in the hospital. Dynamic changes: patients may come late, resources may not be free, equipment may repair, etc. Through dynamic patient scheduling these changes can be scheduled. Adaptive dynamic method is used to automatic optimization of resource calendars. It reduces access time to all resources and increases the patient throughput in the hospital. It scales the scheduling problem for single department. Adaptive approach uses static Flexible Reservation (FlexRes) method to schedule reservation for urgent patients. Human schedulers are still responsible for coordination. First Come First Serve (FCFS) schedules the first available timeslot on each required resources.

First Come Randomly Served (FCRS) schedules the timeslot randomly within a fixed time window on each required resources. Adaptive urgent scheduling is used to schedule the unexpected patients on time. This approach is used to adjust the capacity between patient groups [5]. Operational Research technique is very effective to solve centralized optimization problem. Policies for adaptive resource allocation have been designed to anticipate future resource usage and that are implementable and understandable for planners in hospital practice. A policy optimization approach for dynamic multi-objective optimization has been developed by Anke et al [6]. Evolutionary multi-objective optimization approach improves the optimal resource allocations efficiently.

Multi Agent System (MAS) are supposed to be suitable for real-world problems that have a special need for flexibility and adaptively to dynamic changes. According to Anke et al centralized, aggregated or steady-state optimization techniques are found in hospitals, due to the decentralization of hospital organizations. Due to this, a lower level of modeling and aggregation is needed to consider the inherent diversity in patient attributes and scheduling goals at different units involved in complex patient flow. Decentralization and the dynamics of patient flow scheduling using an agent-based simulation approach in combination with computational intelligence optimization techniques has been discussed by Anke et al. Multi-agent model is used for decision making tool to improve the quality of medical activity and to care for patients in the emergency department. It can handle all patients in the emergency department effectively in order to reduce the waiting time of patients in the emergency department. Dynamic and open multi-agent system described by Amani Daknou et al [7]. This model uses five types of agents to schedule patients and to ensure their treatment plan. Scheduler agent plays an important role. This model towards multi-agent system is implemented in Java Agent Development Framework (JADE). JADE allows flexible execution of multi-agent system and provides effective communication between different agents.

B. Distributed patient scheduling

In a hospital environment, preferences on resources and patients are inherently distributed. Multi-agent systems can adopt distributed patient scheduling for hospital. Decision making process is a tool to improve the quality of resources and to care of patients in the emergency department. Health Examination Scheduling Algorithm (HESA) is used to assign the examinee to any available doctor or resources based on round robin algorithm prioritizing the patient based on their task. But it does not consider uncertainties, such as absent examinees, equipment breakdown or longer than expected examination times. [8]. In Multi-agent Pareto Appointment Exchanging (MPAEX) system used a negotiation approach is to exchange appointment schedules such that no patient is worse off. Nobody worse improvement called Pareto improvement [9],[10]. Partial plan is developed for the patient with limited number of tasks or activities. It is not possible to exchange multiple activities. In MPAEX approach, theil index is introduced to schedule the workload distribution.

Markov Decision Process (MDP) has been modeled for patient admission control. It involves admission planning activities of non emergency patient. It develops a decision model that helps hospital managers to plan at the importance of each hospital resource [11]. MDP approach is modeled to be more effective in decision process for admission of non emergency patient. Multi Agent based Distributed Information Platform (MADIP) approach provides highly distributed system [12]. This model is implemented in JADE for monitoring the patient health condition. Mobility has the great potential to transform the process of health care monitoring. It uses multi-agents and interacts with each agent through FIPA. It is also support for distributed computing. It provides high quality solution for challenging tasks such as minimizing the waiting time of patient and to improve resource utilization. Each agent has very less interaction which may affect the patient health. In multi-agent systems there are techniques of distributed problem solving in which a group of agents may dynamically discuss how to partition a problem, how to distribute the different subtasks to be solved among them, how to exchange information to solve possible dependences between partial solutions, and how to combine the partial results into the solution of the original problem [2]. Thus, multi-agent systems can handle the complexity of solutions through decomposition, modeling and organizing the interrelationships between components.

C. Coordinated Scheduling

Coordination is used to reduce the response time of the system in a distributed environment. If there is a multi-agent then coordination is needed to interact with each agent. It avoids complexity of the problem. Because complex problem broken into simple problem which can be solved easily. Generalized Partial Global Planning (GPGP) with new resource constrained mechanism is used to increases hospital unit throughput and decreases patient stay time [13]. It uses simple multi-round but not multi-stage negotiation process which is not optimal. Bidding is used based on the time interval to get the resources for an agent. Best priority function for the agents minimizes the finish time of their whole task. Earliest task will be given higher priority when two

tasks need to use the same resource at a time. An extended GPGP with a new coordination mechanism is used to handle the mutually exclusive resource relationships. New mechanism can be introduced with other GPGP approach for any problem with the appropriate resource relationship. New mechanism evaluated in the context of the hospital patient scheduling problem. The effects of increasing interrelations between tasks are performed by different hospital units for testing [14].

Agent based, patient-centred approach considers the dynamics of patient scheduling problem and the medical priorities of the patients [15]. A mutual exclusive resources coordination mechanism to GPGP approach is added to achieve scheduling improvements compared to current scheduling without coordination. Resource conflicts are solved by coordination mechanism. Medical Path Agent (MedPAge) shows the agent roles, dynamic interaction and identifying the coordination object [16]. MedPAge project addresses the complex tasks in the hospital through the market mechanism which is supported by software agent. Med PAge project identifies the coordination objects are modeled and act as autonomous agents (patient agent, resource agent). Each agent knows its own schedule and constraints. Agent interaction protocol is used to improve the current scheduling situation. The agents need to interact with each other. Market mechanism is used for coordination to maximize the patient's own utility. Distributed multi-agent based approach is implemented in the Medical Path Coordination (MedPaCo) for coordination of patient agents [17]. The main purpose of this coordination mechanism is to minimize the overall waiting time of the patients. Scheduling for new patients is scheduled on the FCFS basis. Negotiation process is followed to reschedule the patient's activities. This approach implements the patients and hospital resources as software agents through the concept of MedPaCo [18]. Patients and resources are described as coordination object which acts as a autonomous agents. Based on the utility function, the time slots are assigned to the patient agents. This mechanism trusts on mutual selection to improve the satisfaction of the patients. Agent based coordination mechanism is introduced for mutual selection between patient agents. It provides distributed and flexible method to handle the dynamics of the treatment process. This mechanism is based on auction or bidding process which consists of certain phases. These phases make the patient to get highest utility from a timeslot by paying highest amount for that timeslot. This coordination mechanism cannot handle multiple preferences of the patient agents.

TABLE 1. FEATURES OF THE PATIENT SCHEDULING APPROACHES

Approaches	***Features***
Adaptive Dynamic Method [5]	It reduces access time to all the resources. It provides flexible resource allocation.
HESA[8]	It schedules the complex patient scheduling problem efficiently.
MPAEX[9],[10]	Scheduled activity can be exchanged such that no patient is worse off.
Decision making process [7]	This tool provides effective communication between agents.
GPGGP[13]	It gives highest priority to the earliest task of the patient, when two patients needs the same resources at the same time.
Patient - centred coordination mechanism[15]	It solves the resource conflicts and achieves pareto optimal solution. It provides distributed and flexible approach to handle dynamics of the treatment process.
MedPAge[16]	It identifies the coordination objects. During negotiation between patient agent, scheduling can be planned.

Patient scheduling is a complex task to schedule the patients to the resources. Table 1 shows the features of the certain patient scheduling which is used to reduce the waiting time of the patients in the hospital and also reduce the idle time of the patients.

IV. CONCLUSION

In this literature review, patient scheduling techniques are classified into dynamic, distributed, coordinated patient scheduling approaches. From various literatures, challenges and the patient scheduling techniques, which are used to reduce the waiting time of the patients are discussed. Patient scheduling approaches are discussed with its features. It concludes that agent based-scheduling system is better option to schedule the patients efficiently in the hospital.

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