

# Supporting Distributed Planning in a Dynamic Environment: An Observational Study in Operating Room Management

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**Abstract:** Planning in collaborative work is usually distributed among workers, with access to different types of information that make decisions through negotiations. In dynamic work settings, unique changes arise for distributed planning. In this paper, we present a study of activities in coordinating surgical schedules in an operating room suite affiliated with a busy trauma center. Implications for an improved design of a support system for distributed scheduling tasks are discussed.

**Keywords:** coordination, planning board, distributed planning, observational study.

## Introduction

Distributed planning is a widely occurring phenomenon in collaborating activities, where plans of each collaborator are shared and negotiated (Roth et al., 1999). A coordinator is often responsible for the smooth running of these activities and monitors and informs the collaborators. Coordination tools, like large planning boards, help distributed planning (Berndtsson, 1999). Our study focuses on how a planning board was used in managing changing plans in an event-driven, constantly changing work environment. Our goal was to establish a basis for building supporting tools, with visual aids for distributed workers, to help improve efficiency and reliability of distributed planning.

## Setting

The study was conducted in the six operating room (OR) suite of a trauma center. On average 22 surgical cases were performed in any weekday. Certain operating rooms were dedicated to specific types of surgery, such as orthopaedic and emergency surgery. Each afternoon, a hardcopy of lists of surgical cases was delivered to the coordinator of the OR suite. Although every case had an expected duration, only the first case of an OR was assigned to a specific starting time, the rest for that OR was “to follow”. The actual case sequence, case duration, and used OR was usually different from the delivered schedule and was determined by the combination of patient condition, progress of other cases, order of request and surgeon preference. In addition to the cases posted the day before, urgent cases were requested on the day of surgery. In comparison to other types of OR’s, are here many of the decisions on case scheduling made on the day of surgery and more dynamic. A large whiteboard (12 x 4 ft, see figure 1) functioning as a planning board was placed adjacent to the suite where many collaborators came. The coordinator, a nurse, was in charge of updating the board. This planning board showed sequences and progress of the cases for each room. A detailed study of this planning board was reported in (Xiao et al., 2001).

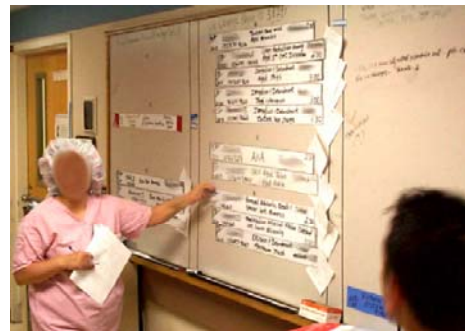


Figure 1 – Overview of the planning board.

## Observations and data analysis

A research observer shadowed three different coordinators for nine days. The collected data include the communications concerning determination of surgery start times between the coordinator and the collaborators. To get better understanding of these communications, semi-structured interviews were conducted. The data contained also the representation of surgical cases on the planning board, including all

the changes occurring during the day, and the expected start time and duration of the cases and the actual starting time and ending time of the cases.

The first step in the data analysis was to construct a sequence of events and activities to reflect as much as possible the observed data. Diagrams were designed and produced to reflect changes in schedules and timing of actual case starts and endings.

## Results

The observation of scheduling activities is used here to illustrate the graphical representation in figure 2. The activities associated with two (out of six) OR's are represented in this figure (OR4 and OR6). In this chart, the upper lines represent the actual start- and end time of a surgery. The two bars below the lines (strip #1 and strip #2) represent the schedules for the first two cases planned for the corresponding OR's. The non-planned bar (bottom of the figure) represents a strip on the planning board that is posted but not scheduled, and is put aside until there is more information about the patient, surgeon or timeslot in the OR's. The patient names (aliases) are inside the bars or above the lines. The actual durations are above the lines while the expected durations are inside the bars. The case of Roy in OR 4, for instance, was scheduled for 2 ½ hours, but actually it took only 1 hour and 9 minutes.

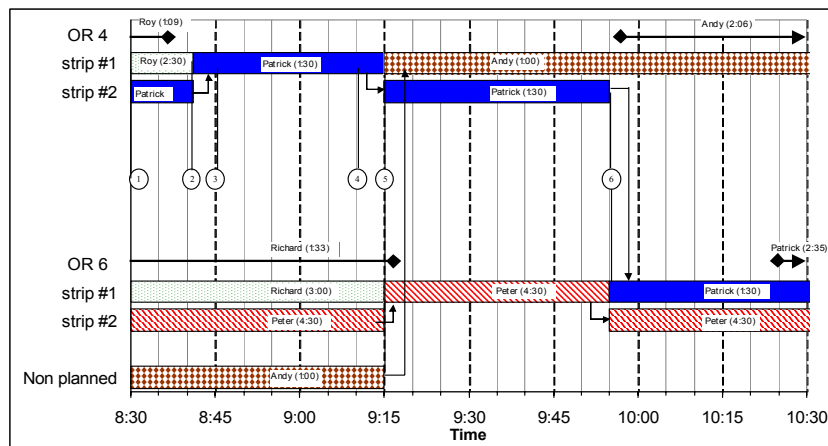


Figure 2 - A graphical representation of the schedule during two hours with the start and end time of cases

*Activity time line:* The list below shows the activities of the coordinator during re-scheduling of surgical cases. The numbers correspond with figure 2.

- 1- 8:30 Patient Roy was in OR4; case Patrick was to follow.  
Patient Richard was in OR6 till 9:17; case Peter was to follow.
- 2- 8:41 An OR nurse **informed** the coordinator **in front of the planning board** that case Roy in OR4 was finished; 1 hour earlier than expected. The coordinator **removed the strip from the board**.
- 3- 8:45 The coordinator made a new plan to forward the next surgery **by overseeing the planning board**. She called and paged the surgeon of patient Patrick from 8:45 till 9:15 to tell him that the operation could start earlier, but he did not answer.
- 4- 9:10 The coordinator generated another plan. She wanted to let the non-planned case Andy go before case Patrick, because she knew that this surgeon was available for almost the whole day. The coordinator **asked** the surgeon of case Andy **in front of the planning board**: "Are you available to do the surgery for your patient Andy when OR 4 is cleaned?" He confirms that he is available.
- 5- 9:15 The coordinator finally reached the surgeon of case Patrick and said that his case is delayed because case Andy goes first. After that the coordinator **changed the schedule on the planning board** and asked the patient's availability.
- 6- 9:55 The surgical fellow of case Patrick, who assists the attending surgeon, **requested the coordinator in front of the planning board** if her case could start earlier. The coordinator changed case Patrick to OR6 after agreement with the surgeons of patients Peter and Patrick.

From this example and data from other days, a number of distributed planning functions are derived that were associated with the use of the planning board. Part of the activities by the coordinator was to

disseminate plans for their execution. The coordinator disseminated plans in part by updating information on the planning board for the other participants. The collaborators would discuss the planning while pointing to the board. An example of using the board was observed when a case was cancelled. Through the changes on the board, the nurse assigned for that case knew that they did not have to prepare for it. The coordinator knew that the nurse was aware of the new situation without talking to her. The collaborators (surgeons, anaesthesiologists and nurses) planned their activities with the overview of the planning board and sometimes requested changes while pointing at it.

We found that the planning board supports the following planning functions: 1. Disseminating individual tasks, 2. Orientating in a wider context about the previous, current and future situation in the OR's, 3. Establishing shared awareness, such as when observing people in front of the board and therefore assuming that they are aware of the last updated schedule, 4. Establishing common basis during negotiating, 5. Displaying opportunities for new plans and the consequence problems can cause.

## Discussion

Our results have several implications for designing computerised artefacts to support cognitive activities in distributed planning. We will discuss three areas: distributed access of information, input of status information and visual aids. In general, these implications are to improve situation awareness as well by the coordinator as by dispersed collaborators, both in terms of accuracy of situation awareness and in terms of speed of gaining situation awareness.

The use of a planning board without distributed access requires many (long) phone calls. Telephone communications are a disruptive form of communication. Through a planning board with distributed access, the coordinator can distribute status and plan information asynchronously. Conversely, people remote to the coordinator can enter status information at their desk with low workload impact. For example, a nurse can enter the important landmarks of a surgery case to allow better monitoring by the coordinator. Wireless devices, such as personal digital assistants (PDA), can potentially be connected with the coordinator to lower the cost of communication, especially through asynchronous means. Short messages could be sent to relevant collaborators. In the case of OR management, a message can be "Your surgery is delayed for at least one hour" or "This case is cancelled, stop preparing the equipment." Other access methods are also as possible, such as those tested in (Berkowitz et al., 1999).

Electronic planning boards are commercially available, for example Navicare® Systems. They make it possible to deploy visual aids to the coordinator. The overview we developed for capturing events (figure 2) can be used for a graphical representation of the current status and events. The visual aids can reduce cognitive workloads by comprehending the current situation and projection of future status. The visual aids can potentially also help analyse and show opportunities and bottlenecks for new plans. This early analysis allows the coordinator to act more proactively. If this overview of current and future status can be distributed fast to collaborators, it can serve as a basis for negotiating new plans.

In short, this article shows that the planning board supports situation awareness. We recommend more research on usability of distributed planning tools, especially for visual aids and wireless personal digital assistants.

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