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A model based study of concept development for hospital wayfinding to improve operational efficiency

Peter Peter Campbell
CSIRO, Institut National de la Recherche Scientifique

William R. Scott
University of Wollongong, wscott@uow.edu.au

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A Model Based Study of Concept Development for Hospital Wayfinding to Improve Operating Efficiency

Authors: Peter Campbell (pcampbel@uow.edu.au) and William Scott (wscott @uow.edu.au)

1. Introduction

There are a number of major new hospitals under development in Australia – on the Gold Coast, in Melbourne, Adelaide and Perth for example, each of which will cost well in excess of $1billion. Each has broadly similar goals involving improved patient outcomes, improved patient and visitor perceptions of hospital care, more efficient and lower error rate delivery of clinical services, and of course, reduced costs. Each also needs to consider how it will achieve these goals while eventually operating in and integrated way with Australia's proposed electronic health record (EHR) system. (www.ehealth.gov.au)

One element that will be critical to meeting these goals is the efficient movement of people around the hospital. To achieve this there has been a focus in on the ability of outpatients and visitors to find their destinations with minimal ancillary staff to supply directions and other information. This is seen to be a more effective use of resources and is anticipated to be necessary to meet the efficiency of movement targets. An equally important goal is to minimise the time spent in waiting rooms, which has multiple benefits including to reduce the possibility of cross infection among outpatients, to reduce space used for this function and to improve public perceptions by providing smaller waiting times. One means identified to realise these goals is to adapt the type of electronic wayfinding systems that are used in some large shopping centres for hospital use. However this adaptation will be to a much more complex use than simply directing people to a commercial location. This hospital wayfinding system will have to be integrated into the operations of the hospital and be highly agile to respond to the dynamic situations found in an operational hospital facility. The systems capabilities selected will directly impact aspects of the hospital's final physical and IT design.

2. Stakeholder Wayfinding Needs

In the context of provision of a wayfinding system for a new hospital the major stakeholders are likely to be – the State Health Authority, the hospital construction/operating organisation (which is likely to be a PPP or some other hybrid contracting vehicle), and the sub-organisations responsible for the delivery of both the wayfinding system and the data feeds the wayfinding system will have to rely upon to respond appropriately – usually some collection of contractors delivering the IT systems.

Recognising that the primary factors needing to be considered in developing the concept for the wayfinding system all involve human behaviour, as a simplified first approach we begin by only considering the needs arising from the State Health Authority responsible for delivering the 21st century model of care that each of the new hospitals mentioned above has adopted some version of.

1) Provide timely guidance to outpatients and patient visitors on entering the hospital. In the case of outpatients this includes information in relation to delays in scheduled appointments, as well as suggestions as to waiting places other than waiting rooms, such as coffee shops and outdoor areas in the near vicinity of the hospital. In patients are not considered since their entry route will not be via the wayfinding system.

2) Cater for various levels of information available about the entrant to be entered into the hospital IT system by means of the wayfinding system. Outpatients will have medical details pertinent to their appointment and visitors will have registered visitor status recorded in the hospital IT system. The wayfinding systems will need to be able to handle both EHR cards and the scanning and interpretation of written referrals, until such time as EHR cards become universal. Unidentified entrants will need to be assisted by staff.

3) Provide the above services in a selection of languages.

These needs highlight the socio-technical nature of the system Therefore in developing the concepts for such an application it will be critical to adopt an approach that is capable of considering the wide variety of human behaviour that is to be managed by the wayfinding system.

Other stakeholders provide constraints on these requirements based on what can be technically achieved by existing technology and the contract specifications for the hospital IT system that is required to support the operation of the wayfinding system. As this is a preliminary study these have been limited to:

1) The frequency with which information in the wayfinding system can be updated, and whether this would be by individual event or in block mode.

2) Data capture from outpatients and visitors, within expected daily use cycles, and from a range of user profiles.

3) Data display and/or printouts for the same set of users.

4) The number of users by time during the 24 hour day.

Underlying factors 0driving these top level needs that should be considered for inclusion in the modelling study are:

1) Minimise waiting room size and occupancy times to reduce space issues and to minimise cross infection opportunities.

2) Ensure privacy and safety of patients and staff.

3) Integration of the wayfinding system data needs and transfers with the rest of the hospital IT system.

4) The physical location and number of wayfinding stations (kiosks) in the hospital – that is, just at entrances or at other key locations as well, and the number of terminals per station.

There are of course many other more detailed low level requirements that need to be considered before making a final selection of capability and the system which can deliver it, but for the initial development of the concept there should be a focus on the capabilities and ability to meet the level of demand anticipated for the hospital in relation to the expected numbers and types of users. .

3. The Model Based Concept Engineering (MBCE) Context

The use of Model Based Systems Engineering **(**MBSE) concepts in MBCE utilises a modelling language such as SysML to depict aspects of system design which then drive the relationships that need to be depicted in the modelling. These design aspects are focussed on the physical architecture, interfaces and behaviour models. A use case diagram similar to that shown in Figure 1 is employed to capture the stakeholder goals that are then expressed in a requirements diagram within the SysML model. These are then detailed in a set of sequence diagram modelling that depicts the actual sequence of events between the wayfinding system and its users, an example of which is shown in Figure 2- for outpatients only. We found that addressing just the primary use cases – for outpatients, for visitors to patients and for "other" visitor types – was adequate to explore a useful range of options able to meet the design concepts expressed by the stakeholder. As noted above, alternatives to support the outpatient spectrum of all ages and abilities in terms of mobility and mental acuity, as well as a range of non-English speakers must be represented in the model.

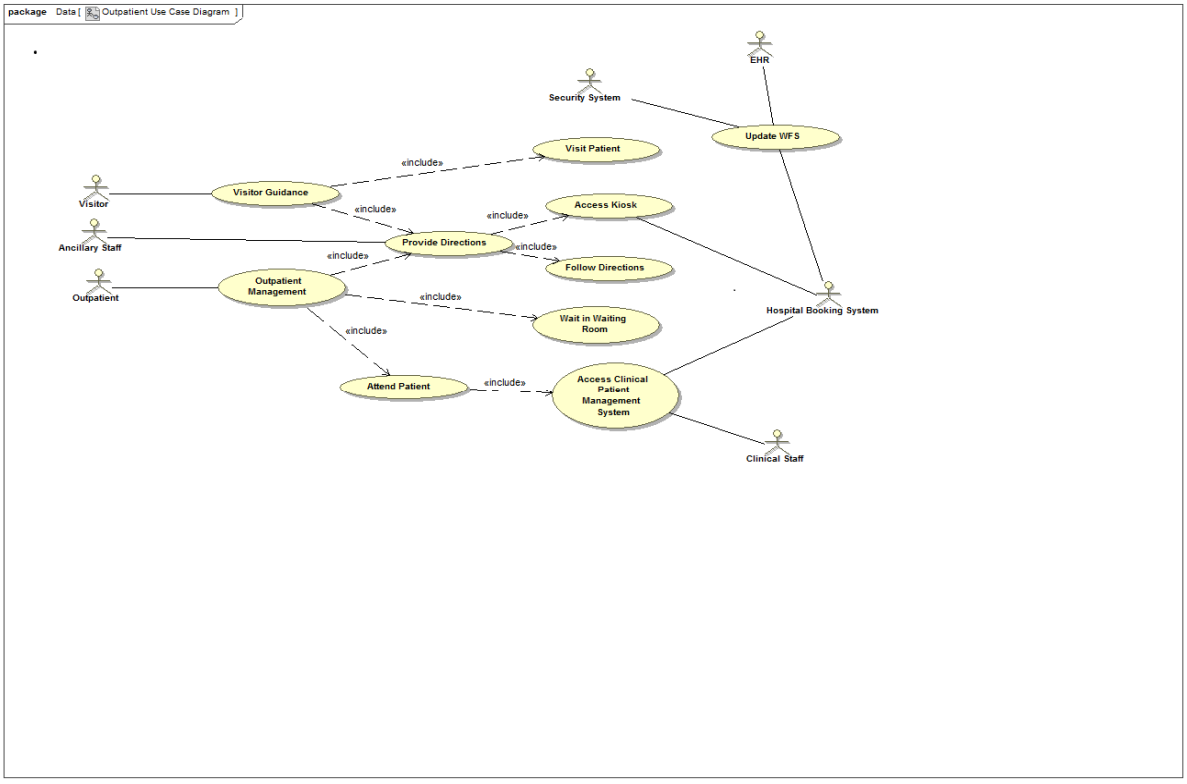

Figure 1. Notional Use case Diagram for Three User Types

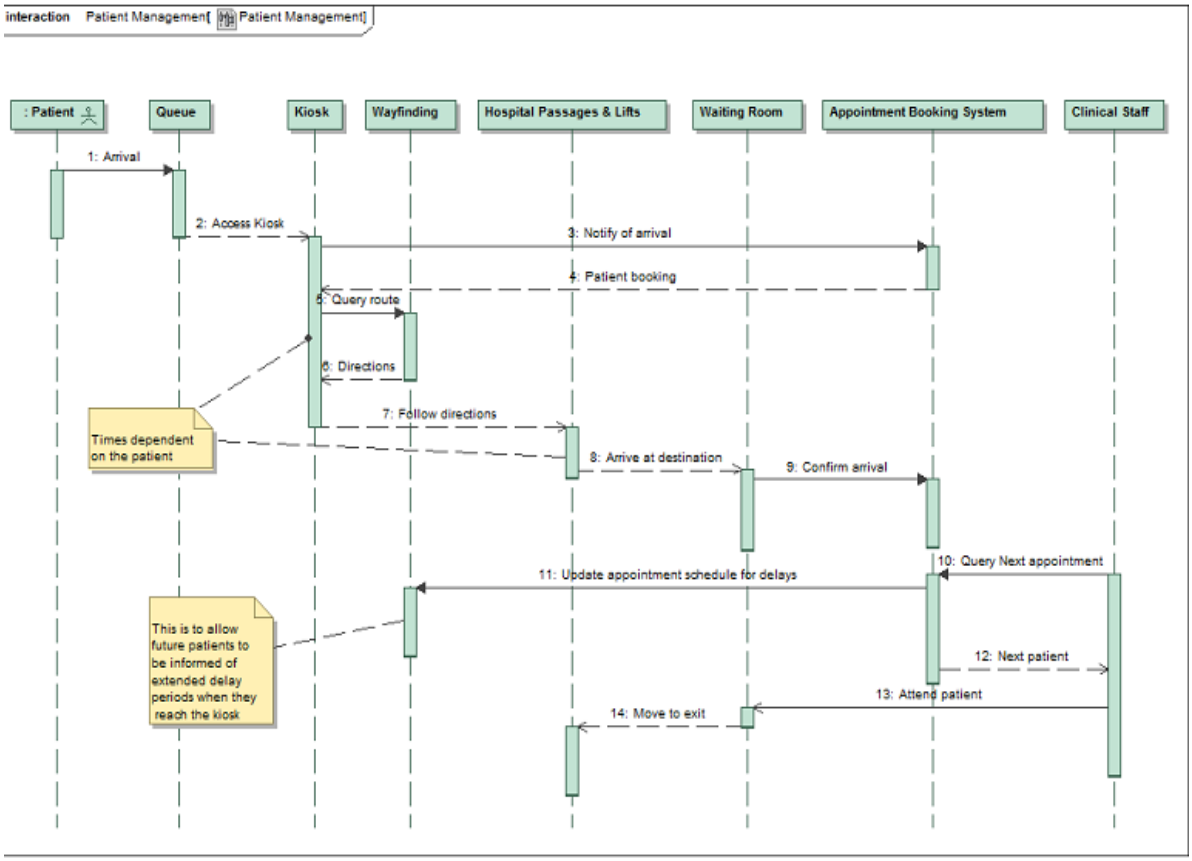

Figure 2. Notional Sequence Diagram for Outpatient

4. Wayfinding Behavioural Model Definition

The concept modelling is oriented towards the limited goal of developing the concepts of the operation of the wayfinding system in the context of meeting the needs of the hospital model of care and also the model of visitor experience desired by the stakeholder. This phase of the wayfinding concept development is focussed on its operation in relation to human behaviour rather than exploring the physical equipment options available. An Agent Based Model (ABM) was therefore a natural choice as the modelling approach because in addition to the ability to include different types of models such as a queuing model, the ABM allows for the modelling of other more complex individual behaviour by the users of the wayfinding system, as discussed in paragraphs 3 and 4 below.

The following needed to be considered in the development of the design:

1) The attributes of the planned users of the system. For the outpatient portion of the user population, it was assumed that there would be a spectrum of all ages and abilities in terms of mobility and mental acuity. For the patient's visitors and "other" visitors, a simplifying assumption of early to middle aged adult capability age was made. Default values based on existing statistics of the user population need to be provided in the model, but the user interface also allows a range of changes to these

user attribute values to support exploration of various scenarios including any planned changes to outpatient population in the future operation of the hospital.

2) The functions of the wayfinding system. These fall into 3 distinct areas:

a. User data entry options. Those available are scan of electronic EHR card, scan of a paper document provided by the patient's physician, with or without some type of RFID coding, and a keypad entry. The two scanning operations are very different from one another.

b. Information output to the user. Those available are screen based text and printed text, including a map with directions.

c. Connection to the hospital IT system. Discussion with the stakeholder showed that the way this was implemented would be very important. The way chosen to register new arrivals into the hospital effects safety and privacy management, synchronization of an outpatients' arrival with the hospital appointments system, including checking for schedule updates and delays in clinical treatment areas, alerting the help desk when necessary, and perhaps most important of all, the update frequency and mode with which the hospital IT system would feed the wayfinding system. The stakeholder preferred a batch update mode rather than an individual event mode. This has significant consequences on how the wayfinding system functions, as does the frequency of batch updates.

3) The physical geometry of the hospital. Hallways, lift systems, signage location, possible kiosk number and locations, kiosk interface numbers and types and waiting room locations and sizes, are these that affect the level of instructions that need to be given and the time taken by users to reach their destination.

4) The wayfinding systems role in emergent user behaviour. Before any agent based model can be built it is necessary that deep insight into the manner in which the wayfinding system is expected to support the efficient functioning of the hospital is gained, so that that the behaviours that affect it can be included in the model. For example it is necessary to have some model of the clinical activities driving the movement of patients through each waiting room in order to have the model know how many people are waiting at any one time, so that the wayfinding system can advise new outpatient arrivals to delay moving to the waiting room when schedule slippage occurs. It is also necessary to have a model of user transit times from the kiosk to their destinations. Both these sub-models also need their own interfaces to allow the model user to make a range of assumptions about these aspects of human behaviour, so that the appropriate range of options can be explored. Finally the organisation that will operate the hospital needs to provide information in relation to its expected operating procedures.

For a relatively unconstrained concept development study the variables listed in Section 2 are available for the model user to vary in order to explore the useful response space with the results being used to modify and further develop the sequence diagrams, ending with a workable concept. The model can output metrics such as the ability of the wayfinding system to manage access queuing in busy periods, arrival times to waiting rooms, the number of people in waiting rooms, the effectiveness of several different ways of providing information to users, the cost saving involved in reduced numbers of ancillary staff to manage the flow of people, and finally the longer term value of increasing numbers of users having adopted the EHR.

5. Conclusion

It can be seen that doing even simplified models of human behaviour in the context of MBCE has limitations and is a challenging problem. Nor is it practical to carry out measurements with groups of people prior to the construction of a physical structure (such as a hospital) to determine accurate estimates upon which decisions for the desired level of capability and some design attributes depend (such as the necessary minimum waiting room sizes). What is possible, however, is to combine MBCE artefacts with simulations to provide the planner /model user with the ability to explore the response space in a systematic way model to gain an understanding of the likely range of behaviour, thereby producing what might be called “soft” metrics as the basis for decision making. These soft metrics are generated as indicative measures from ABMs that investigate the operation of the system through a combination of scenario contexts and the design options under consideration.

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