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1. EXECUTIVE SUMMARY / ABSTRACT

Teamwork, collaboration and coordination are key aspects of the patient-centric approach taken by modern healthcare. Although many projects have been and are currently being undertaken to improve support for health care professionals, adequate support for teamwork, communication and coordination has yet to be achieved. The delivery of the healthcare service is very challenging as it involves heterogeneous distributed systems, multi-professionals and dependent tasks among each. In addition, the treatment journey of each patient is unique, as decisions are usually made according to several constraints related to the patient, medical condition, patient's choice, available resources and/or feedback from doctors' consultation.

We believe that, in order to provide the required support, it is necessary to explicitly acknowledge the patients medical state within their treatment journey. This project proposes the use of a Business Process Management (BPM) system that uses associations between patients, health care professionals, and the Integrated Care Pathway (ICP) to provide improved support for healthcare professionals as individuals and as members of integrated care teams. Moreover, mapping the ICP onto the BPM system will help support the implementation of the best practice according to the national guidelines. By leveraging the information contained in these associations, and understanding the patient progress along the dynamic care pathway this proposal indicates and supports tailored context-based actions. This includes automated notifications, alerts, scheduling and timers as well as support for change management as the patient progresses throughout their treatment journey. Clinicians and developers feedback on this proposal has been very positive.

2. OVERVIEW

Modern healthcare has seen an ongoing move towards a patient-centric approach. This approach emphasises teamwork and collaboration as key aspects of the healthcare process. Patients within such a collaborative model follow an Integrated Care Pathway (ICP). This treatment journey usually involves multi-professional care team members providing different healthcare services at distributed sites. This process requires an effective mechanism to support the interaction and collaboration among the care team members as well as management of potential interactions between complex care pathways being followed by a single patient. Current Hospital Information Systems (HIS) used at different healthcare organisations were originally designed to support the traditional disease-centred delivery model. The challenges imposed by political influence and dealing with legacy systems, add to the challenge of the complex nature of the domain with its many conflicting requirements and confounding factors. It has been a priority to support the implementation of modern healthcare, however it is not yet adequately supported by HISs [1]. Many proposals have been made and followed to address

different aspects of this problem, but there are still many challenges which have not yet been addressed, such as: teamwork collaboration with respect to member's roles, actual care progress and case specific needs.

This project considers the dynamic requirements of health and care practitioners which are beyond the traditional decision support and knowledge management systems provisions. We believe that, in order to address this problem fully, it is necessary to take account of the activities of practitioners as members of a dynamic team handling the treatment of a patient. Moreover, it is important to have this linked to the flow of a patient's treatment(s) and the dynamic processes involved, and to do this in a patient-centric way. This includes associating the patient record with the involved care providers and connecting both back to the patient's ICP. The work described includes tracking care teams and individual team members dynamically as the patient progresses along the dynamic care pathway. It proposes the integration of a Business Process Management (BPM)¹ system into the HISs as it will better support both the individual work of health and care practitioners as well as improve support for team communication, and care coordination throughout the patient's care. A proof of concept prototype was developed to test our assumptions and investigate the capabilities of the BPM system and how much support it could give in the treatment process. Moreover, the prototype will be used to demonstrate the features of the proposed system when multi-professional care team members and HIS developers are evaluating it.

The development challenges involve: first, maximising the flexibility of the system to support the patient's dynamic state as they usually don't follow the anticipated care pathway but follow multiple pathways at the same time. Second, maintaining the logical sequence (dependencies) of the treatment stages depending on the patient's medical state while ensuring that the system is fully controlled by the users. Finally, the individual information requirements of practitioners with different specialties or the dynamic communication requirements beyond pure provision of information are taken into account.

The proof of concept prototype showed that the application of Workflow Technology in the healthcare domain is a very promising development. It can be used to evolve the functionalities of existing HIS, so that they can be used to support implementation of ICP services and associated treatment flow for a patient. It is believed that these functionalities are important as they result in safer more effective and efficient care and treatment. Functionalities of the proposed system include: providing a pro-active system, routing and information filtering.

3. BUSINESS CONTEXT

This research was conducted at Cardiff School of Computer Science & Informatics in her PhD research by Hessah Alsalamah, supervised by Professor Alex Gray. It is based on a joint project between Cardiff School of Computer Science & Informatics at Cardiff University and Velindre NHS Trust cancer centre in Wales,

¹ BPM and WFMS are used interchangeably throughout this document. This is based on the studies stating that WFMS is part of BPM. Conversely, BPM is a superset of WFMS with more control over processes, integration and optimisation. Source: <http://www.opensystems-bs.com/Portals/0/BPM+vs+Workflow.pdf>

UK. Velindre NHS Trust is one of the largest tertiary specialist cancer centers in the UK. At Velindre, the Information System for Clinical Organisations (ISCO) HIS was evolved and developed, which is currently used across Wales as Cancer Network Information System Cymru (CaNISC) [2].

There is a long-term cooperation between Cardiff school of Computer Science & Informatics and the Clinical Information Unit (CIU) at Velindre. The CIU usually brings to our attention problems they have with their HIS and we research these issues and recommend solutions. These solutions are evaluated by the developers and healthcare providers at the centre. If the CIU team are convinced by our ideas, they adopt them for implementation by their team in a future evolution. This project concentrates on one of these suggestions to show how the interaction works.

4. THE KEY INNOVATIONS

The implemented proof of concept prototype showed that adapting the Workflow Technology into the HIS will evolve the CaNISC system positively. Specifically by mapping the ICP into a BPM system and incorporate into the existing HIS will help extend the offered functionalities by these systems. This will have a positive impact at business, case handling, and system levels in the treatment.

4.1 Business

This is not a proposal for a completely new system but a proposal to evolve an existing HISs and improve its support functionalities. This can be done by mapping the clinical guidelines into a BPM system engine and having this operate as an invisible intermediate layer between users and the HISs currently used (see Diagram 1). This aims to make the support for care teams more proactive by taking appropriate actions with regard to the support needed at the treatment stage, while utilising the information and facilities of the existing HISs. The extensions will follow the best clinical practice available to healthcare professionals through the National Institute for Health and Clinical Excellence (NICE) [3] and other projects, such as the Map of Medicine (MoM) [4]. These clinical guidelines aim to enforce quality standards to achieve: clinical effectiveness, patient safety and improved patient experience through the support given by the enhanced system [5].

Diagram 1 shows the WFMS as an upper layer which is independent of the structure of the HISs acting underneath. Moreover, the Workflow Management System (WFMS) can interact with any number of HISs and is a hub among the systems (see Diagram 2). The strength in the BPM systems is in its ability to invoke existing systems at any stage during the process flow in a way which overcomes the system heterogeneity challenge. This makes their data available through the system as an aid to decision making.

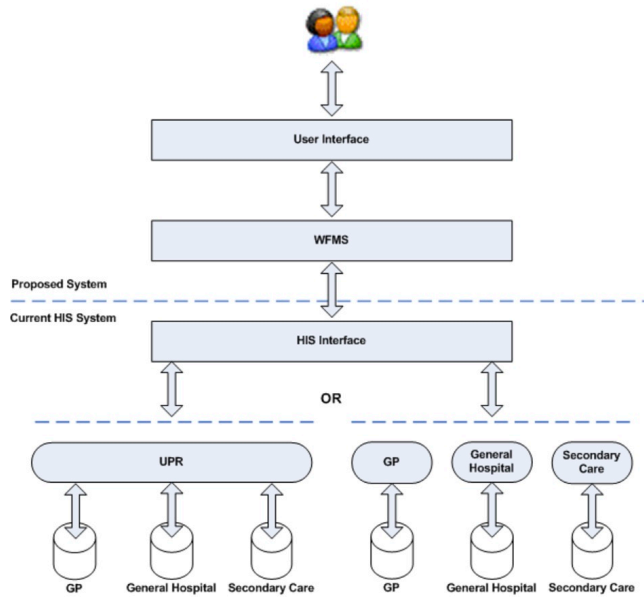


Diagram 1- System's Architecture

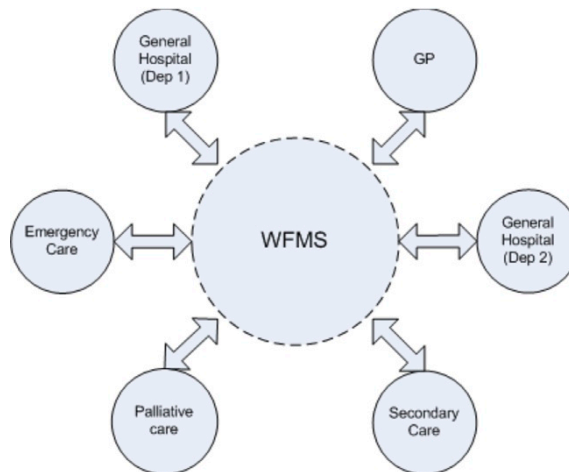


Diagram 2- WFMS Operating as a Hub

BPMs can be adjusted to enforce a specific sequence and/or enable an extremely flexible order of processes. In the breast cancer scenario, some stages of the treatment journey are pre-structured examples, for instance single tasks performed in subprocesses such as tests. While other stages are dynamic where the process flow cannot be predicted in advance. This commonly occurs among patients who have multiple diseases. In order to achieve

maximum flexibility, the system should be driven by the patient's condition yet fully controlled by the multi-professional care team members. The proposed system provides suggestions and support for the process according to best practice guidelines, however the final decision is controlled by medical team users. This is to ensure and stress the fact that this proposal represents a tool to support the treatment process and is not meant to takeover the treatment flow decisions from the care team members.

At a business level, the system will facilitate multi-professional care team communication and therefore care coordination across the multiple healthcare organisations involved in the treatment of patients. The direct advantage will be support for implementation of an ICP used in the modern NHS.

4.2 Case Handling

The diagnostic breast cancer clinical guidelines were selected as the trial scenario to be used in the proof of concept prototype development, since there is extensive information about cancer and its clinical guidelines online which made searching and understanding the treatment process easier; the process is complex enough to show the challenges involved in the treatment delivery, as it involves interaction among different systems, organisations and care team professionals; and our co-operation with the Velindre cancer unit has occurred over the last 20 years.

The guidelines for diagnosing breast cancer and the treatment choices used in the implementation of the prototype are taken from the MoM diagnostic for breast cancer [6] and treatment options [7]. These guidelines show the different stages of the treatment process and have an attached document explaining the details about the organisations involved, information required, roles involved, flow logic and any constraints. By using this information, a good sense and understanding of the treatment process was achieved.

The scenario represented in Diagram 3, is a version created by combining [6] and [7]. It starts with a General Practitioner (GP) suspecting a patient has cancer and therefore referring the patient to a Surgeon Oncologist. The Surgeon Oncologist checks the patient's history and requests assessments such as an examination, imaging, fine needle aspiration, and core biopsy. The results of these tests will then be reviewed at an Multi-Disciplinary Team (MDT) meeting to decide whether there are any abnormalities, if more tests are needed, or if there are positive findings. In the case of no abnormalities, the patient will be reassured and discharged to primary care. In the case of more tests being needed, the MDT will decide whether a surgical or core biopsy is needed before the patient is reviewed again in an MDT meeting. In the case of a positive finding, the reviewers will decide whether it is benign or if cancer is confirmed. If a benign disease is confirmed, the patient will be educated on the principles of management and the patient will be discharged to primary care. If Breast cancer is confirmed, the GP will be informed. This will be followed by a number of care stages until the care reaches a point where a decision is made on the treatment options for this patient, which could be a surgical or non-surgical option, such as radiotherapy or chemotherapy.

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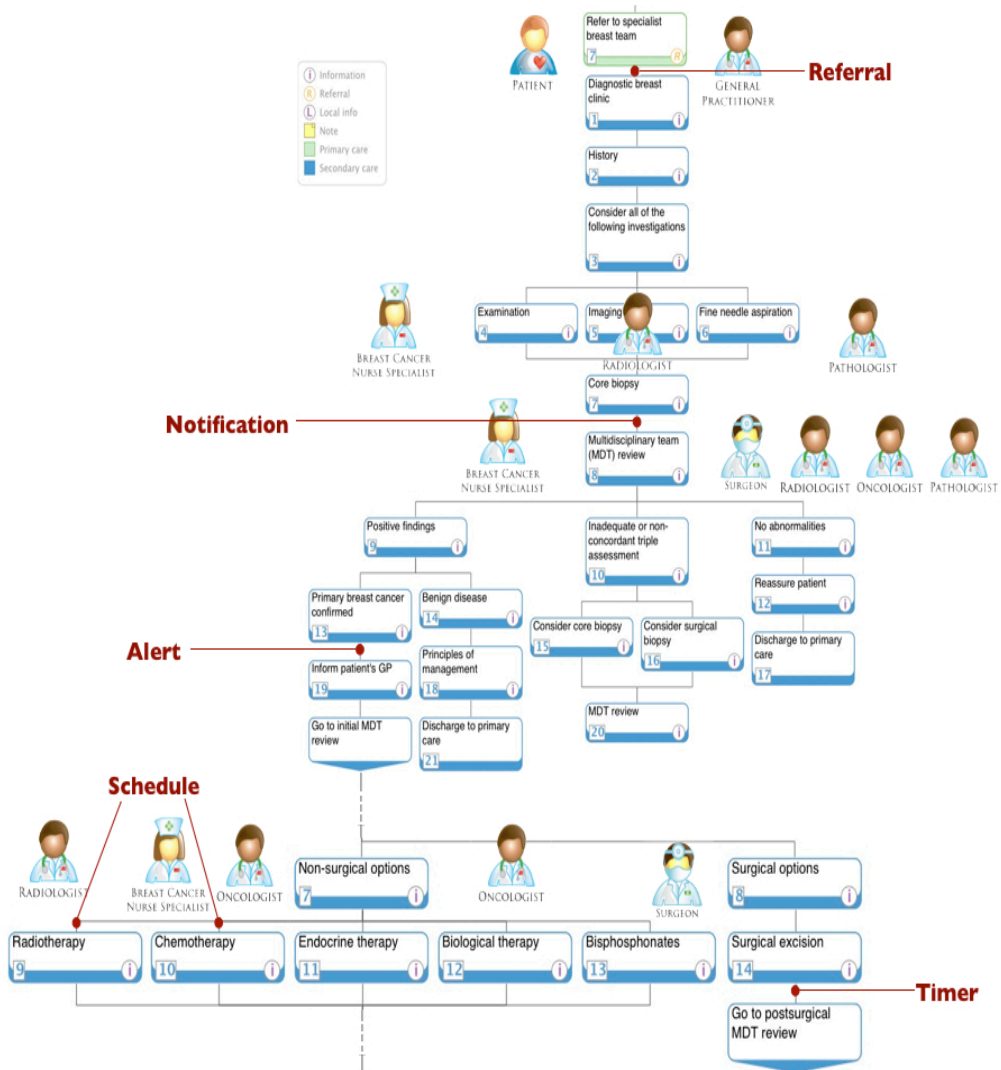


Diagram -3- ICP of Breast Cancer Treatment

By looking at the flow in MoM guidelines and its associated document, and the literature, we can identify the treatment stages where there is a need for communication and care coordination among the different MDT care professionals involved in this flow. Diagram 3 highlights the different critical stages of the treatment flow, which are:

- referral from the GP to the surgeon oncologist. This is initiated by the GP, performed by the primary care nurse and sent by the administration at the GP surgery. The referral is picked-up by the administration at the secondary unit, scheduled on the secondary care system and picked up by the breast cancer nurse to be processed by the surgeon oncologist.
- notification of MDT reviewers about the triple assessment results and clinical examination notes; these have to be gathered and made available to the team before the MDT meeting. The notes will be forwarded by the breast cancer nurse to the haematologist, radiologist, and pathologist from the

stored information in the secondary care records, (haematology laboratory system, radiology system and pathology system). The results are gathered by the MDT coordinator so that they can be discussed at the MDT team meeting involving a surgeon oncologist, radiologist, pathologist, clinical and medical oncologist, and a nurse.

- alert of a patient diagnosed with breast cancer, this informs the patient's GP. It is initiated by the surgeon oncologist, performed by the breast cancer nurse and sent by the administrator at the secondary care unit. The message is picked-up by the administrator at the GP surgery, scheduled by the primary care nurse to inform the GP and update the patient's record in the GP surgery system.
- alert of a patient undertaking chemotherapy or radiotherapy. This is used to avoid any conflict. It is usually managed and controlled by the clinical oncologist using available information about the patient's medical and treatment history and the medical information revealed by the patient.
- scheduling required if the patient is under both chemotherapy and radiotherapy; a minimum break of two weeks must occur between these two treatments. This is managed and controlled by the clinical oncologist using available information about the patient's medical and treatment history and the medical information provided by the patient.
- Time lapse before referring patients to their oncologist to allow recovery after a surgical operation. This is usually a specified waiting time. The patient's condition is reviewed at a post-surgical MDT meeting to agree on the treatment plan after surgery. This will be requested by the surgeon oncologist, performed by the nurse and picked up by the MDT.

Diagram 3 shows a simple flow with no complications which is not the usual case. Patients do not usually follow the anticipated care pathway and each patient's flow is unique as many elements interact to affect its progress.

At the case handling level, the information system will support the critical stages of treatment flow which require support at critical stages. Support includes taking the following actions alert, notify, refer, schedule, and set timers. These are all customised to the patient's condition and controlled by the users interacting with the system who are the actual decision makers of the care process.

4.3 System

The proof of concept prototype showed that the application of Workflow Technology in the healthcare domain is very promising. It can be used to evolve the functionalities of existing HIS, so that they can be used to support the implementation in the ICP and associated treatment flow for a patient. It is believed that these functionalities are important as they result in safer more effective and efficient care and treatment of a patient. Functionalities of the proposed system include: providing a pro-active system, routing, task automation and information filtering. These functionalities are:

- Pro-active System: this is the primary advantage of using Workflow Technology in the healthcare domain. It is the difference between having a reactive or a proactive system. In the case of a reactive system, which most traditional HISs are, reactions are a response to requests made by users while proactive systems are capable of identifying the need to take an action and activities it activates. The workflow engine within the workflow manage-

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ment system can be coded to fetch triggers, understand which of the users or roles are affected by this trigger, how they are affected and finally, take appropriate actions to inform them. These pro-active functionalities can be used to execute many different actions, such as: alert, notify, refer, schedule and set timers.

- **Alert:** is fired when urgent or immediate action is required, or when specific information about a patient's condition needs to be noticed (e.g. a patient under chemotherapy).
- **Notify:** this is gathering the information required at a certain stage of the process flow so that members are fully informed when taking decisions (e.g. gathering all requested test results before a clinic patient's visits).
- **Refer:** this is done automatically and targeted not at the organisation but to the exact administrator or even to the specific role. This is done by delivering a referral letter to a targeted user and making it available in their in-tray\inbox (e.g. GP referring a patient to an Oncologist when new symptoms appear).
- **Schedule:** is needed to formalise a process. This involves maintaining prerequisites or a sequence of steps which are essential and required in the care process (e.g. a patient stops taking aspirin two weeks before scheduled surgery, or maintaining two weeks waiting time between chemotherapy and radiotherapy sessions for a patient).
- **Set timers:** these are required when a certain action needs to be processed at a specific time. This is important in ensuring continuity of care and that patients do not get overlooked in the process. This functionality is carried out by making sure that information is delivered to a targeted user before the time it is needed. This can involve: sending letters to a user's in-tray, executing alerts, sending notification, and/or doing referrals (e.g. at end of two weeks recovery period following surgery, a patient needs to be scheduled for a clinical visit, and reminders sent after a certain waiting time).
- **Routing:** this helps the system determine the sequence of the processes and the consequences of any decision made. This is either by suggesting the next stage or automating a set of processes. While routing is a tool that WFMSs provide, routing is only made with a user's approval or suggestion. This is done by providing a message to the user showing the alternative routes according to the ICPs' logic and the user can approve any or simply skip it (e.g. MDT referral after a set of examinations for a patient is performed, and the system suggests an imaging test according to age (mammogram for older than X or an ultrasound otherwise)).
- **Task automation:** is performed when a number of tasks need to be processed as a set. In this context, it includes tasks that do not require user interaction.
- **Information extraction and filtering:** to ensure summary of important information is visible to healthcare professionals when viewing a patient's records. This aims to facilitate tracking a patient and improving the decision-making process by making healthcare professionals aware of the development of the care process and therefore making better use of their

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time. This includes improved visibility of: treatment history, milestones, order and time, and acting healthcare professionals.

At the system level, the HIS will become more pro-active and capable of performing the following actions: alert, notify, refer, schedule, and set timers. It also provides a flexible system that handles dynamic changes happening during a patient's treatment. This includes routing the flow and performing automatic tasks. Moreover, the workflow system provides a tool to track patients and ensure continuity of the flow by filtering and extracting important information. The treatment information extracted includes: history, milestones, order and time and involved care team professionals.

5. HURDLES OVERCOME

This is a research project. It aims to investigate a specific problem and propose solutions to address it. This involves implementation of a proof of concept prototype, evaluation of it which leads to recommendations. Different factors are considered in the study. These include adoption barriers as well as users resistance, and cost. This is meant to identify ways of evolving a system Nevertheless, users and developers of current HIS system are involved at different stages of the research for validation. The main approach considered in this study was to follow the evolutionary framework. Here we work on enhancing existing systems rather than proposing a totally new system. This is aiming to: First, reduce cost and failure risk. Second, overcome the technical and political barriers of adoption. Finally, reduce the changes made to the environment as unnecessary changes can lead to increased users' resistance. Moreover, users were involved from the early stages of this research to ensure that their needs are considered and met as the top priority.

Although the current proposal has been demonstrated to show its potential, there are still several areas requiring further investigation. These include assessing the impact of alerts on working practise and interface usability. Future work will also identify the needs of the different roles to be extracted from the patient record, the information requirements of each and how they would like to receive it. The focus of this research was on a Breast Cancer scenario and its requirements. Future plans include specifying a generic pattern flexible enough to accommodate more medical scenarios. This will ensure that the system is capable of accommodating any national or local ICP and that it has maximum flexibility. Currently, automation within the system is done according to treatment history and current treatment stage. Future work will include considering the anticipated care pathway in the automation process. This will improve care efficiency and reduce costs by avoiding redundancy and future complications. It will allow the system to inform practitioners whether a complication is likely to affect upcoming patient appointments, and to schedule tests to fulfil not only current requirements but also those likely to occur in the near future and thereby improve planning and scheduling of patient treatment.

6. BENEFITS

The technical aspects and usefulness of the prototype were examined at the evaluation stage. The technical evaluation was conducted by implementing a

proof of concept prototype and interviewing members of the CIU at the Velindre Trust to evaluate the possibility of adopting the proposed ideas. The usefulness evaluation is conducted through a literature survey and sessions with medical users (brainstorming sessions and one-to-one interviews with actual users of the current Trust HIS CANISC).

An evaluation session with a group of six developers at the CIU at Velindre will evaluate the possibility of getting this proposal implemented in practice. This will include the technicalities involved in mapping, integrating, and interacting with the system. However, we have had several sessions with technical experts in BPM and HIS, who agree on the possibility of these ideas being implemented in reality. BPM experts are the developers and founders of Alia systems Ltd. (see section 9), and they assured us that it is technically possible to implement this proposal using current systems.

The coordination problem was originally brought to our attention by the team at the CIU at Velindre Trust. They pointed out their need for a more intelligent proactive system. They highlighted that there is a need for a system that facilitates following patients up and providing interaction. In discussion sessions about our proposal, they confirmed that the functionalities that workflow technology can provide are already in their agenda for the current system's improvements and more. Members of the CIU agreed the general ideas and assured us of their need for a more proactive system to help support the current system in use.

Finally, five one-to-one semi-structured interviews with care team professionals with different specialties in cancer treatment were conducted. These one hour interviews aimed to evaluate the multi-professional care team member's opinions on this proposal in terms of its usefulness, advantages, disadvantages and to identify any concerns. All five care team members interviewed agreed on the potential benefits that could be gained from having such a system. They agreed that there is need for a more proactive system that facilitates care coordination among care team members. The majority provided examples where they had been unable to make a decision due to inappropriate or unavailable information at a clinical visit. They also highlighted some of the difficulties they face in using the existing system to search for certain information and that it would be very useful to have highlights of the case visible in one place. They all agreed that it would not reduce their current work load, as this is mainly spent with patients, however it would save them time searching for medical information in a patient's records. A physiotherapist interviewed highlighted that she can see the benefits of having this proposal implemented for care team members other than physiotherapists, as she believes that the physiotherapist's role in cancer care rarely requires urgent reaction unless they are in-patients and that she finds manual communication tools to be effective and so there is no need for a change. An oncologist interviewed discussed his concerns that it would lead to information overload and being over-alerted about his cases. He suggested giving the users an option to turn the private alert messages off and having a patient's information visible only when viewing the patient's case.

However, he stated that having important information highlighted in a patient's records would be beneficial. He also identified that we need to measure the benefits gained by implementing this system against the effort and cost required for implementation. The oncologist later explained that the information gathering process for his cases is conducted by a general oncologist before cases are transferred to him, which explains why he did not experience similar challenges to his colleagues.

7. COMPETITIVE ADVANTAGES

In recent years, there has been wide exploitation of Information Communication Technologies (ICT) in the healthcare domain. Recent informatics projects emphasise the implementation of standards and providing access to knowledge resources and patient data. Examples of these ICT projects include: Electronic Patient Records (EPR) (e.g. [8]), knowledge management systems (e.g. [9]), triage systems (e.g. [10]), assessment systems, prescribing systems (e.g. [11]), test ordering and result delivery systems [12]. Within the National Health Service (NHS) in the UK, notable projects in this domain include: developing and making available guidelines and standards through NICE and MoM, the Scottish emergency care record [13], and proposals for a shared, unified patient record accessible at any location, when required [14, 15].

We believe that, while these projects are an important first step in improving healthcare support systems, there is still more work to be done. For example, shared patient records support the treatment process in terms of provision of patient information and medications prescribed. However, they do not actively indicate to practitioners that relevant information is available, nor do they consider the individual information requirements of practitioners with different specialties or the dynamic communication requirements beyond pure provision of information. Similarly, decision support and knowledge management systems support coordination between different tasks or processes by managing their sequence. This is suitable for patients following the anticipated treatment pathway; however a patient's state is dynamic, and often patients needs evolve and they follow a non-predicted care pathway. As each patient is unique, changes to the treatment plan can happen at any time and in many ways. This requires support for dynamic team allocation and the management of changes along the care pathway as it is an extremely dynamic process.

8. TECHNOLOGY

The following sections will detail the criteria of the system selected and the mapping technique.

8.1 System Characteristics

Different WFMSs were investigated in order to determine the most appropriate engine to address the collaboration problem in the healthcare domain. These different WFMSs were tested and compared taking account of aspects such as: availability, portability, functionality, operation, behaviour, information and organisation [16], and also the characteristics of the WFMSs engine that had been identified as making the approach. These were:

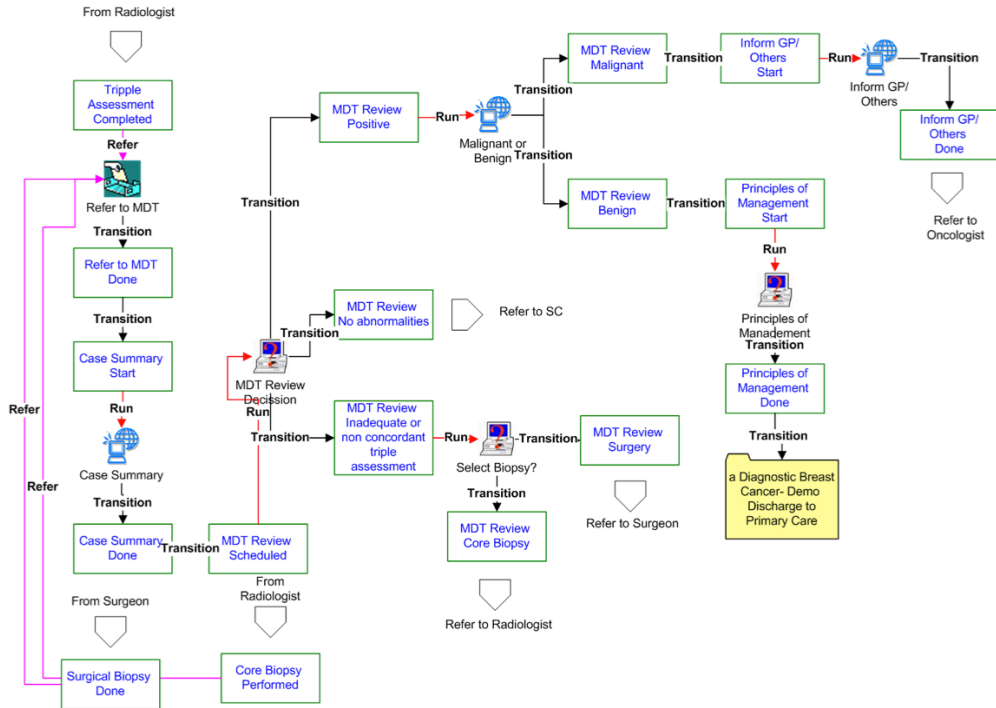
- **Business Workflow:** This is required to model the huge number of processes interacting in a healthcare system. Business workflows support human interaction with the system. This is necessary in healthcare systems, where different care team professionals interact with the system and support the decision making process and therefore the routing of the flow. Moreover, the ability to set security and privacy controls is extremely important in such a domain, as is assigning activities to different roles or associating a role with a team member. Human interaction is a major element that must be considered in a healthcare system to support security and privacy. Another benefit from using business workflows is the ability to set timers that are capable of starting activities and alerts, as this can add enormous benefits to a HIS's support.
- **Activity-based Workflow:** This is where the centre of the process is the activities. Activities represent all the treatment and diagnosis options a patient can follow. These options should be modelled in the WFMS and form the main block of the system.
- **Support Control Flow:** This can be coupled with an activity-based workflow systems. It is normally the controller of the routing process along the flow. In the healthcare scenario and for our proposal, the system should be state-driven. This means that a patient's medical condition is the main driver along the treatment journey. Other drivers could interfere in the routing process, such as the available resources and the decision of multi-professional care team members.
- **Support Data Flow:** This option is also extremely important in the healthcare scenario as information referencing the patient should also be sent along the flow to relate the running process\activities to a patient.
- **Support Workflow Patterns:** The variety of the patterns supported by the WFMS must ensure that multiple cases can be mapped. This is extremely important for patients with multiple conditions as the treatment journey becomes very complex. If the system does not support different patterns, it should provide tools to implement them.

8.2 Process Mapping

After selecting the scenario it is mapped into our chosen BPMs. The Stateframe process designer tool is used. This mapper uses Microsoft Visio with a custom-used template. The map designed by the mapper is linked dynamically to the system's engine. The data about the flow logic and the cases processed is stored in the process server database and organised as a User Data Properties (UDP), which is used at runtime to manage the process. The process map consists of of the following elements:

- **A Process:** this is the actual workflow map of the clinical guidelines. Each process could be a representation of a specific task within the guidelines or the whole disease treatment. Sub-processes representing specific tasks within a treatment could be internally (within the map) linked to the task. Tasks repeated along the treatment pathway could be mapped in separate processes which will be called when required. For this project, the whole treatment journey represented in Diagram 3 was mapped into a single process. The scale of the project is small and therefore it did not require splitting the treatment guidelines into multiple processes. However, to improve the visibility of the processes and for a more organised manageable mapping, the map is divided into separate sheets, each representing a dif-

ferent role or location the patient is referred to. Diagram 4 is a sample of a process map showing an MDT's sheet. It shows a small portion of the whole process map representing Diagram 3, however the different steps are linked with anchors to sustain the flow of the treatment according to



clinical guidelines.

Diagram 4- Process Map of MDT's Actions

- An Activity: the steps of the clinical guidelines. Activities represent tasks which provide productivity gains throughout the process flow. An activity can be: a prompt for manual decisions, an automated referral, an automated step where no user interaction is required, or a decision support tool (ASP activity) where relevant information is displayed to the user and their decision is expected. Activities along the map will be associated with the acting roles (if any) which will be then linked to the patient as he/she progresses along the treatment journey. In this project, each stage within the treatment flow of the breast cancer diagnosis and treatment was represented by at least one activity. The choice of type depends on the nature of the task. These activities can be coded to add constraints to the logic and access related data when additional information is required.
- A Process object: this provides control or audit to the case according to its state. As a state-driven engine, the actual driver of the flow is the case process object state representing the patient's status or condition at certain points of the treatment. Process objects can change the state of another object, initiate an activity or just state a condition. Activities, on the

other hand, change the state of the process object that initiated them. Process object states identify the state of the case. This is usually defined before and after each activity by showing the initial state and the resulting state after processing the task. For this project, process object states are a representation of either the treatment flow progress or the patient condition. In most of the cases, treatment flow progress is used. Examples include: examination start or examination completed (see diagram 3). When the object state initiates an activity, it should identify its state before and after it is processed. The patient condition state is used at some stages in the process map, such as MDT review decision of malignant, benign or no abnormality (see Diagram 4).

- A case: this is the scenario in progress. Each case represents a patient's treatment flow. For each patient, the treatment pathway is unique and is processed by considering a patient's health condition and the available resources. The case hierarchy at run time usually shows treatment history, the progress, the state in each and the roles or users involved in different stages.

At runtime, as the patient's case progresses along the care pathway, the reference to the patient's record will be passed through. The driver of the case progress will be the process object state. When an activity gets activated, if a role is associated with the activity, the role will be associated with the case. Moreover, if a rule is associated with the activity, the rule will be processed by considering the different roles involved with the patient.

9. THE TECHNOLOGY AND SERVICE PROVIDERS

Stateframe BPM system at Alia Systems Ltd. is the system used for implementation. The developers of the system agreed to support a number of our researches including this research. They support the installation and development of our prototypes and we investigate and present their system's capabilities in different areas.

Alia Systems Limited Website: <http://www.stateframe.com/>

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REFERENCES

- [1] Campbell, H., et al., Integrated care pathways. *BMJ*, 1998. 316(7125): p. 133–137.
- [2] Informing Healthcare. CaNISC. [cited 2008 24 September]; Available from: <http://www.wales.nhs.uk/sites3/page.cfm?orgid=770pid=33639>.
- [3] NICE. National Institute for Health and Clinical Excellence – Home Page. [cited 2011 16 Jan]; Available from: www.nice.org.uk.
- [4] Map of Medicine. Map of Medicine – Home Page. [cited 2008 16 June]; Available from: <http://www.mapofmedicine.com/>.
- [5] NICE. National Institute for Health and Clinical Excellence– Quality Standards. [cited 2011 16 March]; Available from: <http://www.nice.org.uk/guidance/qualitystandards/qualitystandards.jsp>
- [6] Map of Medicine. Map of Medicine – Diagnostic Breast clinic. [cited 2011 20 March]; Available from: <http://www.mapofmedicine.com/>.
- [7] Map of Medicine. Map of Medicine – Breast Cancer – Advanced. [cited 2011 20 March]; Available from: <http://www.mapofmedicine.com/>.
- [8] NHS Wales. Informing Healthcare – Home Page. [cited 2009 1 May]; Available from: <http://www.wales.nhs.uk/IHC/>.
- [9] Map of Medicine. Map of Medicine – Home Page. [cited 2011 16 Jan]; Available from: <http://www.mapofmedicine.com/>.
- [10] NHS Direct. NHS Direct – Home Page. [cited 2009 30 June]; Available from: <http://www.nhsdirect.nhs.uk/>.
- [11] NHS Connection for Health. NHS Connecting for Health – Home page. [cited 2009 1 May]; Available from: <http://www.connectingforhealth.nhs.uk/>.
- [12] Natasha, M., et al., A national survey of computerized decision support systems available to nurses in England. *Journal of Nursing Management*, 2009.
- [13] Scottish Executive Health Department. Your Emergency Care Summary: What Does it Mean to You? 2006 [cited 2009 30 June]; Available from: <http://www.scotland.gov.uk/Publications/2006/08/16152132/1>.
- [14] Informing Healthcare. Welsh Clinical Portal. 2007 [cited 23/01/2008]; Available from: <http://www.wales.nhs.uk/ihc/page.cfm?pid=23396>.
- [15] Connecting for Health. Connecting for Health– Home Page. 2007 [cited 2007 07 August]; Available from: <http://www.connectingforhealth.nhs.uk/>.
- [16] Al-Salamah, H., et al., Change Management Along the Integrated Care Pathway (ICP), in *International Symposium on Health Information Management Research (ISHIMR)*. 2009: Kalammar, Sweden.