Medical Process Modeling: a Case Study Modeling Adult Outpatient Chemotherapy Using Little-JIL

A Capstone Experience Manuscript

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Title: **Medical Process Modeling: a Case Study Modeling Adult Outpatient Chemotherapy Using Little-JIL**
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Safety has been a monumentally important issue in the medical field. Preventable medical errors in hospitals are estimated to cause the death of over 98,000 patients a year. Typical errors include miscommunication between medical professionals, incorrect drug administration, miscalculated drug doses, and many other minor yet life threatening mistakes. One of the reasons that such mistakes occur is that medical processes are complex and have many stages that require the collaboration and coordination of several professionals and departments. This kind of complexity often leaves processes insufficiently defined, so participants are unsure how or what needs to be done in unusual situations or make mistaken assumptions about the behavior of other participants.

The overall goal of the project is to enhance the safety and efficiency of complex medical processes by applying new methods developed in software engineering. These techniques support formalizing the process definitions and using verification techniques to check them for possible errors.

My work is for the Laboratory for Advanced Software Engineering Research (LASER) and concentrates around the use of Little-JIL, an agent coordination language, to continue the modeling and analysis of a real-world medical process: the Adult Outpatient Chemotherapy Process that is being performed at the Baystate Hospital's D'Amour Cancer Center. I will concentrate my efforts around defining the process itself, applicable medical terminology, participating agents, the resources that are required, artifacts (such as medical charts) that are created and used, the non-normative behaviors that must be accommodated and the safety properties that must all be maintained.

In this thesis I describe the process and the methodology I used to elicit it, along with findings indicating that defining and evaluating the process helps in identifying weaknesses in it, thus leading to an improved medical process and greater patient safety.

I.   INTRODUCTION

Safety has been a monumentally significant issue in the medical field. It has been estimated in a National Academies/Institute of Medicine study that the number of deaths per year resulting from preventable medical errors in US hospitals is at least 98,000 [1], a number of deaths that is higher than is due to motor vehicle accidents (43,458), breast cancer (42,297) or AIDS (16,516) [2].

The effects of medical errors reach beyond the death of the victim. An adverse event is defined by the Institute of Medicine as an injury caused by medical management rather than by the underlying disease or condition of the patient [3]. The national costs of these adverse events are over half the total cost of health care (between $17 and $29 billion.) In addition, public trust in the medical system decreases substantially when preventable medical errors that cause discomfort, injury, or worse, death, become known. Health Care professionals also experience frustration at not being able to provide their patients with adequate care and society at large suffers due to loss of work productivity or attendance at schools [1].

The most common adverse events are technical errors (44 percent), diagnosis errors (17 percent), failure to prevent injury (12 percent) and errors in the use of a drug (10 percent) [1]. Several causes for these events stem from the complexity of today's medical processes that require medical professionals to cooperate with more individuals and manage more tasks. Unfortunately, processes of healthcare delivery are frequently poorly organized, highly complex, yet poorly described. Although solutions to this and many other error-causing problems in the medical domain span several fields and

approaches, the Institute of Medicine recognizes the potential of Information Technology in improving the medical system [4].

In the University of Massachusetts, the Laboratory for Advanced Software Engineering Research (LASER) has been collaborating with faculty from the School of Nursing, and professionals from Baystate Hospital on a National Science Foundation funded Medical safety project to investigate means in which information technology can improve medical safety [5]. It is unreasonable to expect that any approach will be able to detect and prevent all errors. But, it is our belief that careful elicitation, representation, and analysis of medical processes can help to identify process features that increase the potential for error, and whose remediation can thus improve patient safety.

In this project, several of the principals of, and technologies developed by, the LASER lab have been applied to the process of Adult Outpatient Chemotherapy Treatment. The process has been elicited in collaboration with the Oncology department of Baystate Hospital's D'Amour Cancer Center through recurring and frequent meetings. It was then modeled using Little-JIL, a visual process programming language. In this thesis I will report on the actual process elicited through repeated meetings at Baystate Hospital, findings made about the nature of the process itself, as well as findings about process elicitation methods and our process modeling approach.

I.II.   PARTICIPATING PARTIES

There are three participating parties in this project. The LASER lab conducting the research and analysis and the Baystate Hospital Oncology Team representatives comprise the primary participants in the elicitation and modeling of the process. The

patients, who were affected by decisions made as a result of findings throughout elicitation of the process, were secondary participants who did not directly contribute to the project. However their experiences provided the Oncology department with information which was then relayed to us.

I.II.I LASER LAB

The LASER lab is comprised of several groups the goals of which are to research and investigate techniques for reducing software development costs while improving the quality of the systems produced [6]. A 'Medical Safety' group in the lab is conducting research to discover how process definition and execution, and software verification and analysis can be applied and extended to the medical domain in order to improve safety and efficiency of processes. The project outlined by this thesis is within the purview of this group.

I.II.II BAYSTATE TEAM

The Baystate team is comprised by Dr. Wilson Mertens, the Medical Director of the Baystate Cancer Program; Dr. Lucinda Cassells, Oncologist; Dr. Dave Brown, Pharmacy Specialist; Trisha McGovern, R.N, Nursing Manager and several other staff members occasionally participating in the elicitation process on demand.

I.II.III GOALS

Each of the project participants has goals that the project is expected to address. The LASER lab is interested in expanding existing knowledge of process elicitation techniques as well as understanding the efficacy and drawbacks to currently used methods. In addition, the modeling of a real world process often highlights the support missing from the process programming language Little-JIL, thus allowing the team to

expand and adjust their technologies in order to more effectively address the problems of the real world. Also, the lab has developed several tools to support analysis and simulation of the process. One of them is PROPEL, a tool that supports property elucidation [7], and will be used to model safety properties to which the process must adhere. Following property elucidation, FLAVERS, A flow analysis tool for verification of systems, will be used to verify that properties specified using PROPEL are (or are not) conformed to by the modeled process.

The Baystate team, as we understand, is interested in creating a unified representation of the entire existing Adult Outpatient Chemotherapy process as it currently is performed. By doing so they hope to gain understanding of the contributions of the various agents and their activities. They also hope to identify areas of vulnerability that have previously been overlooked. This will allow the team to evaluate the process, to handle unaddressed error-prone areas, and to improve process efficiency by removal of redundant activity that slows the process down and utilizes resources inefficiently. It is our hope that the importance of maintaining one representation of the process in a central location, and in a way that is understood and agreed by all, will be acknowledged by the Baystate team, and will cause them to create an official process support entity that will continue aspects of our work beyond our research.

I.III.   ROADMAP

The remainder of this paper is organized as follows: Section 2: Process - A description of the methodology used in this project as well as a description of the process, Section 3: Results and findings – Observations made about process elicitation and modeling through the project and Section 4: Conclusion – Summary of

Observations, personal reflection and current status of the project as well as any future work. An appendix contains the visual representation of the Little-JIL process definition.

II. THE PROCESS

II.I OVERVIEW

The Adult Outpatient Chemotherapy process is one of several in a series of medical processes elicited and modeled by the LASER group. The current process model defines the events that occur prior to the first day of chemotherapy administration including the consultation leading to the treatment and up until (including) the administration of the chemotherapy drugs. The process is divided into five principal parts: Consultation and Assessment, Triage Tasks, Pharmacy Tasks, Final Pre Chemo Tasks and First Day of Chemo (Appendix B, Figure 1).

My work on the process is a continuation of effort initiated by Natalie Podrazik. When I inherited the project, a substantial part of the process had already been modeled in Little-JIL but lacked several necessary aspects crucial to analysis, such as exceptional behavior representation. I continued eliciting the missing information as well as extending the process to include the first day of chemotherapy administration.

II.II   LITTLE JIL TERMINOLOGY

Little-JIL, the language which I used to model of the Adult Outpatient Chemotherapy process, is a new language for programming the coordination of agents with a formal yet graphical syntax and rigorously defined operational semantics [9].

An agent is an entity (human or electronic) that is responsible for performing the work entailed in a step. *A step* (Appendix A, Figure 1) represents a task that is to be done by one or several agents. Each step is identified using a name which describes the task it represents. A step can have *requisites* which define guards on the entry and exit of a step. If a requisite fails, an exception (ie. An event that prevents the normative conclusion of the execution of the step) will be propagated to the parent of the step which may or may not handle it [10].

A process is organized in a hierarchical fashion. Because a process model is often very large, the hierarchy is broken into separate diagrams that are linked through references. A step can have multiple sub steps (children) in which case it will have a *sequencing badge* and its children will be executed in one of the following ways: sequentially, in parallel, by the making of a choice, or by sequentially trying alternatives (Appendix A, Figure 2). The child steps of a sequential step will execute in order (from left to right), as the name implies; The children of a parallel step will execute in any order, perhaps even concurrently; The agent of a choice step will choose which child step to execute; In a try step, the agent will try each step sequentially until one of them succeeds. If a step does not have any children it is called a leaf step and has no sequencing badge. In this case, the step's agent is free to execute the step in any way, without process guidance or control.

When the execution of a step fails (ie. A non-normative situation arises), an exception is thrown by the step to its parent, which handles the exception in a way described by an exception-handling substep having a *handler badge* that matches the type of the exception that has been thrown. A handler step must be created for each exception type that can be thrown. Several pre-build exception types are included with Little-JIL but custom exceptions are simple to create and add to the process model. If a

handler does not exist for the type of exception thrown it will be passed to the grand-parent and so on until an appropriate handler is found or until there are no more parent steps. A handler step specifies a *control badge* that indicates how the step which threw the exception will continue once the handler is done executing. There are four possible control badges: continue, complete, re-throw and restart. The continue badge will instruct the step handling the exception to continue onto the next step, the complete badge indicates that the step throwing the exception must be completed, the re-throw badge instructs the step to stop its execution and throw the exception to its parent, lastly the restart badge indicates that the step should be restarted once the exception is handled.

Finally, Each step can specify the need for a set of resources which are used by the step's agent and are required for its execution. Agents are a type of resource and are assigned as the executing entity. For example in the process created as part of this project, examples of agents are a pharmacist, a doctor, or a chemotherapy dosage device. Examples of resources might be a stethoscope, a patient history database, or a pharmacy reference manual [10].

II.III   MEDICAL TERMINOLOGY

Several medical terms are frequently used throughout the process and their understanding is central to comprehending the process. There are key agents in the process that drive it. The *MD Team*, which is comprised of an Attending MD and possibly a Fellow MD, initiates the process and is responsible for tasks such as consultation with the patient and writing of the orders and the treatment plan. A Triage Medical Assistant (Triage MA) is responsible for many aspects of the process such as obtaining patient information and handling artifacts that are needed in order for the

process to continue. A Triage Registered Nurse (Triage RN) handles tasks such as verification and calculation of sensitive numerical data such as the Body Surface Area (BSA.) Not all Triage RNs are allowed to administer chemotherapy drugs and therefore there are licensed Triage RNs who are certified in chemotherapy drug administration, and some who are not certified. The Pharmacist heads the pharmacy department and is responsible for verifying and executing the orders provided by the MD team. Under the pharmacist's supervision, pharmacy technicians fulfill tasks such as mixing drugs.

There are also several artifacts that drive the process. A treatment plan written by the MD Team contains instructions that will be executed throughout the patient's chemotherapy treatment. Orders are 'prescriptions' of sorts that contain the dosages and drugs that will be used for a particular patient. A treatment plan also contains the names of drugs that will be in the orders but does not contain additional necessary information such as dosages. A Patient's chart contains patient information, a signed treatment plan, orders and any other data pertinent to the diagnosis and treatment. Both exist in a central computer system, the CIS, but original signed paper copies are also kept. Other artifacts will be explained throughout the process description and a glossary of terms known to date can be found in Appendix C.

II.IV   THE ADULT OUTPATIENT CHEMOTHERAPY PROCESS

II.IV.I   CONSULTATION AND ASSESSMENT (APPENDIX B, FIGURE 2)

OVERVIEW: During this section of the process the MD Team, which is the primary agent for this sub process, evaluates the patient's condition and writes a treatment plan and orders.

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DETAIL: First, a patient consultation (Appendix B, Figure 3) takes place during which the height and weight of the patient are measured and recorded (Appendix B, Figure 6). If the patient is unable to stand up for their height and weight to be taken in the standard fashion, an alternative method for obtaining those values must used. Currently no standard method for doing this has been defined, and agents are allowed to perform this step under these conditions as they deem suitable. The desirability of defining a standard method it is under investigation at the Baystate Oncology department. It is important to note that our work does not, and cannot, provide such process details, if they do not exist. It does, however, seem to be an effective way of pointing out when and where such details are absent.

Once height and weight values are obtained, the Pathology report, a description of cells and tissues made by a pathologist based on microscopic evidence, and sometimes used to make a diagnosis of a disease [11], is reviewed, if it exists. If it does not exist, a request is sent to the Baystate pathology department to create a report. Once a report is obtained, the review process begins. The first stage of the process is a verification that the report is from Baystate's Pathology department. If it is not, then an exception is thrown and a request is sent to the Baystate pathology department for a review. Once a review is complete the process restarts at the verification of the report at which point it is verified by the MD Team. The MD Team also verifies the cancer diagnosis. For the process to continue, the biopsy of the patient must exist, must indicate cancer and must be conclusive, if any of the conditions is not met then the biopsy will be reevaluated.

Once the review is concluded, further arrangements are made with the patient (Appendix B, Figure 4). During this phase Chemotherapy is discussed with the patient

and additional testing is ordered or arranged if needed. This terminates the patient consultation sub process.

Following the Patient Consultation, the patient's readiness for treatment is evaluated and then a treatment plan is written by the MD Team. A treatment plan can be written in one of two ways (Appendix B, Figure 5:) Using a careset, which is one of several templates generated and approved by Baystate Oncologists that outline standard treatments for various diagnoses, or manually from scratch if no careset exists for the diagnosis of the patient.

Once the treatment plan is written the orders can be generated. At this step the orders do not actually have to be completed by the MD Team, but they can be generated from this point on. This is a difficult condition to represent in Little-JIL and isn't actually reflected in the process model. This concludes the Consultation and Assessment sub process.

II.IV.II TRIAGE TASKS

OVERVIEW: In this sub process (Appendix B, Figure 7) the Triage MA handles tasks such as scheduling the patient's appointments and verifying the orders and the dosages. Also the Business Office (BOS) begins verification of the patient's insurance coverage.

DETAIL: At first, the Triage MA handles BOS related tasks which involves printing out a face sheet and then delivering it to the BOS so that the BOS can begin processing the patient's insurance coverage. Following BOS related tasks the Triage MA begins several Pre-RN Tasks (Appendix B, Figure 8.)

The Triage MA prints a copy of the orders if they exist. If they do not exist, the MA notifies the MD Team of missing orders. Once the orders are obtained, he/she checks to

see if they match the treatment plan and notifies the MD Team in the case of a mismatch. A checklist, in which the Triage MA records various activities implying the state of completion of the process, is then attached to the patient's chart. Appointments for a teaching session are then scheduled with the patient, so that the patient can be educated about the treatment to be undergone, and about what will happen on the first day of treatment. The Triage MA then prepares a package containing patient related documents for the RN (Appendix B, Figure 9) and then hands it to him/her.

Once the Triage RN receives the package of documents he/she uses them to perform several verifications (Appendix B, Figure 10). Initially he/she reviews the existence of appointments, cycles, orders and doses (Appendix B, Figure 11). Following that, the Triage RN recalculates the Body Surface Area (BSA). To do so, the height and weight values are retrieved from the patient's chart and they must be less than a month old. In the case that they are older, an exception will be raised and a flag, which should be checked at a later point, is set. The obtained height and weight values are compared against the values in CIS (The Hospital's Computer System) and they must match. In case they do not match, an exception is raised and must be handled appropriately. Once accurate height and weight values are obtained the BSA is recalculated and the treatment plan is reconciled (Appendix B, Figure 12.) During this sub Process the Triage RN verifies that the drugs match the ones that the MD prescribed in the orders. The doses are then calculated and they must match the doses specified in the orders. If they do not match then an exception is thrown and the Triage RN attempts to recalculate it. If the results still so not match, the mismatch will be reported to the Medical Advocacy. If the newly calculated doses match the existing doses then other orders are verified such as the presence of Anti Emetics etc.

Once the verifications are complete, the Triage RN signs the treatment plan and returns it to the Triage MA along with the rest of the package received from the Triage MA.

When the Triage MA receives the package from the RN he/she conducts several post-RN actions (Appendix B, Figure 13.) Any remaining steps on the checklist are completed, the patient is notified of the scheduled appointment, the patient's chart is returned to medical records, a clinical summary is printed, and the treatment plan, along with the clinical summary, are placed in the Pharmacy tray. This concludes the Triage Tasks sub process.

II.IV.III   PHARMACY TASKS

OVERVIEW: This sub process involves the pharmacist's verification of the treatment plan, orders and doses (Appendix B, Figure 14).

DETAILS: The pharmacist begins by verifying the treatment plan and orders (Appendix B, Figure 15.) In order for the treatment plan and orders to be verified they must be present. If they are not an exception is thrown at which point the pharmacist will notify the MD team that the orders are missing. Once the orders are obtained the pharmacist verifies that they are complete. Following that, the pharmacist checks that the drugs in the treatment plan are appropriate for the cancer diagnosis. If they are not, then the MD team is notified appropriately. Following that verification, the pharmacist verifies the BSA calculation (Appendix B, Figure 16.)

In order to verify the BSA calculation the pharmacist retrieves the history of patient's height and weight from CIS and then verifies that they have not changed

significantly (The two heights must differ by less than 3.2 cm and the weights must differ by less than 10%.) If the height or weight have changed significantly, the pharmacist notifies the MD Team and proceeds. Using the most recent height and weight the pharmacist recalculates the BSA by hand or using an electronic calculator provided in CIS. The resulting calculations must then differ from each other by less than 10% and if they do not then the MD Team is notified of this discrepancy.

Once the BSA is verified, the pharmacist reviews lab results and counts in CIS. In case the counts are too low, an exception is thrown and the MD Team is notified by the pharmacist. After the review, the orders are verified in another sub process (Appendix B, Figure 17.)

If the orders were generated from a careset, then the pharmacist verifies them. If they were manually written by the MD Team then the pharmacist researches the orders. In this case, the MD Team may have provided the pharmacist with an abstract upon which the orders were based. If so, then the pharmacist becomes familiar with that treatment from the given abstract. If one was not provided then the Pharmacist looks for one on PubMed, the U.S. National Institutes of Health free digital archive of biomedical and life sciences journal literature [12]. When an abstract is found the pharmacist becomes familiar with it and then makes and files a copy of the abstract for the patient's chart. The pharmacist then contacts the MD Team to verify that the orders were based on the info found in PubMed. A copy of the abstract is then made and filed for self reference. This concludes the pharmacist's verification.

At this point (Appendix B, Figure 14) the pharmacist signs the treatment plan and makes a copy of the orders and the signed plan. A copy of the orders is then placed in

an active treatment file storage and the treatment plan, orders, and patient's chart are dropped off in the out basket.

II.IV.IV FINAL PRE CHEMO TASKS

OVERVIEW: These tasks occur prior to the first day of chemotherapy but they terminate the preparation process that takes place before the actual first day (Appendix B, Figure 18)

DETAIL: A Nurse Practitioner holds a chemo teaching session with the patient. At some point during that meeting a written patient consent will be requested (which does not have to be given immediately). Lastly, installation of a port used for chemotherapy infusion may be necessary and so a decision about that is a made at that point.

II.IV.III FIRST DAY CHEMO TASKS

OVERVIEW: These tasks occur on the actual day of chemotherapy administration. They involve patient evaluation and placement tasks performed by the chemotherapy nurse and drug preparation performed by the pharmacist. Definition of this part of the process has only recently been initiated, and has not been sufficiently elaborated and rechecked. As a result, there are gaps throughout this process in areas that were discovered during the process modeling phase (after the process elicitation meetings at Baystate). These gaps will have to be filled in as the elicitation progresses.

DETAIL: At first preparation for patient arrival takes place (Appendix B, Figure 19.) This involves several tasks that can happen in parallel: the pharmacist locates the patient's drug bin containing the unmixed chemotherapy drugs, also, the nurse locates the patient's chart, and the patient can arrive at any point at this time. Several

exceptions are possible here: The drug bin or the patient's chart may be missing. Also the patient might not arrive for the appointment. Once the patient arrives, two forms of identification are used by the chemo nurse to confirm the identity of the patient. The chemo nurse and she then begins the specified tasks (Appendix B, Figure 20.)

The first task conducted by the chemo nurse is verification of patient information in CIS (Appendix B, Figure 21.) This entails ensuring that the height and weight values have been consistent, checking the patient's BSA calculation and then checking that the chemotherapy doses are correct. Any of the three can be inconsistent which would be considered non-normative, and would thus require the definition of a handling mechanism in the process. Once the information is verified the chemotherapy nurse signs the treatment plan and proceeds to allocate a chair or a bed for the patient (Appendix B, Figure 24.)

A chair is assigned to the patient during the scheduling of the chemotherapy appointment. The nurse will attempt to locate a patient's assigned chair. If that chair is unavailable an exception will be raised in the process. The nurse will then keep trying to find a chair or a bed for the patient until one becomes available. Once a chair or bed has been allocated the nurse will conduct a 'Review of Systems' (Appendix B, Figure 23) which includes the following activities in any order of execution: Checking the patient's blood pressure, checking vital signs, checking respiration, checking pulse and measuring the height and weight. At any point any of these may have non-normative results, which will raise an exception that the nurse will have to handle appropriately. Once a review is complete, the nurse starts an intravenous (IV) and obtains blood specimens which are then brought to the lab for analysis. The nurse will then retrieve the lab results (Appendix B, Figure 22), which involves checking with the lab every 15 minutes until the lab results are ready for pickup. Once the results are obtained the

nurse handles them (Appendix B, Figure 25) by confirming that the results are ok. If they are not then the MD is notified at which point the MD will decide whether to use the same dosage of chemotherapy drugs, reduce the dosage or cancel the chemo administration. Once a decision is made, the nurse requests that the pharmacy mix the drugs, which brings us to the Pharmacist's tasks (Appendix B, Figure 26.)

The pharmacist prints out a copy of the orders from CIS and creates the labels that will be applied to the chemotherapy drug containers. A pharmacy technician then mixes the drugs obtained from the drug bin in a hood. Once the drugs are mixed the pharmacist will verify the resulting mixtures. First he will verify that the container labels match the orders. If they do not then the mixed drugs are set aside and new labels are created. Dosage related calculations are redone and a technician proceeds to mix the drugs in the hood. The pharmacist then verifies those mixed drugs and documents the error. Once the drugs are ready they are picked up by the chemo nurse for administration.

III.   RESULTS AND FINDINGS

Regular meetings with the Baystate staff followed by the modeling of the Little-JIL process provided me with an insight into process elicitation and modeling, thus allowing me to make several general observations about both.

III.I   PROCESS ELICITATION OBSERVATIONS

Initially, being unsure of the most productive and constructive way to meet with the Baystate team, I tried various techniques during the first few meetings. At first I attempted to use a power point presentation containing the Little-JIL diagrams which

gave the meeting a very formal tone. There were several drawbacks to this approach. First, several of the diagrams were far too large which made the text too small to be read, even though it was projected. As a result, several of the meeting's participants were struggling to read what was being displayed. Also, by projecting the diagrams I created a much more formal atmosphere in the room which turned our discussion into a monologue with occasional commentary. The Baystate team did not make many comments (which could also have been related to the small font) and I felt that they had a difficult time following what I was presenting. By projecting the diagrams I also did not allow the Baystate team to ask me concrete questions regarding the diagrams because they couldn't necessarily point out which step of the process they were referring to without getting up and pointing directly at the projected canvas. Being somewhat unfamiliar with the Little-JIL notation (despite previous work done by Natalie Podrazik with the team,) the formality of the meeting did not encourage questions and clarifications from the medical staff.

I concluded that this meeting format was not very conducive to our efforts in eliciting the process. Since all our knowledge depended on the Baystate team informing us of their process, we had to create a comfortable environment that would foster discussion and encourage the Baystate team to tell us about their work while following the process already in place. To try to achieve this I went into the next meeting with a set of handouts containing the process diagrams. This approach seemed to work out much better. There were many inquiries and requests for clarifications about the Little-JIL notations, none of which were requested during the prior formal power point presentation. Errors in the process were now frequently pointed out as well. Also the roles of 'lecturer' and 'audience,' which existed during the formal presentation, were no

longer there since each member of the discussion group had a process handout. This allowed for a more comfortable environment, and our productivity rose considerably.

Now that a meeting format was established, an additional question arose pertaining to the preferred number of attendees. Initially, the meeting room contained representatives from each group involved in the chemotherapy process (MD Team, pharmacist, nursing etc…) Since each group had its own separate understanding of the process there were frequently conflicts prompting discussions in an attempt to clarify those misunderstandings and decide what the details of the process *should be,* rather than proceeding with assisting us to understand the process *as it actually is.* It was important to us to elicit the process as each group understood and executed it, rather than to precipiate a unified agreement about some different process description that may not represent what was actually in place. Part of the reason medical errors occur is because of misunderstandings such as those we observed, which cause the process flow to have gaps both in understanding and implementation. Thus, it is important to obtain a clear picture of the actual gaps and errors, so that an effective remedy for them can be fashioned. Not only did the hypothetical discussions of possible changes jeopardize the process accuracy of the process definitions being developed, but they also wasted valuable meeting time by spending it extensively on unproductive discussion. Also, not all Baystate groups knew sufficient details of other groups' work. Frequently new aspects of the process performed by other groups would be revealed and discussed extensively, thus again using up meeting time. Although issues of this sort were important to us, we really wanted to move forward with the process and perhaps hear the conclusions of these discussions rather than listen to all of the details of each discussion in its entirety.

To resolve the problem of too many attendees I attempted to meet with a single representative at a time. This proved to be a fairly useful technique. I was able to discuss that participant's role in the process alone. This provided the most accurate description of the process in place since no other members were attempting to provide their own view of it. This also gave me a better idea of what each group *thought* the other group was doing. Since the sub processes are connected and many artifacts were being passed from group to group such as the patient's chart, there were many points of contact that should have been identically presented to us by both groups involved, which was not always the case. In most instances the changes were not monumental but none the less they did not match. For example while the pharmacy group indicated that paperwork was being dropped off in the outgoing tray for the nurse to pick up, the nurse expected a notification of some sort from the pharmacist. Although many instances such as this one were clarified in later meetings, the inconsistency of the process description brought to light the fallibility of the process.

There were several drawbacks to this meeting approach as well. Frequently the sub processes belonged to a single group but still contained steps that were executed by representatives of other groups that were not present in the meeting. In order to clarify questions that arose during discussion pertaining to those groups, the Baystate representative often left the meeting to seek out a member of the missing group who could shed some light on the issue in question. This occurred several times, most notably during the patient consultation (Appendix B, Figure 3) elicitation phase which is the responsibility of the MD team. In that sub process there is a height and weight measuring subprocess (Appendix B, Figure 6) which is performed by a Triage MA. While discussing the patient consultation process with the MD team, we realized that handling the case in which a patient can't stand up to have their height and weight measured was

unclear. A triage MA was found and it became apparent after some time that there was not a clear process in place to do so, however the act of locating a triage MA and discussing this issue with the group that was present took a considerable amount of time. Although it revealed a vulnerability in the process, issues such as this took a lot of time to investigate when meetings were conducted in a one-on-one format.

Discussions that involved both the computer science research team and the medical team proved to be somewhat of a challenge as well for both teams, as terminology became a very important issue in such meetings. On our part, the computer science researchers, we were accustomed to such terms as "throwing an exception", "parameter" and "hierarchical structure" while these were generally unfamiliar to the medical teams. We had to translate the Little-JIL diagrams into a clear verbal description when presenting them while pointing to the location in the process that we under discussion.   This translation of the diagrams allowed the medical team to learn and understand the notation and various modeling concepts through practice and observation, while some other terms had to be 'converted' from a technical language to one that would be understood by all. Additionally, comment boxes, annotations that could be placed anywhere on the diagrams from within the Little-JIL editor, were used extensively to list as much explanatory information about each step as possible. It became clear that the medical team members relied on the information in the comments just as much, if not more, as they did on the formal step definition information.

Being versed in technical terminology did not assist us when new medical terms and agents were introduced into the process. The variety of medical terminology is vast and is not often intuitive. Much like any other group whose members work in the same location, the Baystate team had a 'slang' of their own that we could not always translate back to the original meaning unless it was explained to us at some point.

One particularly serious problem was the frequent use of the same word to refer to more than one different entity or concept. For example, the term 'Nurse' was used to refer at various different times to different specific types of nurses, such as Registered Nurses, Chemo Nurses, Assigned Nurses etc. This was especially a confusing issue because not all nurses were licensed to perform all tasks of the process (such as the actual infusion of chemotherapy which only a licensed chemo nurse is allowed to perform.) Due to that, obtaining the actual term in question was monumentally important to the correctness of our process model.

Also, in addition to using a single term that had various meanings, the medical team also frequently used different terms to mean the same thing, which caused inconsistencies in our process. For example the interchangeable use of the terms 'drugs', 'orders' and 'chemotherapy' were all used at different times to refer to the actual chemotherapy drugs infused into the patient's system. But it was not always clear that this was the case.

Furthermore, terms with double meanings were rare but did appear throughout the process and it was not always easy to determine the correct meaning. For example the term 'orders' referred to both the physical orders written by the MD team containing instructions for the patient's chemotherapy treatment as well as the actual chemotherapy drugs used during the treatment. In most cases the true meaning of the term was discernable based on the discussion in place and the process being elicited or reviewed, however there were several points where clarification was necessary.

Lastly a misuse of terminology that was less frequent, but more difficult to identify, would occur when a group of artifacts was referred to as a whole and then by its parts. For example, a nurse conducts a 'review of systems' of the patient on the first

day of chemotherapy to confirm the patient's general health and ability to receive treatment that day (Appendix B, Figure 23). This process entails several other sub tasks such as taking the patient's blood pressure etc. These tasks were not always described as part of the review of systems but appeared to be separate until we requested clarification. This kind of carelessness with terminology is far more detrimental to process modeling because our understanding of the terminology is limited and relies mostly on the information we receive from the medical team. Given the wrong or incomplete definition of a term or separating its parts unnecessarily can cause inconsistencies in our process and create the appearance of vulnerabilities that were not there to begin with.

These common terminology issues suggested the creation of a glossary defining terms in words that the Computer Science team could understand. Creating this glossary required a considerable effort on the Baystate team's part.   The glossary was very helpful in highlighting the inconsistency of medical team's choice of words. That, in turn, encouraged and improved their use of precise and correct terminology. A glossary of terms known to date can be found in Appendix C.

An additional difficulty presented itself when I attempted to elicit all exceptional behavior in the process. Correct and complete definition of all possible exceptional (ie. non-normative) behavior is highly important to this work because the improper detection and handling of exceptions creates monumental risks to patient safety. Because of that, I wanted to make sure that every possible flaw in the process is represented in the diagrams. This task was much more difficult than I suspected it would be. In the daily routine of medical professionals, handling exceptional behavior is considered to be

routine, and happens frequently enough that it is not considered special, especially if it does not create undue delays. Indeed it turned out that some non-normative conditions arise so frequently that they are not regarded as being non-normative at all. Thus, our decisions about how to represent these situations as exceptions created some confusion and difficulty themselves.

My assumption that I would be provided with the details of how all exceptional behaviors are handled, resulted in very little information. Naturally there were very obvious areas of the process that could present life threatening and exceptional situations such as mixing the wrong drugs for a patient. Those situations were brought to my attention and properly incorporated into the process model. However, the details of handling smaller exceptions, such as missing paperwork, incorrect measurements, incorrect use of measurement units, etc were not always provided because these exceptions do not happen often enough, and their handling is often ad hoc. As noted above, this represents a potentially serious patient safety hazard, often brought to light by our process modeling.

To elicit the smaller and more subtle exceptional behavior I had to take a more direct approach and actually suggest exceptions on every possible step in the process that could possibly have one. For example, in a step that would verify details such as the patient's lab counts, I would tend to ask questions about the state of the object or activity under consideration such as "What if they are too low? What if they are too high? Could they not be present?" followed by the fairly standard "What would you do in that case?" question to elicit the handling behavior. Frequently, those exceptions would be valid and incorporated into the process. However in many cases those ideas would trigger recollection of actual exceptional behavior which was then added to the process. Lastly,

given my limited subset of medical understanding my suggested exceptions were occasionally implausible and therefore got discarded.

In several instances our work reaped the benefits and discovered exceptions and vulnerabilities in the process that were not previously known and therefore had no predefined solution to handle them. An example of that is in the Height and Weight (Appendix B, Figure 6) sub process in which there was no way to alternatively measure the height and weight of a patient that is unable to stand up. This discovery was made during a meeting discussing the patient consultation phase of the process and the Baystate team took it very seriously and made note to investigate ways to resolve this problem. An additional benefit that arose from discovering this vulnerability was that it triggered a discussion of an improper circumvention that was being taken in cases in which the issue came up. For example patients unable to stand were often merely asked their height and weight, or these were estimated simply by looking at the patient. These parameters are monumentally important to the calculation of chemotherapy drug doses for the patient's treatment and accurate values are of high importance. It became clear that they are not always accurately obtained in non-nominal situations, creating safety risks. Our discussions of this situation has led to a sharpened focus on defining the precise details of the process to be used in this situation.

Overall it was evident that non-normative situations arise frequently, and it is often the case that medical practitioners use their professional judgment about how to handle them, rather than seeking standard procedures that have been adequately considered. Frequently exceptional behavior was not regarded as being particularly worth careful specification, which made it difficult to elicit. This is a testimony to both how common abnormal behavior is in the medical field and how ways of handling it are not always predetermined and often rely on the professional judgment of individuals for

resolution and handling. Unevenness and lack of careful consideration can render this casual approach to exception handling a potential source of errors and threats to patient safety.

III.II   PROCESS MODELING OBSERVATIONS

III.II.II   NOTATIONAL OBSERVATIONS

Having been exposed to hierarchical structures and various tree models in my computer science curriculum, I did not anticipate the difficulties that arose when the Baystate team was presented with the diagrams. The hierarchical structure of Little-JIL diagrams along with its various notations was not intuitive to the Baystate team and frequently caused confusion in our first few meetings. Although used to flow chart notations, the medical staff found the Little-JIL step types to be confusing and often, for example, did not notice whether the steps were parallel or sequential. In order to convey the actual model of the process a very particular verbal explanation was needed along with the diagrams, that combined the meaning of all of Little-JIL's notation into one explanation.

This was often a difficulty on its own. The amount of information embedded in a step varies from very little to a lot. For example the 'print orders' step in the Pre-RN Actions diagram (Appendix B, Figure 8) has a post requisite and a prerequisite as well as an exception, agent and artifacts. In comparison to other steps which can be very simple such as the 'Attach Checklist to Patient's chart' on the same diagram, this step contained a wealth of information that was difficult to convey as one unit, and was often confusing to the team since visual changes were difficult to identify at times. Combined with the unique notation it was often necessary to point to the exact notation of a step while describing it. The uneven quantity of information in the steps made it difficult to

identify them based on their verbal explanation alone thus possibly prolonging the learning period.

Pre and post requisites proved to be confusing notational concepts. . Although the idea of a requisite was not in question, it became an intuitive representation for "something that has to precede something else." There was an increase in requests from the Baystate representatives to make steps prerequisites rather than leave them as steps in the model of the process. For example in the event that a copy has to be made prior to filing it away, the Baystate team would say that the copy action was a prerequisite to filing the copied document. Although a true, and even logical statement, a prerequisite in Little-JIL should not have side-effects [10] and since the action of copying a document produces a copy of that document, it is not a proper use of the requisite mechanism.

An additional area of confusion stemmed from the concept of parameter and artifact 'flow' through the diagrams. This flow is represented using small arrows on the lines connecting a step to its parent and they were frequently difficult to identify once the diagrams were extracted from Little-JIL and converted to handouts due to image resizing. In addition to that, the actual parameters/artifacts were not clear from that notation alone. In order to overcome that issue I used comment boxes to annotate the artifact/parameters that 'flowed into' the step and those that 'flowed out'. Although a helpful solution, it did not produce a graphical representation equal in its expressiveness to that of the step execution order for example.

In addition to difficulties created by artifact/parameter flow notation, the redundancy that is an inherent feature of artifact/parameter definition in Little-JIL posed additional problems. For example, if a leaf step is defined to have artifact 'A' as a

parameter, and the arrow connecting the step to its parent indicated that artifact 'A' was being passed up to its parent, it is evident and logical that the parent would then also have artifact 'A' as a parameter. The Little-JIL editing tool does not automatically make this inference, and create the desired parameter, however, requiring the process definer to define artifact 'A' as a parameter of the parent step as well. This need to specify every parameter in every step became an issue when multiple levels of parent steps existed and many iterations were necessary through each of them to ensure that parameters were flowing properly in and out of each step. This could have been an assumption that would ease the creation of the process model and decrease the number of 'lost' parameters or artifacts that were not defined, or misspelled, at some point in the process.

Moreover, A point of confusion also arose in the notation of a try step. The concept behind a try step is that the first leaf step on the left will be executed and if it fails the one following it to the right will be executed next. Seeing this definition I made the assumption that to establish this mechanism I only had to create a try step with the proper leaves. This assumption was incorrect and in order to actually create this situation every step had to throw an exception that would be then caught by a continuation handler under the parent try step that would handle the exception and then tell the process to try the next step in line. This mechanism seemed redundant and non intuitive to me especially since I could envision that a similar setup in a sequential step would produce the same result. I understand the need to allow for a robust definition mechanism that would allow for each exception to be handled separately but according to my understanding of a try step not every exception needs its own handler. Logically, if one step fails then the way to handle that error is to proceed to the next step which is what the definition of a try step entails to begin with.

III.II.II   EXPRESSIVENESS OBSERVATIONS

Besides the above mentioned notational issues there are several limitations of Little-JIL's expressiveness with regards to particular types of events. For example, Little-JIL mandates that for a task to begin it must have a step that will represent it in a clear and pre-defined location in the process. Although this is a logical requirement it creates a situation that does not allow for the case in which a task *can* begin at a certain point in time but does not have to. Instead it just has to complete by a certain deadline or before another task. An example of this in the chemotherapy process occurs during the 'Consultation and Assessment' sub process (Appendix B, Figure 2.) Once a patient's readiness for treatment is evaluated and the treatment plan is written the MD Team *can* begin writing the orders but they don't have to do it immediately. In fact, the process can continue its execution regardless of the existence of the orders until the Triage RN's 'Pre-RN Actions' sub process (Appendix B, Figure 8) in which the orders are printed and they must exist for that to take place. Unless a step in which orders are created is specified somewhere prior to the printing step the process will fail. This mandates the use of a step during the consultation and assessment phase, however this is not an accurate representation of the process in place at Baystate because the literal translation of the diagram is that the order writing task begins and ends in the consultation and assessment phase.

The expressiveness of uncertainty from the Baystate team has also been a challenging task in Little-JIL. For example, during the 'Height and Weight' (Appendix B, Figure 6) measuring procedure we discovered that the Baystate oncology department does not have an alternative method for measuring the height and weight of a patient

that is unable to stand up. This is obviously an area of vulnerability since chemotherapy

doses are based on the height and weight measurements and incorrect values could be

lethal. Because we strive to represent areas of vulnerability so that during analysis they

are discovered, we wanted to represent the gap in the process as such. However, since

there were no clear steps to represent we were forced to use a 'stub' step as a

temporary place holder that merely indicates that the height and weight are measured

alternatively. During the analysis of the process this will not be caught as an error nor

treated differently than any other leaf step in the process. In fact it will not be identified

as an area of vulnerability at all which defeats our purpose to some degree. The need to

express known gaps as errors in the process is highly necessary so that these areas of

high vulnerability and potential error are discovered and given the proper attention.

Grouping is also a concept that cannot be expressed using the current resource

manager used by Little-JIL. For example, the MD Team consists of a Baystate Resident

Oncologist and possibly an additional Fellow MD who is training with the Resident. The

Fellow MD does not have to be part of the team and in the case that he/she is, tasks in

the process are performed by both teammates. Both team members are also not equal

in terms of their privileges because the Oncology Resident has higher authority with

regards to signing documents such as the treatment plan. Group membership as well as

roles and privileges cannot be defined in Little-JIL. This prevents the process from

expressing certain exceptional behavior such as the Fellow MD signing a document they

were not supposed to, which again does not portray the full span of known and handle-

able vulnerabilities.

An additional example of a grouping related issue occurs in the Triage MA's Pre-

RN Actions sub process (Appendix B, Figure 8.) During this sub process a package is

assembled for the Triage RN containing several documents that were previously

generated and referenced in the process such as the treatment plan and patient chart. Because grouping is not available, the idea of a package is merely a conceptual one that is not represented in the process. If I were to create an artifact titled 'Triage RN Package' it will not actually be associated with its components and therefore the artifact flow would be incorrect and the parts of the group will not be available for reference in steps that use the chart package.

An issue that was discovered during our process elicitation brought forth another expressiveness difficulty; When the Body Surface Area (BSA) is recalculated in the 'Triage RN's Verify BSA and Orders' sub process (Appendix B, Figure 11) the height and weight used must not be older than 30 days. In the case that the values are older, a flag is set in some form which then should be checked when the patient comes in so that a new height and weight can be obtained. The only way to programmatically specify that a flag has been set is to set a parameter indicating so in an exception handler and that parameter will then travel through the entire process (an additional modeling inconvenience.) At some point there has to be a step that will check to see whether this parameter has been set or not, but this point in the actual process is not clearly defined because no specific location in the process mandates that check. Also, if the flag is never checked then no exception can be raised at which point a flag could potentially traverse the entire process, never be checked and not indicate a serious and dangerous vulnerability (patients undergoing chemotherapy treatment often suffer a loss of weight and even height).

Lastly, capturing the entire process accurately proved to be impossible. The Baystate staff has portions of the process defined but it is not unlikely that events can occur that would require a complete dynamic modification of the process in order to adapt to a patient's need and the Baystate staff is trained to use their medical and

professional judgment to change the process accordingly. Those events are impossible to elicit because their domain is vast and can include events completely unrelated to the medical field. Although those events are rare, they pose a greater danger to the patient because of their low frequency and on-the-fly process modification.

Also, with every additional meeting substantial changes have been made to the actual process that required restructuring of large portions of the Little-JIL process model. As a result it often appeared that the Baystate process is ever-changing and that continually changing our model of it would not allow us to create a solid and fully defined process. However if we were to create a 'baseline' process model, one that will not be changed but rather further defined and elicited we would end up working with an older version that does not accurately represent the process in place at Baystate. By doing so we would miss new vulnerabilities that occur as a result of newly added policies and we would potentially concentrate our efforts on exceptional behavior that has been resolved or addressed.

VI.   FINAL REMARKS / CONCLUSIONS

VI.I   STATE OF THE PROCESS

The process has not been completed due to time constraints. Currently an initial elicitation of the first day of chemotherapy has been conducted and several diagrams have been charted (though not verified with the Baystate team.) Many more revisions of this process will have to take place and it will have to be extended to encompass the actual administration of chemotherapy drugs, a missing part of the process as of now.

Additionally, exceptional behavior, although addressed in commented sections throughout the first day sub processes, is not actually represented in Little-JIL syntax (for the most part) and most of the exceptions have been thought of only after the conclusion of elicitation sessions, during the modeling phase. They need to be discussed with the Baystate team and incorporated into the process or discarded if not plausible.

VI.II   CONCLUSIONS

This process elicitation and modeling experience has left me with mixed feelings about this process. On one hand I was thrilled to discover with every meeting at Baystate that new vulnerabilities are discovered by the Baystate team through the process elicitation procedures. In addition these discoveries were not disregarded or filed away, rather, they were addressed and corrected if need be. Every new meeting with the team illustrated that they are taking our findings very seriously and adapting their process to improve it and eliminate areas of weakness and uncertainty. The process of elicitation also proved to be a valuable activity for the Baystate staff because they were not aware of the process as it stood and were at times amazed to discover what really happens as opposed to their beliefs. Naturally this encouraged me immensely to continue my work.

On the other hand, I felt that the process elicitation was never ending. In my attempts, I was trying to elicit not only the documented adult outpatient chemotherapy process at Baystate but the thought and decision making process of medical professionals as well. Naturally this is a vast and never ending area because medical professionalism cannot be fully documented and specified. It involves the individual personalities and preferences of the staff members which are not always clear to the staff members themselves. In times of need they are ready to act and instinctively know

how to address the issues at hand. However, unless put into that position they will not always be able to explain how they *would* act *if* the case occurred nor would they necessarily be able to think of the case to begin with. It was very evident throughout this experience that the staff had a difficult time expressing verbally what it is that they do and in which order, which supports my statement further.

Additionally, I felt that the majority of the benefits to the Baystate team were coming from the elicitation meetings and that beyond that point our work was somewhat futile. I admit, I have not witnessed a case in which a process analysis has discovered a major flaw in a real world process that has not been previously known, and thus my feelings about this may be somewhat biased. I felt that the 'nitty gritty' work required in order to run a complex analysis only to confirm that an area is indeed prone to vulnerability was simply too much. I realize that as Computer Scientists we strive to quantify, parameterize, prove and automate everything we can and I do belong to that group most of the time but it was difficult for me at times to see the benefits in the distant future when I was making headway now through simple discussion and diagrams.

I believe that with substantial improvements of Little-JIL's capabilities in addressing both issues mentioned by me and those previously discovered in other processes, the act of process modeling will become more enjoyable and far less time consuming. Much of my time was spent understanding small intricacies that were more Computer Science related than process related which would be simply too confusing for an average process group such as the one we hope will be established at Baystate as a result of our effort. Being an academic organization rather than an enterprise charging fees for our work, I understand that Little-JIL is more of a concept prototype than a full-blown commercial application and it is outstanding in proving its significance and contribution despite the occasionally-painful usage.

Finally, I realize that big accomplishments begin with small steps. I have been fortunate to have taken part in this research and I learned an immense amount about processes, their elicitation and how seemingly non-trivial they actually are, even in their simplest form. I realize that my accomplishment oriented nature somewhat prevented me from enjoying, to the fullest, the thought of innovation that will stem from this research in years to come but I realize and admire its significance none the less.

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APPENDIX A

Figure 1: LITTLE JIL STEP ICON
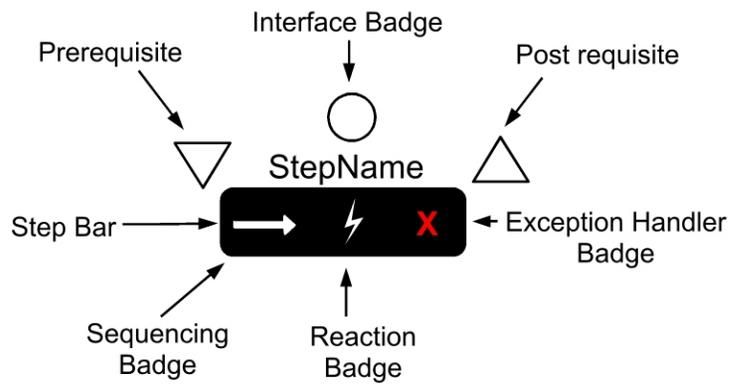
Figure 2: LITTLE JIL STEP TYPES
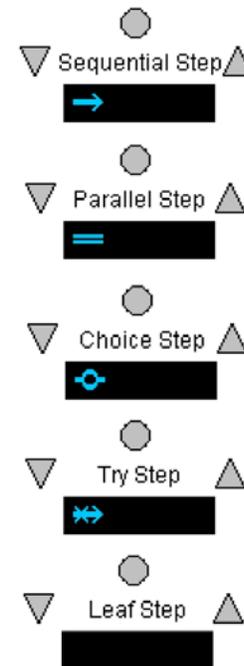
APPENDIX B: LITTLE-JIL DIAGRAMS

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APPENDIX B

Figure 1: Adult Outpatient Chemotherapy: From Consult to First Day of Treatment

PRE: 'Patient was referred to
Baystate for cancer management

AO CHEMOTHERAPY: FROM CONSULT TO PRIOR TO FIRST DAY OF Rx

CONSULTATION AND ASSESSMENT

** This subprocess involves the MD
Team's visit with the patient, as well as
the writing of the Rx plan and orders. **

A: MD Team
Parameters:
in: Pathology Report
     Biopsy
     Patient's Chart
Out: Rx Plan
     Orders

FIRST DAY OF CHEMO

** These tasks occur on the first
day of chemo treatment **

TRIAGE TASKS

** This subprocess involves the Triage
MA scheduling the patient's appointments,
the Triage RN double checking the MD Team's
orders & dosages, and the beginning of
the BOS's verification of insurance coverage. **

A: Triage MA
Parameters:
in: RX plan
     Orders
     Patient's Chart

PHARMACY TASKS

** This subprocess involves
the pharmacist's verification of
the Rx plan, doses, and orders. **

A: Pharmacist
Parameters:
in: RX plan
     Orders

FINAL PRE-CHEMO TASKS

** The agents perform their respective
tasks after all initial verifications
have been performed. This does not include
first day, pre chemo tasks.

A: Nurse Practitioner

Note: Patient's chart comes
from Medical Records

APPENDIX B

Figure 2: Consultation and Assessment

▽ CONSULTATION AND ASSESSMENT △

PATIENT CONSULTATION

A: MD Team

** This subprocess takes the
Pathology Report and biopsy
and performs the actual patient
consultation. If the height or weight
is more than a month old, they are
retaken by the Triage MA. **

Parameters:
in: Pathology Report
     Biopsy
     Patient chart

Out: Patient Chart

▽ WRITE ORDERS △

A: MD Team

** Needs to be further elaborated.
-> Get Patient Name and Medical record # (Where from?)
   Get Height and weight (If not there (Exception),
       check paperchart, otherwize call patient
       in)
   write orders (This needs more details)

Parameters
out: Orders

▽ EVALUATE PATIENT'S READINESS FOR Rx △

A: MD Team
**This is separate from
consultation because
this happens in a weekly
conference rather than
right after/during meeting
with patient.**

WRITE Rx PLAN

A: MD Team

** The MD Team writes an
Rx plan which will auto
print twice (pharmacy and
triage MA) once it is
complete. **

Parameters:
out: RX plan

Figure 3: Patient Consultation

PATIENT CONSULTATION

HEIGHT & WEIGHT

A: MA
MA measures the patient's height and weight, and records the data in the patient's chart and CIS.

Parameters:
in: Patient's Chart

A: MD Team
Parameters:
in: Pathology Report
    Biopsy
Pre: 'Pathology report present'
xHandler: 'Send Request for Pathology report'

PATHOLOGY REPORT

VERIFY PATHOLOGY REPORT

A: MD Team
Parameters:
in: Pathology Report

PRE: 'Pathology report was preformed at Baystate'
xHandler: 'Send path report to Baystate Pahtology for Review'

VERIFY DIAGNOSIS OF CANCER

A: MD Team
R: Patient

Parameters:
in: Pathology Report
    Biopsy

POST:'Biopsy indicates cancer'
xHandler:'Reevaluate Biopsy'

MAKE ARRANGEMENTS WITH PATIENT

A: MD Team

The following actions take place in this sub diagram:
 – Chemo RX is discussed with the patient.
 – Additional testing is ordered or arranged as needed.

REEVALUATE BIOPSY

'Biopsy is invalid':
  – Inconclusive
  – Benign
  – No Biopsy
Paramters:
in: Pathology report
In this case re-asses the patient

SEND PATH REPORT TO BAYSTATE PATHOLOGY FOR REVIEW

'Path report not done in Baystate'
A: MD Team
R: Baystate Pathology Dept.
Parameters:
in: Pathology Report

SEND REQUEST FOR PATHOLOGY REPORT

'No pathology report for patient'
A: MD Team
R: Baystate Pathology Dept.
Parameters:
out: Pathology Report

* xHandler – Handler responsible for handling exception generated when pre or post condition is not met.

APPENDIX B

Figure 4: Make Arrangements with Patient

Figure 5: Write Rx Plan

Figure 6: Height and Weight

▽ TRIAGE TASKS △

A: Triage MA
PRE: 'RX Plan has been printed.'
xHandler: 'NOTIFY MD TEAM OF
UNPRINTED RX PLAN'
administrative advocacy'
Once an RX plan is completed
it is AUTO printed and that must
be complete prior to this stage.

▽ ADMINISTRATIVE TASKS △

Patient's Chart
RX plan

▽ NOTIFY MD TEAM OF UNPRINTED RX PLAN △

A: Triage MA
'RX plan has not been
printed'

REPORT FOR NURSES'ADMINISTRATIVE ADVOCACY

▽ PREFORM BOS RELATED TASKS △

PRE-RN ACTIONS

TRIAGE RN's VERIFICATIONS

POST-RN ACTIONS

** This subprocess contains
the preparatory actions before
the Triage RN performs the
verifications necessary. **

Parameters:
in: RX plan
     Patient's Chart

** Using the checklist,
Rx Plan, and hard copy
of the orders attached
to the patient's chart,
the RN performs several
necessary verifications. **

Parameters:
in: RX plan
    Copy of orders
    Patient's Chart
    Checklist
out: RX plan
    Copy of orders
    Patient's Chart
    Checklist

** The Triage MA follows
the final steps in the
checklist, makes some
copies, and passes on the
artifacts to the next agents
in the process. **

Parameters:
in: RX plan
    Copy of orders
    Patient's Chart
    Checklist

▽ PRINT OUT FACE SHEET △   ▽ GIVE PATIENT'S FACE SHEET TO BOS △

A: Triage MA
R: CIS

Parameters:
out: Face Sheet

A: Triage MA

Parameters:
in: Face Sheet

Figure 8: Pre-RN Actions

PRE-RN ACTIONS

PRINT ORDERS

A: Triage MA
R: Hard copy of orders
   CIS
PRE:'Chemo orders present'
POST:'Orders and RX plan
match'
E: 'Orders and RX plan
don't match'

Parameters:
in: RX Plan
out: Copy of orders

NOTIFY MD TEAM OF ABSENT ORDERS BY EMAIL

'Orders are absent'
A: Triage MA

NOTIFY MD TEAM OF MISMATCH BETWEEN ORDERS AND RX PLAN

'Orders and RX Plan don't match'
A: Triage MA

ATTACH CHECKLIST TO PATIENT'S CHART

A: Triage MA

Parameters:
in: Checklist
    Patient's Chart

SCHEDULE APPTS

PREPARE PAPERWORK FOR RN

A: Triage MA
Parameters:
in: Rx Plan
    Copy of orders
    Patient's chart
out:Patient's chart

GIVE TRIAGE RN CHART PACKAGE

A: Triage MA
Pre: 'MAKE A COPY OF RX PLAN AND
      BACK UP INTO PENDING TRAY'
 * Chart package is:
  - Rx Plan
  - copy of orders
  - checklist
 (all attached to patient's chart)

Parameters:
in: Rx Plan
    Checklist
    Copy of Orders
    Patient's Chart

SCHEDULE CHEMO TEACHING

A: Triage MA
R: Lantis Sched. Sys., CIS

*Note: time has to be before
first chemo rx day. How to
represent this?

SCHEDULE FIRST CYCLE

A: Triage MA
R: Lantis Sched. Sys., CIS

APPENDIX B
Figure 9: Prepare paperwork for RN

▽ PREPARE PAPERWORK FOR RN △

▽ MAKE COPY OF RX AND FILE △

```
A: Triage MA
Parameter:
in: RX plan
```

▽ MAKE A COPY OF RX PLAN AND BACK UP INTO PENDING TRAY △ ▽ ATTACH CHECKLIST, Rx PLAN, PRINTED ORDERS TO CHART △ ▽ LOG PATIENT TREATMENT STATUS △

```
A: Triage MA
Parameters:
in: RX Plan
local: Pending Tray
```

```
A: Triage MA

Parameters:
in: Rx Plan
    Checklist
    Copy of Orders
    Patient's Chart
```

```
A: Triage MA
Parameters:
local: Treatment Status Log
```

APPENDIX B
Figure 10: Triage RN's Verifications

▽ TRIAGE RN's VERIFICATIONS △

REPORT FOR MEDICAL ADVOCACY

P: Problem/Error/Question

TRIAGE RN'S VERIFY BSA & ORDERS

▽ SIGN & PASS ON △

REPORT FOR NURSES' ADMINISTRATIVE ADVOCACY

P: Problem/Error/Question

A: Triage RN
PRE: 'Review existance of appts,
cycles, orders and doses'

** Subprocess to recalculate
     the BSA and doses.**

Parameters:
in: Rx Plan
     Orders
     Patient's Chart
     Checklist

▽ SIGN Rx PLAN △   ▽ GIVE Rx PLAN, ORDERS, CHECKLIST, & PATIENT'S CHART TO TRIAGE MA △

A: Triage RN

Parameters:
in: Rx Plan

A: Triage RN

Parameters:
in: Rx Plan,
     Orders
     Patient's Chart
     Checklist

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Figure 11: Triage RN's Verify BSA and Orders

Figure 12: Reconcile RX Plan

RECONCILE RX PLAN

VERIFY SAME DRUGS

: Triage RN

Parameters:
in: Orders

CALCULATE DOSES

A: Triage RN

Parameters:
in: New BSA
     Orders
out: New Doses

VERIFY OTHER ORDERS

VERIFY PRESENCE OF ANTI-EMETICS

A: Triage RN
E: 'Resource Chain
of Command'

Parameters:
in: Orders

VERIFY PRESENCE OF IV FLUID (if needed)

A: Triage RN

Parameters:
in: Orders

VERIFY PRESENCE OF IV FLUID (if needed)

A: Triage RN

Parameters:
in: Orders

HANDLE ERROR

RECALCULATE DOSES

REPORT FOR MEDICAL ADVOCACY

** This subprocess has the
agent report up the chain
of command to resolve an
unexpected error. **

APPENDIX B
Figure 13: Post RN Actions

▽ POST-RN ACTIONS △

▽ FOLLOW REMAINING STEPS ON CHECKLIST △

A: Triage MA

Parameters:
in: Checklist

▽ CALL PATIENT WITH APPOINTMENT △

A: Triage MA
R: Lantis

▽ GIVE PATIENT'S CHART TO MEDICAL RECORDS △

A: Triage MA

Parameters:
in: Patient's Chart

▽ PRINT PATIENT'S CLINICAL SUMMARY △

A: Triage MA
R: CIS

Parameters:
out: Clinical Summary

▽ PLACE DOCUMENTS IN PHARM. TRAY △

A: Triage MA
Parameters
in: Rx Plan
    Clinical Summary

APPENDIX B
Figure 14: Pharmacy Tasks

▽ PHARMACY TASKS △

VERIFY Rx PLAN AND ORDERS

A: Pharmacist

Parameters:
in: Rx Plan
    Orders

▽ SIGN Rx PLAN △

A: Pharmacist

Parameters:
in: Rx Plan

▽ MAKE A COPY OF ORDERS AND SIGNED RX PLAN △

A: Pharmacist

Parameters:
in: Orders
    RX Plan
out: Copy of Orders
     Copy of RX Plan

▽ FILE A COPY OF ORDERS IN "ACTIVE TREATMENT FILE" STORAGE △

A: Pharmacist

Parameters:
in: Copy of Orders

▽ DROP RX PLAN, ORDERS AND PATIENT'S CHART IN OUT BASKET △

A: Pharmacist

Parameters:
in: Rx plan
    Orders
    Patient's Chart

REPORT FOR MEDICAL ADVOCACY

REPORT FOR PHARMACIST'S ADMINISTRATIVE ADVOCACY

APPENDIX B
Figure 15: Verify Treatment Plan and Orders

VERIFY Rx PLAN AND ORDERS

VERIFY Rx PLAN AND ORDERS ARE COMPLETE

```
A: Pharmacist
Parameters:
in: Rx Plan
    Orders
PRE: 'Chemo orders present'
xHandler: 'NOTIFY MD TEAM
OF MISSING ORDERS'
```

NOTIFY MD TEAM OF MISSING ORDERS

NOTIFY MD THAT COUNTS ARE TOO LOW

NOTIFY MD TEAM OF DRUGS INAPPROPRIATE FOR DIAGNOSIS

VERIFY DRUGS IN Rx PLAN APPROPRIATE FOR DIAGNOSIS

```
A: Pharmacist

Parameters:
in: Rx Plan
Exception:
DrugsInappropriateForDiagnosis
```

VERIFY BSA CALCULATION

```
** This subprocess recalculates
the BSA to make sure it's correct. **

Parameters:
in: Orders
```

REVIEW LAB INFO & COUNTS IN CIS

```
A: Pharmacist
R: CIS

Exception:
CountsTooLow
```

PHARMACIST'S VERIFY ORDERS

```
** This subprocess reviews the orders
written, and looks at additional
resources if a careset was not used to
generate the orders. **

Parameters:
in: Orders
```

Figure 16: Verify BSA Calculation

VERIFY BSA CALCULATION

REPORT FOR MEDICAL ADVOCACY

GET HISTORY OF PATIENT HEIGHTS AND WEIGHTS

```
A: Pharmacist
R: CIS

Parameters:
out: Heights
     Weights
```

NOTIFY MD BSA CALCULATIONS VARY >= 10%

VERIFY BSA CALCULATIONS VARY < 10%

```
A: Pharmacist
R: CIS
E: 'BSACalculationVariesTooMuch'

Parameters:
in: New BSA
    Old BSA - ?WHERE DOES THIS COME FROM? ORDERS?
```

VERIFY HEIGHTS & WEIGHTS HAVE NOT CHANGED SIGNIFICANTLY

```
Grandparent step
has an agent-specific
exception handler
```

VERIFY HEIGHTS VARY < 3.2 CM

```
A: Pharmacist

Parameters:
in: Height

Exception:
HeightAndOrWeight
VaryTooMuch
```

RECALCULATE BSA USING MOST RECENT HEIGHT & WEIGHT

VERIFY WEIGHTS VARY < 10% KG

```
A: Pharmacist

Parameters:
in: Weight

Exception:
HeightAndOrWeight
VaryTooMuch
```

RECALCULATE BSA USING CALCULATOR IN CIS

```
A: Pharmacist
R: CIS

Parameters:
in:  Most Recent Height
     Most Recent Weight
out: New BSA
```

RECALCULATE BSA BY HAND

```
A: Pharmacist
Parameters:
in:  Most recent weight
     Most recent height
out: New BSA
```

APPENDIX B
Figure 17: Pharmacist Verify Orders

▽ PHARMACIST'S VERIFY ORDERS △

▽ VERIFY ORDERS △

PRE: 'Orders were
generated from a careset'

Parameters:
in: Orders

▽ RESEARCH ORDERS △

REPORT FOR MEDICAL ADVOCACY

REPORT FOR PHARMACIST'S ADMINISTRATIVE ADVOCACY

▽ BECOME FAMILIAR WITH TREATMENT BASED ON ABSTRACT △

PRE: 'MD provided an abstract...'
Parameters:
in: Orders
    Abstract

▽ LOOK FOR AN ABSTRACT △

▽ MAKE AND FILE COPY OF ABSTRACT FOR SELF △

R: PubMed

▽ LOOK FOR RELATED TREATMENTS ON PUBMED △

R: PubMed

▽ CONTACT MD TEAM TO VERIFY ORDERS BASED ON INFO IN PUBMED △

R: MD Team

▽ BECOME FAMILIAR WITH TREATMENT BASED ON PUBMED DATA △ ▽ MAKE AND FILE COPY OF ABSTRACT FOR CHART △

R: PubMed   R: PubMed

---- (all steps) ----
    A: Pharmacist

APPENDIX B
Figure 18: Final Pre-Chemo Tasks

FINAL PRE-CHEMO TASKS

PERFORM CHEMO TEACHING WITH PATIENT

REQUEST WRITTEN PATIENT CONSENT

DECIDE WHETHER PORT IS NECESSARY

A: Nurse Practioner

E:'Patient doesn't give consent'
Get consent and proceed with teaching.

A: Nurse Practitioner

Figure 19: First Day of Chemo

APPENDIX B
Figure 20: First Day Chemo Nurse Tasks

FIRST DAY CHEMO NURSE TASKS

Questions:
1. Is Assigned Nurse = Chemo Nurse?
2. What is the clinical Summary for?

VERIFY PATIENT INFORMATION IN CIS

SIGN RX PLAN

A: Nurse Practioner
Parameters:
   in: Patient Chart

Questions:
1. What is needed
here?

ALLOCATE CHAIR/BED FOR PATIENT

A: Nurse Practitioner

Question:
1. Where does the
assigned chair info
reside?

Exceptions:
1. No chair/bed av

CONDUCT REVIEW OF SYSTEMS

A: Chemo Nurse
Resource:
   Patient

Questions:
1. What exceptions can
occur here?
2. What artifacts are
needed here?

START IV

A: Nurse Practitioner
Resource:
   Patient
Parameters:

Questions:
1. Any exceptions?
2. Can patient refuse
IV?

OBTAIN BLOOD SPECIMENS

A: Chemo Nurse
Resource:
   Patient
Parameters:
 out: Blood specimens
Questions:
1. Any exceptions?
2. Can patient refuse
blood draw?

BRING BLOOD SPECIMENS TO LAB

A: Nurse Practitioner
Resource:
   Lab

Parameters:
 in: Blood specimens

HANDLE BLOOD COUNTS

A: Nurse Practitioner
Paramaters:
   in: Lab Counts

RETRIEVE LAB RESULTS

A: Nurse Practitioner
Resources:
   CIS
Parameters:
 out: Blood Counts
Questions:
1. Any info needed here?
2. Any exceptions can occur?

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APPENDIX B
Figure 21: Verify Patient Information

▽ VERIFY PATIENT INFORMATION △

▽ CHECK HEIGHT AND WEIGHT CONSISTANCY △

▽ CHECK BSA △

▽ CHECK CHEMO DOSES △

What happens if any of these are inconsistent?

A: Nurse Practioner
Parameters:
   in: Patient Chart

Questions:
1. What is needed here?

Exceptions:
1. Height and weight are inconsistant.

A: Nurse Practioner
Parameters:
   in: Patient Chart

Questions:
1. What is needed here?
2. Is BSA recalculated? and then checked against the old one?

Exceptions:
1. BSA is inconsistant.

A: Nurse Practioner
Parameters:
   in: Patient Chart

Questions:
1. What is needed here?
2. How is it checked? Any calculations involved?

Exceptions:
1. Chemo Doses are inconsistant.

Figure 22: Retrieve Lab Results

RETRIEVE LAB RESULTS

CHECK CIS FOR LAB RESULTS

WAIT 15 MINUTES

```
A: Nurse Practitioner
Resources:
   Lab


Parameters:
 out: Lab counts
```

If results were not updated in
cis yet, check every 15 minutes.
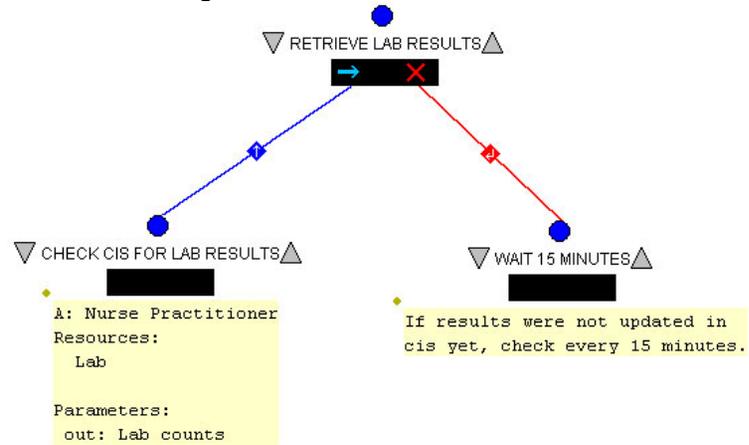
Figure 23: Conduct Review of Systems

CONDUCT REVIEW OF SYSTEMS

CHECK BLOOD PRESSURE

MEASURE HEIGHT & WEIGHT

CHECK VITAL SIGNS

CHECK RESPIRATION

CHECK PULSE
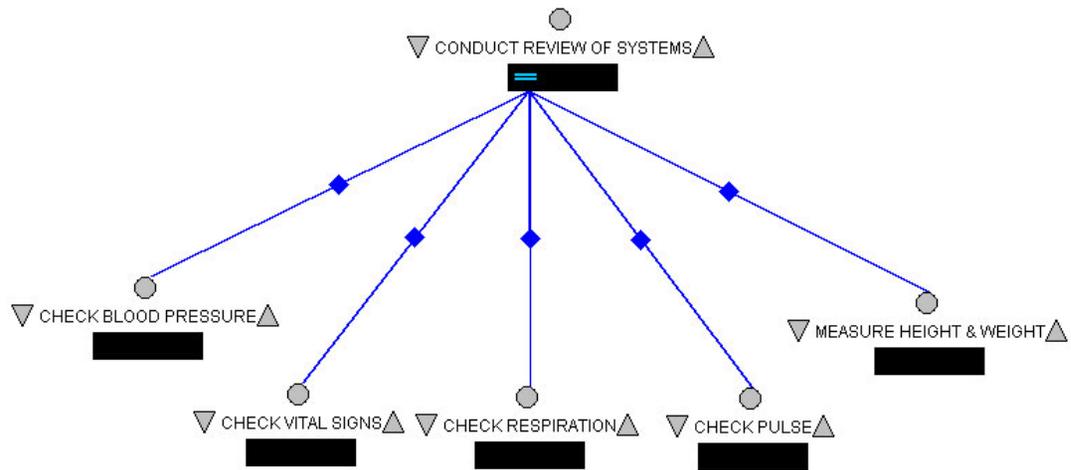
Figure 24: Allocate Chair/Bed for Patient
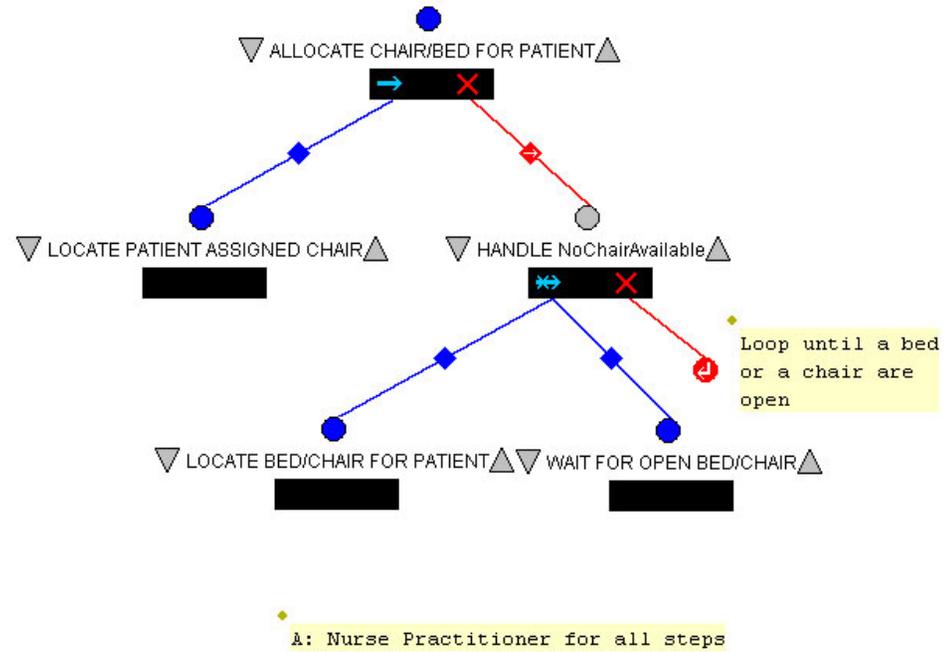
APPENDIX B
Figure 25: Handle Blood Counts

▽ HANDLE BLOOD COUNTS △

▽ CONFIRM BLOOD COUNTS OK △

A: Chemo Nurse
Parameters:
    in: Blood counts

▽ TELL PHARMACY TO MIX DRUGS △

A: Chemo Nurse
Parameters:
    in: dosages
    out: dosages

▽ NOTIFY MD THAT BLOOD COUNTS ARE NOT OK △

▽ MD OPTS TO USE THE SAME DOSAGES △

A: MD Team
Parameters:
    in: Blood counts

▽ MD OPTS TO REDUCE DOSAGES △

A: MD Team
Parameters:
    in: Blood counts
    out: new dosages

▽ MD OPTS TO GIVE NO CHEMO △

A: MD Team
Parameters:
    in: Blood counts

Should this throw
an exception that
is never caught, so
that the chemo
process will stop?

APPENDIX B
Figure 26: First Day Pharmacy Tasks
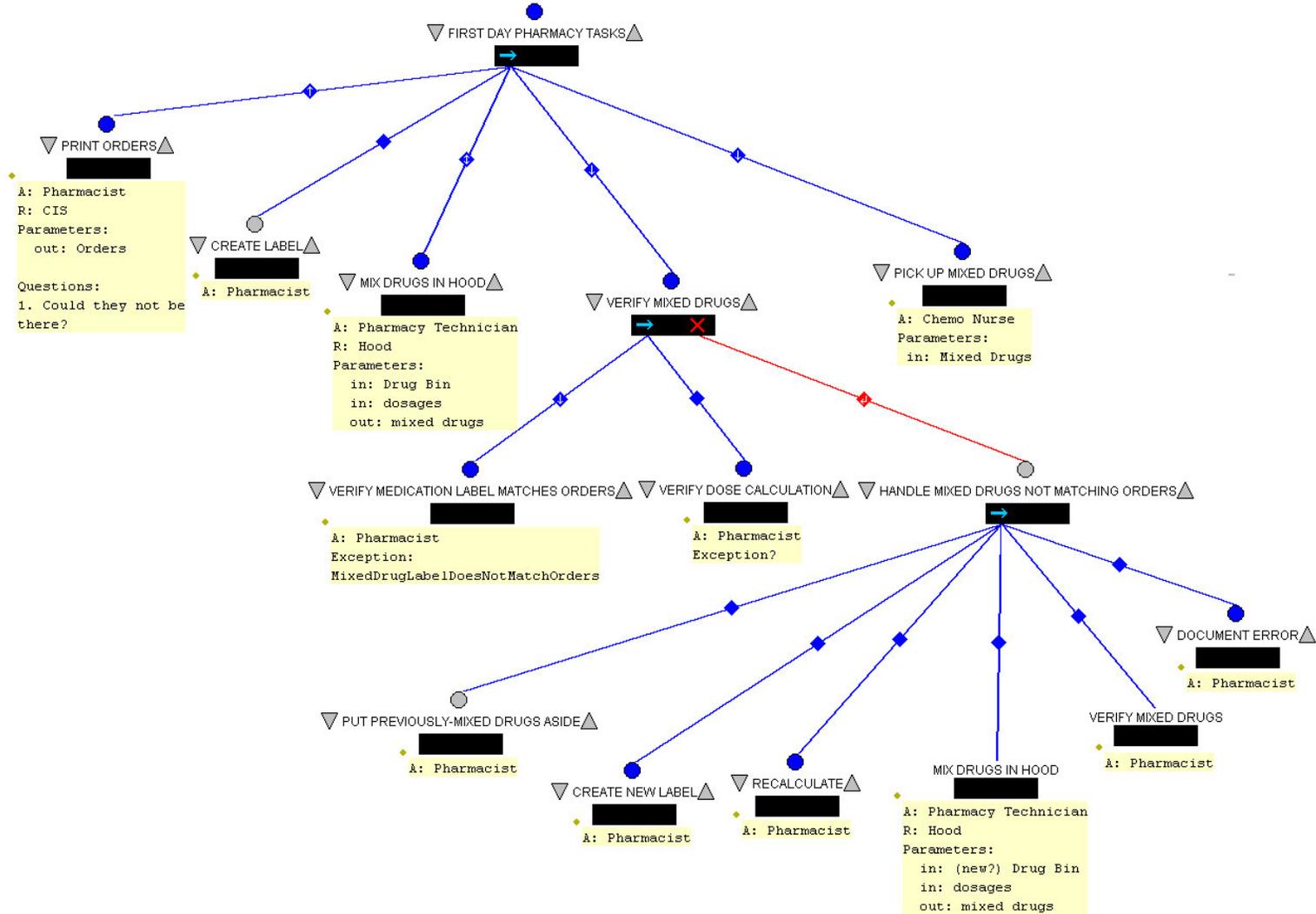
Glossary of terms known to date

Term	Definition	Sample Associated Verbs
Active Treatment File	Used by the pharmacist to maintain records of treatments in progress	file
Assigned RN	Nurse assigned to a particular patient.	notice, refer
Attending MD	A Resident staff oncologist at Baystate	sign, consult, contact, assess, send, calculate
Biopsy	The act of removing and examining of a sample of tissue from a living body for diagnostic purposes	verify, reevaluate
Blood count	A result obtainable from lab tests	verify
BSA	Body Surface Area - A value obtained using the patient's height and weight	calculate, verify
BOS	Business Office, in charge of handling patient's insurance coverage	give to, print for
Cancer diagnosis	-	confirm, verify, indicate, match, identify
Careset	A template generated and approved by Baystate Oncologists that outlines a standard treatments for particular cancer diagnosis.	
Checklist	A document maintained by the Triage MA in which he/she check of tasks as they are completed	
Chemotherapy	Frequently refers to : The treatment or the drugs.	administer, order
Chemotherapy drug	The drugs administered to the patient during a chemotherapy treatment	administer, enter, match
Chemotherapy drug dose	The quantity of chemotherapy drug used.	draw up, mix
Chemotherapy orders	A document containing chemotherapy drugs and doses per cycle with all the patient's treatment cycles	execute, validate, write, match
Chemotherapy nurse	A nurse certified in chemotherapy treatment and administration	
Computer system (CIS)	A central computer information system containing patient information, the treatment plan and orders. Has utilities used by the staff such as a BSA calculator	enter

Consent form	A contract signed by the patient giving consent to the chemotherapy treatment	sign
Cycle	1..n days of the administration of chemotherapy as prescribed by the MD Team	
Day of chemotherapy	administration of chemotherapy to a patient on a predefined date	
Error	An act, assertion, or belief that unintentionally deviates from what is correct, right, or true.	resolve, reveal, create
Fellow MD	An MD in training observing an Attending MD	enter
Hood	A device used by a pharmacy technician to mix chemotherapy drugs	mix
Medication	Pharmacist prepares this, it is not the same as chemotherapy drugs. There are other drugs involved in the process of administering chemotherapy.	prepare
Orders	same as chemotherapy orders	-
Pathology report	a description of cells and tissues made by a pathologist based on microscopic evidence, and sometimes used to make a diagnosis of a disease	create, review, indicate
Patient	The individual undergoing chemotherapy treatment	treat, assess, book
Patient chart	A document containing patient records related to their treatment	be in
Patient height		verify
Patient lab work, lab results		review, check, access
Pharmacy	A department in charge of handling the chemotherapy drugs	create, draw up, mix, calculate, co-sign, verify
Port	A device installed onto the patient to allow easier access to the blood flow	install
Pre-treatment medication	Medication that is often given to the patient to ease the side effects of chemotherapy	assess
Review of systems	An examination of the patient that includes checking the blood pressure, vital signs, respiration, pulse and height and weight.	
Stale-record flag	A flag indicating that a record is too old to be used.	set, check?

Teaching / Teaching appointment	A session held with the patient in which information about the treatment is provided and a consent is requested	take place
Treat patient	Any medical intervention performed on a patient	
Treatment plan	A document containing patient information and outlining their condition and corresponding treatment.	create, sign, co-sign, exist, enter, send, receive, validate, match, follow, be in
Triage MA	Triage Medical Assistant	book, receive
Triage RN	Triage Registered Nurse	validate, contact, calculate