Visualizing Medical Processes
DREU 2011 Final Report

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I. Introduction

Preventable medical errors lead to around 98,000 patient deaths in the US each year [1]. These errors are not the result of individual failures; rather, they are caused by inherent complexities in the system [2], such as patient handoffs between shifts, synchronization between multiple agents, multi-tasking, and concurrency.

The LASER Lab realized that process definition and execution and software verification and analysis could be applied in the medical domain. So far, researchers in the LASER Lab have collaborated with medical professionals from Baystate Medical Center and the nursing school at the University of Massachusetts in Amherst to define three medical processes as specific case studies: a blood transfusion process, a chemotherapy process, and the process for evaluating and diagnosing a patient upon arrival in the ER. Creating definitions for these processes in Little-JIL has revealed unexpected complexities and subtleties in the processes. For example, there are many exceptional cases (ex. a patient losing consciousness during a blood transfusion) that must be handled in the process definition. Once a process has been defined, static analysis tools like PROPEL and FLAVERS (software developed in the LASER Lab) are used to detect errors, vulnerabilities, and inefficiencies in the processes.

The next step is process guidance, which requires knowledge of an agent's progression through the process. Research in the medical domain has shown that even a simple checklist can reduce the likelihood of medical errors [3]; however, checklists have not been widely adopted, because they add a cumbersome extra step without providing any other benefits. We propose an interactive visualization of the process that displays the steps that can currently be completed and allows agents to indicate when they have finished a step.

The goal for my DREU project was to create mockups of a user interface for executing a medical process that could be automatically generated from a process definition. I concentrated on creating mockups of the blood transfusion process, but the design could be applied to any process designed in

Little-JIL. This will help guide doctors and nurses through complicated processes, hopefully reducing the likelihood of errors. In order for process guidance to become accepted by medical professionals, it is vital that it is not burdensome to use (i.e. generally requires as few clicks as possible) and that it provides an incentive beyond mere guidance (ex. automatically produces documentation that would otherwise have to be completed manually).

II. Background

Outside of the LASER Lab, most work in process guidance has been related to software development processes. Boehm, et al., for instance, published work on using Electronic Process Guides (EPGs) to create and model software development processes. Avrunin, et al. also published a related paper in 2010, *Supporting Human-Intensive Systems*.

Since the process visualization should be generated from a process defined in Little-JIL, a high level overview of the language is helpful for understanding the decisions. A Little-JIL process definition precisely captures a process for performing a particular task. The process consists of a hierarchical decomposition of steps where each step represents a subtask to be performed by a particular agent. A non-leaf step specifies the sequencing of its children steps. Sequencing can be sequential (perform children steps in order from left to right), parallel (perform children steps in any order or at the same time), choice (perform any combination of the children steps in any order), or try (perform children steps sequentially from left to right until one succeeds). Agents execute leaf steps. A step is declared once but may be referenced multiple times. Resources and artifacts can also be specified for specific steps. Additionally, a step may throw exceptions. The exceptions are then propagated through the step hierarchy and another step may catch one or more exceptions, handle them, and specify where the control proceeds.

Part of the Little-JIL process for a blood transfusion is shown in Figure 1. The blood transfusion process involves performing an in-patient blood transfusion, which requires an agent to carry out the physician's order for transfusion. The step "carry out physician order for blood transfusion" has several sequential substeps. The steps "check for existence of type and screen," "prepare documentation for blood pick-up," "pick up blood from blood bank," "perform transfusion," and "perform follow through check" must be done in order (i.e., from left to right). Several of these steps are non-leaf steps and can be decomposed into even more steps.
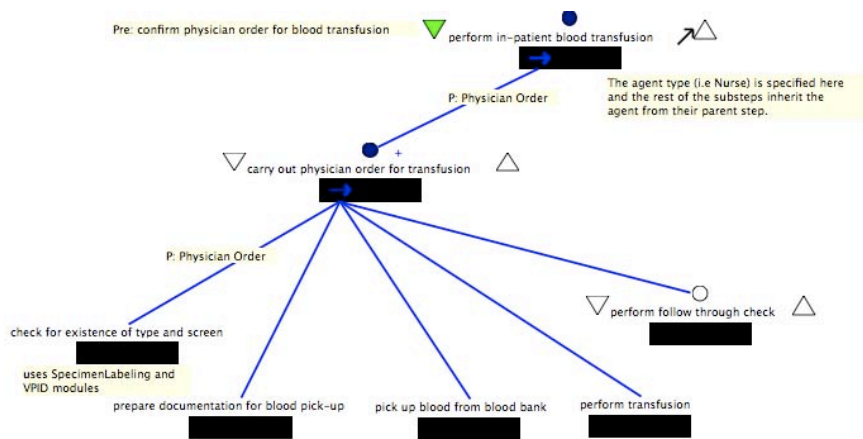
Figure 1: Little-JIL Definition of the Blood Transfusion Process

A previous undergraduate researcher in the LASER Lab, Mario Barrenechea, started work on this project as his senior capstone project during the past academic year (2010-2011). His main contributions were a prospective/introspective/retrospective view of the process that enables agents to easily see past, present, and future steps and a hierarchical view of the process that allows users to maximize and minimize parent steps in the process in order to get a high-level overview or a detailed view of the process.

It has not yet been definitively decided how this process guidance will be realized. Computers could be placed next to each patient's bed, contained in a central location or wheeled from room to room on carts, or medical professionals could carry handheld tablets with them. Baystate Medical Center's Emergency Room currently has most computers in a central location and several computers on carts, but adjusting this (and purchasing new machines) would be a relatively low cost. The mockups I have created are relatively general, but some future decisions will need to be determined with this in mind.

The mockups in this paper were created using the Mockingbird UI Mockup Tool (www.gomockingbird.com).

III. My Work in Process Guidance

1. **Full Scenario:** I begin by presenting a full walkthrough scenario of the blood transfusion process. Although this was a culminating product of my work this summer, it serves as a good introduction to the overall look, basic elements, and other aspects of the visualization. The full scenario was especially useful as a demonstration for medical professionals who preferred to "paint a picture" of how process guidance would work. The following figures show the execution of the process sequentially. In some instances, there are parallel steps that could be executed in any order; however, I only show one possible trace through the process.

   Screenshots from the mockup of the full scenario walkthrough are labeled "Full Scenario 1" through "Full Scenario 35." In each screenshot, a mouse icon hovers above the region that would be clicked to advance to the next screenshot that is shown. Explanations of various elements from the mockup follow the screenshots.

Full Scenario 1:

- A **patient's information** must always be visible on the screen. We choose to display a patient's name in a very large font, since proper patient identification is incredibly important, and incorrect patient identification is a major cause of medical errors. We also include a link to the patient's electronic medical record so that doctors and nurses can quickly review the patient's history. Although a patient's picture can be useful in helping identify them in some medical settings, like general practitioners offices and nursing homes, it is not necessarily useful in other settings, like emergency rooms where patients might not appear as they do in a picture. Since screen space is

limited, we allow the patient's information to be minimized so that only essential information is visible. We have gotten some feedback from medical professionals about what types of information should be included in the maximized and minimized information, but further consultation should be done before implementation. For example, we have been told that medical record number, birth date, and gender should always be visible, and that patient names should always appear in the "last name, first name middle initial" format. The minimized version of a sample patient's information is shown in Figure 2.
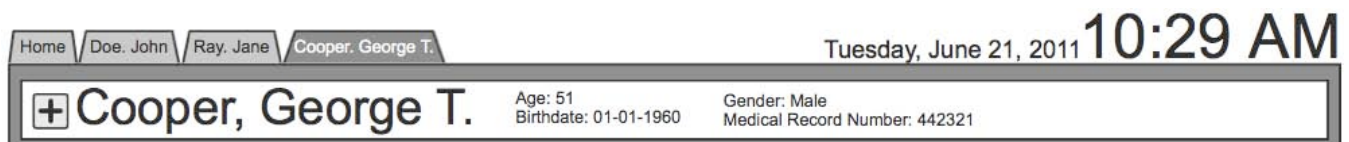
Figure 2: Minimized version of a sample patient's information

- Tabs allow the user to switch between **multiple patients**, since medical professionals are generally working on many patients at once. A popup box, like the one shown in Figure 3, ensures that users never unintentionally or unknowingly switch patients. This was added at the request of medical professionals. Since most people find popup boxes very annoying, other options could be explored, but it is vital that it is not possible to accidentally switch between patients.
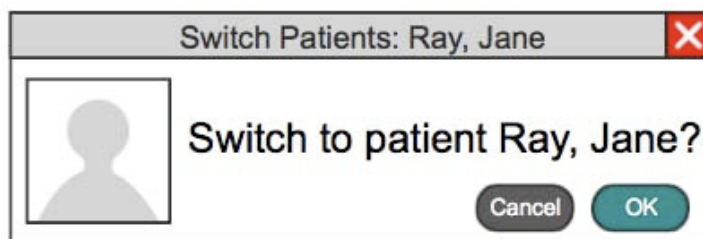
Figure 3: Popup Box prevents accidentally switching between patients

- Tabs are also used to show **multiple processes per patient**. It might sometimes be useful to actually show multiple processes at once. Although I did not have time to create a mockup of this, one option would be to allow multiple tabs to be open at once and show the processes side-by-side. For example, if two tabs are open, each tab could be allotted half of the screen horizontally.
- **Font sizes** are relatively large and should be adjustable since many nurses are older.
- Some **steps** from the Little-JIL process definition are **not shown** in the visualization, so this doesn't exactly reflect the current Little-JIL process. This change was a response to feedback about some of

the top-level steps that could be left out. For example, the top-level step in the blood transfusion process is "perform in-patient blood transfusion" and its only child step is "carry out physician order for transfusion." Often steps are included only for control flow, and this is not necessarily how medical professionals think about the processes. Some lower level steps are also probably also too detailed, but knowing which steps should or shouldn't be shown requires intimate knowledge of the process. It might be useful to have an indicator in each Little-JIL step as to whether or not it should be shown in the visualization. In some cases, it might make sense to link to a full description of a step whose lower-level details are not elaborated. For example, the step "assess patient" is something most doctors know how to do without needing to see all of its children steps, but novices might find a description of the sub step useful. Other minor changes to the Little-JIL process might also be necessary, to ensure that the language in the process matches the language used by medical professionals.

- Parent steps **encapsulate** their children steps, and steps in a process can be **maximized** to show more detail or **minimized** for a high-level overview of the process.

- **Future** process steps have not yet been completed and cannot yet be started. They are shown in dark grey and give a prospective view of the process.

- **Sequential** steps are stacked vertically, as seen with the steps "Check Existence of Type and Screen" and "Prepare Documentation for Blood Pick-up."

- **Pre- and Post-Requisites:** Steps in a Little-JIL process can have pre- and post- requisites. A pre-requisite is represented like a sequential step directly before the step it is a pre-requisite for. Post-requisites are added as a final sequential child step inside of the step that they are a post-requisite for. A small note that this is a pre-requisite is shown beneath the step label. "Confirm Physician Order for Blood Transfusion" is a pre-requisite step for the Blood Transfusion process.

- Clicking the bright green **start** button starts the process. The start button is also used to indicate when a non-leaf sub step is started. It might be useful to start some leaf steps, but I did not consider this in my mockup.

- Hospitals use military **time**, and the time and date are displayed prominently on the screen.

- A vertical **scroll bar** allows users to scroll to past and future steps in the process while keeping the patient's information on the screen. Since the scroll bar in the mockup is not actually functional, I have simply adjusted the size of the actual mockup. In the real implementation, automatic scrolling would keep the current (available) steps visible at the top of the screen.

Full Scenario 2:

- **Available** steps and **current** steps are shown in green. A lighter shade of green is used for maximized parent steps

- Sometimes an action associated with an event makes it clear when an event is done, but sometimes there is no overt action and, in this case, the user has to explicitly let us know that they believe the task is done. A blue **done** button is used to indicate when a process step has been completed. In my mockups, and in general, a parent step has been completed when all of its children steps have been completed; however, some parent steps should have a done button to indicate their actual completion.

Full Scenario 3:

- **Completed** steps are shown in a light grey color that blends in with the background. Start time and completion time are recorded and displayed on the left of the process step for future documentation purposes. This provides a retrospective view of the process (history). The accumulation of completed steps in the process view serves as the main view of history. We also propose a "timeline view" of history that would be a less graphical, more succinct, view of what has been done so far (but I did not have time to mock this up).
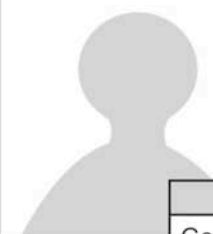
Full Scenario 4:

- In order to make this system as useful as possible for medical professionals, we propose **integration with other medical systems** and allowing users to complete **electronic documentation**. Links to important documents and forms are available directly in the process step. For example, steps that require documentation contain a link to the form that must be completed.

Full Scenario 5:

- Some electronic documentation information can be filled in automatically; other information must be completed by the agent. To ensure compatibility with non-electronic systems, we provide options for users to print forms or submit them electronically.

Full Scenario 6:

Home | Doe. John | Ray. Jane | Cooper. George T.

Tuesday, June 21, 2011 10:29

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

Confirmed 10:25 — Confirm Physician Order for Blood Transfusion
(Precondition)

Completed 10:30 — Check for Existence of Type and Screen
Contact Lab for Availability of Type and Screen

Documentation Printed 10:37 — Prepare Documentation for Blood Pick-up — Electronic Documentation — Done

＋ Pick up Blood from Blood Bank

－ Perform Transfusion - Administer a Single Unit of Blood Product

＋ Perform Pre-Infusion Work

＋ Infuse Unit of Blood Product

＋ Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 7:

- Medical processes are often carried out by multiple performers. When a step is **blocked** because another medical performer must first complete a task, that performer's progress is shown so that the waiting performer can track progress. Blocked steps are shown in purple and do not contain start or done buttons. Smaller text in the step indicates that the step is being completed by someone else. Final feedback indicated that it is important to know whether another agent has been assigned to complete those sub steps yet and, if so, who.

Full Scenario 8:

- Currently, all completed steps are shown the same way, but it would be beneficial to indicate if steps were completed by another agent.

Full Scenario 9:

Home | Doe. John | Ray. Jane | Cooper. George T.

Tuesday, June 21, 2011 10:29

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion (Precondition) | |

| Completed 10:30 | Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

[+] Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

[−] Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

[−] Perform Pre-Infusion Work

[+] Assess Patient — **Start**

Confirm Presence of IV Catheter

Gather Infusion Materials — See List of Infusion Materials

[+] Perform Bedside Checks

[+] Infuse Unit of Blood Product

[+] Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 10:

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

(View Medical Record)

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion (Precondition) | |

| Completed 10:30 | Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

[+] Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

[−] Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

[−] Perform Pre-Infusion Work

[+] Assess Patient   (Start)

Confirm Presence of IV Catheter

Gather Infusion Materials   See List of Infusion Materials

[+] Perform Bedside Checks

[+] Infuse Unit of Blood Product

[+] Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 11:

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

[View Medical Record]

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion (Precondition) | |

| Completed 10:30 | Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

[+] Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

[−] Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46

  [−] Perform Pre-Infusion Work
  Started 10:46

    [−] Assess Patient
    Started 10:46

| Review Patient History | View Patient History | Done |

    [+] Evaluate Patient Clinically

  Confirm Presence of IV Catheter

| Gather Infusion Materials | See List of Infusion Materials |

  [+] Perform Bedside Checks

[+] Infuse Unit of Blood Product

[+] Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 12:

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion (Precondition) | |

| Completed 10:30 | Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

+ Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

− Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

  − Perform Pre-Infusion Work

  Started 10:46

    − Assess Patient

    Started 10:46

| Completed 10:47 | Review Patient History | View Patient History |

+ Evaluate Patient Clinically **Start**

Confirm Presence of IV Catheter

| Gather Infusion Materials | See List of Infusion Materials |

+ Perform Bedside Checks

+ Infuse Unit of Blood Product

+ Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 13:

Home | Doe. John | Ray. Jane | Cooper. George T.

Tuesday, June 21, 2011 10:29

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

(View Medical Record)

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion (Precondition) | |

| Completed 10:30 | Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

[+] Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

[−] Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46

  [−] Perform Pre-Infusion Work
  Started 10:46

    [−] Assess Patient
    Started 10:46

| Completed 10:47 | Review Patient History | View Patient History |

    [−] Evaluate Patient Clinically
    Started 10:48

[+] Check Vital Signs **Start** | Perform Clinical Evaluation **Done**

Confirm Presence of IV Catheter

| Gather Infusion Materials | See List of Infusion Materials |

[+] Perform Bedside Checks

[+] Infuse Unit of Blood Product

[+] Perform Post-Infusion Work

Perform Follow Through Check

- **Parallel** steps are shown side by side horizontally. It was pointed out that this representation is confusing since one step has sub steps and a start button and the other is a leaf step with a done button. It might be useful to automatically maximize the non-leaf step.

Full Scenario 14:

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion (Precondition) | |

| Completed 10:30 | Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

+ Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

— Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

— Perform Pre-Infusion Work

Started 10:46

— Assess Patient

Started 10:46

| Completed 10:47 | Review Patient History | View Patient History |

— Evaluate Patient Clinically

Started 10:48

| + Check Vital Signs | St | | Completed 11:00 | Perform Clinical Evaluation |

Confirm Presence of IV Catheter

| Gather Infusion Materials | See List of Infusion Materials |

+ Perform Bedside Checks

+ Infuse Unit of Blood Product

+ Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 15:

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

(View Medical Record)

Blood Transfusion

Started 10:24

Confirmed 10:25	Confirm Physician Order for Blood Transfusion (Precondition)
Completed 10:30	Check for Existence of Type and Screen — Contact Lab for Availability of Type and Screen
Documentation Printed 10:37 / Completed 10:38	Prepare Documentation for Blood Pick-up — Review Electronic Documentation

[+] Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

[–] Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46

  [–] Perform Pre-Infusion Work
  Started 10:46

    [–] Assess Patient
    Started 10:46

Completed 10:47	Review Patient History	View Patient History

      [–] Evaluate Patient Clinically
      Started 10:48

        [–] Check Vital Signs
        Started 11:01

          (Obtain Vital Signs) (Done)

          (Document Vital Signs)

        Completed 11:00 — Perform Clinical Evaluation

  Confirm Presence of IV Catheter

  Gather Infusion Materials — See List of Infusion Materials

  [+] Perform Bedside Checks

[+] Infuse Unit of Blood Product

[+] Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 16:

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

(View Medical Record)

Blood Transfusion

Started 10:24

Confirmed 10:25	Confirm Physician Order for Blood Transfusion (Precondition)
Completed 10:30	Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen
Documentation Printed 10:37 Completed 10:38	Prepare Documentation for Blood Pick-up — Review Electronic Documentation

[+] Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

[–] Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46

[–] Perform Pre-Infusion Work
Started 10:46

[–] Assess Patient
Started 10:46

Completed 10:47	Review Patient History	View Patient History

[–] Evaluate Patient Clinically
Started 10:48

[–] Check Vital Signs
Started 11:01

Completed 11:05	Obtain Vital Signs

Completed 11:00	Perform Clinical Evaluation

Document Vital Signs | **Done**

Confirm Presence of IV Catheter

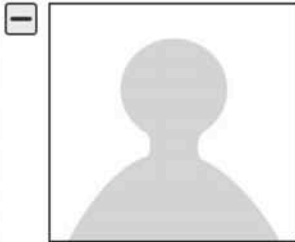Gather Infusion Materials — See List of Infusion Materials

[+] Perform Bedside Checks

[+] Infuse Unit of Blood Product

[+] Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 17:

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

Confirmed 10:25	Confirm Physician Order for Blood Transfusion *(Precondition)*

Completed 10:30	Check for Existence of Type and Screen *Contact Lab for Availability of Type and Screen*

Documentation Printed 10:37 Completed 10:38	Prepare Documentation for Blood Pick-up	Review Electronic Documentation

Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

Perform Pre-Infusion Work

Started 10:48

Assess Patient

Started 10:48
Completed 11:05

Confirm Presence of IV Catheter	Done

Gather Infusion Materials	See List of Infusion Materials

Perform Bedside Checks

Infuse Unit of Blood Product

Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 18:

Tuesday, June 21, 2011 10:29

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

[View Medical Record]

Blood Transfusion

Started 10:24

Confirmed 10:25	Confirm Physician Order for Blood Transfusion (Precondition)
Completed 10:30	Check for Existence of Type and Screen — Contact Lab for Availability of Type and Screen
Documentation Printed 10:37 Completed 10:38	Prepare Documentation for Blood Pick-up — Review Electronic Documentation

[+] Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

[−] Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

[−] Perform Pre-Infusion Work

Started 10:48

[+] Assess Patient
Started 10:48
Completed 11:05

Completed 11:15 — Confirm Presence of IV Catheter

Gather Infusion Materials — See List of Infusion Materials — **Done**

[+] Perform Bedside Checks

[+] Infuse Unit of Blood Product

[+] Perform Post-Infusion Work

Perform Follow Through Check

- It makes sense to link to a list of required resources in the process step "Gather Infusion Materials." Feedback from medical professionals, however, suggests that this may be an extraneous step in the process (since it is impossible to perform the transfusion without gathering materials, and nurses generally gather materials much earlier in the process). Instead, it might be helpful to have a link to required resources at the beginning of the process (or somewhere in the visualization outside of process steps). Also, physical resources (like infusion materials) are not the only resources that should be shown. It would also be helpful to show human resources that will be needed. For example, some processes require that two nurses perform some steps, so it would be good to know in advance that someone else needs to be around (so that the process isn't started right as everyone is, for example, leaving for lunch).

Full Scenario 19:

Home | Doe. John | Ray. Jane | Cooper. George T.

Tuesday, June 21, 2011 10:29

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

Confirmed 10:25 — Confirm Physician Order for Blood Transfusion *(Precondition)*

Completed 10:30 — Check for Existence of Type and Screen *Contact Lab for Availability of Type and Screen*

Documentation Printed 10:37 / Completed 10:38 — Prepare Documentation for Blood Pick-up — Review Electronic Documentation

Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46

Perform Pre-Infusion Work
Started 10:48

Assess Patient
Started 10:48
Completed 11:05

Completed 11:15 — Confirm Presence of IV Catheter

Completed 11:25 — Gather Infusion Materials — See List of Infusion Materials

Perform Bedside Checks — Start

Infuse Unit of Blood Product

Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 20:

Home | Doe. John | Ray. Jane | Cooper. George T.

Tuesday, June 21, 2011 10:29

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

(View Medical Record)

Blood Transfusion

Started 10:24

Confirmed 10:25 | Confirm Physician Order for Blood Transfusion
(Precondition)

Completed 10:30 | Check for Existence of Type and Screen
Contact Lab for Availability of Type and Screen

Documentation Printed 10:37
Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation

[+] Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

[−] Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46

[−] Perform Pre-Infusion Work
Started 10:48

[+] Assess Patient
Started 10:48
Completed 11:05

Completed 11:15 | Confirm Presence of IV Catheter

Completed 11:25 | Gather Infusion Materials | See List of Infusion Materials

[−] Perform Bedside Checks

Verify Patient ID to ID Band | Done

[−] Verify Blood Product Information

[+] Infuse Unit of Blood Product

[+] Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 21:

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

| Confirmed 10:25 | **Confirm Physician Order for Blood Transfusion**
(Precondition) | |

| Completed 10:30 | **Check for Existence of Type and Screen**
Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37
Completed 10:38 | **Prepare Documentation for Blood Pick-up** | *Review Electronic Documentation* |

+ Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

− Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

− Perform Pre-Infusion Work

Started 10:48

+ Assess Patient

Started 10:48
Completed 11:05

| Completed 11:15 | **Confirm Presence of IV Catheter** | |

| Completed 11:25 | **Gather Infusion Materials** | *See List of Infusion Materials* |

− Perform Bedside Checks

| Completed 11:26 | Verify Patient ID to ID Band | |

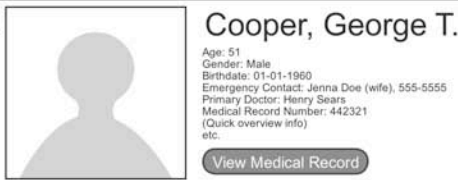| **− Verify Blood Product Information** | | **Start** |

+ Infuse Unit of Blood Product

+ Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 22:

Home | Doe. John | Ray. Jane | Cooper. George T.

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion |
| | (Precondition) |

| Completed 10:30 | Check for Existence of Type and Screen |
| | Contact Lab for Availability of Type and Screen |

| Documentation Printed 10:37 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |
| Completed 10:38 | | |

Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

Perform Pre-Infusion Work

Started 10:48

Assess Patient

Started 10:48
Completed 11:05

| Completed 11:15 | Confirm Presence of IV Catheter |

| Completed 11:25 | Gather Infusion Materials | See List of Infusion Materials |

Perform Bedside Checks

| Completed 11:26 | Verify Patient ID to ID Band |

Verify Blood Product Information

Started 11:27

Check Product Expiration Date & Time

Check Blood Product by 2 Nurses

Confirm Match
Product Type, Patient Record (how to abbrev?)

Confirm Product Tag Matches ID Band

Read Patient First and Last Names from ID Band

Listen & Confirm Patient First and Last Names Match Product Tag

Read Medical Record Number from ID Band

Listen & Confirm Medical Record Number Matches that on Product Tag

Confirm Product Label Matches Product Tag

Read Donor Unit Number from Product Tag

Listen & Confirm Donor Unit Number Matches that on Product Label

Read Blood Type from Product Tag

Listen & Confirm Blood Type Matches that on Product Label

Infuse Unit of Blood Product

Perform Post-Infusion Work

Perform Follow Through Check

- We realized that the current representation for parallel steps becomes cluttered when there are too many steps in parallel (columns become too skinny) or when one of the parallel steps becomes too "deep" (has many children steps) as seen in this screenshot. Alternatives that were considered include:
    o showing parallel steps sequentially and relying on color to indicate that steps can be done in parallel.
    o "stacking" parallel steps so that only one or two are visible at once, but it is clear that others are available.
    o using a horizontal scroll bar inside the parent step.

In the end, we decided that the current representation is still the best. We think that adjustable-width columns would be the best solution.

Full Scenario 23:

Full Scenario 24:

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

Confirmed 10:25	Confirm Physician Order for Blood Transfusion (Precondition)	
Completed 10:30	Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen	
Documentation Printed 10:37 Completed 10:38	Prepare Documentation for Blood Pick-up	Review Electronic Documentation

Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

Perform Pre-Infusion Work

Started 10:48
Completed 11:27

Infuse Unit of Blood Product

Started 11:35

Begin Infusion of Blood Product — Done

Check Patient at 15 mins
(here's where a timer would be useful)

Perform Post-Infusion Work

Perform Follow Through Check

Full Scenario 25:

- The parent step "Infuse Unit of Blood Product" is an example of a parent step that requires a done button, since it has not been completed when its last child step "Check Patient at 15 mins" has been completed.

Full Scenario 26:

Tuesday, June 21, 2011 10:29

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion |
| | (Precondition) |

| Completed 10:30 | Check for Existence of Type and Screen |
| | Contact Lab for Availability of Type and Screen |

| Documentation Printed 10:37 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |
| Completed 10:38 | | |

[+] Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

[−] Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

[+] Perform Pre-Infusion Work
Started 10:48
Completed 11:27

[+] Infuse Unit of Blood Product
Started 11:35
Completed 11:50

[+] Perform Post-Infusion Work   **Start**

Perform Follow Through Check

Full Scenario 27:

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion (Precondition) | |

| Completed 10:30 | Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

Pick up Blood from Blood Bank

Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

Perform Pre-Infusion Work

Started 10:48
Completed 11:27

Infuse Unit of Blood Product

Started 11:35
Completed 11:50

Perform Post-Infusion Work

Started 13:35

Evaluate Patient Clinically   Start

Record Infusion Information

Discard Infusion Materials

Perform Follow Through Check

Full Scenario 28:

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

[View Medical Record]

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion (Precondition) | |

| Completed 10:30 | Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen | |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

| [+] Pick up Blood from Blood Bank Started 10:40 Completed 10:45 | | |

Perform Transfusion - Administer a Single Unit of Blood Product
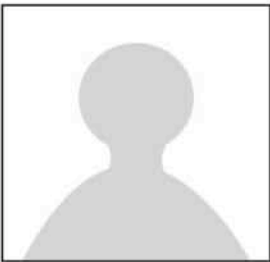
Started 10:46

| [+] Perform Pre-Infusion Work Started 10:48 Completed 11:27 | | |

| [+] Infuse Unit of Blood Product Started 11:35 Completed 11:50 | | |

Perform Post-Infusion Work

Started 13:35

Evaluate Patient Clinically

Started 13:36

| [+] | Check Vital Signs | Start | | Perform Clinical Evaluation | Done |

| Record Infusion Information |

| Discard Infusion Materials |

| Perform Follow Through Check |

Full Scenario 29:

Full Scenario 30:

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

Confirmed 10:25	Confirm Physician Order for Blood Transfusion (Precondition)	
Completed 10:30	Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen	
Documentation Printed 10:37 Completed 10:38	Prepare Documentation for Blood Pick-up	Review Electronic Documentation

Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

Perform Pre-Infusion Work
Started 10:48
Completed 11:27

Infuse Unit of Blood Product
Started 11:35
Completed 11:50

Perform Post-Infusion Work
Started 13:35

Evaluate Patient Clinically
Started 13:36

Check Vital Signs
Started 13:36

Completed 13:45   Obtain Vital Signs

Document Vital Signs   Done

Perform Clinical Evaluation   Done

Record Infusion Information

Discard Infusion Materials

Perform Follow Through Check

Full Scenario 31:

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

Confirmed 10:25 — Confirm Physician Order for Blood Transfusion
(Precondition)

Completed 10:30 — Check for Existence of Type and Screen
Contact Lab for Availability of Type and Screen

Documentation Printed 10:37
Completed 10:38 — Prepare Documentation for Blood Pick-up — Review Electronic Documentation

Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46

Perform Pre-Infusion Work
Started 10:48
Completed 11:27

Infuse Unit of Blood Product
Started 11:35   NOTE: this really takes more than 15 mins, left it this way for consistency. How to show when a parent step takes longer?
Completed 11:50

Perform Post-Infusion Work
Started 13:35

Evaluate Patient Clinically
Started 13:36

Check Vital Signs
Started 13:36

Completed 13:45   Obtain Vital Signs

Completed 14:00   Perform Clinical Evaluation

Document Vital Signs
(another chance to document electronically)   **Done**

Record Infusion Information

Discard Infusion Materials

Perform Follow Through Check

Full Scenario 32:

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

Confirmed 10:25 | **Confirm Physician Order for Blood Transfusion**
(Precondition)

Completed 10:30 | **Check for Existence of Type and Screen**
Contact Lab for Availability of Type and Screen

Documentation Printed 10:37
Completed 10:38 | **Prepare Documentation for Blood Pick-up** | *Review Electronic Documentation*

Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46

Perform Pre-Infusion Work
Started 10:48
Completed 11:27

Infuse Unit of Blood Product
Started 11:35
Completed 11:50

Perform Post-Infusion Work
Started 13:35

Evaluate Patient Clinically
Started 13:36
Completed 14:01

Record Infusion Information
(again, there should be a way to record electronically) | **Done**

Discard Infusion Materials

Perform Follow Through Check

Full Scenario 33:

Tuesday, June 21, 2011 10:29

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

| Confirmed 10:25 | Confirm Physician Order for Blood Transfusion |
| | (Precondition) |

| Completed 10:30 | Check for Existence of Type and Screen |
| | Contact Lab for Availability of Type and Screen |

| Documentation Printed 10:37 Completed 10:38 | Prepare Documentation for Blood Pick-up | Review Electronic Documentation |

Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product

Started 10:46

Perform Pre-Infusion Work
Started 10:48
Completed 11:27

Infuse Unit of Blood Product
Started 11:35
Completed 11:50

Perform Post-Infusion Work
Started 13:35

Evaluate Patient Clinically
Started 13:36
Completed 14:01

| Completed 14:07 | Record Infusion Information |
| | (again, there should be a way to record electronically) |

Discard Infusion Materials   Done

Perform Follow Through Check

Full Scenario 34:

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion

Started 10:24

Confirmed 10:25 — **Confirm Physician Order for Blood Transfusion**
(Precondition)

Completed 10:30 — **Check for Existence of Type and Screen**
Contact Lab for Availability of Type and Screen

Documentation Printed 10:37
Completed 10:38 — **Prepare Documentation for Blood Pick-up** — Review Electronic Documentation

Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46
Completed 14:16

Perform Follow Through Check — Done

Full Scenario 35:

Home | Doe. John | Ray. Jane | Cooper. George T.

Tuesday, June 21, 2011 **10:29**

Cooper, George T.

Age: 51
Gender: Male
Birthdate: 01-01-1960
Emergency Contact: Jenna Doe (wife), 555-5555
Primary Doctor: Henry Sears
Medical Record Number: 442321
(Quick overview info)
etc.

View Medical Record

Blood Transfusion | Chemotherapy

Started 10:24   Completed 14:34

Confirmed 10:25	Confirm Physician Order for Blood Transfusion (Precondition)
Completed 10:30	Check for Existence of Type and Screen Contact Lab for Availability of Type and Screen
Documentation Printed 10:37 Completed 10:38	Prepare Documentation for Blood Pick-up Review Electronic Documentation

[+] Pick up Blood from Blood Bank
Started 10:40
Completed 10:45

[+] Perform Transfusion - Administer a Single Unit of Blood Product
Started 10:46
Completed 14:16

Completed 14:34	Perform Follow Through Check

2. **Features Not Shown in the Full Scenario:** Some features of the process visualization were not shown in the full scenario. Many of these have not been fully decided, some are alternate ideas that we decided against, and many are features that I didn't have time to create mockups of.

- **Sending messages:** Communication is another major cause for medical errors and a huge problem in hospitals. An example from the nurse who collaborates with our lab group is that often blood is ordered by a physician and arrives without the nurse who is intended to administer the blood being aware of the order. In this case, the blood often has to be sent back or it goes bad before it can be used, since it can only sit out for 30 minutes. Currently, doctors and nurses communicate primarily through text messages, so it would be good to have the ability to send texts and email directly from the process. Sometimes messages pertain to a patient or to a particular step in the process. In this case, the patient's information (ex. medical record number) and the context should be included in the message. Initially, it seemed that certain steps in the process called for communication, like the step, "Contact Lab for Availability of Type and Screen," shown in Figure 4. However, this is not necessarily an instance of when an email message would be useful, but there are certainly many other instances when it would be useful to send a message. Ideally, given the context of the process, we can figure out what the body of the message should probably say and automatically generate an editable draft so that the nurse doesn't have to compose a full email. We have considered a "workspace" view rather than a button contained in the actual step. Another option is giving the current step more space, but both of these ideas need more work.
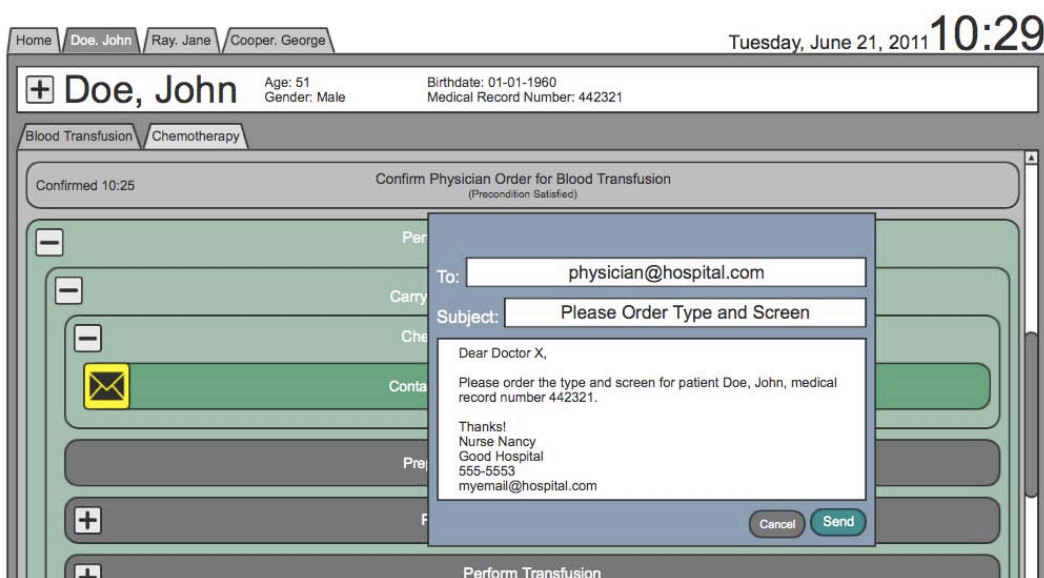
Figure 4: Preliminary vision of sending messages from the process visualization.

- **Exceptional Cases:** The mockups I created this summer do not consider exceptional behavior. How and where the user indicates that something exceptional has happened and how we show exception handling steps must still be decided. If we allow current steps to take up more space, the user could indicate that an exception has occurred in the actual step, or there could be some kind of drop-down menu in a central place in the process view that allows the user to select what exception has been thrown (from a list of possible exceptions that could be thrown, given the available steps). Other questions that must be answered concern the visualization of exceptions once they have been thrown. Does the exception block steps that were available? If the exception occurred in a parallel step, does it block all of the previously available steps or just some of them?
- **Timed steps:** Sometimes it is useful to start a timer when a step is started. In this case, it must be decided where the timer should go, whether it should count up or down (we think down), whether it should flash or beep to indicate that something needs to be done soon. There might also be an option to stop or disable the timer. It is important that it does not become annoying. Another issue that was pointed out during my final presentation was that often sub steps must be executed repeatedly. Showing the full sub process each time would become redundant, so other options need to be explored.
- A **novice and experienced version** of the user interface have been proposed. Novices would be shown low-level details that experienced users might find unnecessary.
- Mario mocked up other types of steps, such as **choice steps and try steps**; however, their representation will probably require more thought so that they fit in with the overall changes that have been made to the design.
- One proposal was to always show the **current step at the top** of the screen in a separate place from the rest of the process, but we think that showing the steps in context is very important.
- **Task lists:** Medical professionals already use task lists. It would be nice to have a view where all of the available steps for all of the patients are shown together, possibly alongside other tasks. It would be important to indicate clearly which steps correspond to which patients. It might also be useful to allow users to prioritize tasks.

IV. Conclusion and Future Work

Future work in medical process visualization involves finalizing remaining decisions about process guidance features. Next, the visualization must be implemented so that it can actually be generated from a Little-JIL process. A review of the blood transfusion process and subtle changes to the process also seem to be necessary. Finally, the LASER Lab plans to conduct experiments to let nurses evaluate how effective and useful our process guidance seems, and determine whether it actually reduces the number of medical errors made.

V. Works Cited

[1]   Kohn, Linda T., Janet M. Corrigan, and Molla S. Donaldson. "To Err is Human: Building a Safer Health System (Executive Summary)." (2000).

[2]   W. W. Stead and H. S. Lin, editors. *Computational Technology for Effective Health Care: Immediate Steps and Strategic Directions*. Nat. Acad. Press. 2009.

[3]   J. M. Wilkinson and K. V. Leuven. Procedure checklist for administering a blood transfusion. http://davidplus.fadavis.com/wilkinson/Procedure_Checklists/PC_Ch36-01.doc.