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HCI Project NASA Team
Mid-Semester Review

Introducing PROPHET

The next several decades will be critical to the future of NASA, and human space exploration as a whole. Currently, plans are being laid to ground the Space Shuttle fleet, and bring in a new phase of space research: Project Constellation. As part of this project, a movement underway at the NASA Ames HCI Group is aimed at preventing the catastrophic, high-profile failures of NASA's past by centralizing problem management in such a way that engineers and technicians from anywhere within NASA's network of departments and contractors can report hardware, software, and process problems through a handheld interface into a unified problem management system.

This system is known as PRACA and is currently under development. In order to allow engineers and technicians to quickly and easily report problems into this database, a handheld interface is required. The project to create this interface, under way at the Carnegie Mellon University HCII, is named PROPHET: Problem Reporting on PRACA Handhelds by Engineers and Technicians.

Mission Statement

Our goal is to create a well-designed handheld interface for front-line NASA technicians that will facilitate problem reporting and management, improving the safety and risk management for the Constellation Program, while proving compatible with NASA culture. The final product must be a functional prototype built to win the approval of end user witnesses by successfully demonstrating specifically-defined tasks chosen for their frequency and importance.

Focus Setting

One of the first tasks our team undertook was to undergo focus-setting, composing an affinity diagram that consolidated all the questions each of us had about the project in order to identify the fields of our research. The results of the focus-setting are listed below, in Figure 1.

Our fields fall into two essential foci: handhelds and problem reporting. We would later find that this division was appropriate, as our literature review found this to be the first major project intended to create a problem reporting system using handheld devices.

These disparate foci therefore have caused much of the research done thus far to fall either entirely under one classification or the other.

Certain points in the diagram require clarification, and are discussed below.

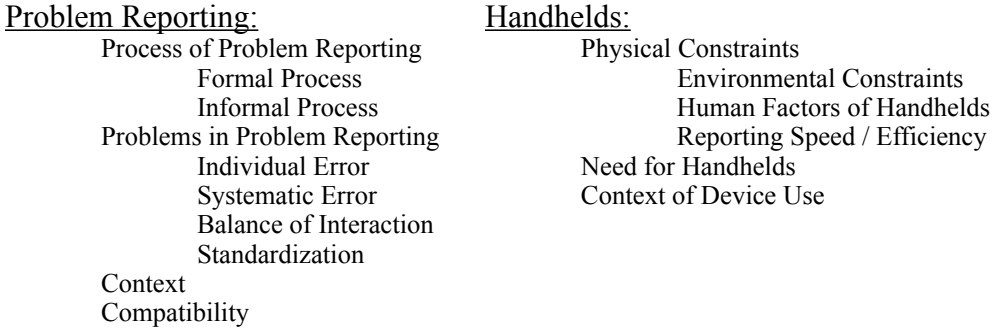

Figure 1: Dual foci that resulted from early focus-setting

First, the difference between Individual and Systematic Error is one largely of process. Individual error occurs because a single individual made a mistake or slip that caused or aggravated a breakdown; systematic error occurs when multiple individuals, doing their formally-assigned tasks, fail on an organizational level. NASA is currently well aware of a blind spot in its ability to detect process problems, and by keeping these definitions within our focus, we hope to be sensitive to the presence and means of detection of such problems.

Second, Standardization refers to problems largely within the domain of problem entry, including jargon and length of entries, whereas Compatibility refers to the ability of the problem reporting system to accept legacy problems, and mature into a legacy system itself.

Third, the Context of Problem Reporting and the Handheld Context of Device Use are subtly different in that the former refers mainly to social and psychological issues such as prioritization, while the latter is more centered on physical concerns, such as the ability to carry a handheld and myriad other engineering tools.

Project Timeline

Our timeline was created in order to allow for regular deliverables to NASA once every four weeks throughout the Spring Semester, starting with the literature review. As of the time of the delivery of this document, March 7th 2007, the Contextual Inquiry phase is approximately halfway completed, and the group is slightly ahead of schedule.

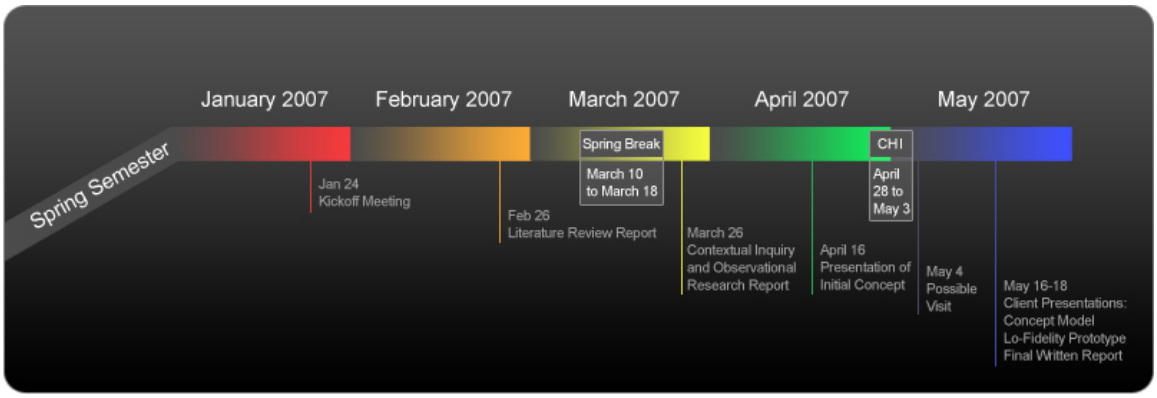

Figure 2: Timeline for the Spring Semester of PROPHET.

Literature Review Results

The Literature Review was completed on time and delivered to NASA. A copy is appended to this document.

Our articles fell into roughly three categories: those recapitulating the NASA experience (such as the PRACA retrospective), those examining currently ongoing research and development in handhelds and/or problem reporting (such as the MoRe and Wiisard projects), and those that were metastudies of various other systems (such as the CM3 report). The first category was useful for getting us up to speed on the current situation the Ames HCI Group is facing, the second were useful as direct background that helped to inform our collection of Contextual Inquiry data, and the third have not yet been of significant value, but are expected to be useful for comparison with our own CI data later on in the project's lifecycle.

Current Contextual Inquiry Results

As of the delivery of this report, we have completed and modeled Contextual Inquiry data with five different subjects: the Bellefield Boiler Plant, a UPS deliveryman, a manager (or CMon) at Carnegie Mellon University's Cluster Services, a HVAC contractor, and a professor at Carnegie Mellon University's Robotics Institute. Each of these interviews provided its own selection of useful data. The models are appended. (Please be discrete with these models in accordance with the IRB requirements. At least on individual may be in danger of losing his job should this information get out.)

Although the Contextual Inquiry phase of our semester has not yet been completed, and discussion of all aspects of our CI data would be premature before the team has consolidated the models, certain trends have already made themselves clear enough to commit to discussing them in this review.

The first trend is that of the so-called "dick move," a memorably ribald piece of slang given to us by the HVAC contractor. In the process of repairing a boiler, radiator, or other piece of hardware, it is not unusual for contractors to deliberately sabotage their work in such a way that, while it is totally functional, other contractors cannot comprehend the system enough to take the customer away. The HVAC contractor himself

utilized this strategy by wiring everything in all white wire, jotting any necessary annotations on them with a fine tip pen.

Although the “dick move” is appropriate only to divisions between organizations, and therefore individual employees within NASA or its contractors will be unlikely to use this action as a means of competitive protection, it is an accepted practice between companies. For example, Lockheed’s technological competitiveness depends on the opacity of its designs to competitors such as Boeing, and so its designs (and problem reports on those designs) must remain secret. As such, in order to preserve competition, NASA insists that the “dick move” (on an organizational level) be protected, rather than named as a breakdown and deliberately fought.

Secondly, in the domain of handheld devices, the UPS CI showed us the value of redundancy as a characteristic of handheld design. The DIAD (Delivery Information Acquisition Device) of the UPS deliveryman was notable in its combination of a variety of communications methods, including a keypad, a stylus touch-screen (that in fact could be used with any edged object, not just the enclosed stylus), a bar-code scanner, infrared communications for between handhelds, radio frequencies owned by UPS for transmitting instant messages between the DIAD and the local headquarters, a wireless modem for a LAN at the local headquarters, and even a speaker and microphone that could be used as a modem by laying a phone across the device.

As the CMU Robotics professor (a former product liability consultant) later advised, UPS requires proof that packages were delivered as a form of legal exoneration that justifies their billing process. Furthermore, as the deliverymen became more wedded to their DIADs over pen and paper, the bar codes of the packages were increased in length, making a breakdown of the device ever more catastrophic to the ability of the deliveryman to execute his deliveries within the required timeframe. Therefore, redundancy is vital for effective usage of this handheld.

Finally, a venue of further CI research will be the ability of users to not just input problem information, but receive output that includes all prior problem entries relevant to the task at hand. The UPS deliverymen use a somewhat convoluted means of entering these annotations, but benefit from them by warning each other of “problem addresses” with dangerous dogs or driveways, or thieving residents. The Cluster Services CCons also have such a system, but apparently do not actually use it. As this is a matter of interest to NASA, we’ll be looking into this subject further in the bottom half of our Contextual Inquiry research phase.

Problems with Our Methods

Although we’ve completed an acceptable level of work so far, and remain on schedule, our project has not been either easy or cleanly executed, and there’s much we have learned about how to improve our process.

First, we’ve had a number of interviews that involve retrospective interviews over observation of work. Although the UPS and HVAC interviews were conducted on the site of work, they did not constitute the participant actually working while the investigators

watched. This is due to the inconvenience of interfering with the person's work. We hope to overcome this barrier with further CIs at the Bellefield Boiler Plant, which has been especially welcoming, and at NASA, which has the capacity to insist that we be given access to areas which other organizations would prefer we kept away from.

Second, we did not set a standard format for our models early on. As a result, we have several different formats as different team members used different software to produce models along different formatting standards. We have only recently begun to standardize our modeling, and this may cause problems during consolidation.

Third, our inquiries have been unusually frequent; while we set a milestone for eight Contextual Inquiries, we already completed five before the halfway point of our CI phase, and this kept us backed up with modeling. As a general rule, we have always been one model behind on our interviews, and although we cannot confirm this, we suspect it may be a cause of lost contextual data.

Fourth, and probably as a result of all the above problems, we have numerous gaps in our CI data. While this is normal in any case, the minimization of gaps in CI data should be a goal of every HCI team. However, by being confronted with these problems, we have learned how to better combat them by refining our techniques.

New Modeling Techniques

These modeling techniques have been devised by the PROPHET team in order to react to and combat circumstances in which the gathered data cannot be easily modeled, or is somehow lacking in context. They are made for three different circumstances: when the contextual data is incomplete, when the process modeled has changed over time, and when tools are required for workflows, but behave more as facilitators of a flow than as either artifacts or repositories.

During the Boiler Plant CI we noticed that there was a bulletin board that apparently had a sort of function within the problem reporting system, as problem reports were occasionally posted upon it. However, we couldn't figure out, from our data, how this came about. As a result, the bulletin board appeared isolated in our heating plant workflow model, yet this was not a piece of information we wanted to convey.

To solve this problem, we began using a shaded color (peach) to represent areas of our models that we openly knew to be incomplete. These areas would represent the focus of later CIs, allowing us to use our models as "roadmaps" in follow-up interviews.

During the Cluster Services modeling, we encountered a workflow that had in fact ceased recently, but was of value to our understanding of the CI data. In order to preserve this flow, we left it on the model, but colored it in blue. This expands the model, in a minimal manner, through time. It is recommended that, should this method be used more than just one line at a time, the chronology of each blue line should be noted as a citation.

Finally, in order to increase our ability to deal with both software and hardware tools, objects used neither as repositories nor artifacts yet essential to workflows, during our Clusters workflow modeling we began placing objects around the girth of the Clusters Manager bubble. Flows passed from the bubble through these stationary objects,

demonstrating them to be tools in the inventory of the user, without which the flows could not occur. We came to call this “tool belt” or “barnacle” representation.

Conclusion

So far, our progress has been in keeping with our schedule. We have gathered information from both review of literature and a steadily growing number of Contextual Inquiries, and are on track to meet our chosen CI milestone.

Currently, the Ames HCI Group is working on arranging a CI trip to NASA facilities, which will augment our understanding of NASA’s working environment. Although this data will of course be valuable, the diversity of NASA departments and private contractors that will be using our design means that all of our CI data will likely be equally relevant.

After these next steps, we will go on to design the first iteration of the PROPHET interface. In this way, we plan to do our part in augmenting the NASA Constellation mission, while introducing a usable interface to thousands of engineers and technicians in one of the largest engineering organizations in the world.