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Comparative Rapid Prototyping, A Case Study

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Comparative Rapid Prototyping: A Case Study


Naval Postgraduate School

Outline

- CARA
  - Overview
  - Available Documents
- The Prototyping Models
  - SEATools Models
- Comparison Effort
  - Criteria
  - Findings
- Conclusions
Computer Aided Resuscitation Algorithm

- A Safety-Critical Software Application
- Battlefield Casualty Intravenous Fluid Control Software
- Integrated with:
  - Infusion Pump
  - Life Support for Trauma and Transport (LSTAT)
- A real-world software development effort and a research case study
- NPS asked by the Army Research Office to examine the effectiveness of SEATools in prototyping the CARA software system.

Infusion Pump

© 2000 by Infusion Dynamics, Inc.
LSTAT

Design Artifacts

- System Description
- Requirements Listing
- Developer – Customer Dialog
Requirements Excerpt

7

The CARA will monitor the occlusion lines whenever the pump is plugged in.

7.1

If an occlusion fault is detected

7.1.1

An appropriate error message should be issued.

7.1.2

A level 1 alarm should be issued

7.1.3

If an occlusion is detected while in auto-control, CARA will terminate auto-control

8

The CARA will monitor the Air OK line whenever the pump is plugged in.

8.1

If the Air OK signal remains low for 10 seconds

8.1.1

An appropriate error message should be issued.

8.1.2

A level 1 alarm should be issued

8.1.3

If an air fault is detected while in auto-control, CARA will terminate auto-control

Q&A Excerpt

<table>
<thead>
<tr>
<th>#</th>
<th>Ref</th>
<th>Question</th>
<th>Answer</th>
<th>Affected Rqts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q25</td>
<td></td>
<td>Should the system alarm if the set point BP is not achieved after a certain time?</td>
<td>2/3/99 – Not in version 1. This may be a feature to consider in version 2.</td>
<td></td>
</tr>
<tr>
<td>Q26</td>
<td>17</td>
<td>Should pressing the ‘start auto-control’ button be logged and have a message?</td>
<td>2/2/99 – Yes, a notation should be made in the file and to the display Add 17.4, 17.5</td>
<td></td>
</tr>
<tr>
<td>Q27</td>
<td>39</td>
<td>Does req. 39 apply only under pause mode?</td>
<td>2/2/99 – No, this applies under all modes as written</td>
<td></td>
</tr>
<tr>
<td>Q28</td>
<td>24</td>
<td>If cuff pressure is not available will the system proceed with pulse wave only?</td>
<td>2/2/99 – This is still an open issue. In this first version using pulse wave only will not be permitted. Calibrating PW with an A-line may be a possibility though. 7/1/00 - No.</td>
<td></td>
</tr>
</tbody>
</table>
5 SEATools Models

Model 1

Model 2

Model 3

Model 4

Model 5
Model 4
Model 5

Luqi, Shing, Puett, et al. ©

Model 5

Luqi, Shing, Puett, et al. ©
Comparison Criteria

- Architectural Understandability
- Simplicity of Design
- Requirements Coverage
- Safety Features

Understandability & Simplicity

- Model 1 made the best use of hierarchical decomposition to simplify the design and to make it understandable
- Model 4, while complicated at the 2nd level of decomposition, made the best use of timing specifications and constraints to simplify the design
- Models 1 and 4 made best use of composite data streams to simplify the design
Requirements Coverage

- ~90% Coverage of High Level Requirements
- ~50% Coverage of Detailed Requirements
- Model #4 had best detailed requirement coverage

For example, only models #3 and #4 attempted to model Requirements 27.1 – 27.4:

*When the cuff pressure is being used for control:*
- If the mean BP is 60 or below, cuff pressures will be taken once per minute;
- If the mean BP is (60 - 70], cuff pressures will be taken once every 2 minutes;
- If the mean BP is (70 - 90], cuff pressures will be taken once every 5 minutes;
- If the mean BP is above 90, cuff pressures will be taken once every 10 minutes.

Safety Features

- Model 1 implemented TMR for safety-critical functionality
- Model 1 implemented a processor watchdog function
- Model 1 & 5 attempted to segregate safety-critical functions in particular modules
Model 4

- Model 4 was chosen (completeness of the design & availability of the design team)

Findings

- It was straightforward to identify the best features of each design
- Differences in the designs led us to some unstated assumptions in the requirements and the problem statement
- Requirement inconsistencies and omissions were identified
- SEATools improvements were noted
Future Directions

- Given a set period of time, is there a tradeoff point in which doing Comparative Rapid Prototyping produces better designs?
  - i.e. given 10 designers for 3 days, what’s the best utilization of that resource?
    - 1 x 10 person team for 3 days
    - 5 x 2 person teams for 3 days
    - 5 x 2 persons teams for 2 days, 1x10 person team for 1 day

- Are there particular types of designs that lend themselves to Comparative Approaches?

- Are there degrees of specificity in the requirements that lend themselves to Comparative Approaches? If so, how do you recognize that need?

- What experiments should be designed to find answers to these questions?

Your Questions?