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IEEE

Luqi et al., "Comparative rapid prototyping: a case study," 14th IEEE International Workshop on Rapid Systems Prototyping, 2003. Proceedings., San Diego, CA, USA, 2003, pp. 210-217.

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Comparative Rapid Prototyping: A Case Study

Luqi, M. Shing, J. Puett,
V. Berzins, Z. Guan, Y. Qiao,
L. Zhang, N. Chaki, X. Liang,
W. Ray, M. Brown, & D. Floodeen

Naval Postgraduate School

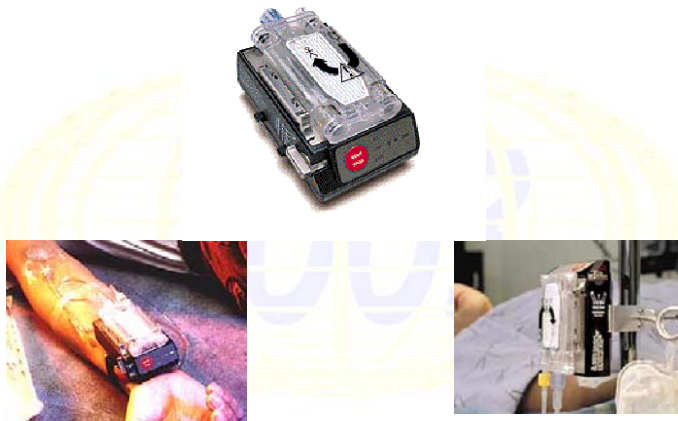
Outline

- 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



LSTAT



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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 is issued.**
 - 7.1.2 **A level 1 alarm should is issued**
 - 7.1.3 **If an occlusion is detected while in auto-control, CARA will terminate auto-control**

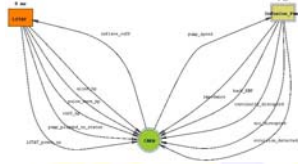
- 8 **The CARA will monitor the Air OK line whenever the pump is plugged in.**
 - 8.1 **If the Air OK signal remains low for 10 seconds**
 - 8.1.1 **An appropriate error message should is issued.**
 - 8.1.2 **A level 1 alarm should is issued**
 - 8.1.3 **If an air fault is detected while in auto-control, CARA will terminate auto-control**

Q&A Excerpt

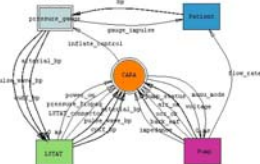
#	Ref	Question	Answer	Affected Rqts
Q25.		Should the system alarm if the set point BP is not achieved after a certain time?	2/3/99 – Not in version 1. This may be a feature to consider in version 2.	
Q26.	17	2/2/99 – Should pressing the ‘start auto-control’ button be logged and have a message?	2/2/99 – Yes, a notation should be made in the file and to the display	Add 17.4, 17.5
Q27.	39	Does req. 39 apply only under pause mode?	2/2/99 – No, this applies under all modes as written	
Q28.	24	If cuff pressure is not available will the system proceed with pulse wave only?	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.	

5 SEATools Models

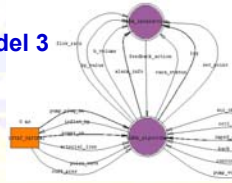
Model 1



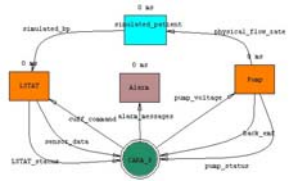
Model 2



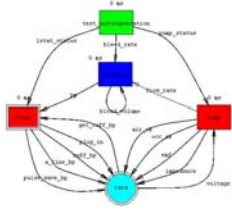
Model 3



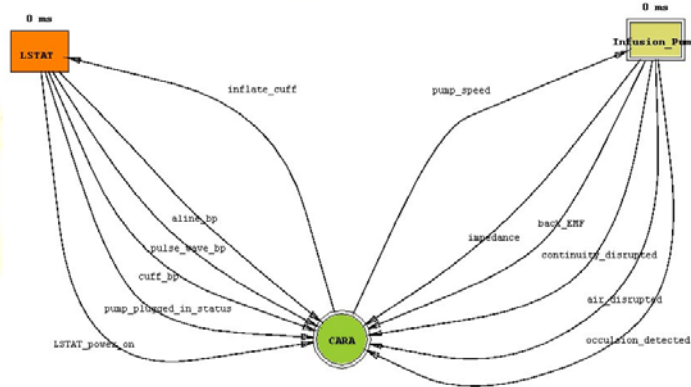
Model 5



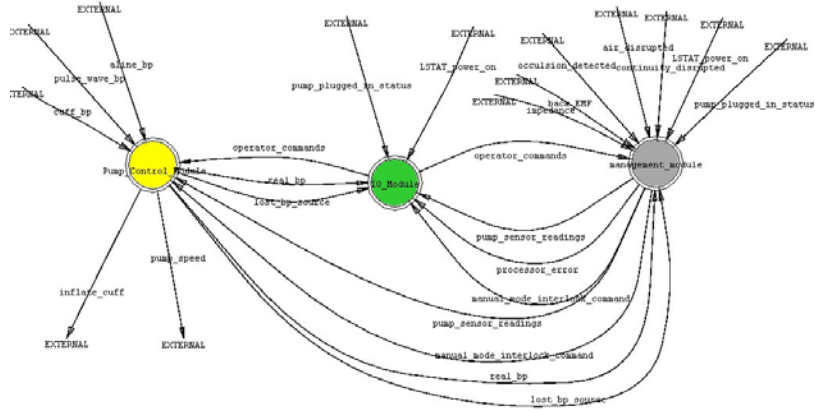
Model 4



Model 1



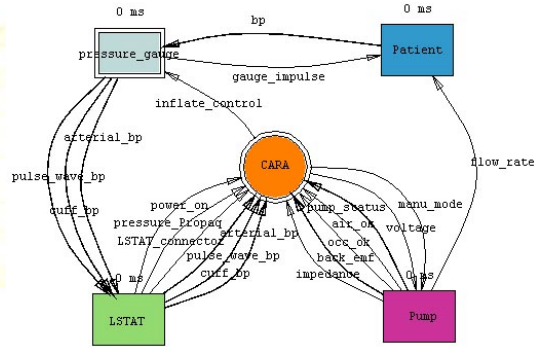
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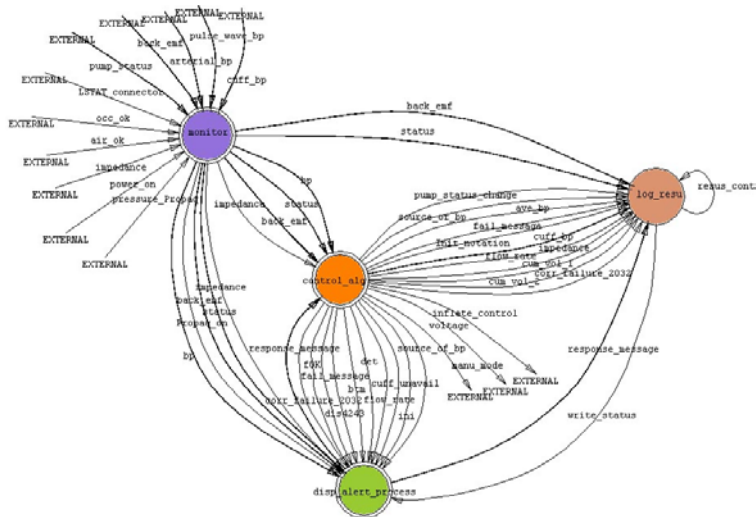
Model 1



Model 2



Model 2



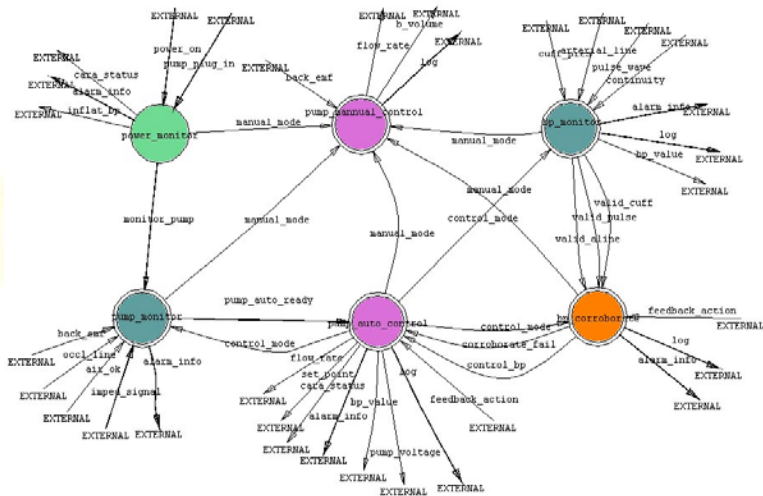
Model 3



15

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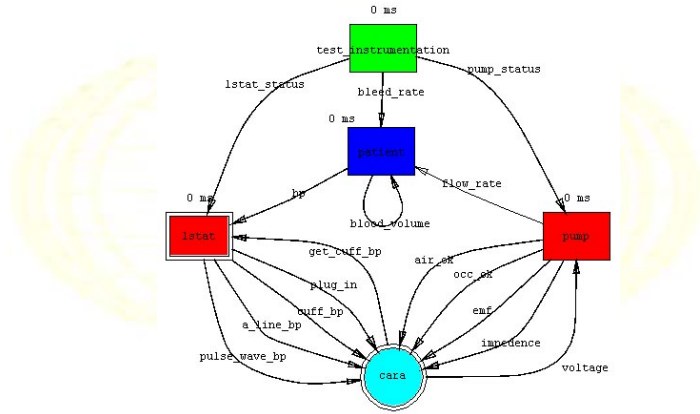
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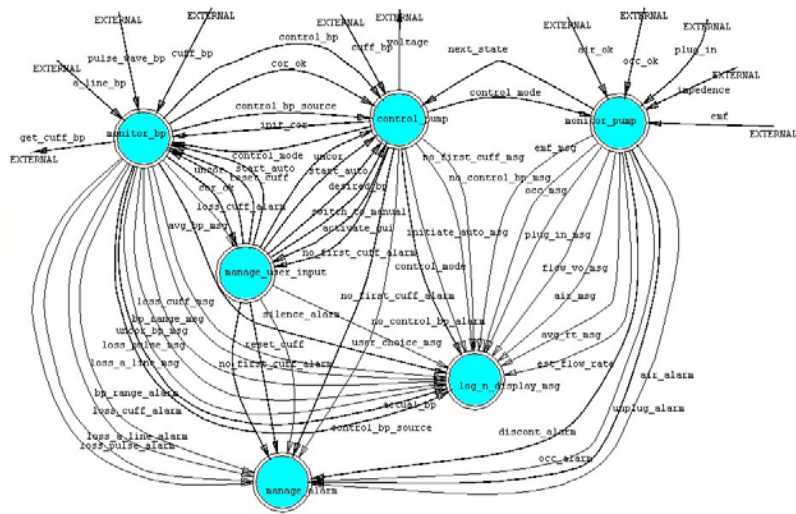
16

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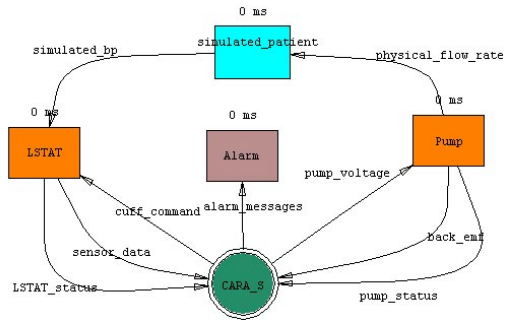
Model 4



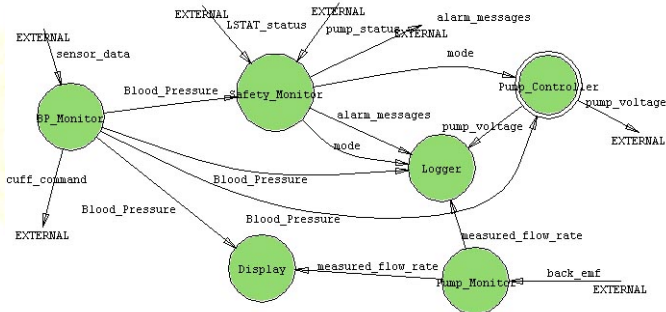
Model 4



Model 5



Model 5



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;

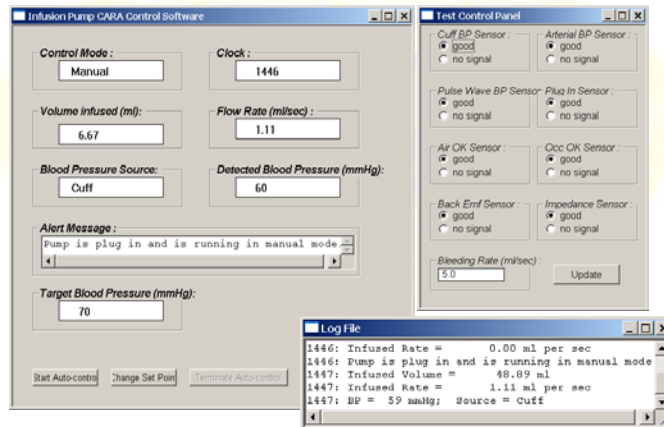
If the mean BP is above 90, cuff pressures will be taken once every 10 minutes.

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)



25

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Findings

- It was straight forward 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

26

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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 ?

