Challenges of Complex Software Systems Adaptation

UNIVERSITY
OF TRENTO - Italy

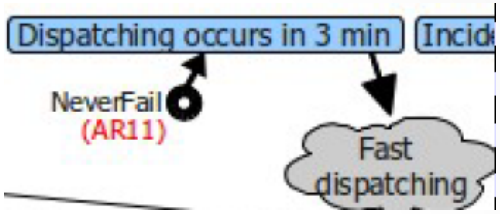
Konstantinos Angelopoulos

Introduction

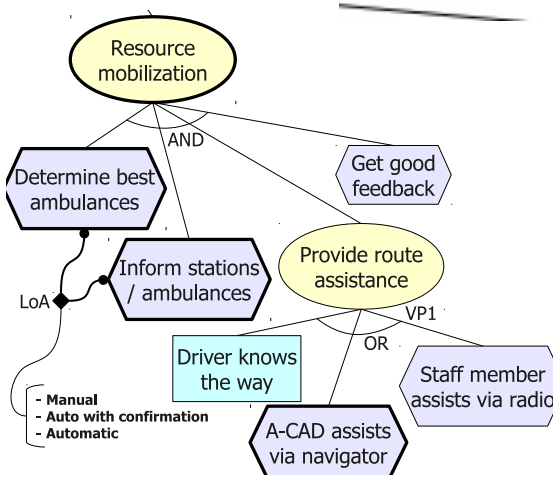
- Software is a system and requirements are the elements that compose it.
- Systems need control mechanisms to guarantee their successful operation and cope with changes.
- We need to control the software system through it’s requirements.

Control Theory for Software Systems

- Awareness Requirements (AweReq) as Indicators over the output.

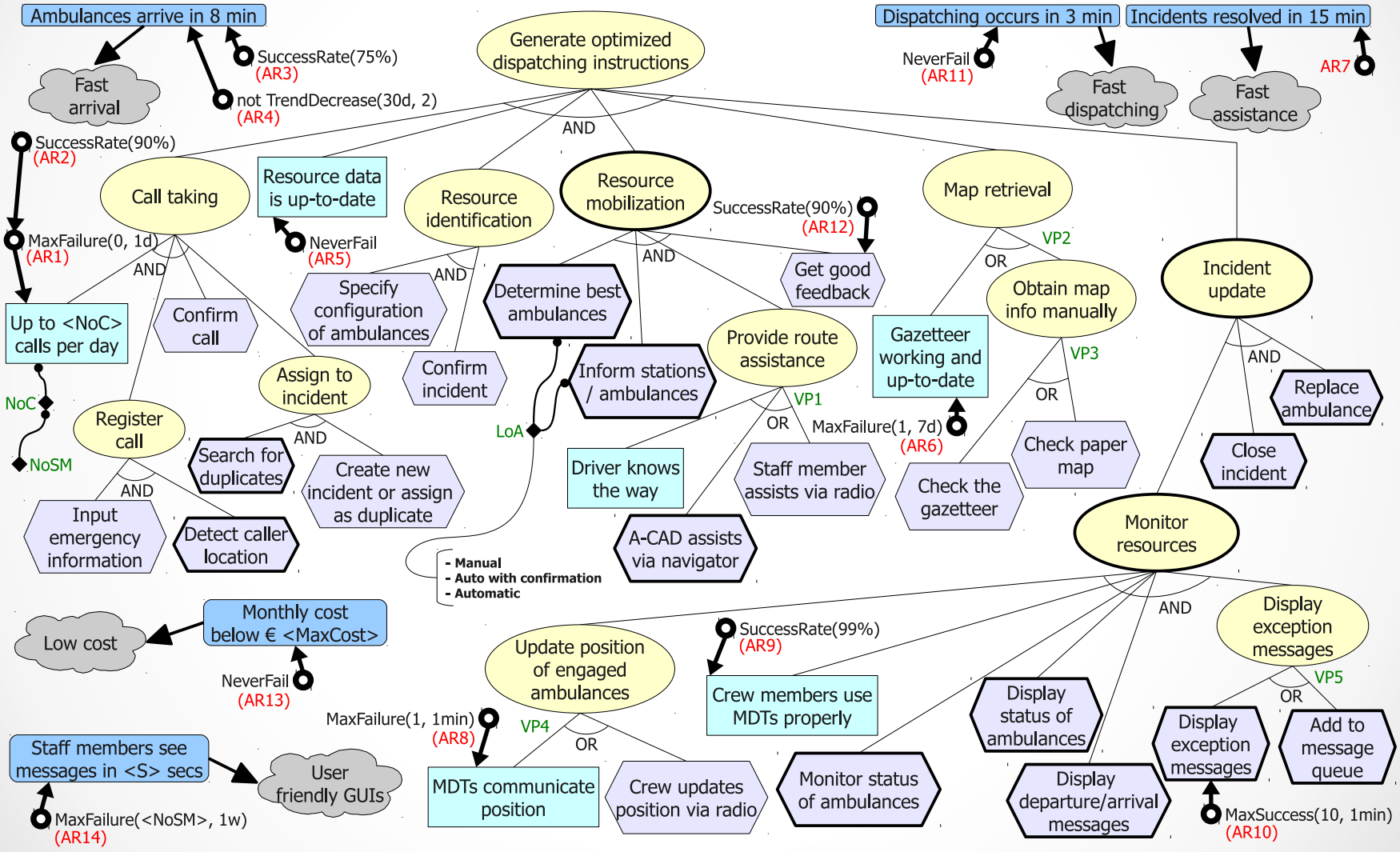


- Control variables and variation points (OR Decompositions) as parameters.



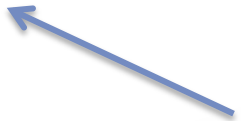
- System identification reveals qualitative relations between indicators and parameters.
- Evolution Requirements (EvoReq) as a way to operationalize adaptation.

Ambulance Dispatch Use Case



System Identification (1)

1. Δ(AR1/NoSM)[0,maxSM]>0
2. Δ(AR2/NoSM)[0,maxSM]>0
3. Δ(AR13/NoSM) < 0
4. Δ (AR3/LoA) < 0
5. Δ (AR4/LoA) < 0
6. Δ (AR9/LoA) < 0
7. Δ (AR11/LoA) > 0
8. Δ (AR12/LoA) < 0
9. Δ(AR3/VP1)>0
10. Δ(AR4/VP1)>0
11. Δ(AR7/VP1) > 0
12. Δ(AR11/VP1) < 0
13. Δ(AR6/VP2)>0
14. Δ(AR11/VP2) < 0
15. Δ(AR12/VP2) > 0
16. Δ(AR6/VP3)>0
17. Δ(AR11/VP3) < 0
18. Δ(AR12/VP3) > 0
19. Δ(AR8/VP4)>0
20. Δ(AR9/VP4)>0
21. Δ(AR11/VP4) < 0
22. Δ(AR10/VP5) > 0
23. Δ (AR14/V P 5) < 0



Qualitative relations between input and output

System Identification (2)

Which parameter to tune?

1. $|\Delta(AR3/V\ P\ 1)| > |\Delta(AR3/LoA)|$
2. $|\Delta(AR4/V\ P\ 1)| > |\Delta(AR4/LoA)|$
3. $|\Delta(AR9/V\ P\ 4)| > |\Delta(AR9/LoA)|$
4. $|\Delta(AR11/VP2)| > |\Delta(AR11/LoA)| > |\Delta(AR11/VP3)| > |\Delta(AR11/VP1)| > |\Delta(AR11/VP4)|$
5. $|\Delta(AR12/V\ P\ 2)| \approx |\Delta(AR12/V\ P\ 3)| \approx |\Delta(AR12/LoA)|$

we choose the most suitable parameter to face a failure

Where is the problem?

- The previous example considers single output
  - The majority of the systems have multiple outputs that are interconnected by common parameters.
  - Tuning a parameter to fix an indicator may lead another one to failure causing infinite loops (optimization problem).
  - It is difficult to control the system when multiple indicators fail simultaneously.
- What we can do:
  - Controllability check at design time
  - Assign priorities on indicators
  - Use locks to avoid to worsen the failure of an indicator (gradual adaptation)

Improving Precision

- SASO properties:
  - Stability
  - Accuracy
  - settling time
  - Overshooting
- We need precision to satisfy the last 3 properties
- Why is difficult?
  - Qualitative approaches are easier to apply but they delay the adaptation process.
  - Derive the quantitative mathematic relations between input and output is hard .
- The problem can be solved at runtime:
  - machine learning and simulations
  - statistical regression

The Role of Architecture in Adaptation

- Why architecture is important:
  - Reveals limitations of the system
  - Reusability for the adaptation strategy
  - Gives an engineering perspective of adaptation

- Rainbow Project:
  - Follows the MAPE loop model
  - The architectural model is the reference for the adaptation strategies
  - But there is absence of the requirements model

- Future Plan:
  - Create an adaptation language that will link the requirements model with the architectural model of the target system

THANK YOU!