

Non-functional analysis of mobile context-aware software systems

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Luca Berardinelli, Vittorio Cortellessa

Dipartimento di Informatica
Università dell'Aquila

E-mail : vittorio.cortellessa@di.univaq.it

URL : www.di.univaq.it/cortelle

Well-known motivations for context-awareness

- Most software applications today (and in the near future) are designed to run on **mobile devices with limited resources**
- Mobility and limited resources lead to **changes in the execution context**
- Context-aware applications should therefore **adapt their behaviors** to provide the **best possible QoS**
- Taking into account **non-functional properties** of such systems is critical (among other):
 - ✓ to **design** high-quality applications (offline)
 - ✓ to take **smart runtime** decisions (online)

Motivations of this research work

- A lot of work has been recently done to **define the application context** (e.g. MUSIC and SENSORIA IST projects)
- New techniques have been also introduced to **design applications that can adapt** their structure and behavior to **different contexts**
- However, to **enable performability-awareness** (à la PACO) such **adaptations should be driven by models** that allow to estimate QoS indices



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3

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Basic ideas of this research work

- The **context** can be a **structured object**, made of **attributes** from different domains:
 - ✓ user preferences
 - ✓ location (e.g. types of logical and physical resources)
 - ✓ status of resources
 - ✓ ...
- Is it feasible to introduce an **unifying approach** to the **modeling and analysis of QoS attributes** of mobile context-aware software systems?



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Basic ideas

The **evolution of single attributes**, or collection of attributes, can be always modeled with stochastic statecharts

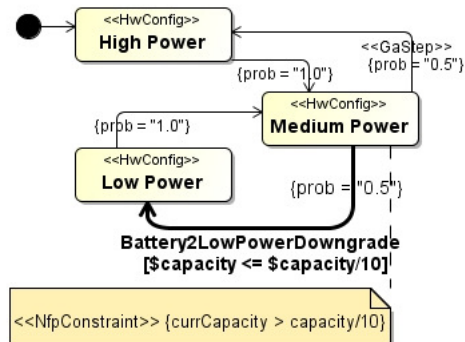


5

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Basic ideas

The evolution of single attributes, or collection of attributes, can be always modeled with stochastic statecharts



*Device
Battery
Consumption*

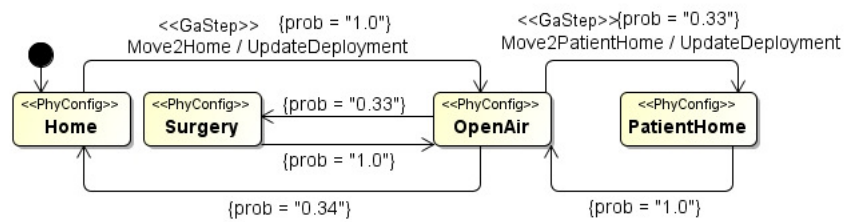


6

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Basic ideas

The evolution of single attributes, or collection of attributes, can be always modeled with stochastic statecharts



User Physical Mobility



7

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An unifying approach

- 1) Separate modeling of the evolution of context attributes (they are not independent each other!)
- 2) Merging models (of interest) in an unique model of context evolution - that includes adaptations
- 3) Performing non-functional analysis in (some) states of the unique model
- 4) Synthetizing context-aware non-functional properties
- 5) Offline and online tasks



8

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1) Modeling evolution of context attributes

Up today we have defined three categories of context attributes related to:

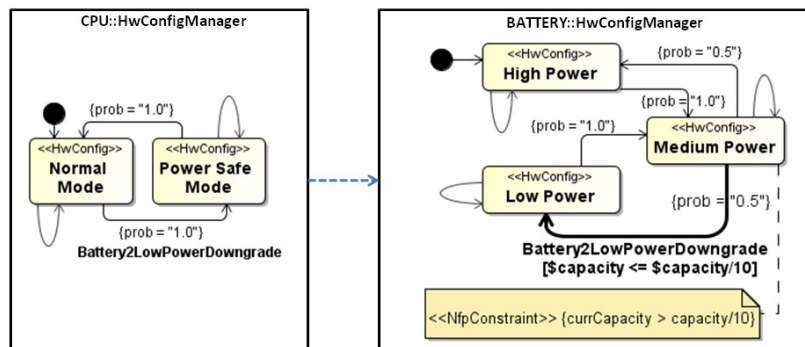
- Physical mobility
- Logical mobility
- Resource degradation



9

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1) Modeling evolution of context attributes



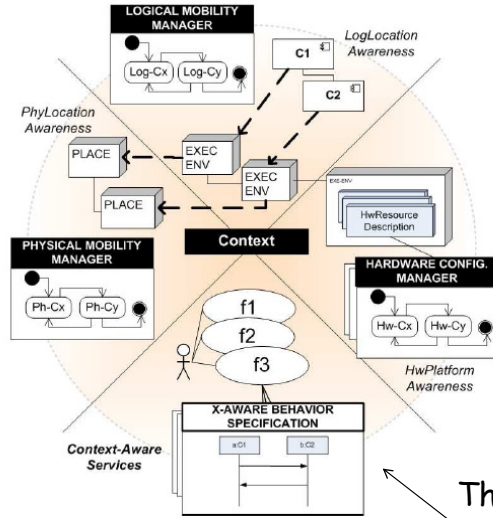
- Dependencies: remote firing among statecharts -



10

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2) Building an unique context evolution model



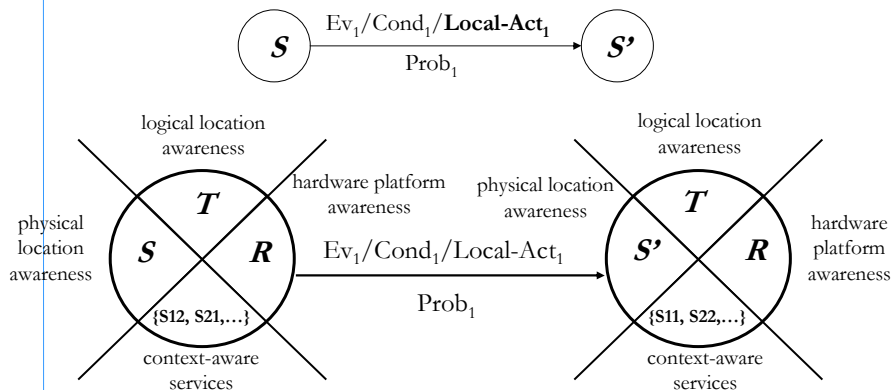
The structure of a *superstate* that merges different states

How to correctly build an unique statechart?

This sector represents the service adaptation

2) Building an unique context evolution model

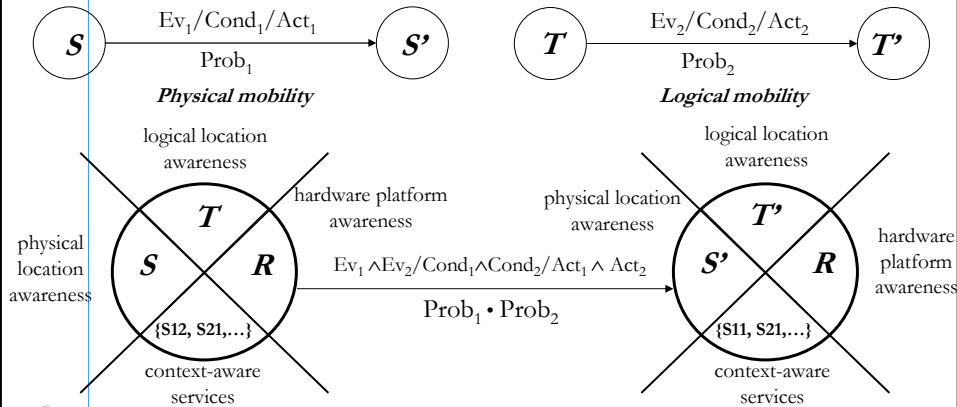
- Simple scenario -



David N. Jansen and Holger Hermanns. Qos modelling and analysis with UML statecharts: the stocharts approach. *SIGMETRICS Perform. Eval. Rev.*, 2005.

2) Building an unique context evolution model

- Simple scenario -



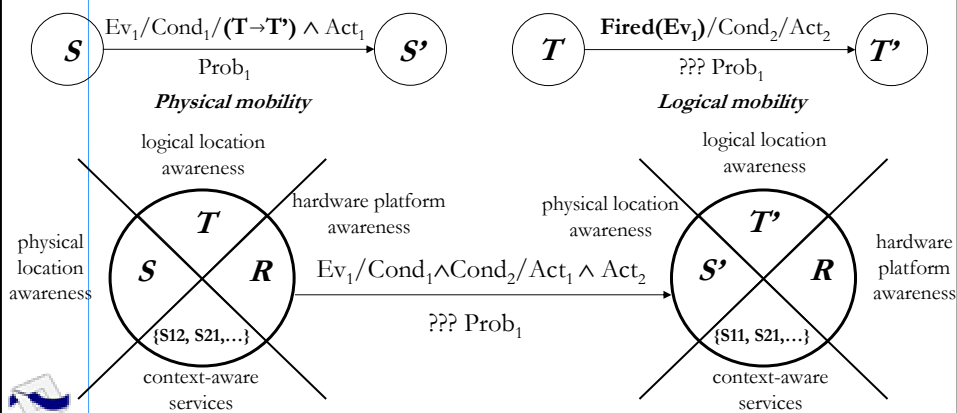
David N. Jansen and Holger Hermanns. Qos modelling and analysis with UML statecharts: the stocharts approach. *SIGMETRICS Perform. Eval. Rev.*, 2005.

13

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2) Building an unique context evolution model

- More complex scenario -

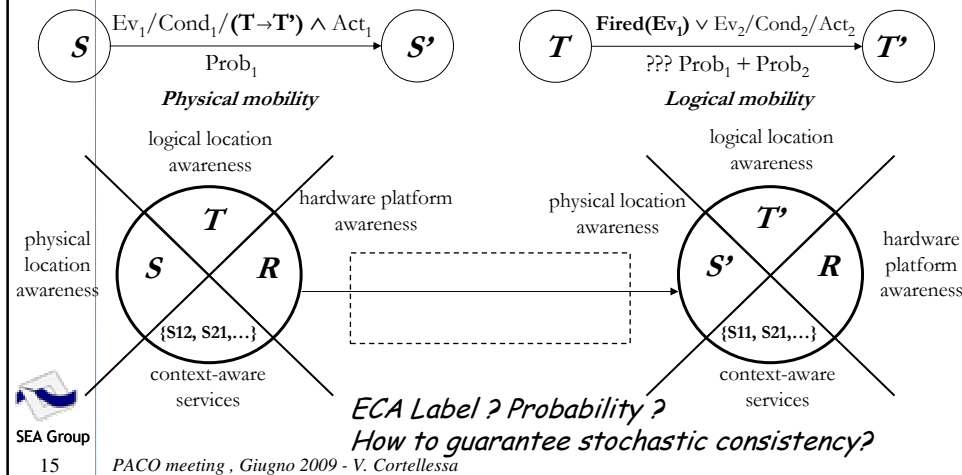


14

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2) Building an unique context evolution model

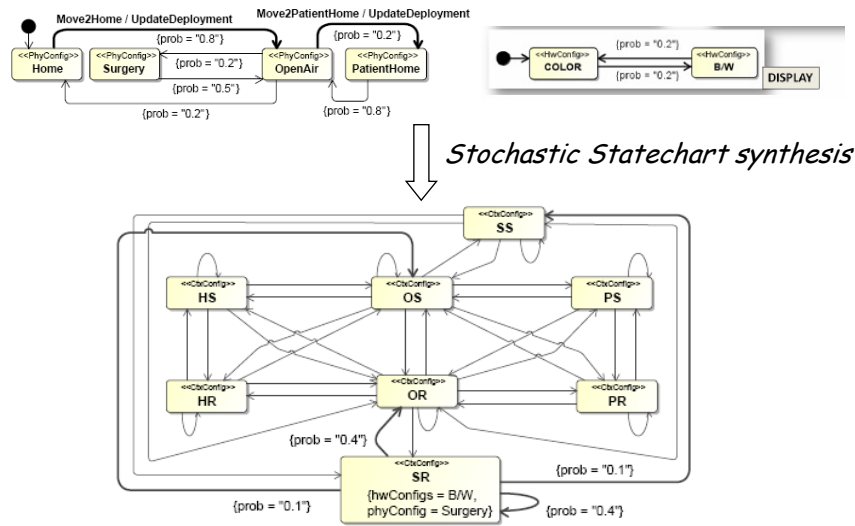
- Even more complex scenario -



3) Non-functional analysis in a superstate

- Each superstate has its own QoS properties
- They can be analyzed by introducing automated transformations from the state model to analysis models
- A modeling environment has been introduced (through customization of UML MagicDraw) to build such a system model, basing on UML profiles
- Some transformations exist and other ones have been introduced

4) Synthesizing context-aware properties



4) Synthesizing context-aware properties

	Home	OpenAir	Surgery	PatientHome
Home	0.1	0.9		
OpenAir	0.1	0.1	0.7	0.1
Surgery		0.1	0.9	
PatientHome		0.9		0.1

	Color	B/W
Color	0.5	0.5
B/W	0.5	0.5

Stochastic Statechart synthesis

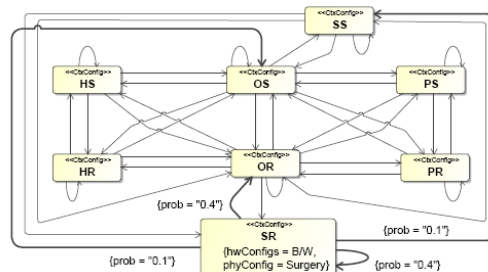
	HS	OS	SS	PS	HR	OR	SR	PR
HS	0.05	0.45			0.05	0.45		
OS	0.05	0.05	0.35	0.05	0.05	0.05	0.35	0.05
SS		0.05	0.45			0.05	0.45	
PS				0.05		0.45		0.05
HR	0.05	0.45			0.05	0.45		
OR	0.05	0.05	0.35	0.05	0.05	0.05	0.35	0.05
SR		0.05	0.45			0.05	0.45	
PR				0.05		0.45		0.05

Under Markovian assumptions...

Steady-state probabilities

HS	OS	SS	PS
0.0067	0.0608	0.4250	0.0067
HR	OR	SR	PR
0.0067	0.0608	0.4250	0.0067

4) Synthesizing context-aware properties



HS	OS	SS	PS
0.0067	0.0608	0.4250	0.0067
HR	OR	SR	PR
0.0067	0.0608	0.4250	0.0067

- A powerful instrument to play with QoS indices
- Max, Min, Average values can be easily analyzed for single/subsets of/all superstates
- Sensitivity analysis of QoS indices wrt probabilities

5) Offline and online tasks

What is this instrument useful for? Some examples...

- Identifying critical components in certain contexts to better allocate performance validation effort
- Suggesting to users certain physical paths to achieve high availability
- Comparing context evolution alternatives with respect to certain QoS indices
- ...

What we have done up today...

Performance: completion time

*L. Berardinelli, V. Cortellessa,
"Performance modeling and analysis of
context-aware mobile software systems",
submitted to Automated Software Engineering 2009*

Reliability: in component-based software systems

*L. Berardinelli, V. Cortellessa, A. Di Marco
"An Unified Approach to Model the Quality
of Mobile Context-Aware Software Architectures",
in submission to NFPinDSML @ MODELS 2009*

... what we will do in the next few months

... recovering from the earthquake...

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- No fund raising, but "skill raising"!

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