Specification and Validation of Non-Functional Constraints

Johan
Lindqvist,
Dragos
Truscan,
Johan Lilius,
Ivan Porres
and Timo O

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# Specification and Validation of Non-Functional Constraints

Johan Lindqvist<sup>1</sup>, Dragos Truscan<sup>1</sup>, Johan Lilius<sup>1</sup>, Ivan Porres<sup>1</sup> and Timo O. Eriksson<sup>2</sup>

<sup>1</sup>Turku Center for Computer Science, Abo Akademi University, Turku, FINLAND

<sup>2</sup>Nokia Research Center, Helsinki, FINLAND

Artist workshop on Foundations of Component-Based Design

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# Changes in the Environment of Mobile Device Manufacturing

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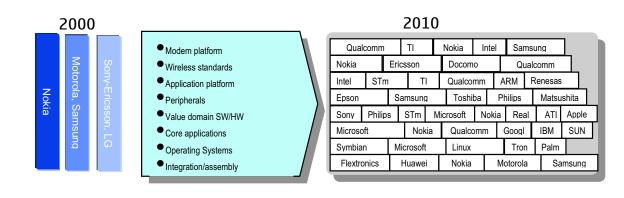
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**Figure 2.** Mobile industry shift from vertical to horizontal mode. (Company names in diagram are examples and are for illustration only).

From [Suo06]

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## What does this imply for Design Methods?

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1.	Suitability for Horizontal R&D mode
2.	Modularity
3.	Flexibility
4.	Scalability
5.	Independent V&V for subsystems
5.	Black-box approach for modularity
7.	Loose coupling of subsystems
8.	Applicability to heterogeneous technologies
9.	Matching modularity in all abstraction levels
10.	Freedom to select the level of integration
11.	Interconnect centric architecture
12.	Open and standard interfaces
13.	Low power design
14.	Heat dissipation limited designs
15.	Platform and Content Security
16.	Appropriate system engineering framework

- Emphasis on modular construction
- Possibilities for reuse
- Need to deal with non-functional constraints
- Support for distributed design
- Cost-effective: low NRE
- Fast time-to-market

From [Suo06]

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# Vision of new Eco-System

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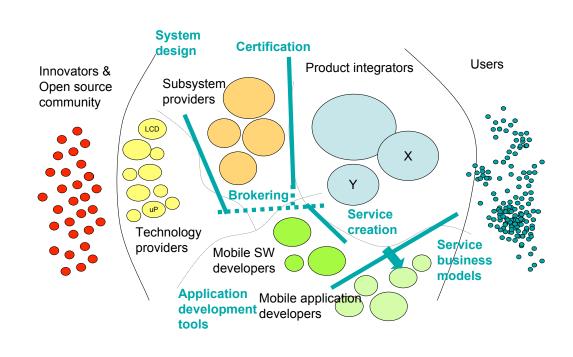
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#### **NoTA**

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NoTA (Network on Terminal Architeture) is Nokia's attempt at addressing the challenge.

Consists of 2 parts:

- A device architecture
  - Service based,
  - Network centric,
  - Loosely coupled,
  - Follows GALS principles
- A design method
  - SOA-based
  - Identification of Services
  - Definition of Subsystems
  - Definition of Tests
    - For subsystem testing
    - For integration testing

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## NoTA Logical Architecture

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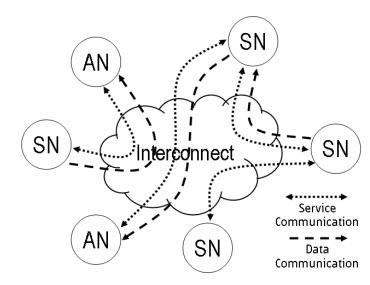


Figure 1: NoTA logical architecture consisting of three types of foundation elements called Application Nodes, Service Nodes and Interconnect

From: [KKE06]

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## NoTA Device Architecture

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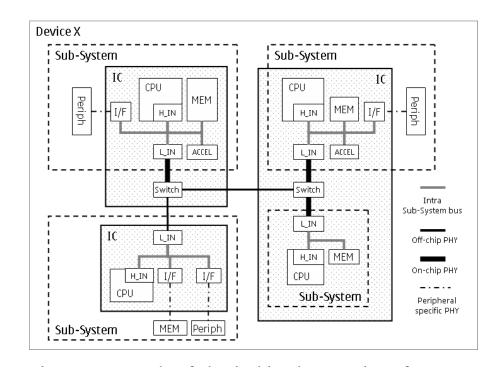
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Example NoTA device architecture from: [KKE06]

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# Specification method

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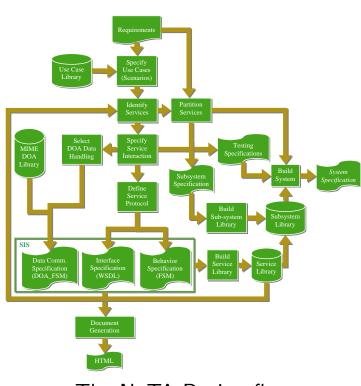
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The NoTA Design flow

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# Specification method (cont'd)

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- Sub-System Specification:
  - Implements a number of services
  - Use cases are given as requirements: these can be use by the manufacturer to optimize the hardware
- Testing amounts to:
  - Generate runs of the system based on the use cases, and the SIS specification
  - Observe behavior and measure energy at hardware interface
  - Report results

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## Specifying energy and timing constraints

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Johan
Lindqvist,
Dragos
Truscan,
Johan Lilius,
Ivan Porres
and Timo O.

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"Take a jpeg image with resolution 1024\*768 and store it on the file server as temp.jpg. From the time the image is requested to the time it is available on the file server no more than 300ms should have elapsed. The image should be captured (but not necessarily encoded or stored) within 100 ms from the time of the request. With one fully charged Li-lon battery (1 Ah, 3.3 V) the user must be able to take 200 VGA-sized still images, including 20 % overhead for additional tasks."

- The informal requirement gives budget
- For a SIS concrete values can be obtained from experience or through negotiations with 3rd parties
- Not every piece of functionality needs to have energy and timing constraints
- Energy and timing constraints can constrain several services

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## **Energy Properties**

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- Power constraints associated to states
- Mean power, Peak power
  - Important to understand how power is used over time
  - Mean power requires tests to be run several times
  - Statistical measures of variation can also be included
- Energy and timing constraints associated to transitions
- {wakeup, shutdown} {energy, time} for services

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# Use Case: Take Single Picture

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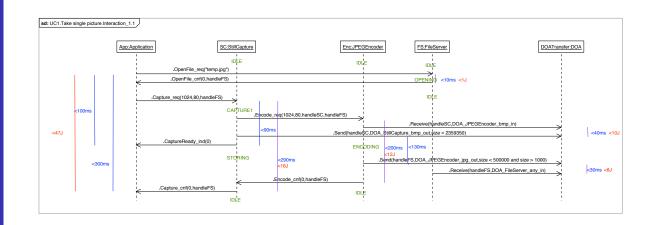
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## Still Capture SIS

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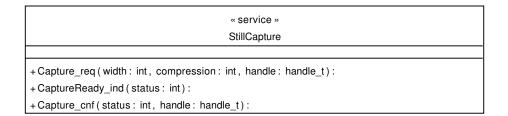
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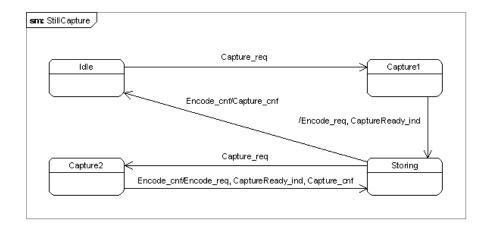
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#### Audio DOA

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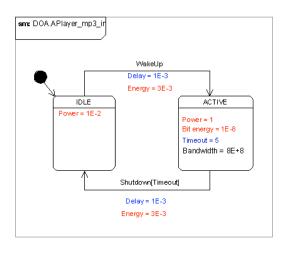
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- Services are asynchronous
- Data transfer is stream based (Direct Object Access protocol)
- Each data type has a state machine with extensions for non functional constraints
- Data handling patterns can be described through cross-product of source and sink

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#### Generation of tests

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- Tests could be generated automatically from the model
- Not used in practice because
  - we don't have good automatic test-selection algorithms for energy
  - we want to use the test to communicate an energy consumption requirement
- Test cases are now defined manually
  - Test traversals: to test single services
  - As use cases: for integration testing

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#### Test Traversal

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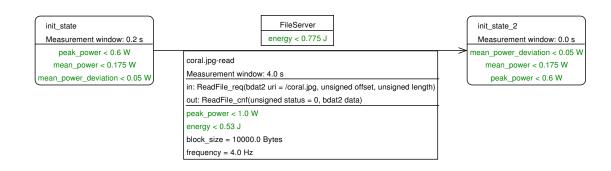
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#### Test setup

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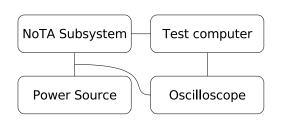
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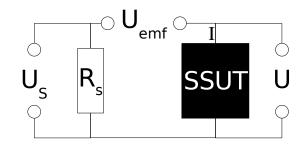
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Standard shunt-resistor circuit ([FN01, JPEW02, FFB+00])





■ The scope measures  $U_s$ .  $U_{emf}$  is a high-quality power supply. Now because  $U = U_{emf} - U_s$  we have that

$$P = UI = (U_{emf} - U_s)(U_s/R_s)$$

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# Test setup (cont'd)

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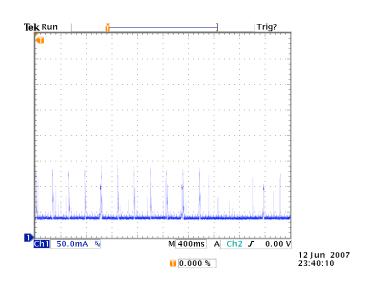
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■ Challenge: synchronization of measurement values with model.

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## Result presentation

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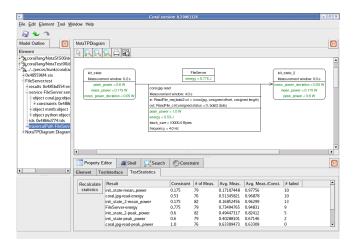
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■ The measurements are mapped back onto the test represented as a "traversal path".

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#### Conclusions

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- We have developed a specification method together with a testing setup
- Partial specifications needed to leave freedom for implementation
- The approach allows for "quick" validation of energy and timing constraints
- It is being introduced into the production process at Nokia

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#### **Future Work**

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- Now we have concentrated on tests a vehicle for communication
  - How would you apply automated test generation methods?
- Proper evaluation: how cost-effective is the approach?
  - Was it easier to communicate? Where the products better?
- Abstract models of services to be used for partial verification.
- Generalise the approach: the NoTA L\_IN and H\_IN protocols act as "adapters". By replacing them we can use the approach for non-NoTa systems.

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Johan
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Dragos
Truscan,
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Keith I. Farkas, Jason Flinn, Godmar Back, Dirk Grunwald, and Jennifer M. Anderson.

Quantifying the energy consumption of a pocket computer and a java virtual machine.

SIGMETRICS Perform. Eval. Rev., 28(1):252–263, 2000.

- Laura Marie Feeney and Martin Nilsson.
  Investigating the energy consumption of a wireless network interface in an ad hoc networking environment.
  In IEEE INFOCOM, 2001.
- Brian Burns Jean-Pierre Ebert and Adam Wolisz.

  A trace-based approach for determining the energy consumption of a WLAN network interface.

  In *Proc. of European Wireless*, pages 230–236, February 2002.

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lan Oliver Klaus Kronlof, Samu Kontinen and Timo Eriksson.

A Method for Mobile Terminal Platform Architecture Development.

In Proceedings of Forum on Design Languages 2006, Darmstadt, Germany, 2006.



Risto Suoranta.

New Directions in Mobile Device Architectures.

In Proceedings of the 9th Euromicro Conference on Digital System Design (DSD'06), 2006.

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