A Design Methodology for the Development of a Complex SoC using UML and Executable System Models

Yves Vanderperren
yves.vanderperren@st.com

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Outline

- Stating the case: the OFDM Wireless LAN Project
- Methodology overview
  - Process
  - Requirements Capturing and Use-Case analysis
  - System Modelling
    - Matlab + SystemC + UC
    - A step further: UML modelling of architecture
- Conclusions and Summary
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Stating the case

**Infrastructure based network**: Business Environment
Centralized Mode

**Ad-hoc network**: Home Environment
Direct Mode

Diagram showing connections between:
- Mobile Terminal (MT)
- Access Point (AP)
- Central Controller (CC)
- Wireless Terminal (WT)

AP - AP Mobility

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Stating the case

- Different flavours
  - Business-environment
  - Home-environment

E.g.: Ethernet, FireWire, ...

- Core Network
- Core Network
- Core Network

CL - Specific Part

Network Convergence Layer
CL - Common Part

Data Link Control Layer
[ MAC - DLC ]

Physical Layer
[ PHY ]

HiperLAN-2

- Hardware
- Firmware
- Software
Stating the case

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Stating the case

- System level specification
  System + Environment

- Target Architecture
  HW/SW partitioning, interfaces

- SW design
- HW design

- System Integration & Test

Easy said...
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Central RUP principles

- Iterative Development
  - Refine system implementation to address risks early

- Use Case Driven Architecture
  - Validate architectural design using Use Cases

- Visual Modelling (using UML)
  - Use well-defined visual language to communicate requirements and design

- Testing
  - Evolves during each iteration in parallel with system
  - Allows efficient regression testing of each iteration
Iterative development

![Diagram showing iterative development phases and workflows](image-url)
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Vision document

- Focus on the Customers & Stakeholders
- Identify Success Criteria
- Top of Requirements Pyramid

The customer needs wireless mobility within the workplace

The system provides seamless connection handover between access points

MT Connection Handover Procedure

The MT shall measure received signal strength when instructed by the AP
Use Case Analysis

- A mechanism to specify functional requirements related to top-level view
  - UC = a service providing value to an external entity

- UC’s are basically textual – a behavioural sequence
  - UML diagrams help to organise and document

- For each UC we document a.o.:
  - Primary (expected) system responses
  - Secondary system responses (e.g. error conditions)
  - Links to other UC’s

Scope of the system, user goals

Failure handling
Sequence diagrams of external interactions

Messages 1-5 are repeated for all associated WTs

1: DLC_InfoTransferReq(H2_MAC_Id, BUS_SUSPEND)

Messages 7-11 are repeated for all associated WTs

7: DLC_InfoTransferReq(H2_MAC_Id, BUS_RESUME)

8: AbstractSendRLC_overLCH( RLC_INFO, DCCH)

9: AbstractSendRLC_overLCH( RLC_INFO_ACK, DCCH)

10: DLC_InfoTransferCnf( H2_MAC_Id, BUS_SUSPEND)

11: ResumeUserPlane( H2_MAC_Id)

3: AbstractSendRLC_overLCH( RLC_INFO_ACK, DCCH)

2: AbstractSendRLC_overLCH( RLC_INFO, DCCH)

4: DLC_InfoTransferCnf( H2_MAC_Id, BUS_SUSPEND)

5: SuspendUserPlane( H2_MAC_Id)

6: CL_SelfIdInd(PhysicalId, NoNodes, ToggleBit, ListOfNodeDetails)

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Vertical Testbench Reusage

Use Case Model

SystemC Testbench

Reused in all stages of the design!

Algorithmic Modelling

Matlab

SystemC Modelling

HW

FW

Implementation

VHDL

C-code

Prototype Tests

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Objectives of the SystemC model

- **An Executable Specification** for communication with designers
  - Designers participate in writing the specification – organic knowledge transfer

- **A Tool** to
  - verify the overall system behavior and architecture
  - run test scenarios covering a global model of HW & FW
  - detail the architecture for critical blocks
  - do finite-precision design

- **A Reference**
  - test benches are the starting point for all other test benches and system test plans (Lab qualification)
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UML Modelling of Architecture

- Applied to analysis of requirements and specification of higher layer SW, using RRT

- Motivation
  - Capture essential information about system architecture and interfaces in a single, common format

- Why UML?
  - UML is the notation of choice for object-oriented analysis and design
  - A SystemC model is an object-based representation of the system elements written in an OO language
  - Tools are available for reasonable costs
    - UML Modelling Environment
    - Document Generation
System functionality can be modelled in abstract terms using conventional OOA approach.

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UML can be tailored to represent SystemC abstractions such as Module, Port, Channel (e.g. using stereotypes)

From Function to Architecture
But...

- UML tools don’t support function to architecture mapping
  - Re-mapping functions results in manual changes to interfaces, collaborations etc.

- UML tools don’t support SystemC directly
  - Manual synchronization between SystemC and UML
  - Standard profile for SystemC?

- UML standardized mainly for SW systems development
  - Different profiles for real-time embedded systems are available
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Conclusions

- Use Case Driven approach drives design
- Unified view, interdisciplinary communication, cross-functional teamworking
- UML-based approaches complement SystemC v2.0 well
- Methodology required to complement language capabilities
- Need to address SystemC - UML synchronisation
- Learning curve for UML and modelling concepts
- How does SoC domain fit with general model of UML for Systems Engineering