A simulation-based approach for performance evaluation of SDR baseband architectures

Brussels, Belgium
28th June, 2012
Goal and objectives

➢ Trends in the field of radio communication
  - Mobile devices with more and more wireless interfaces, user applications and adaptation capabilities
  - Parallel architectures clustered by application category to implement mobile terminals

➢ Goal of our work
  - To facilitate performance evaluation of SDR baseband architectures

➢ Objectives of this presentation
  - To propose simulation-based approach to analyze and compare the growing number of potential architectures
  - To illustrate benefits of this approach with a realistic adaptive multi-service system
Model requirements

➢ Specification design step
  - Definition of the system properties and its performance requirements
  - Executable model to evaluate and compare performances of candidate architectures

➢ Fundamental criteria to respect
  - Quick-to-develop and lightweight to decrease modeling effort of the designer
  - Accuracy and simulation speed for different use cases
Considered modeling approach

- Performance evaluation of system architectures

Considered system architecture

Considered modeling approach

Performance model of system architecture
Considered case studied

- Activity diagram of an adaptive multi-standard and multi-application system and its environment
Modeling the system environment

- Modeling technique based on scenario files

**Scenario User.dat**
1. 1 s VoiceCall Start
2. 15 s WebSession Start
3. 16 s VideoStreaming Start
4. 2 s WebSession Stop
5. 25 s VideoStreaming Stop
6. 5 s VoiceCall Stop

**Scenario Network.dat**
1. 1 ms UTRAN 384
2. 30 s WLAN 1500
3. 9 s UTRAN 130

[Diagram showing the user, radio communication system, and network environment with sequences of events and links between them.]
Modeling the communication interfaces

- Activity diagram of adaptive radio interfaces

- Radio reception
- WiFi reception
- UTRA reception
- Demux
- Assemb
- Stopped
- RAT control
  - = start
  - = stop

- Packet data voice
  - time: $t_1 \uparrow 20 \text{ ms} \uparrow t_2$
  - size: 244 bits
  - $\approx 12000 \text{ bytes}$

- Packet data web
  - time: $t_1 \uparrow 1 \text{ s} \uparrow t_2$
  - size: 8000 bytes

- Packet data video
  - time: $t_1 \uparrow 1 \text{ s} \uparrow t_2$
  - size: 1 s

- Downlink WiFi
  - time: $t_1 \uparrow 347 \mu\text{s} \uparrow t_2$
  - size: up to 2347 bytes

- Downlink UTRA
  - time: $t_1 \uparrow 10 \text{ ms} \uparrow t_2$
  - size: up to 480 bytes
Generation and simulation of the performance model

- Graphical modeler and ANSI C/C++ code editor to capture the performance model
- Generation of executable SystemC code from capture model
- Simulation of the executable SystemC program according to complex use case scenarios
  - Evaluation of real time performances
  - Evaluation of the expected resources
Temporal behavior analysis of the system

- **User**
  - Application request
  - Application response
- **Service management**
  - Service request
  - Service response
  - Switching request
- **System management**
  - RAT discovery
  - RAT control
  - Web page
  - Video frame
- **WiFi reception**
- **UTRA reception**
- **Voice**
- **Video**
- **Web**

Latency (ms)
- **Voice**
  - Threshold voice: 20 ms
- **Video**
  - Threshold video: 500 ms
- **Web**
  - Threshold Web: 1 s

Time (s)
- **VoiceCall Start**
- **WebSession Start**
- **VideoStreaming Start**
- **WebSession Stop**
- **VideoStreaming Stop**
- **VoiceCall Stop**

UTRAN
- 0 s UTRAN 384
- 30 s UTRAN 1500
- 9 s UTRAN 130

WLAN
- 0 kbps
- 1500 kbps
- 130 kbps

Latency (ms)
- **Voice**
  - Threshold voice: 20 ms
- **Video**
  - Threshold video: 500 ms
- **Web**
  - Threshold Web: 1 s

Temporal behavior analysis of the system
Performance evaluation of the flexible baseband architecture

- Studied architecture to perform baseband processing related to activities UTRA and WiFi reception
  - Architecture based on a set of dedicated hardware resources
  - Performance model express computational complexity per time unit each function causes on the resources when executed

Performance model of radio reception and transmission architecture

Studied architecture

\[ P_1 \]
- UTRA baseband functions
- WiFi baseband functions
Simulation results of the model

- Evolution in time of the required computational complexity per time unit (in MOPS) for UTRA and WiFi decoding

  - Observation for studied architecture and operating scenario considered
  - Maximal computational complexity per time unit observed
  - Resource utilization of $P_1$

![Chart showing global computational complexity per time unit (MOPS) with labeled points (1), (2), and (3) for UTRA and WiFi decoding at specific time units]
Sum-up and conclusion

- **Sum-up**
  - Simulation-based approach and modeling technique to evaluate efficiently performances of candidate SDR baseband architectures
  - Simulate easily multiple complex use cases
  - Study dynamic and non deterministic effects in the architecture model

- **Further work**
  - Validation of estimates providing by simulation
  - Applying the same modeling principle to other non functional properties such as dynamic power consumption
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