



Institut Mines-Telecom  
Telecom ParisTech  
CNRS/LTCI  
Sophia Antipolis, France

# Communication Patterns: a Novel Modeling Approach for Software Defined Radio Systems

*Andrea ENRICI  
Ludovic APVRILLE  
Renaud PACALET*

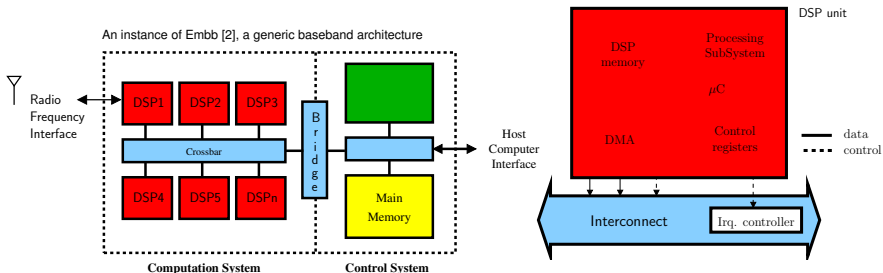
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# The complexity of modern SDR platforms

## Current architecture trend:

"A programmable microprocessor acts as a system controller and is interconnected via a bus-based architecture to a series of computational subsystems (e.g., ASIC components, ASIP/DSP processors)" [1]



[1] Omer Anjum et al., *State of the art baseband DSP platforms for Software Defined Radio: A survey*, EURASIP Journal on Wireless Communications and Networking 2011, 2011: 5

[2] N.-ul.-I. et al., *Flexible Baseband Architectures for Future Wireless Systems*, EUROMICRO Digital System Design, 2008, pp. 39 - 46

## How to efficiently program SDR platforms?

- ▶ The impact of data and control transfers (e.g., performance) is no longer negligible with respect to computations alone
- ▶ Compilers cannot (yet) fully exploit the architecture parallelism to generate efficient code
- ▶ Applications are coded, or at least optimized, manually:
  - ▶ long development cycles
  - ▶ difficult and error-prone

### The open problem:

How to efficiently program these complex systems?

### Our answer:

Raise the level of abstraction at which SDR systems are programmed  
via **Model Driven Engineering**

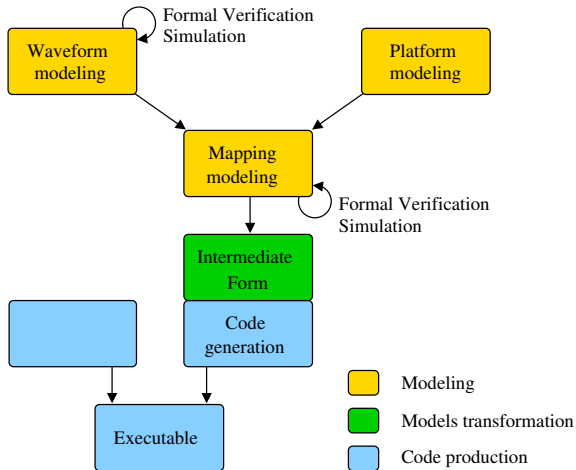
# Model Driven Engineering with DiplodocusDF

## DiplodocusDF :

A UML methodology for **data-dominated systems**.

System-level **modeling**,  
application **code generation**.

Implemented using the  
free software **TTool**.

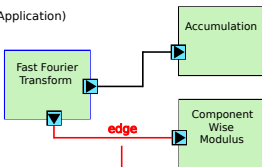


► In this presentation we will focus on DiplodocusDF models

# Modeling data transfers: a mapping problem

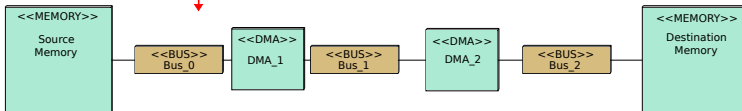
Waveform (Application)

Node:  
Signal  
Processing  
Operation



Platform (Architecture)

How to map an edge?

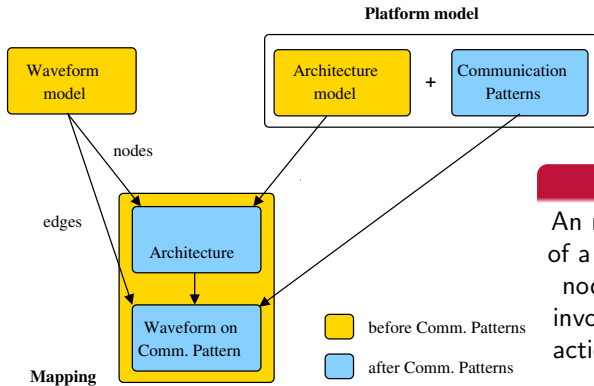


## Limitations:

a transfer in the waveform graph can only be mapped to a point-to-point path in the architecture (e.g., memory-bus-memory)

- ▶ Lack of expressiveness with respect to the platform parallelism
- ▶ Waveform models must be re-arranged to meet the platform addressing capabilities
- ▶ An issue not only specific to DiplodocusDF (graph-based approaches)

# Modeling with Communication Patterns(1)



## In a nutshell:

An modeling artifact made up of a set of generic architecture nodes (e.g., memory, DMA) involved in a transfer plus the actions to carry out the latter (e.g., Read(), Write())

- ▶ Independently with respect to the "real" communication protocols and standards (system-level of abstraction)
- ▶ Both data and control-information transfers are captured

## Modeling with Communication Patterns(2)

- ▶ Communication Patterns come in two flavors:
  - ▶ textual description (models transformation)
  - ▶ graphical representation (graphical interface in TTool)
- ▶ A SysML Activity Diagram to compose multiple transfers:
  - ▶ control variables
  - ▶ order relation: parallel, sequential, join execution
  - ▶ control statements: selection, loop
- ▶ A SysML Sequence Diagram to describe actions within a transfer



## Summary

- ▶ The complexity of modern platforms for SDR Systems (parallel, distributed)
- ▶ The need to efficiently program SDR architectures (Model Driven Engineering, DiplodocusDF)
- ▶ Modeling complex communication schemes to exploit parallelism in graph-based approaches (DiplodocusDF)
- ▶ Communication Patterns, a solution to modeling and mapping communications at system-level:
  - ▶ more expressiveness for models: enhanced Design Space Exploration
  - ▶ increased model portability: waveform and platform models are disjoint





## Future Works

1. Enhance Run Time Environment with dynamic memory management
2. From bus-based interconnects to Networks on Chip: the new challenges of Communication Patterns



## Contacts

**Thank you for your attention!**

**Personal e-mail:** [andrea.enrici@telecom-paristech.fr](mailto:andrea.enrici@telecom-paristech.fr)

**TTool/DiplodocusDF website:** <http://ttool.telecom-paristech.fr>