A COMPONENT-BASED ARCHITECTURE FOR PROTOCOL DESIGN AND DEVELOPMENT IN SDR FRAMEWORKS

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Research activities
- Center of Excellence DEWS
- European Projects: HYCON 2 and PRESTO
- A Methodology to design and simulate a wireless networked embedded system
- Modeling of a protocol stack by using a Basic Tissue Pattern
- Conclusions and future works
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M1: Modelling and control of heterogeneous distributed complex systems

M2: Communication and protocol design for pervasive and cognitive networks

M3: Design methodologies for embedded systems

A1: Intelligent Transportation Systems

A2: Energy

A3: Advanced monitoring and control
OVERVIEW

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- **A Methodology to design and simulate a wireless networked embedded system**
- **Modelling of a protocol stack by using a Basic Tissue Pattern**
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HYCON 2

WP10 Project coordination and management

WP1 Analysis of complex systems

WP2 Networked control

WP3 System-wide coordination and control

WP4 Self-organizing systems and control

WP5 Benchmarks

WP6 Tool integration

AD1 Ground vehicular transportation

AD2 Electrical power systems

AD3 Biological systems

WP7 Training

WP8 Outreach & IAB

WP9 Dissemination networking roadmapping

Show cases Case studies
Distributed Control

\[ C_p \overset{u(kT)}{\rightarrow} \text{Quantizer Encoder Modulator} \overset{u'(kT)}{\rightarrow} \text{Demodulator Decoder} \overset{y'(kT)}{\rightarrow} P \]

\[ C_{com} \overset{g(kT)}{\rightarrow} \text{Wireless Channel} \overset{\sigma(kT)}{\rightarrow} \text{Demodulator Decoder} \overset{y(kT)}{\rightarrow} \text{Quantizer Encoder Modulator} \]
PRESTO vs HYCON 2

- A SDR stack may be a good solution to optimize the behavior of a MANET devoted to support advanced applications, e.g. distributed control systems.

- We propose a methodological approach to manage design, development and test of SDR stacks by Model Driven Architecture.
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A Methodology to design and simulate a wireless networked embedded system

Modelling of a protocol stack by using a Basic Tissue Pattern

Conclusions and future works
A METHODOLOGY TO DESIGN AND SIMULATE A WIRELESS NETWORKED EMBEDDED SYSTEM

Objectives:

- To provide the designer with a tool for creating customizable templates HW / SW; then, by resorting to automatic generation of code, to obtain the deployment of the system;
- To facilitate traceability of requirements;
- To facilitate (automate) procedures for testing and validating HW / SW systems;

Problems:

- What are the actions that must be performed by a designer during the design phase?
- How can we simplify requirements tracking within the implementation of a system?
- What is it needed to automate testing procedures?
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The methodology proposed here to meet the challenges is named Tissue Methodology.

The Tissue Methodology is based on the following modelling paradigms:

- modular programming
- patterns programming
- events oriented programming
- fractal programming

The design patterns used in the Tissue Methodology are called Tissue Patterns.
A METHODOLOGY TO DESIGN AND SIMULATE A WIRELESS NETWORKED EMBEDDED SYSTEM

- modular programming
- patterns programming
- events oriented programming
- fractal programming

- **Req.1** : The environment must allow the creation of modules (S,P and H) with inputs and outputs through which to receive events and generate events

- **Req.2** : The environment must provide for each module (S, H or P), a handling mechanism to drive the behavior of the module

- **Req.3** : The environment must provide a communication protocol to exchange events, data and functionalities between S, H and P (such as Message Passing Interface, MPI or MPI real time)

- **Req.4** : The environment must allow simulation of the architecture that will be implemented on the target system

- **Req. 5** : The simulation code, like so implementation code, must be automatically generated starting from only one model
A METHODOLOGY TO DESIGN AND SIMULATE A WIRELESS NETWORKED EMBEDDED SYSTEM

Basic Tissue Pattern

Fractal programming
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Omnet++
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The events correspond to the “send” or the “receive” of a PDU
The processes are the elaborations of the PDU
the data structures represent the “data base”, and a standard mode to retrieve data can be
designed, with the aim of applying automatic code generation technique
the code for measure could be generated automatically, quicken one’s pace testing and analysis
of the performance of a MANET network.
Following this approach, a protocol stack can be rethought as shown below:
Modelling of a protocols stack by using a Basic Tissue Pattern

PHY IEEE 802.15.4
Modelling of a protocols stack by using a Basic Tissue Pattern
Modelling of a protocols stack by using a Basic Tissue Pattern

The process adopted to perform this conversion includes the following steps:

- definition of data types to cover all the data managed into the phy layer;
- association of a unique identification code to each data type;
- association of a unique handle to each data type;
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- association of a unique handle to each data type;

The following methods have been implemented to manage data types:

- virtual void* `select802154Data`(const char* data, int* typeData, wrapper_t tW): it returns the handle to specified through the typeData ID;
- virtual void `set802154Data`(const char* data, int* typeData, wrapper_t tW, void* dataMP): it adds a new data structure
In order to **retrieve the handle** of the storage module, the needed methods are:

1. `cModule*hs802154PHY=(getParentModule()->getSubmodule("sphy");`
2. `::S802154PHY*hS802154PHY=check_and_cast<S802154PHY*>(hs802154PHY);`
Modelling of a protocols stack by using a Basic Tissue Pattern

This is a way to satisfy Req.1 and Req.2

In order to retrieve the handle of the storage module, the needed methods are:

+ \texttt{cModule*hs802154PHY=(getParentModule()->getSubmodule("sphy");)

+ \texttt{::S802154PHY*hS802154PHY=check\_and\_cast<S802154PHY*>(hs802154PHY);}
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The functionalities developed for the H module to manage the events are:

- `virtual void fCSend(cMessage* msg,int idGate,int sel,simtime_t t);` it is needed to control the generation of events in the H module;
- `virtual void fCSelfMsg(simtime_t t,cMessage* msg);` it is needed to set internal events (e.g. Timer);
- `virtual void fCancEvent(cMessage* msg,int sel);` it is needed to cancel an event which has expired or that was processed;
- `virtual void deleteSelfMsg(cMessage* msg);` it is needed to cancel an internal event which has expired or that was processed;
Modelling of a protocols stack by using a Basic Tissue Pattern

When an event is received on the H interface, the H module ask the P module for the execution of one of the following operations:

- `updateDisplayString(*drawCoverage,*sensitivity,*transmitterPower,updateString,*updateStringInterval);`
- `handlePrimitive(msg->getKind(), msg)`: it is useful to manage exchange of primitives between the 802.15.4 physical layer and 802.15.4 mac layer;
- `handleUpperMsg(airframe)`: it is useful to manage messages originated from the MAC layer;
- `handleSelfMsg(msg)`: it is useful to manage internal messages;
- `handleLowerMsgStart(airframe);`
- `bufferMsg(airframe)`: it is useful to manage queues of the air frames Protocol Data Units;
Example of dynamic tissue pattern reconfiguration
Conclusions and future works

- We have considered modelling of network of wireless embedded systems for distributed controls in an SDR framework.
- We have proposed a new methodology, called Tissue Methodology, to design, develop and testing SDR protocols stacks.
- We have developed an implementation of the 802.15.4 Physical layer that is compliant with the Tissue Methodology.
- Future works are related to exploitations of Req.4: and Req. 5: automatic code generation for design and for filling the gap between simulation and implementation.
Thanks for your attention!

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