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

M. Colizza, M.Faccio, C.Rinaldi, F.Santucci
Center of excellence DEWS
University of L'Aquila Italy

OVERVIEW

- 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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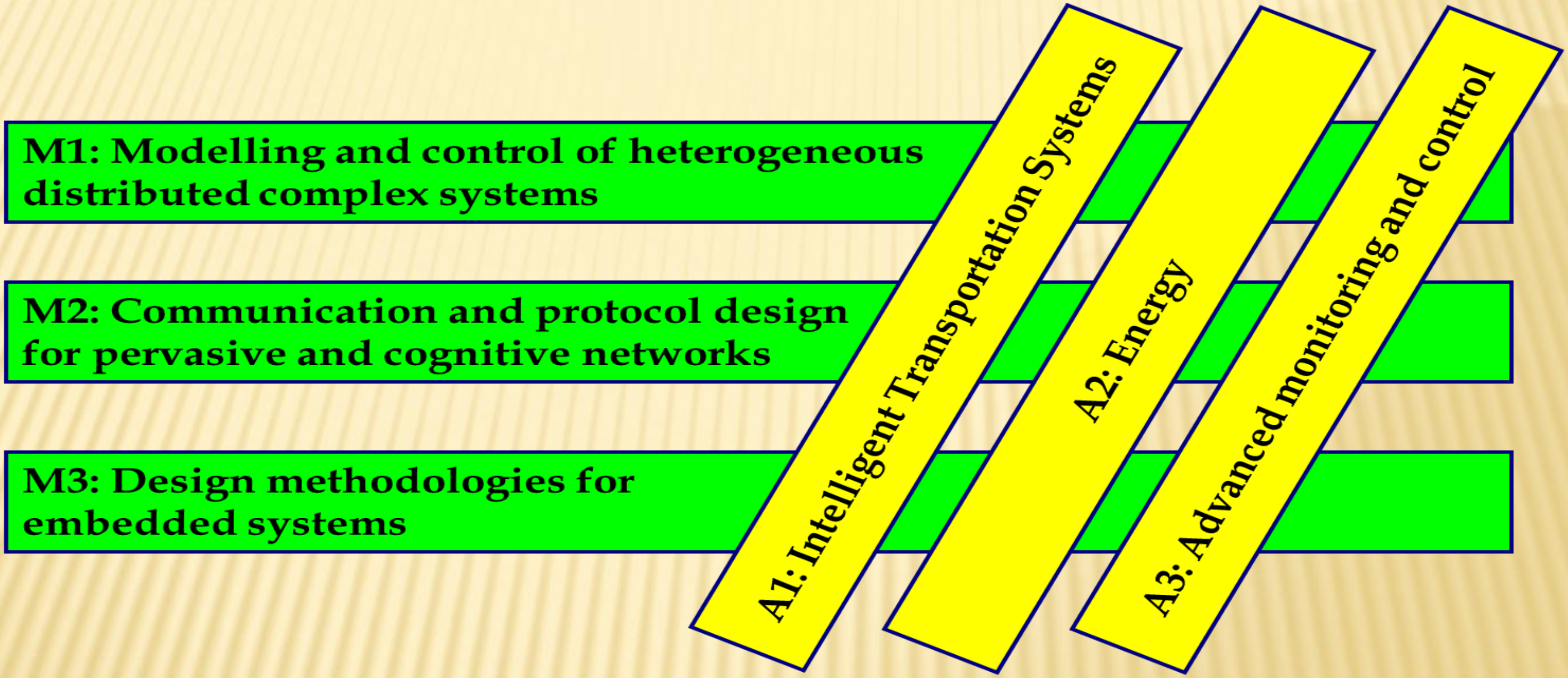
CENTER OF EXCELLENCE DEWS



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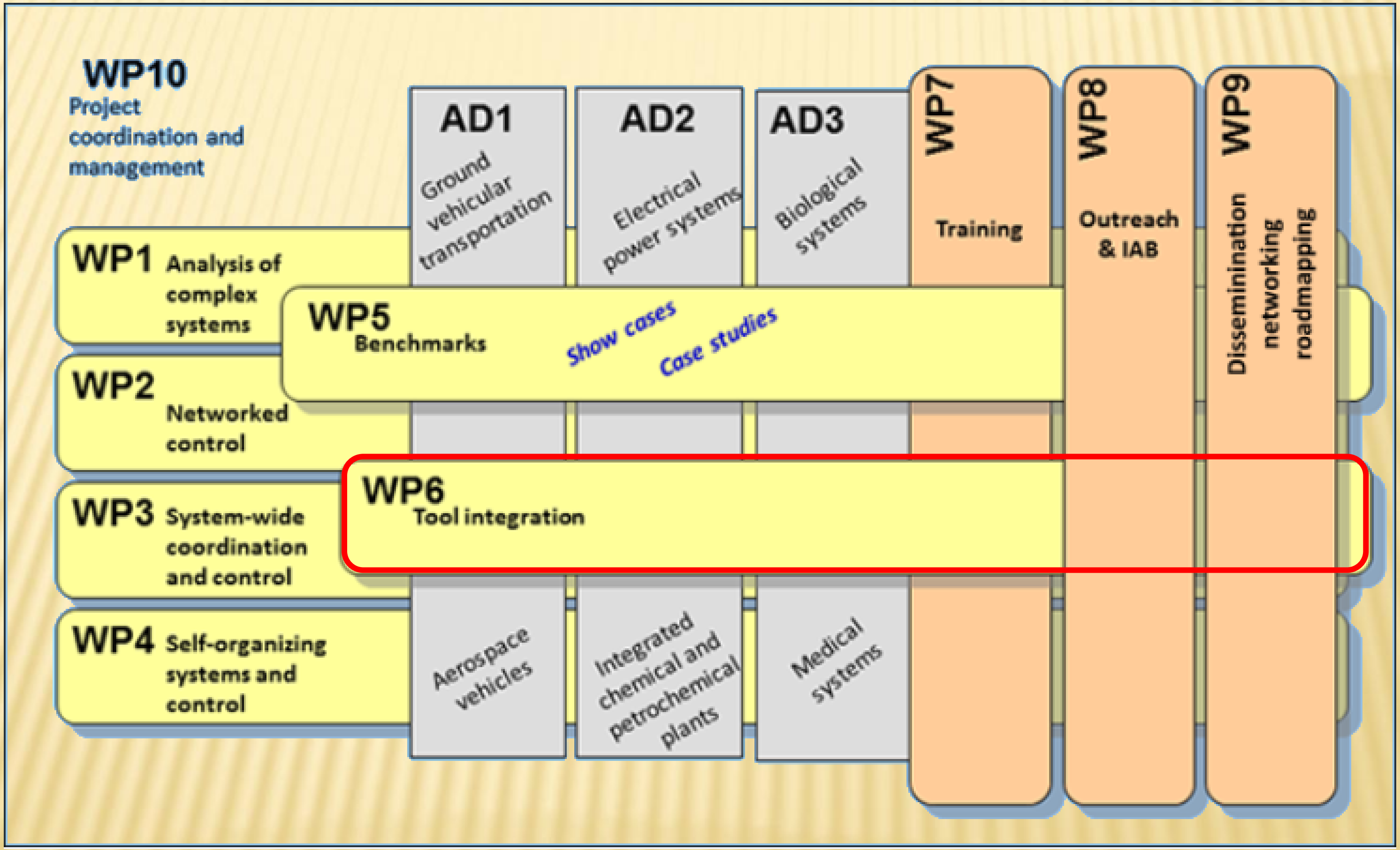
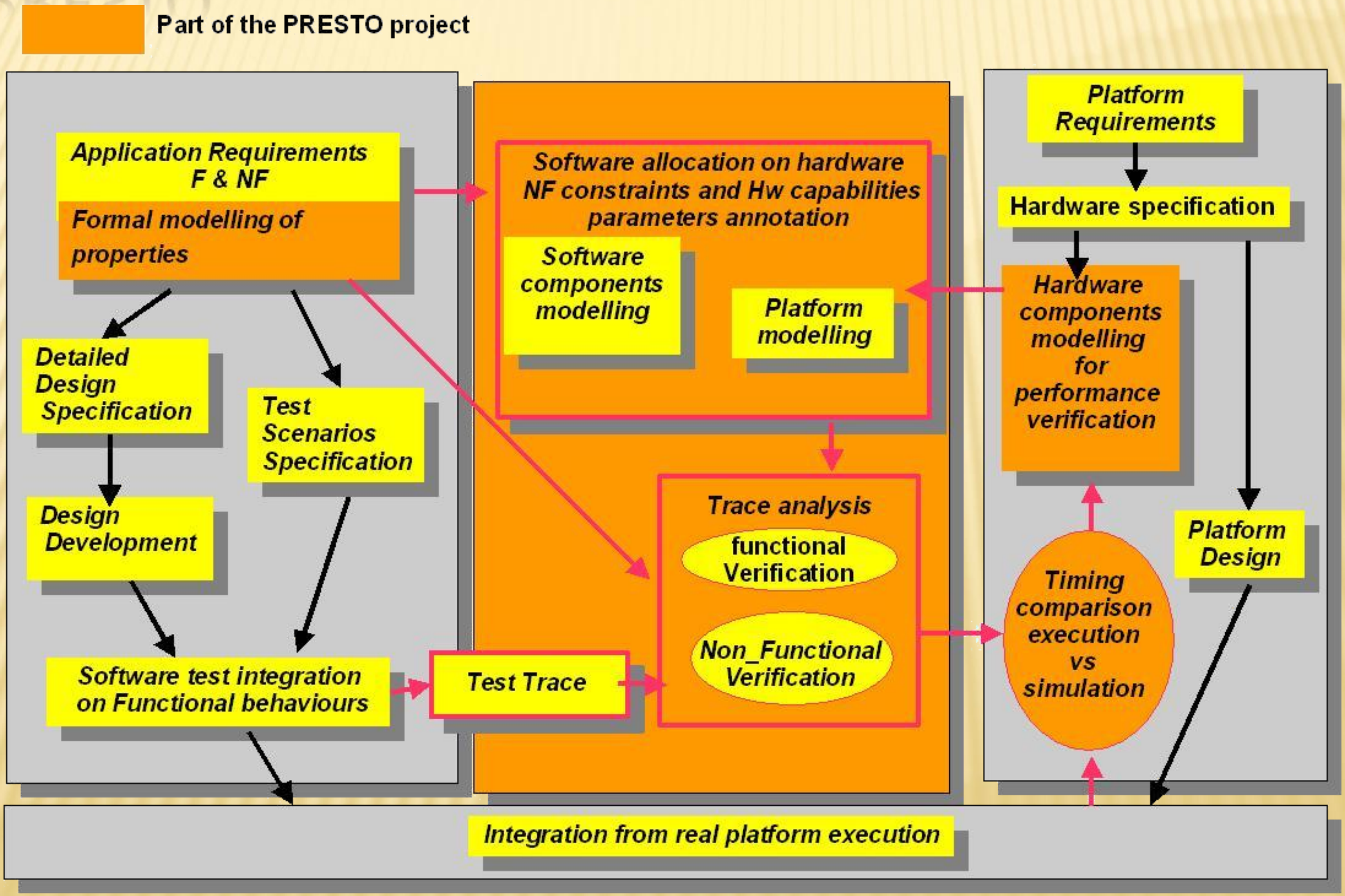
HYCON 2


WP10
Project coordination and management
AD1
Ground vehicular transportation
AD2
Electrical power systems
AD3
Biological systems
WP7
Training
WP8
Outreach & IAB
WP9
Disseminination networking roadmapping
WP1 Analysis of complex systems
WP5
Benchmarks
Show cases
Case studies
WP2
Networked control
WP6
Tool integration
WP3 System-wide coordination and control
WP4 Self-organizing systems and control
Aerospace vehicles
Integrated chemical and petrochemical plants
Medical systems

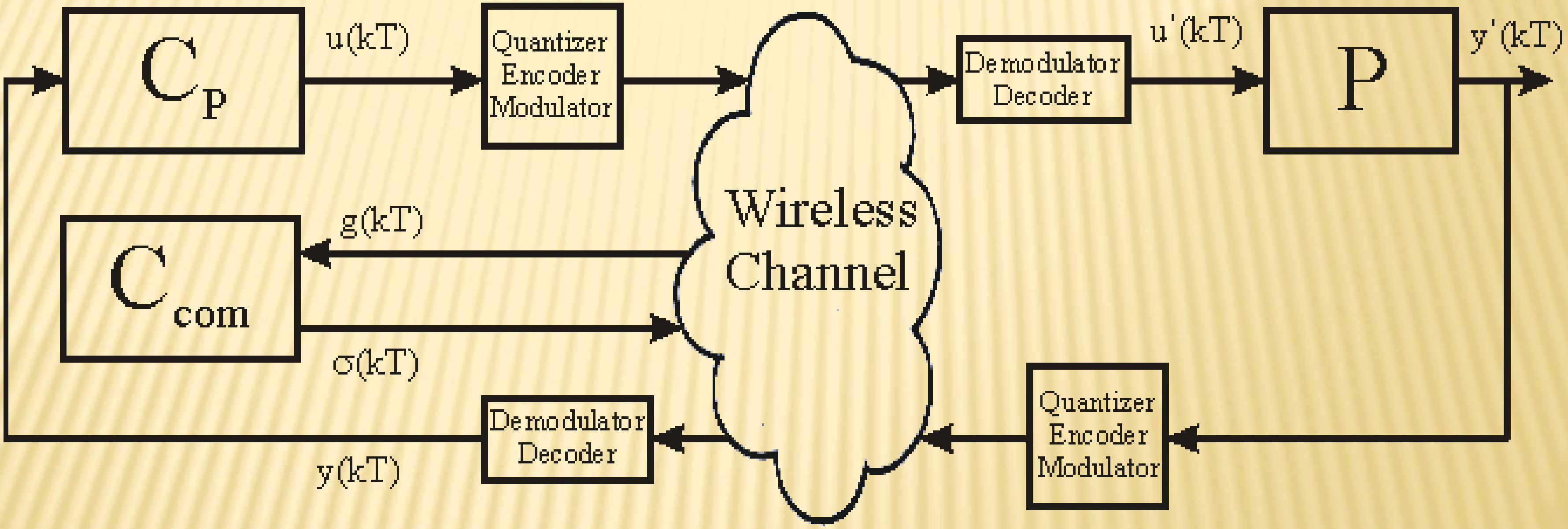
PRESTO



Part of the PRESTO project
Application Requirements F & NF
Formal modelling of properties
Detailed Design Specification
Test Scenarios Specification
Design Development
Software test integration on Functional behaviours
Test Trace
Software allocation on hardware NF constraints and Hw capabilities parameters annotation
Software components modelling
Platform modelling
Trace analysis
functional Verification
Non_Functional Verification
Platform Requirements
Hardware specification
Hardware components modelling for performance verification
Platform Design
Timing comparison execution vs simulation
Integration from real platform execution

HYCON 2

Distributed Control



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

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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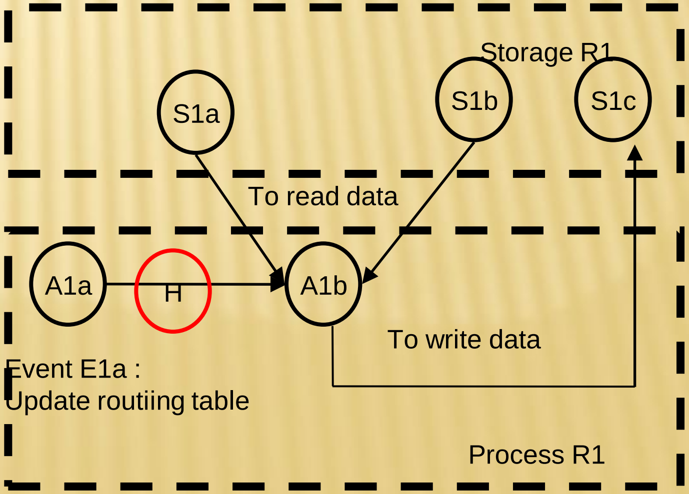
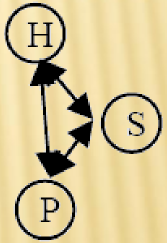


A METHODOLOGY TO DESIGN AND SIMULATE A WIRELESS NETWORKED EMBEDDED SYSTEM

- 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

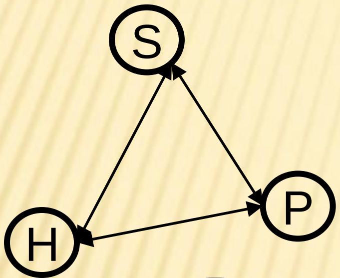
A METHODOLOGY TO DESIGN AND SIMULATE A WIRELESS NETWORKED EMBEDDED SYSTEM

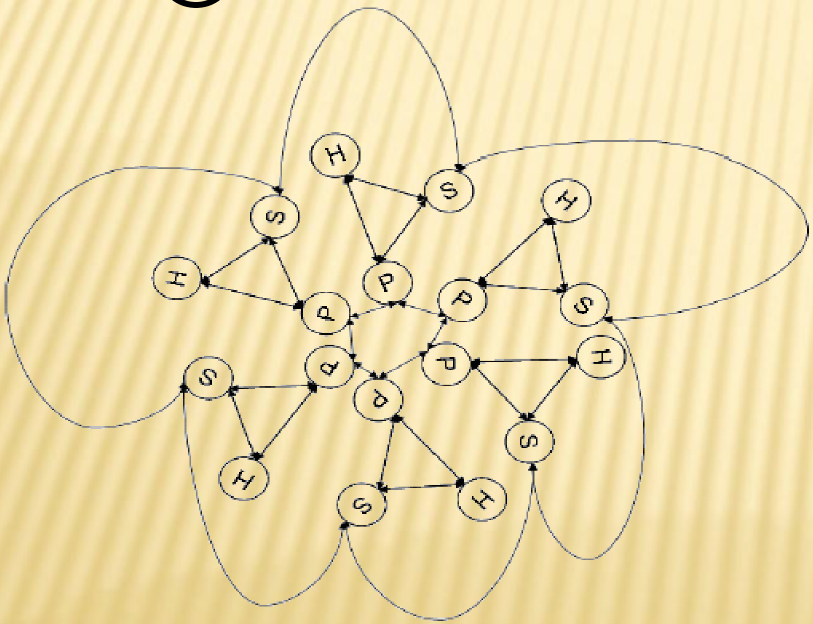
- modular programming
- patterns programming
- events oriented programming
- fractal programming

- 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

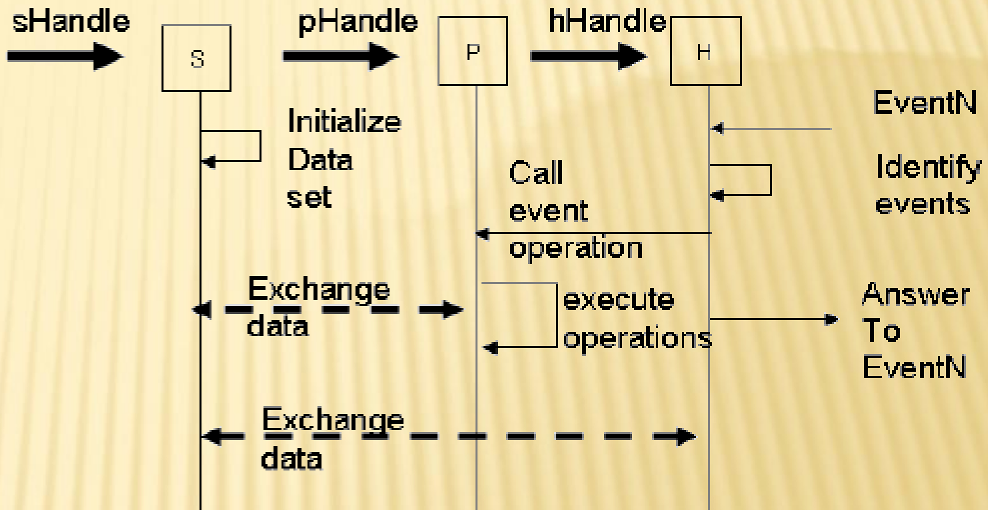
A METHODOLOGY TO DESIGN AND SIMULATE A WIRELESS NETWORKED EMBEDDED SYSTEM

Basic Tissue Pattern





Fractal programming



Data Set

ID-Data	handleD
IDD1	handleD1
IDDN	handleDN

Operation Set

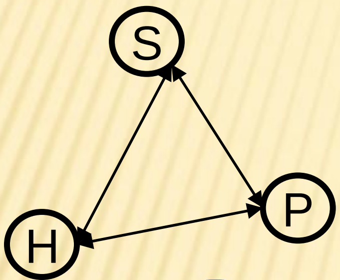
ID-Process	handleP
IDP1	handleP1
IDPN	handlePM

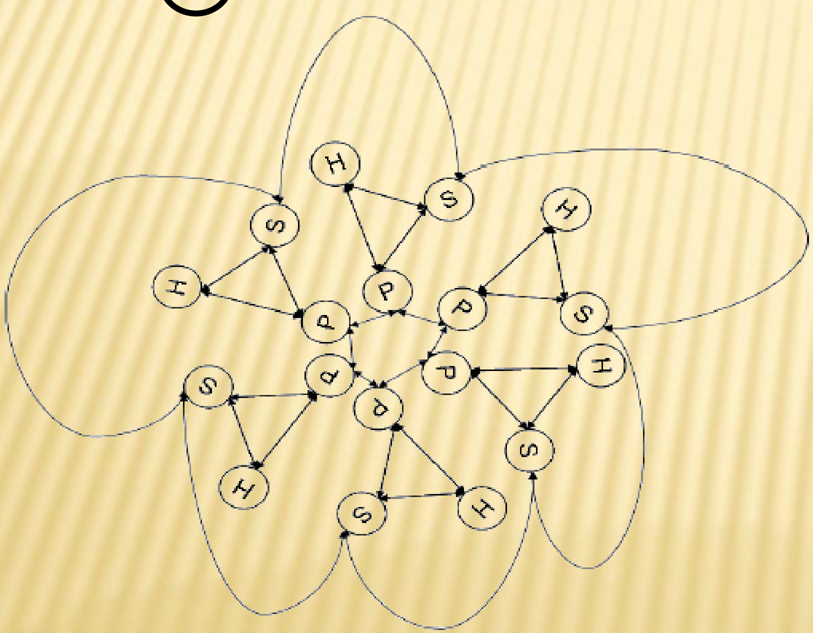
Event Set

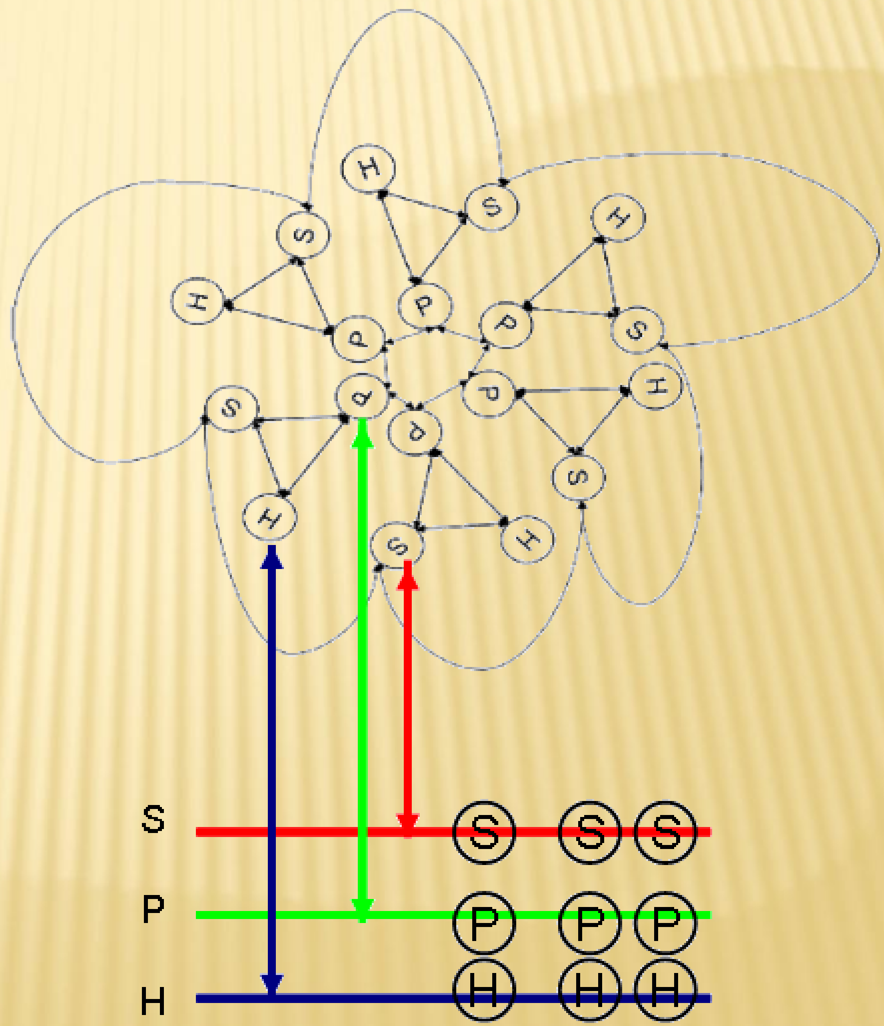
ID-Event	Operation
IDE1	handleP1
IDEN	handlePL

A METHODOLOGY TO DESIGN AND SIMULATE A WIRELESS NETWORKED EMBEDDED SYSTEM

Basic Tissue Pattern





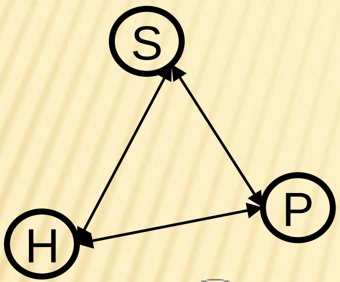


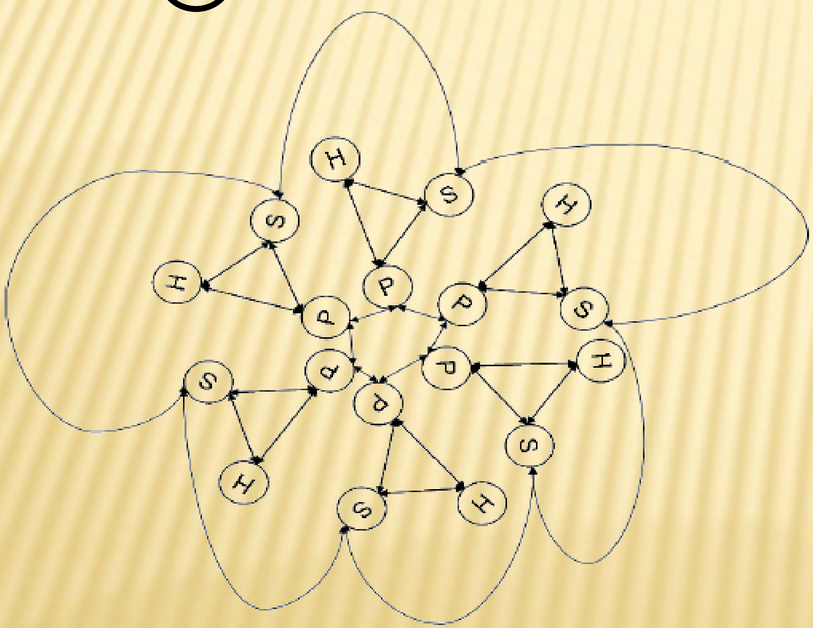
Fractal programming

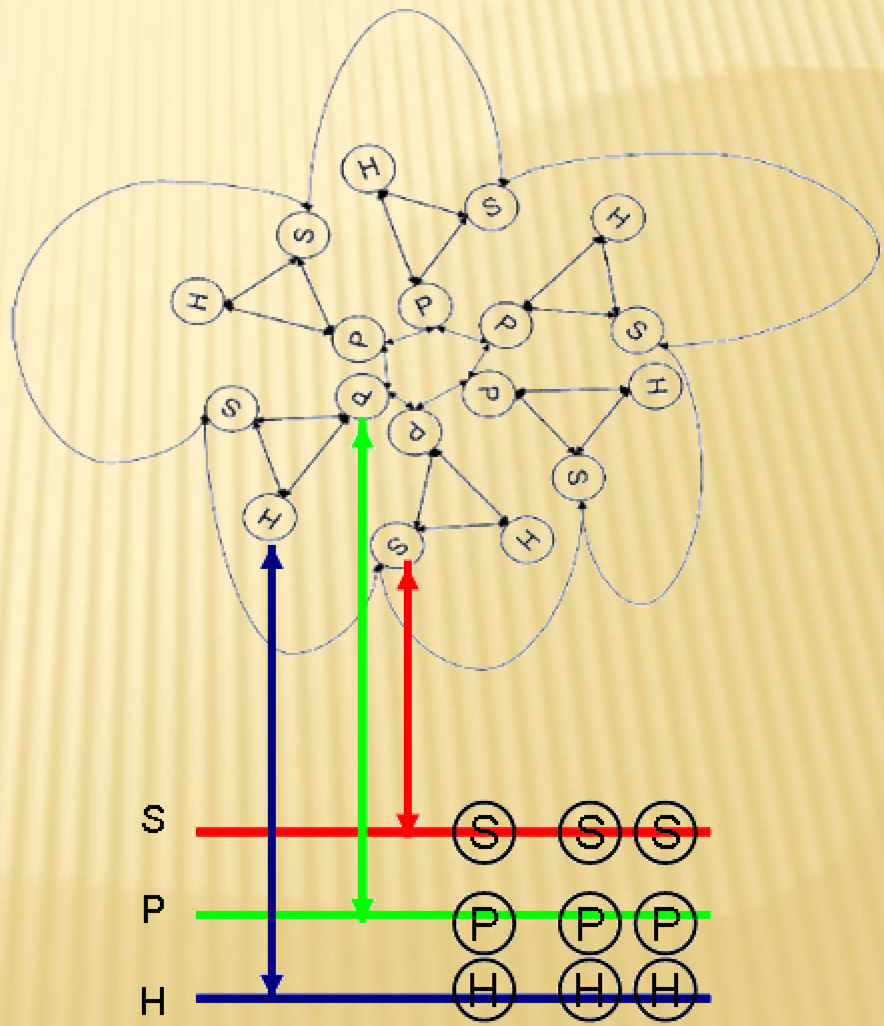
A METHODOLOGY TO DESIGN AND SIMULATE A WIRELESS NETWORKED EMBEDDED SYSTEM

Omnet++

Basic Tissue Pattern







Fractal programming

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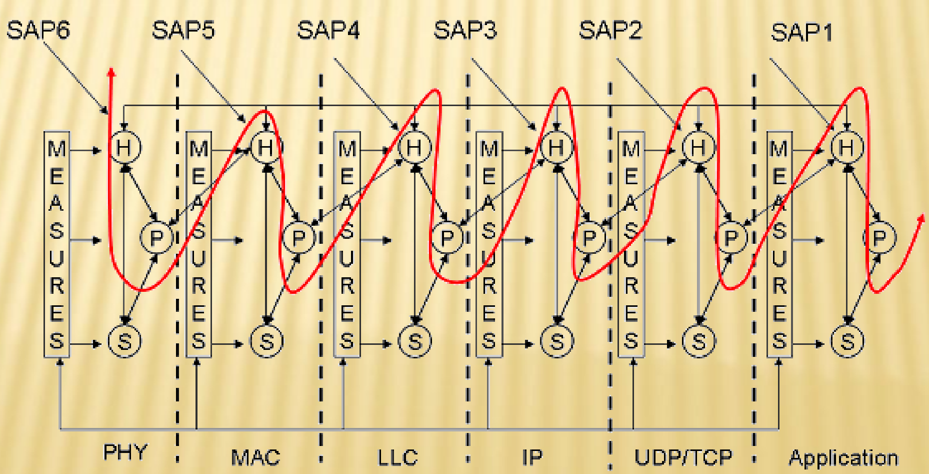
Modelling of a protocols stack by using a Basic Tissue Pattern

- 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 :



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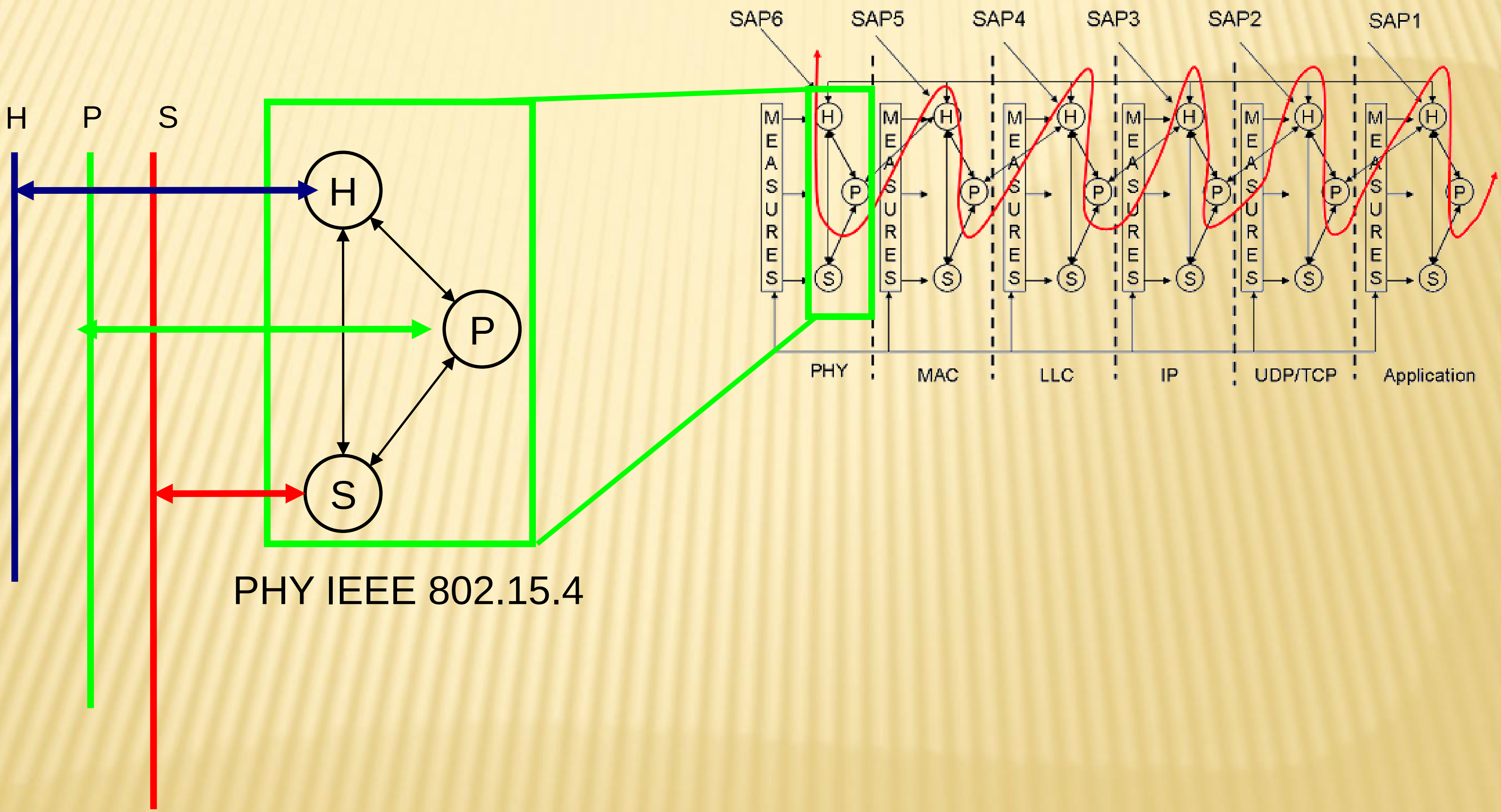

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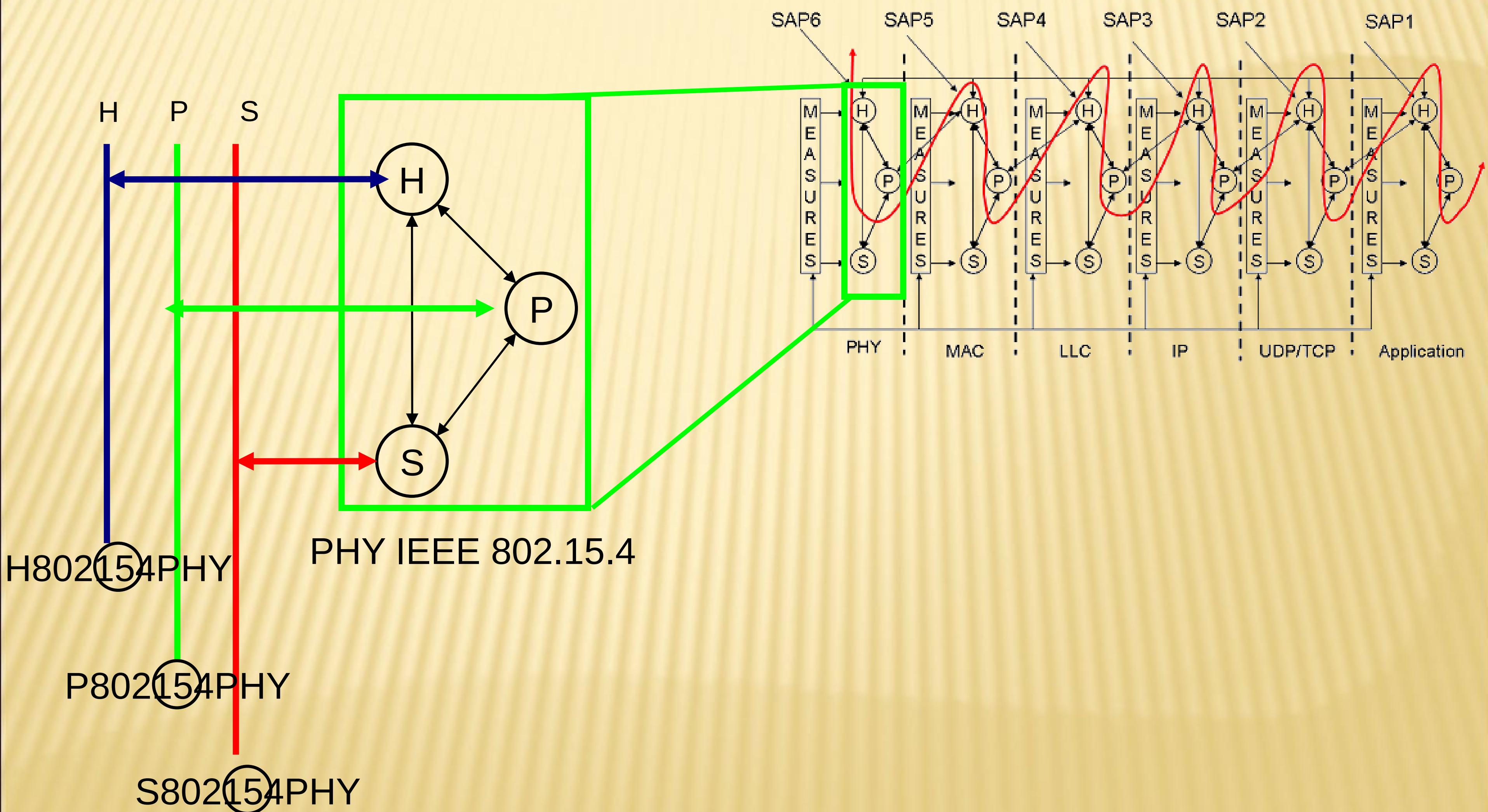
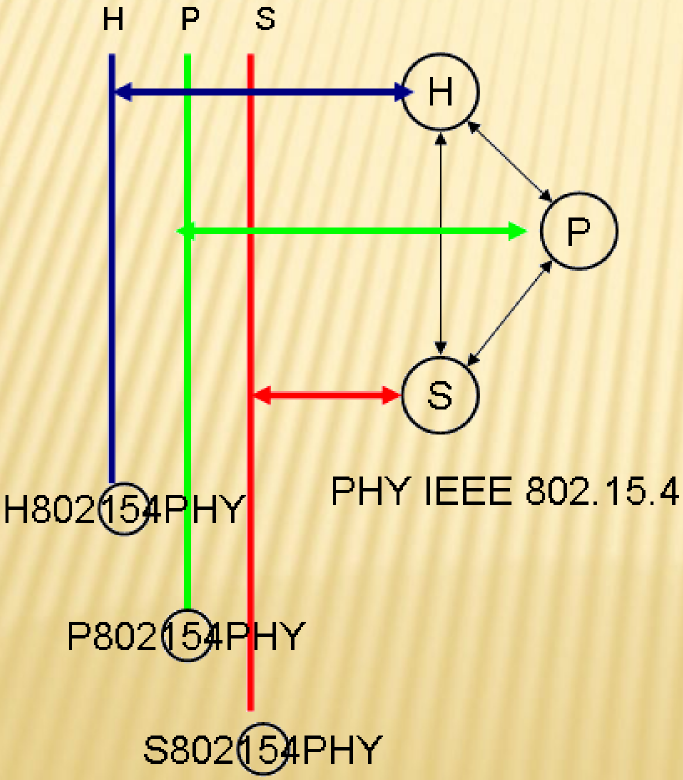
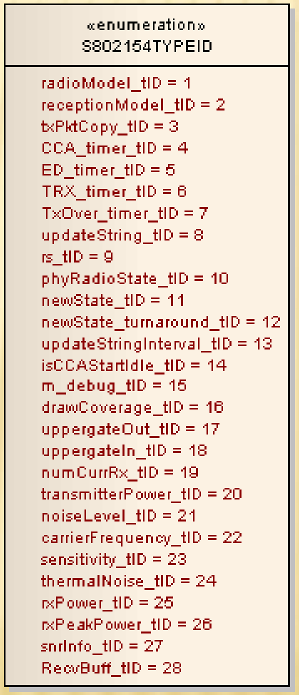


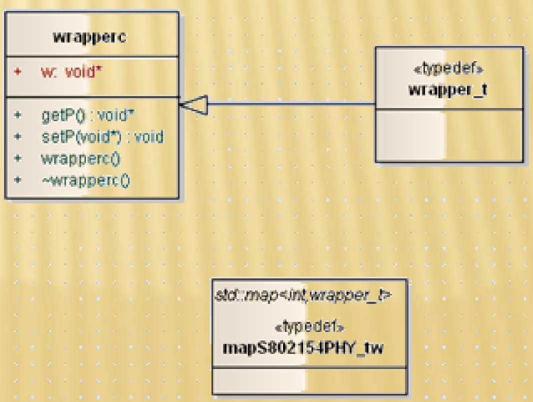
Modelling of a protocols stack by using a Basic Tissue Pattern

- 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;





ID	handle
ID1	handle1
IDN	handleN



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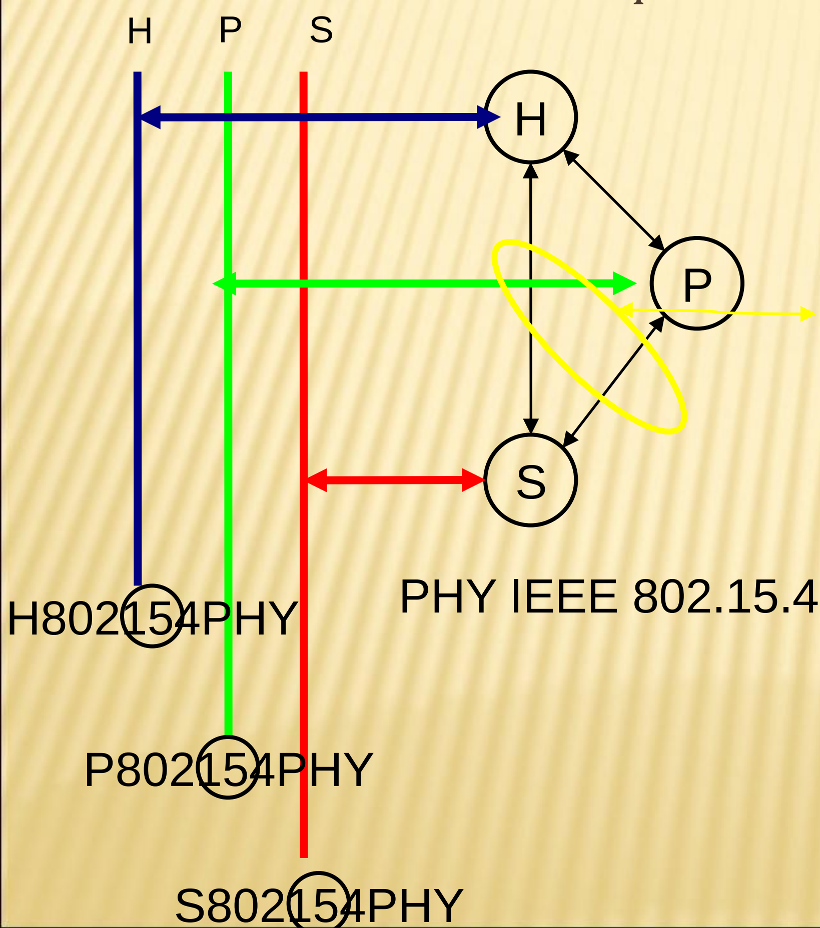
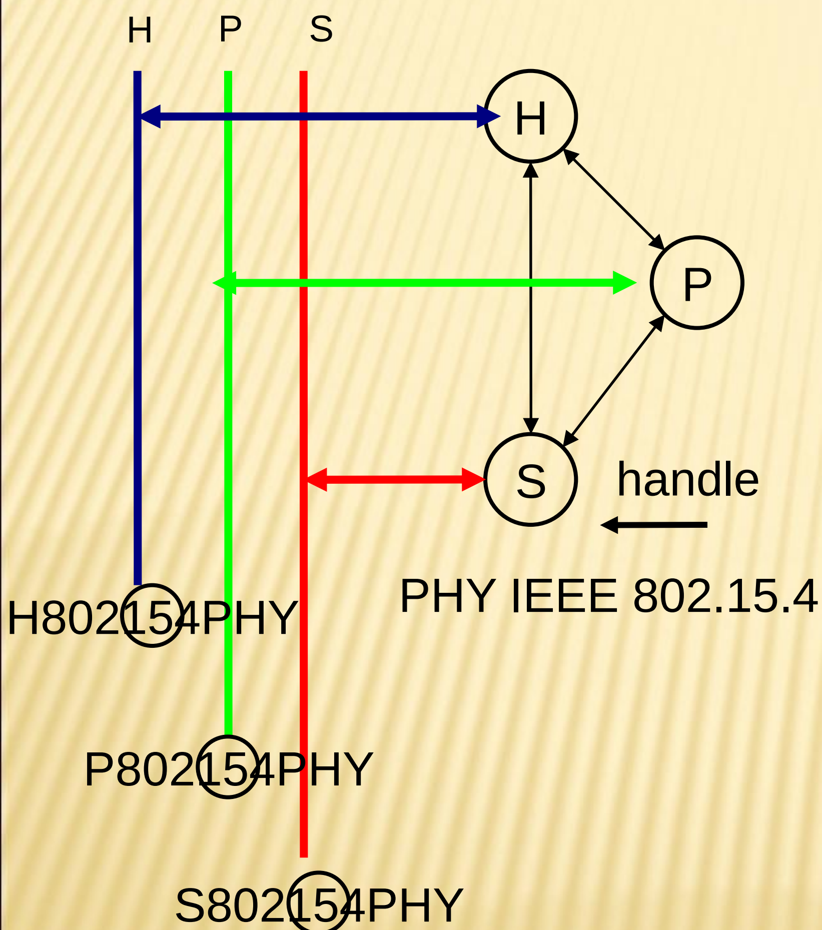


- The following methods have been implemented to **manage data types**:
  - virtual void* **select802154Data**(const char* data,int* typeData,wrapper_t tW): it returns the handle to specified through the typeData ID;.
  - virtual void **set802154Data**(const char* data,int* typeData,wrapper_t tW,void* dataMP): it adds a new data structure

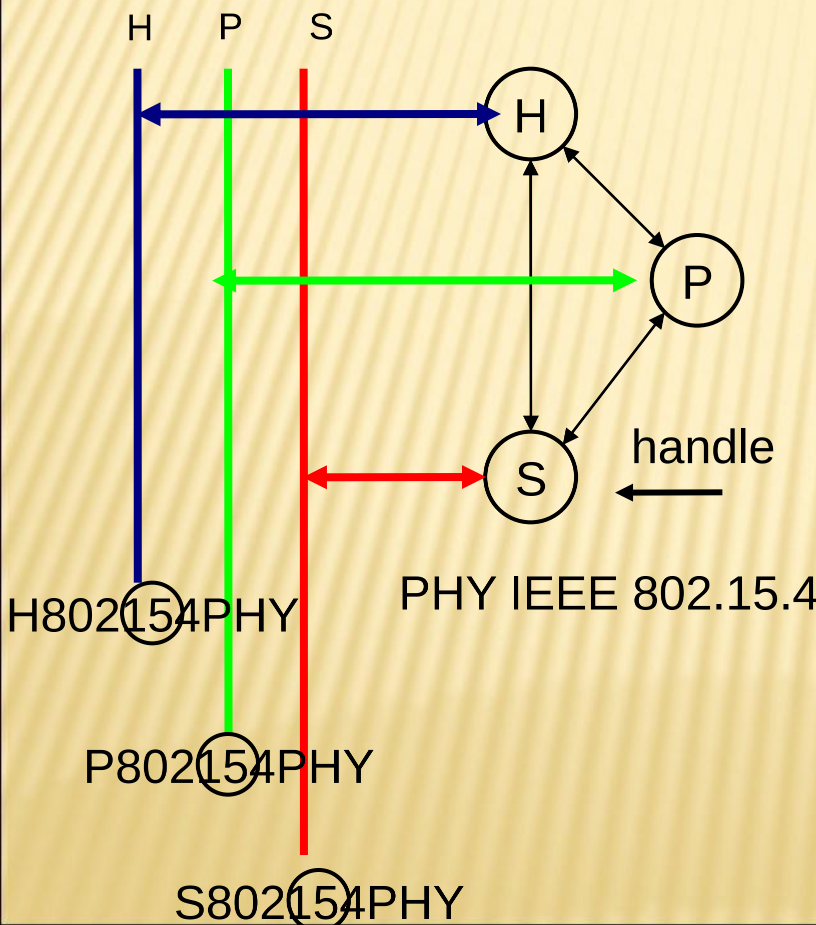
Modelling of a protocols stack by using a Basic Tissue Pattern



- In order to **retrieve the handle** of the storage module, the needed methods are :
  - cModule*hs802154PHY=(getParentModule( )->getSubmodule("sphy"));
  - ::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 :
  - cModule*hs802154PHY=(getParentModule()->getSubmodule("sphy"));
  - ::S802154PHY*hS802154PHY=check_and_cast<S802154PHY *>(hs802154PHY);

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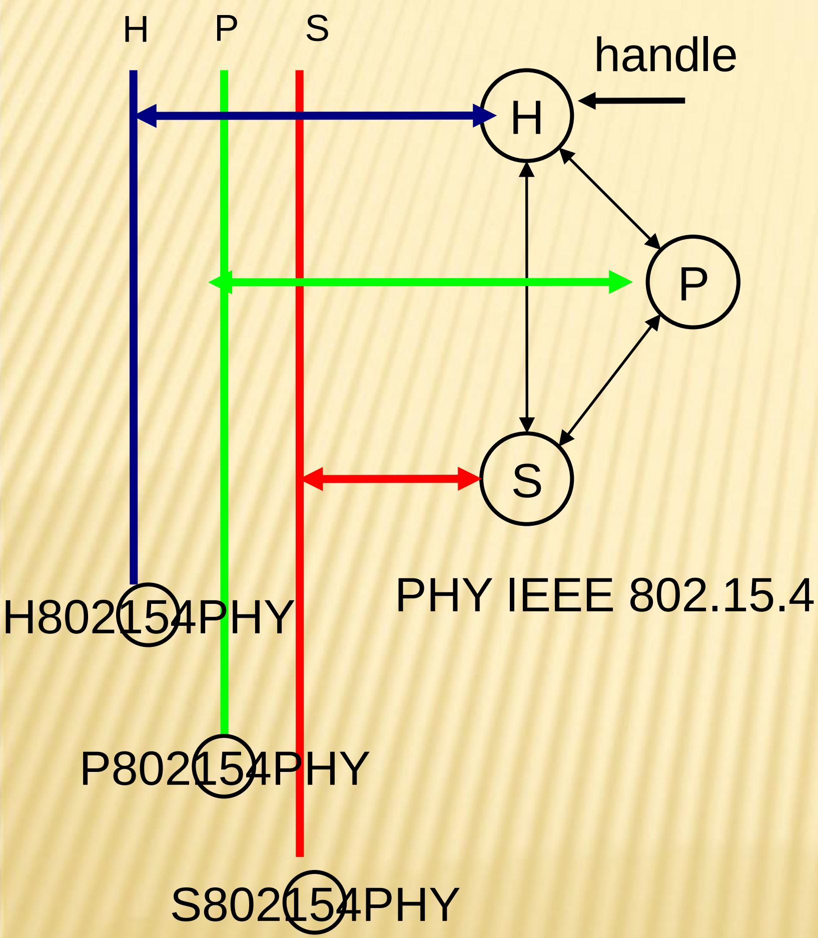
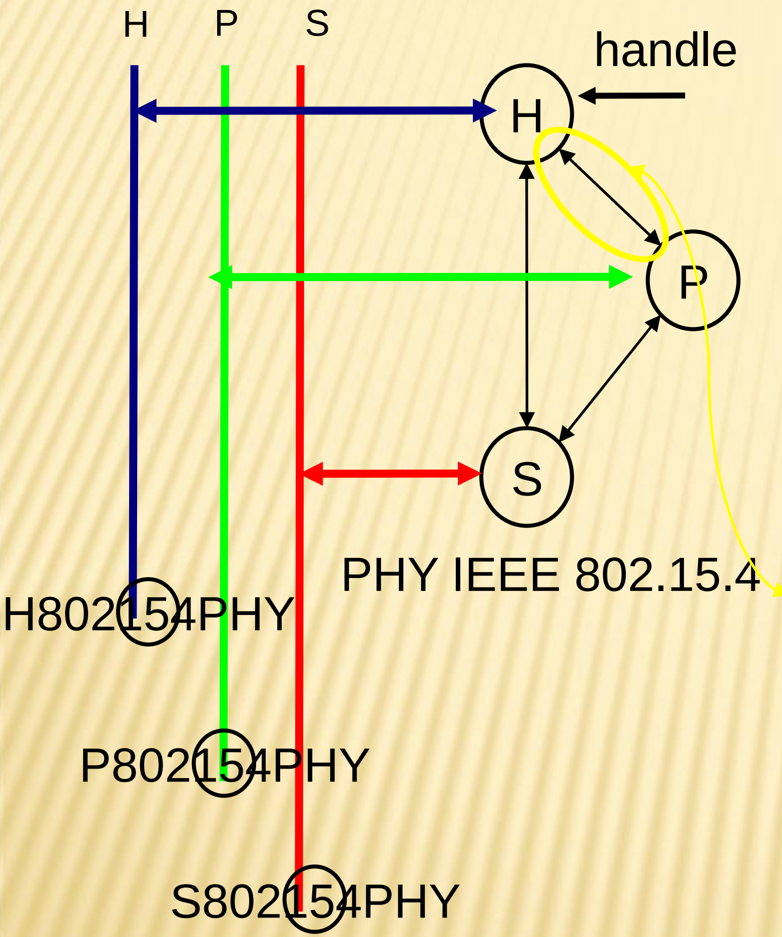


- The functionalities developed for the H module to **manage the events** are:
  - virtual void fCSend(cMessage* msg,int idGate,int sel,simtime_t t); it is needed to control the generation of events in the H module;
  - virtual void fCSelfMsg(simtime_t t,cMessage* msg); it is needed to set internal events (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

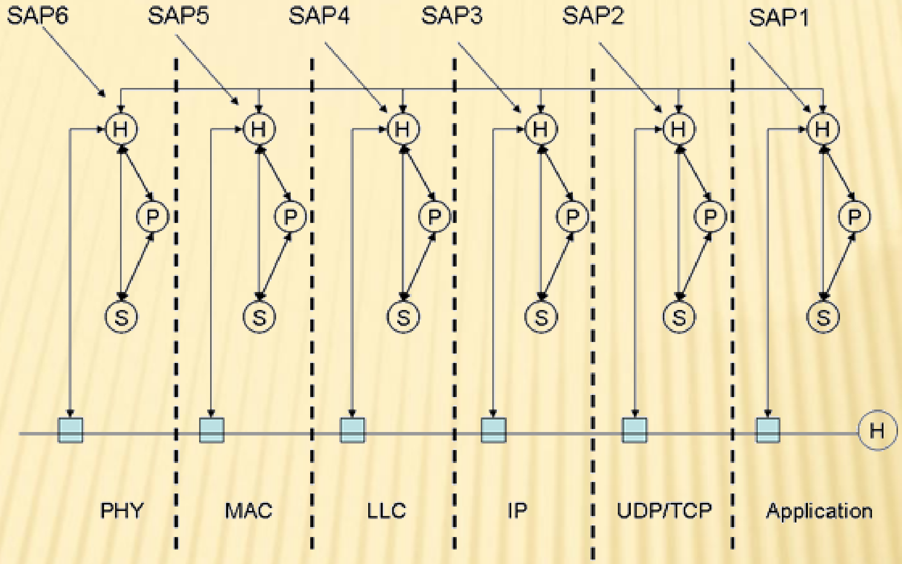


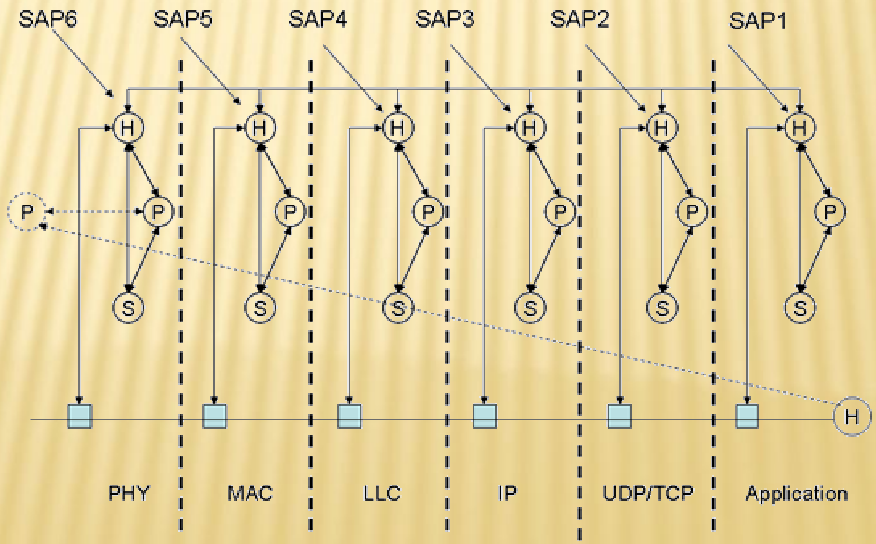
- When **an event is received** on the H interface, the H module **ask the P module** for the execution of one of the following operations :
  - updateDisplayString(*drawCoverage,*sensitivity,*transmitterPower,updateString,*updateStringInterval);

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, develope 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!

colizza@westaquila.com
claudia.rinaldi@univaq.it