MiXiM – The Physical Layer
An Architecture Overview

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Outline

- MiXiM Introduction
- Motivating Example
- MiXiM PHY Architecture
- Interaction Example: Receiving an AirFrame
- Common Model for Analog Effects
- The Mapping Concept

MiXiM Introduction

- MiXiM is a combination of several frameworks for wireless simulations in OMNeT++
  - Mobility Framework (MF)
  - Channel Simulator (ChSim)
  - MacSimulator
  - Positif framework

- For an overview of MiXiMs capabilities see last years paper:

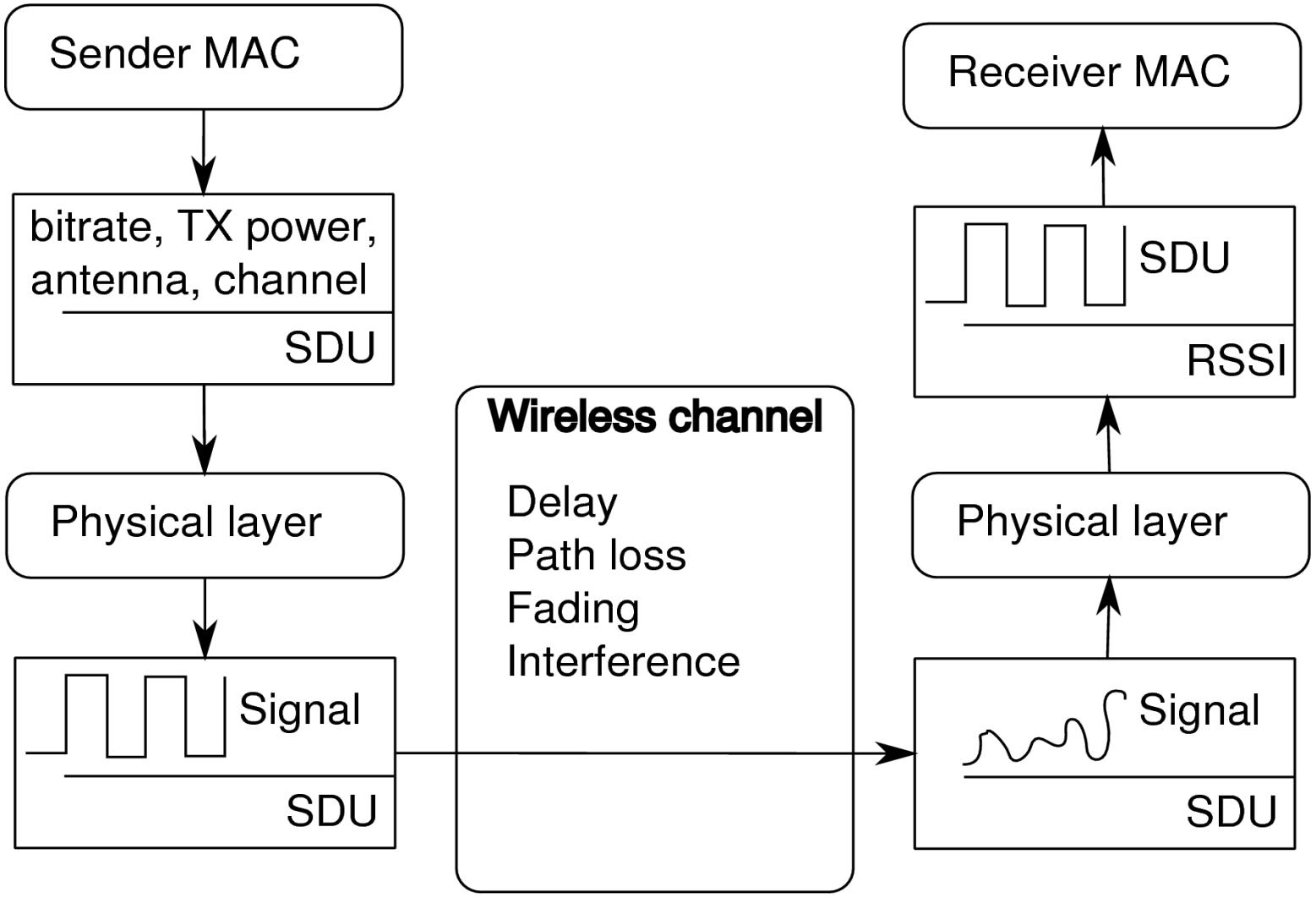
Simulating Wireless and Mobile Networks in OMNeT++
The MiXiM Vision

- This years paper: Focus on PHY architecture

Challenges in PHY layer simulation

- Example: 802.11n
  - Multiple channels
  - Multiple frequencies (OFDM)
  - Multiple antennas (MIMO)
  - Multiple bit rates (header, message body)
  - Forward error correction
- Suppose you want to examine co-existence with an 802.15.4 based sensor network, this requires a PHY that
  - Treats time, frequency and space as separate dimensions
  - Works with in-system and out-of-system interferers
  - Evaluates the influence of coding (DSSS vs OFDM+FEC)
- The MiXiM PHY architecture gives a hand in writing it

Elements of a wireless transmission



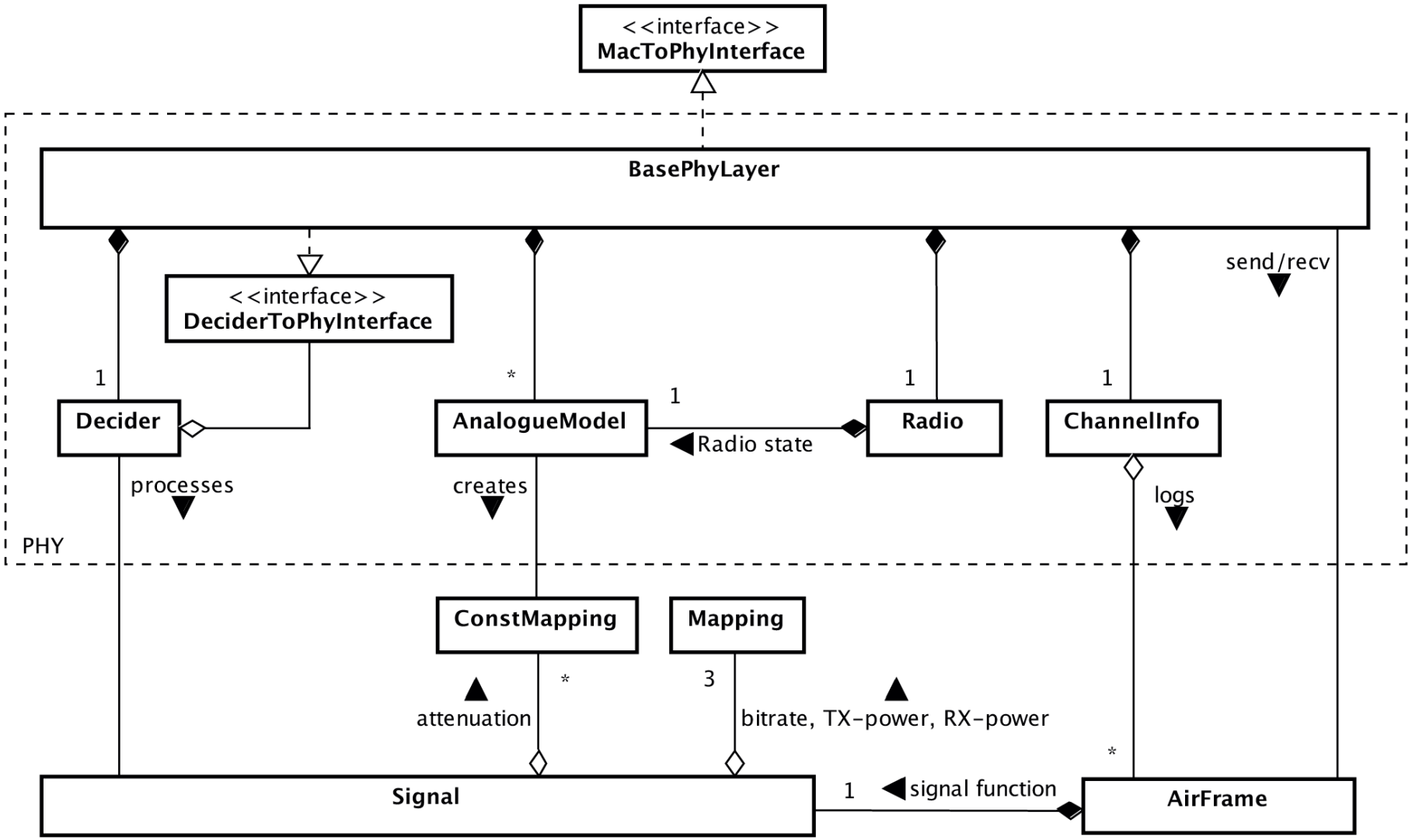
PHY Requirements (I)

- Sending of messages
  - Interface to MAC to set appropriate parameters
    - Sending power, modulation, …
    - Radio switching
- Receiving of messages
  - Modeling propagation and transmission delay
  - Frame synchronization / frame detection
  - SINR calculation / bit error analysis
- Channel sensing
  - RSSI / channel state estimation

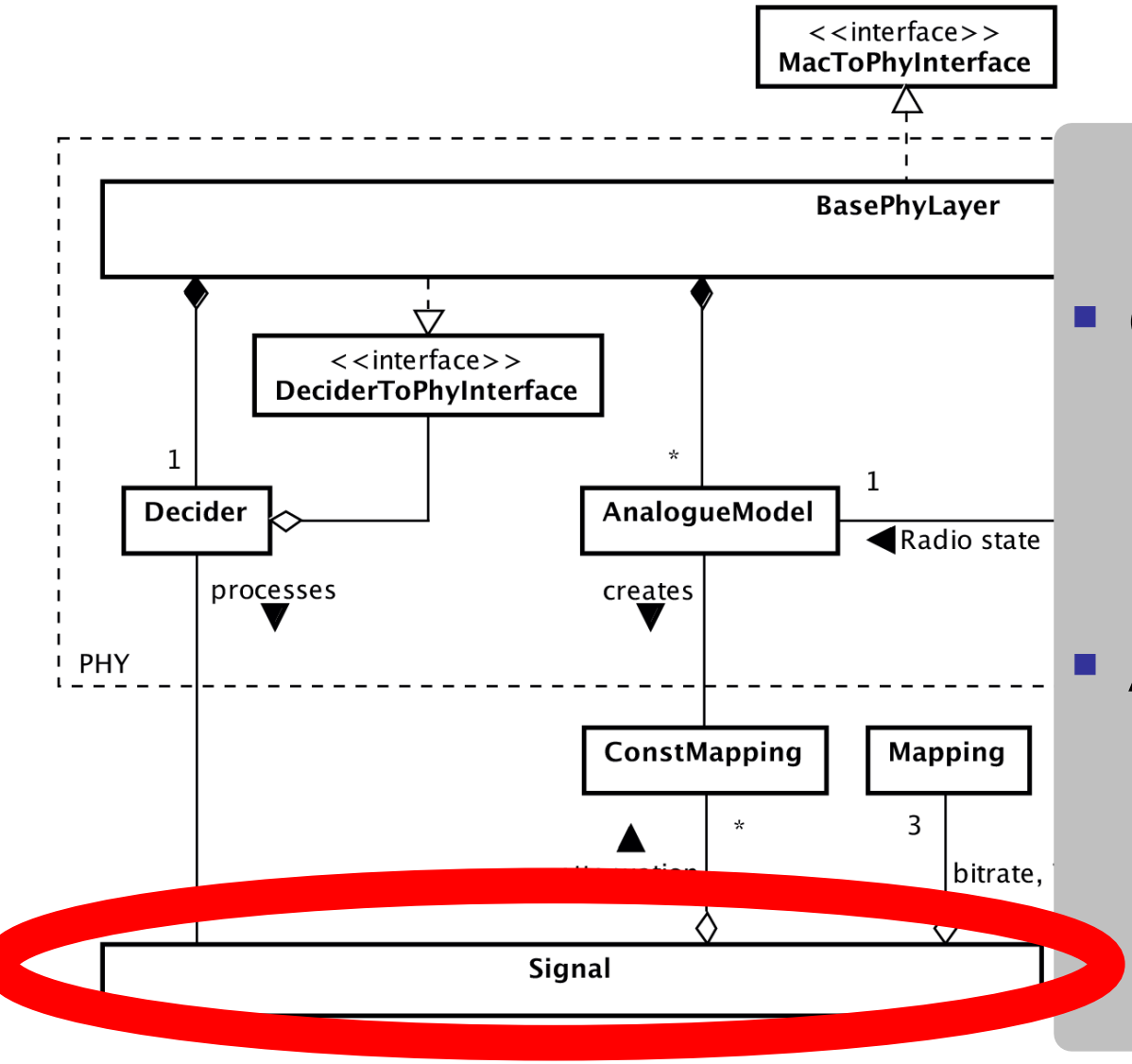
PHY Requirements (II) – The Signal Concept

- Modeling of the message as an electromagnetic wave
  - Multiple dimensions
    - Time
    - Frequency
    - Space
  - Influences of the environment on the message
    - Pathloss
    - Shadowing
    - Fading
  - Antenna models
    - Antenna gain
    - MIMO

MiXiM PHY Architecture Overview

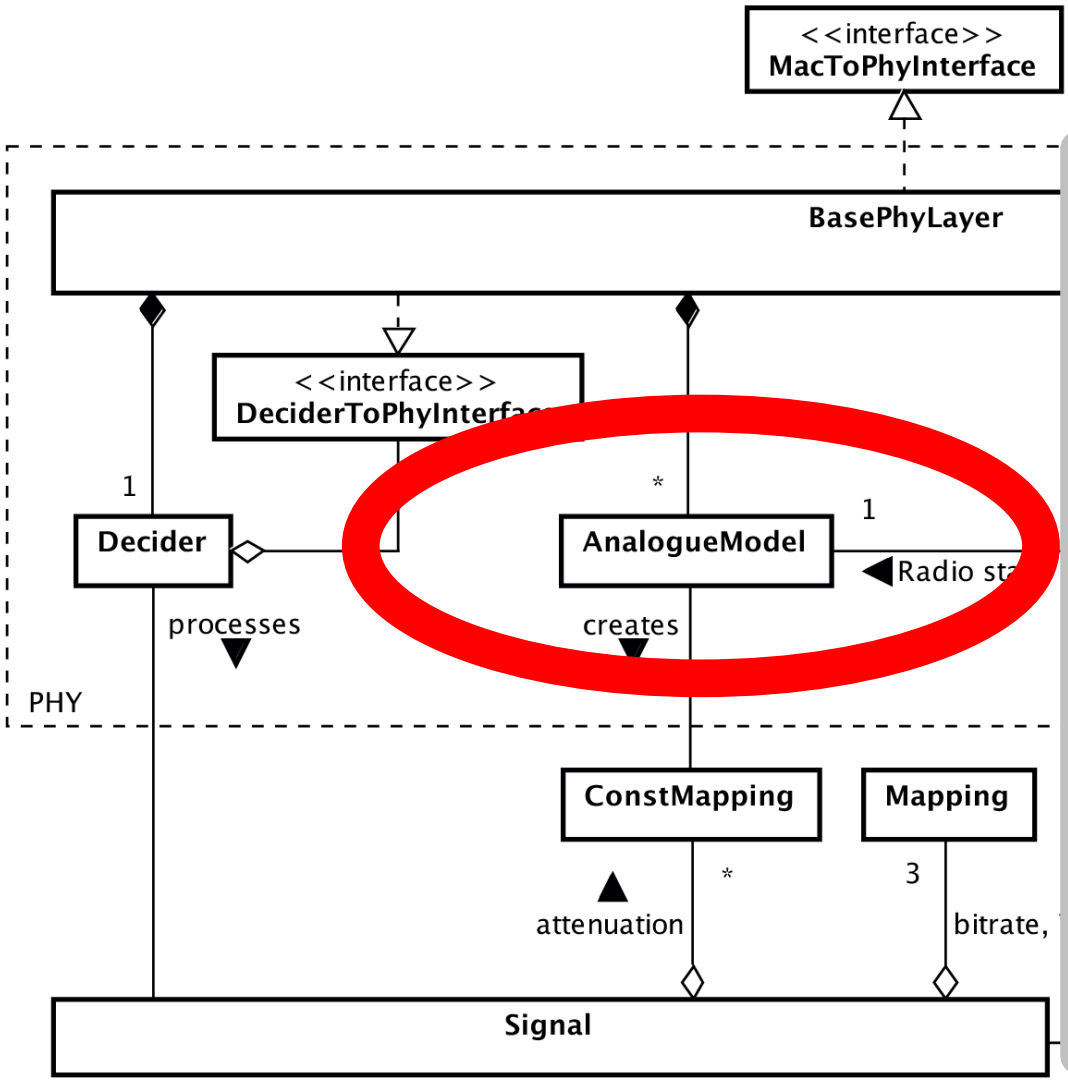


MiXiM PHY Architecture



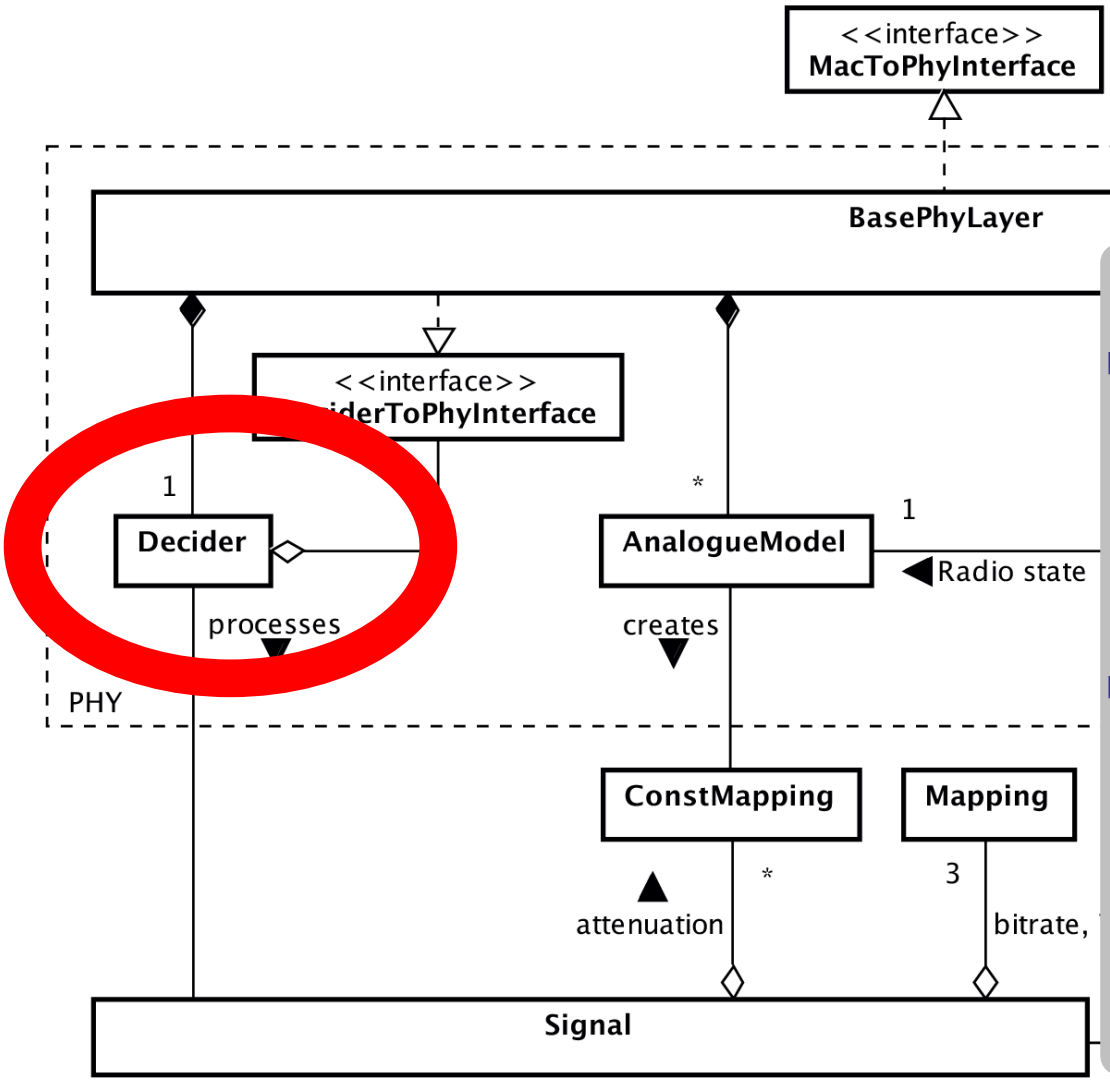
- On sender side
  - TX power
  - Channel
  - Bitrates
  - Transmission Antenna
- After reception also
  - Path loss
  - Shadowing
  - Fading
  - Receiving Antenna

MiXiM PHY Architecture



- Computes
  - Path loss
  - Shadowing
  - Fading
  - Antenna Gain

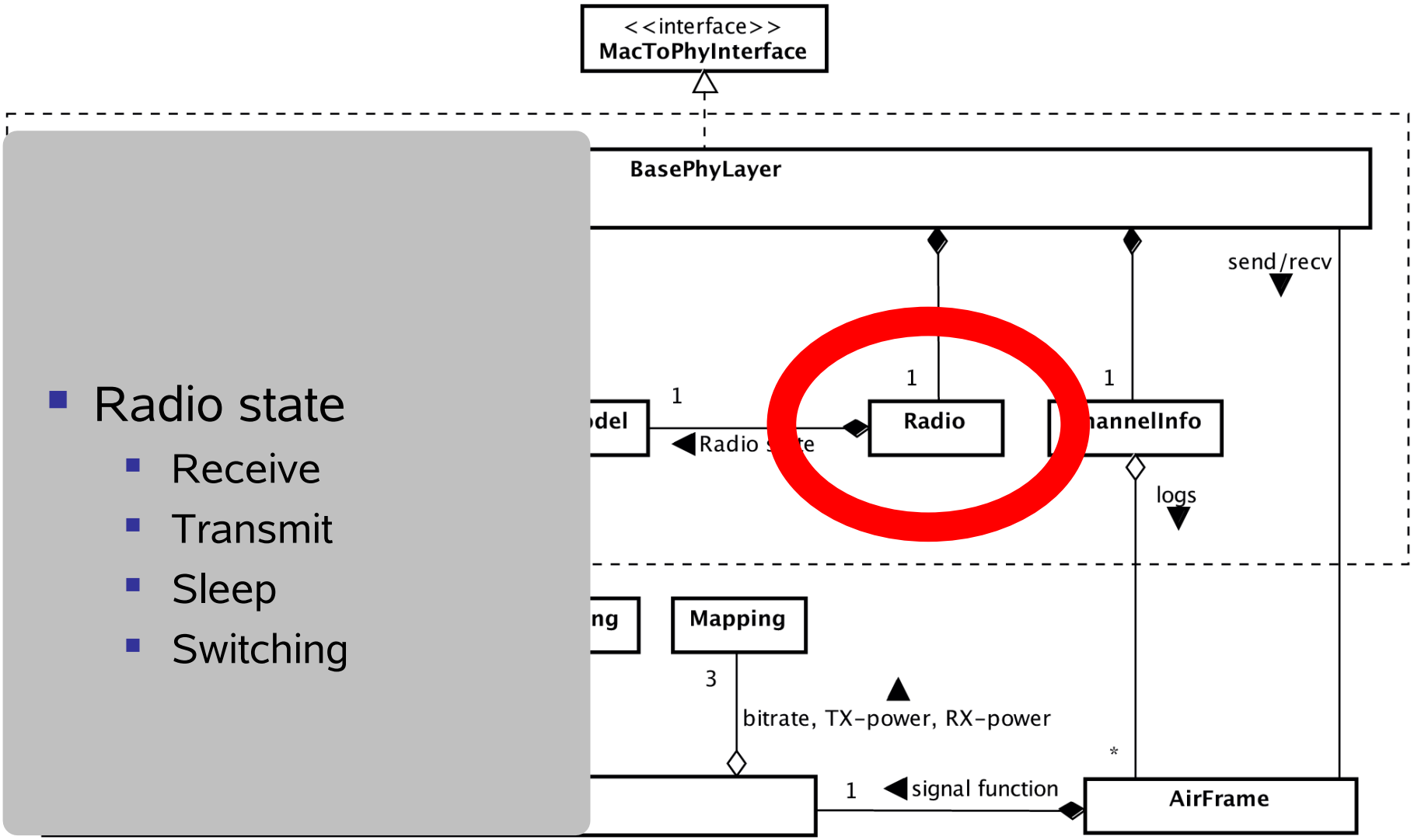
MiXiM PHY Architecture



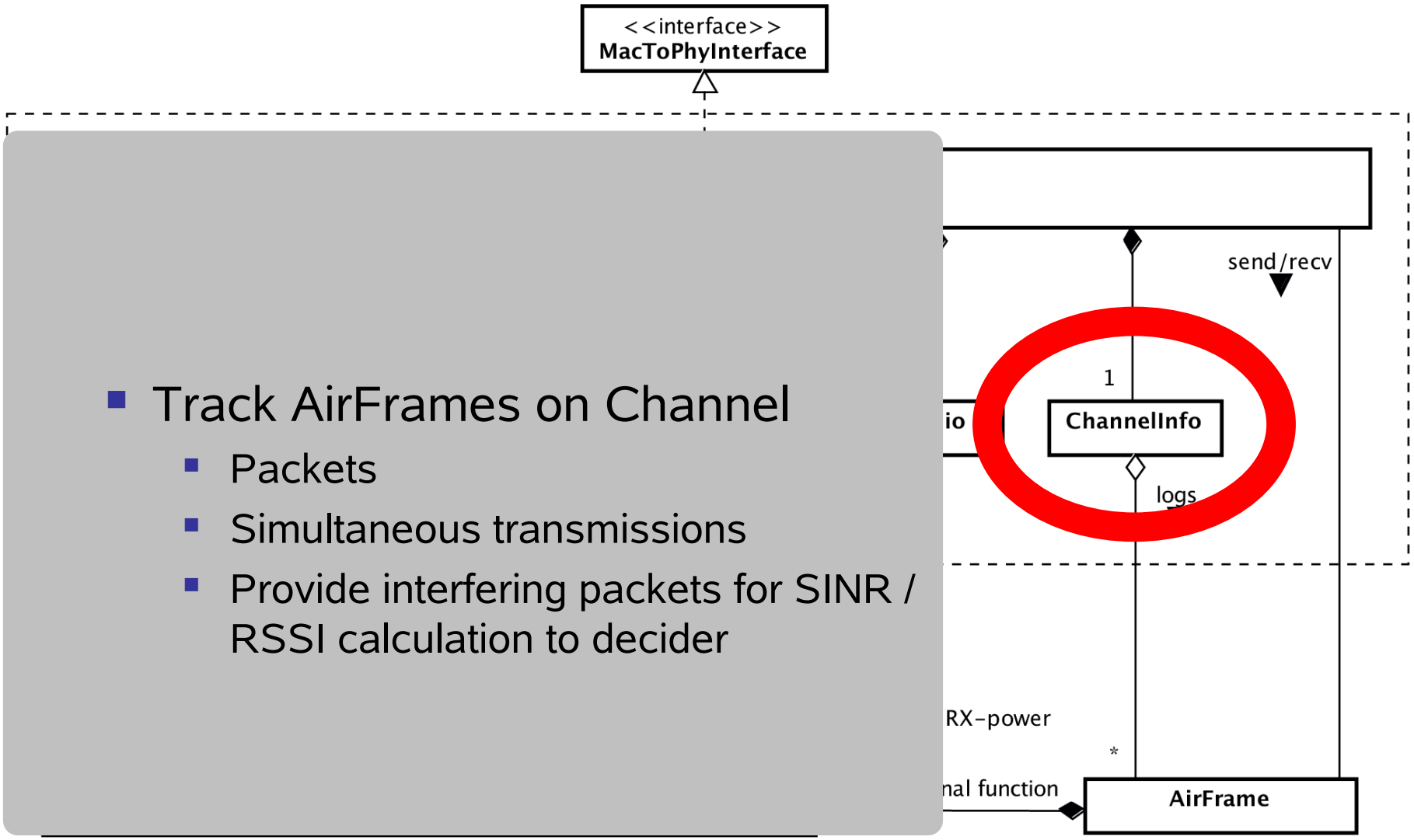
- Classifies signals
  - Noise
  - Potential packet
  - Channel busy or idle
- "Decodes" packets
  - Apply FEC
  - Apply interference
  - Decide packet reception or packet loss

MiXiM PHY Architecture

- Radio state
  - Receive
  - Transmit
  - Sleep
  - Switching

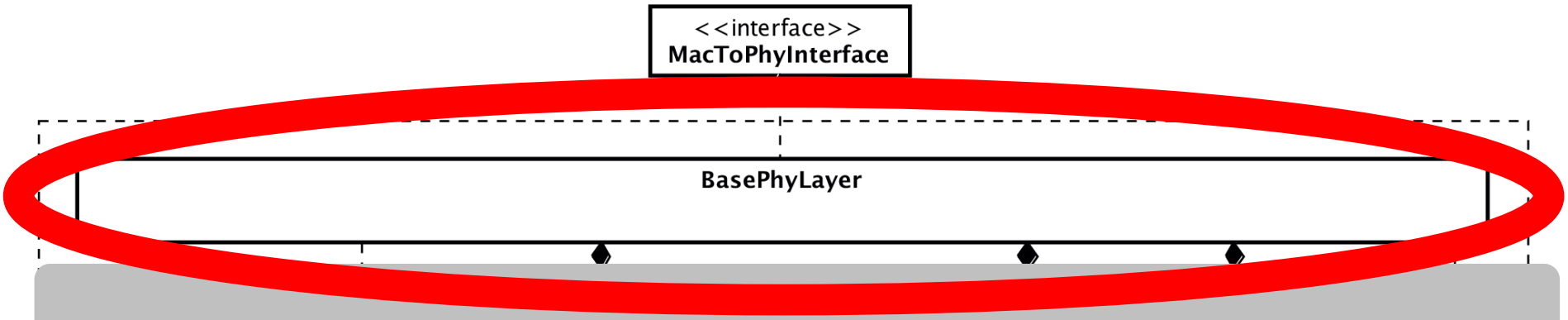


MiXiM PHY Architecture



- Track AirFrames on Channel
  - Packets
  - Simultaneous transmissions
  - Provide interfering packets for SINR / RSSI calculation to decider

MiXiM PHY Architecture

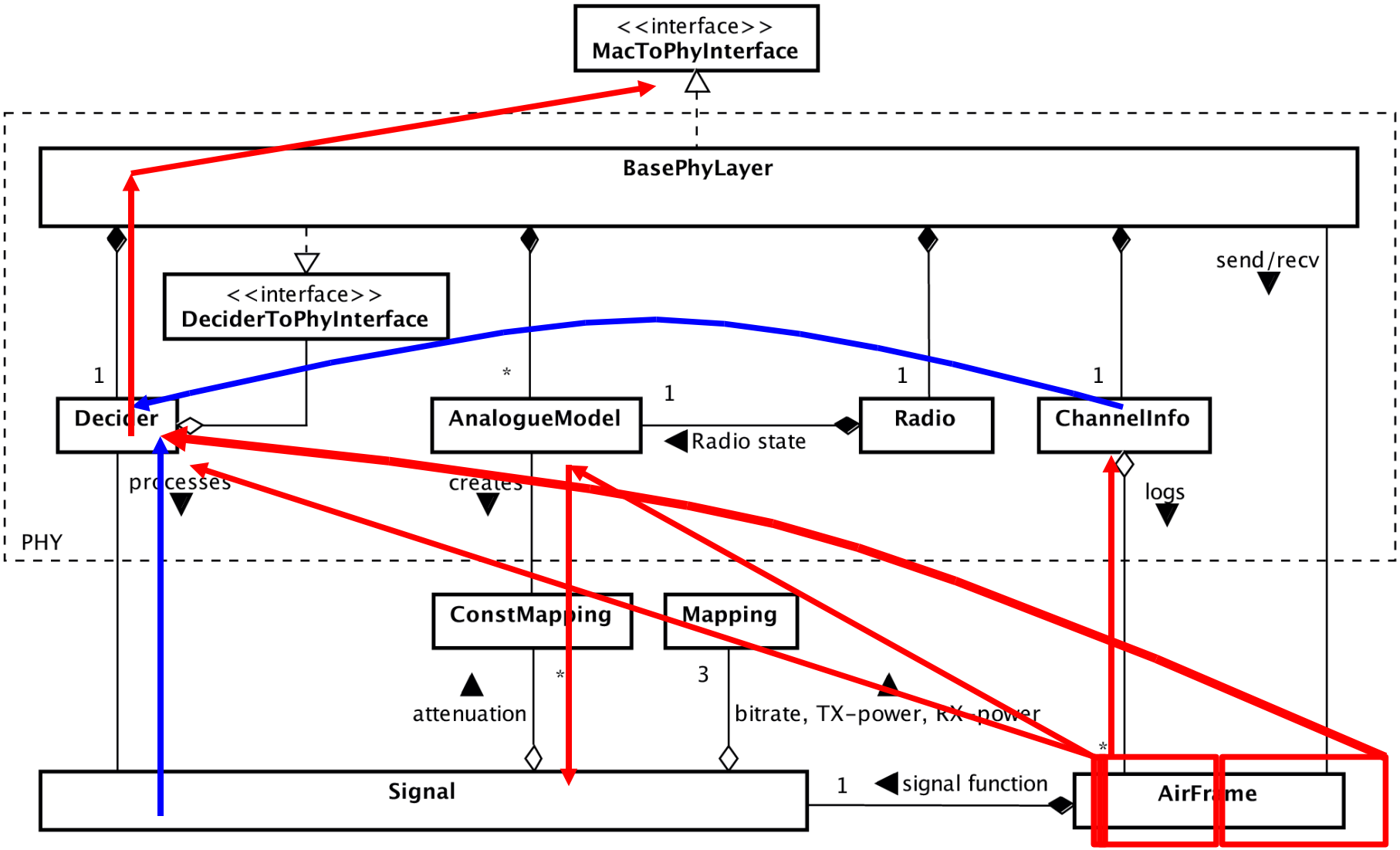


- Only OMNeT++ module
  - Reception of OMNeT++ messages
  - Transmission of OMNeT++ messages
  - Configuration of used models

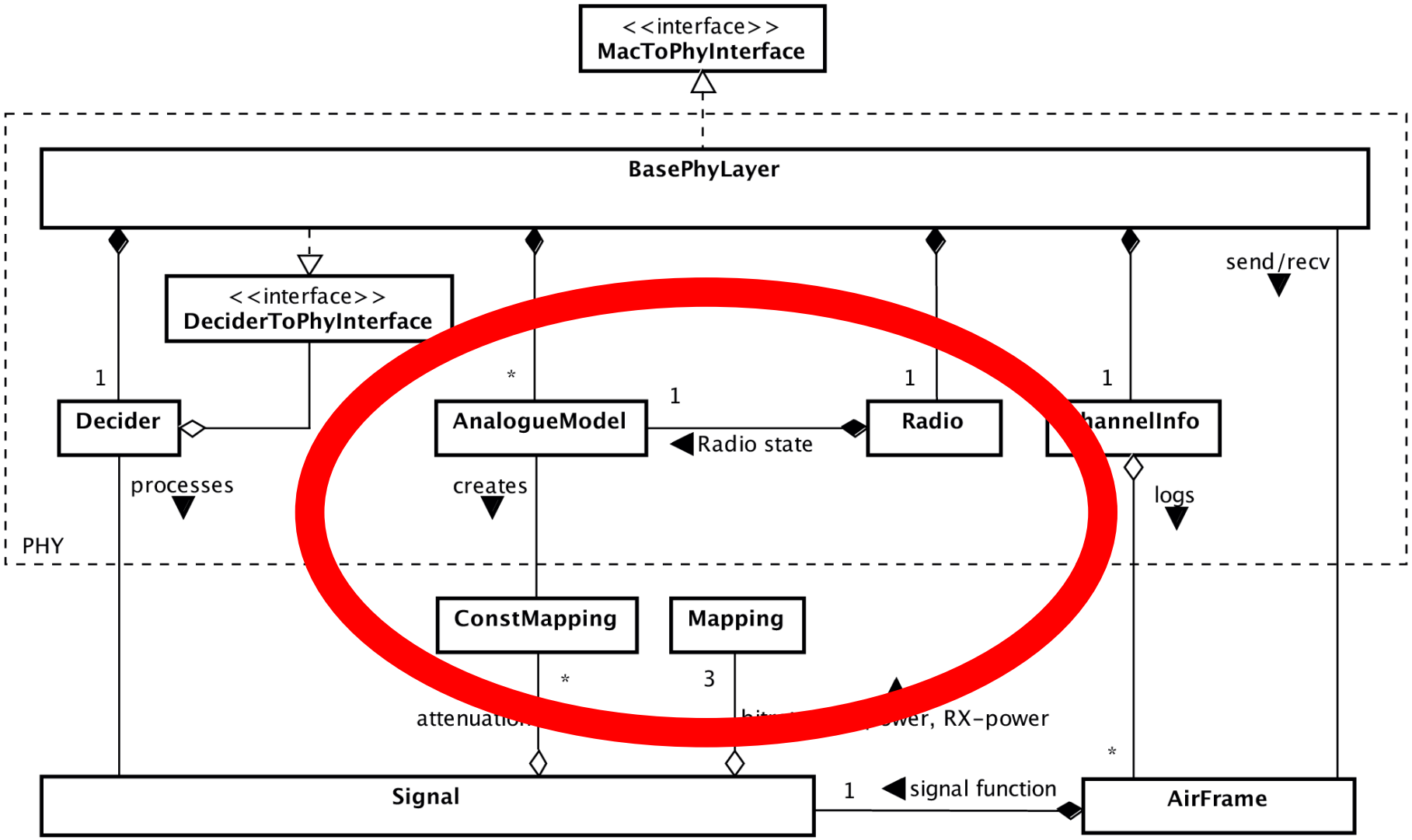
Summary: PHY Class Model

- BasePhyLayer: Interface to OMNeT++
- Signal: Container for analogue aspects
- AnalogueModels: Fading, path loss, shadowing,...
  - You can sepcify an arbitrary number of AnalogueModels
- ChannelInfo: Track state of wireless medium
- Radio: Transmitting / receiving / sleeping
- Decider: Abstract MAC requirements, “convert” analogue signal to bit/packet errors
  - Can be easily exchanged /extended

Interaction Example: Receiving an AirFrame

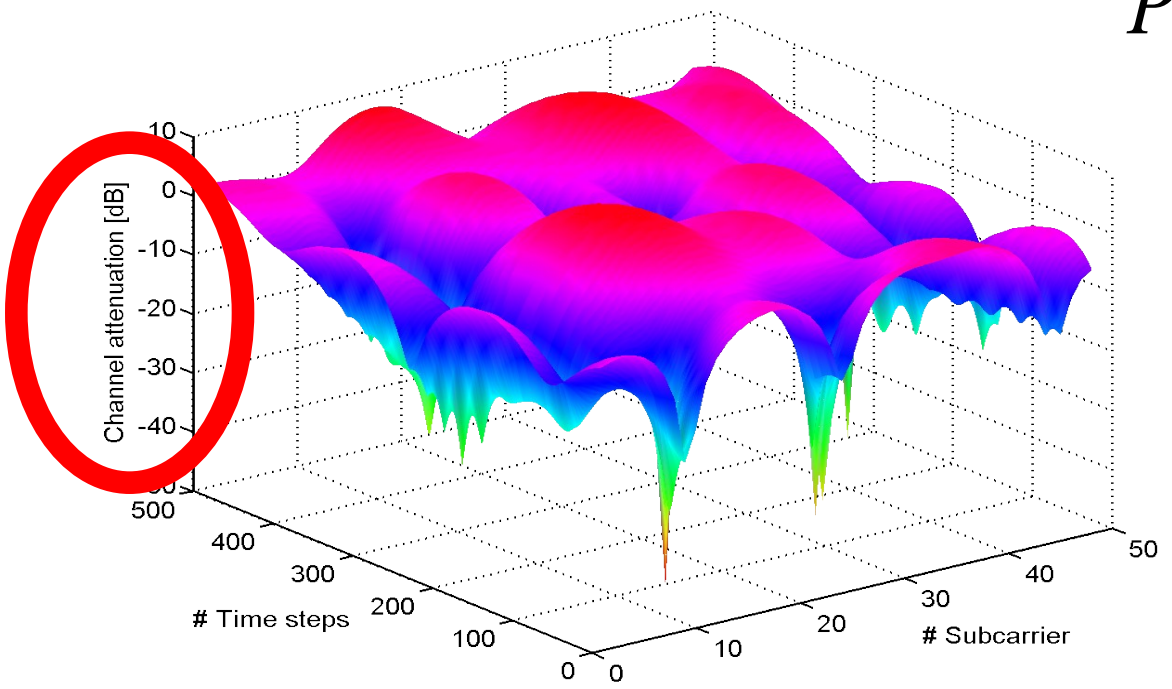


Applying analogue models



Common Model for Analogue Effects

Fading



Path loss

$$P_r = P_t \left(\frac{\lambda}{4\pi} \right) \frac{1}{d^{\alpha}}$$

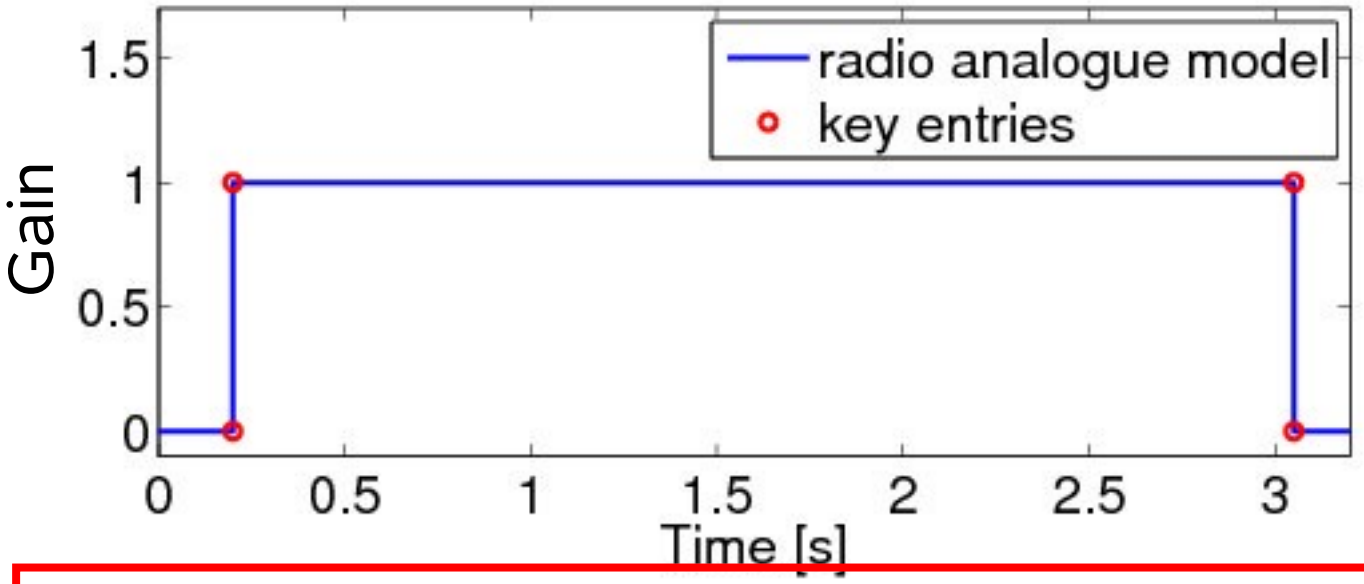
FEC: Coding gain

Mapping

- FEC, fast fading, slow fading, path loss and antenna gain can all be expressed as a mapping:

$$P_{RX} = f(t, f, s) P_{TX}$$

- Radio state can be expressed in a similar fashion

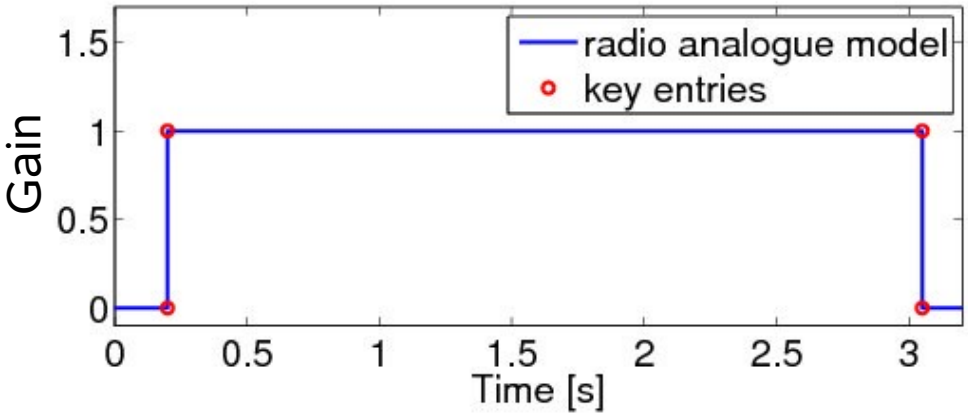


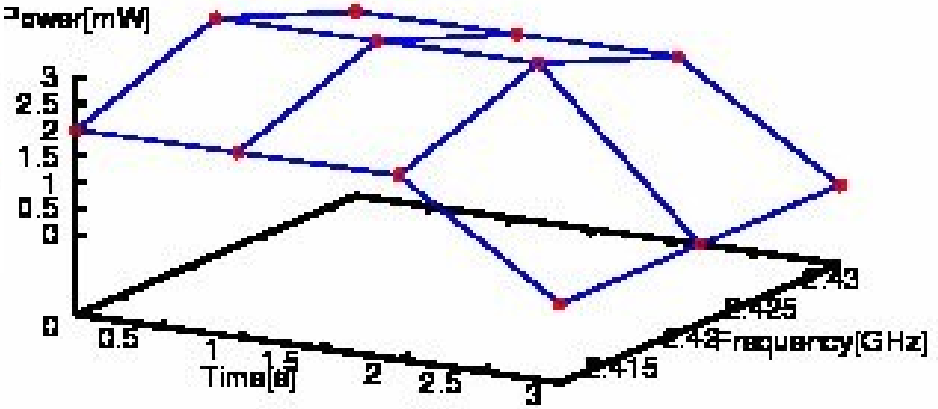
Express all effects on a signal as GAIN

(Define gain smaller 1 for attenuation effects)

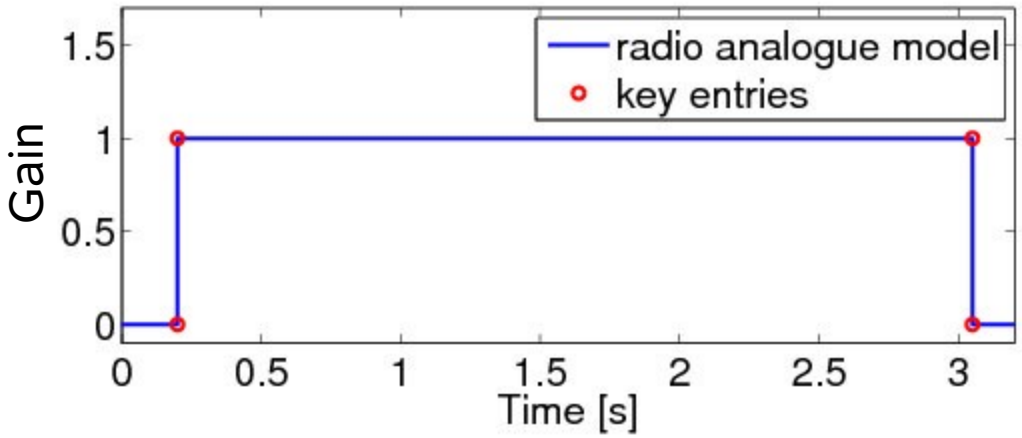
How to Handle Different Dimensions?

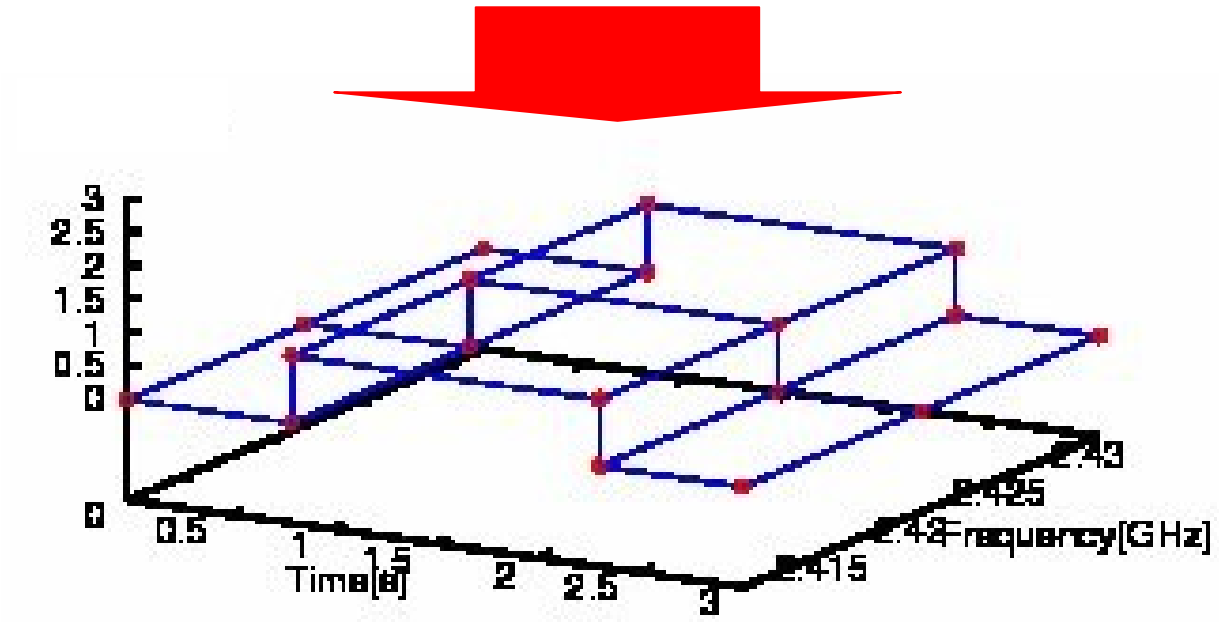
- Problem: dimension mismatch, e.g.:
  - Radio: define gain in one dimension
  - Transmitter: defines a two-dimensional signal (time, frequency)
- How to compute the received power?





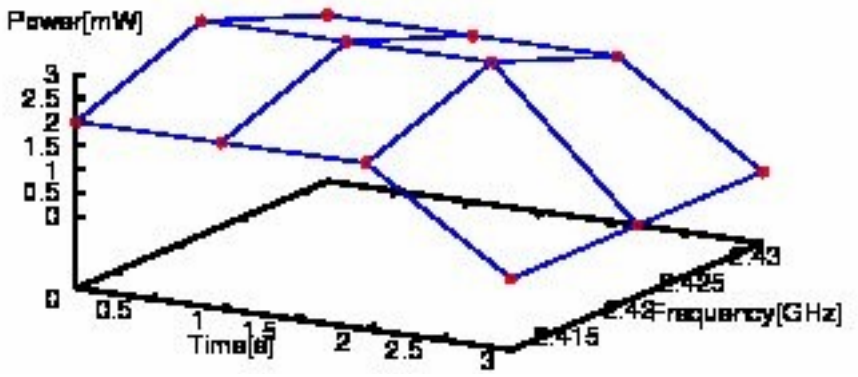
Fill Mapping





Multiply Mappings

RX power



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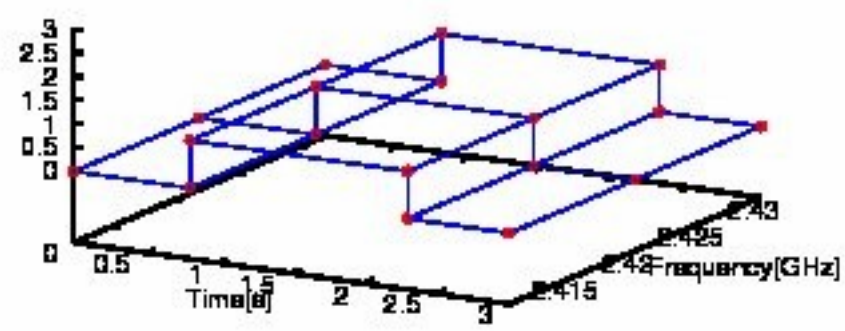
Radio state



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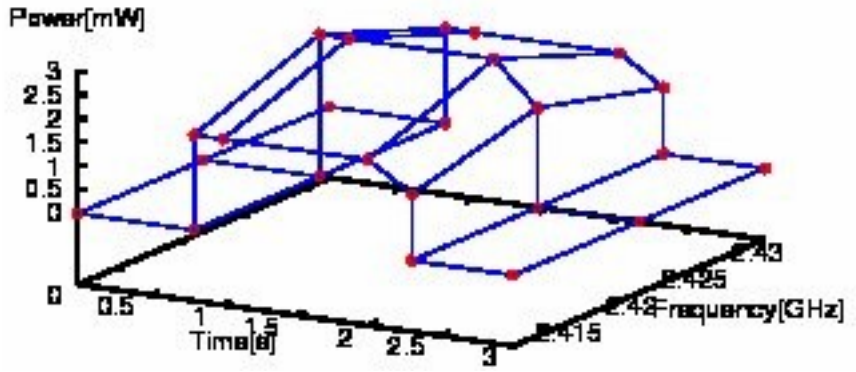
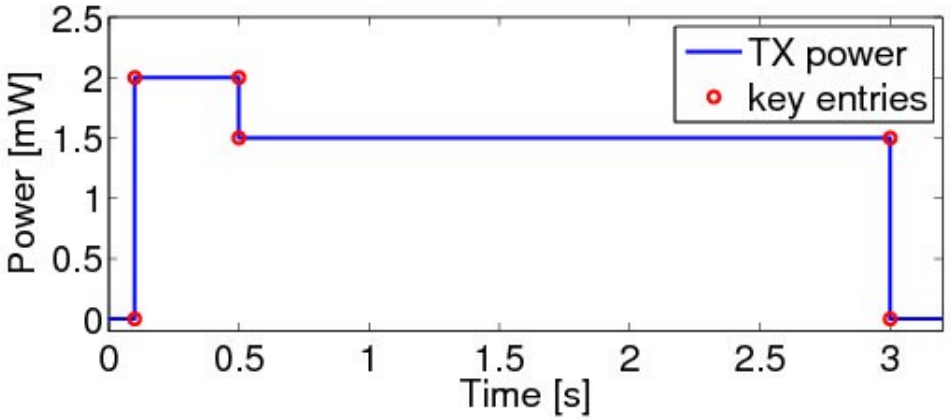
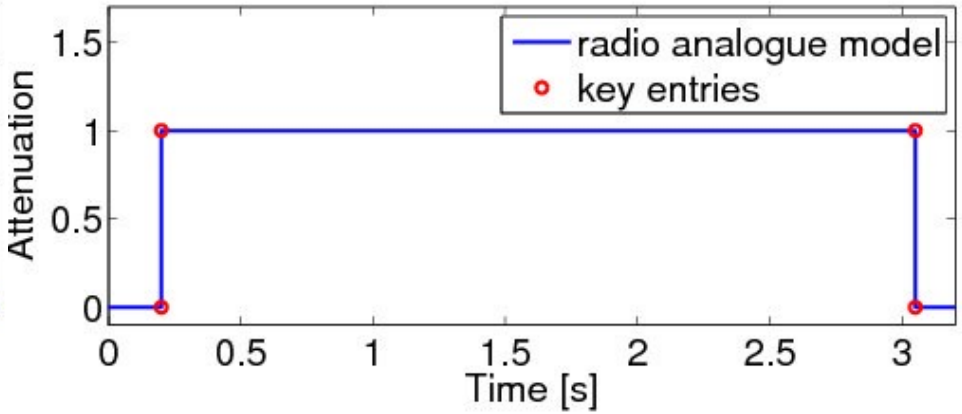
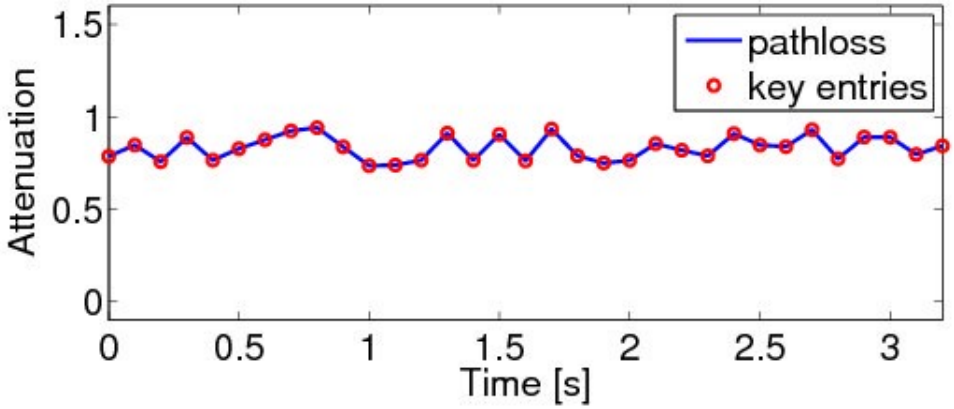


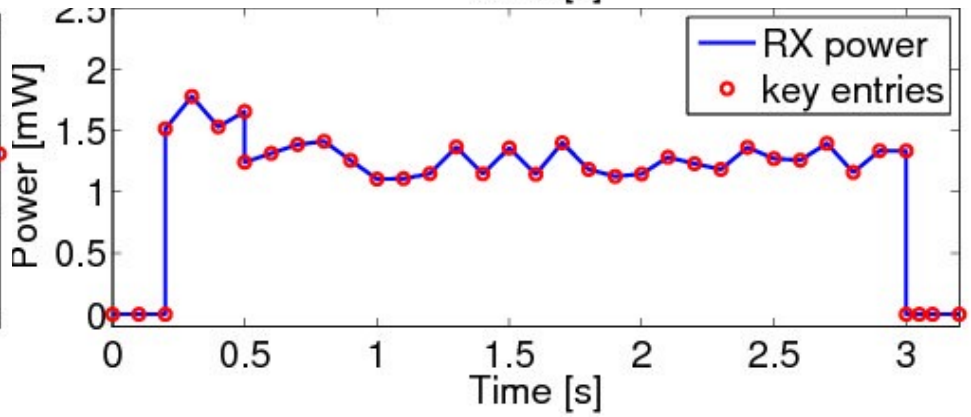
TX power

Mapping Key Entries









Conclusion

- The MiXiM PHY architecture
  - Enables researchers to explore all three dimensions of a signal (time, frequency and space) to derive better protocols
  - Provides utilities that help to cope with the resulting complexity
  - Allows very complex and realistic models, while simple models are still fast
  - Allows a high degree of re-use due to its modularity

Thank you

Questions? Comments?

Hands-on Tutorial:

Write your own MiXiM PHY

Today, 6pm

Requirements:

OMNet++ 4rc2, MiXiM, Tutorial code

Please prepare before coming, ask me if you have problems