# Cross Layer Design using fountain code

Nicolas Barbot

The Eighth Advanced International Conference on Telecommunications

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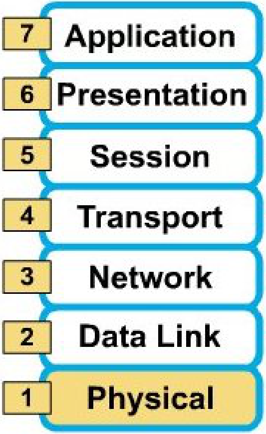
# OSI Model




- Independant Layers
- Each layer provides functionality to upper layer
- Interoperability

The emitter generates an endless sequence of symbols from a finite length message

The receiver collects output symbols and can recover the message when enought symbols have been received

# LT Code: encoding

Each output symbol is generated form the source file independantly:

1. Randomly choose the degree $d_n$ of the packet from a degree distribution $\rho(d)$
2. Choose, uniformly at random, $d_n$ distinct input packets, and set the output symbol equal to the bitwise sum, modulo 2 of those $d_n$ packets. This sum can be done by successively exclusive-or-ing the packets together.

The connexion of each packet is also send to the receiver

# LT Code: decoding

1. Find an output symbol that is connected to only one source packet. (If there is no such check node, this decoding algorithm halts at this point, and fails to recover all the source packets.)
2. Decode the source packet
3. Add the source packet to all output symbols that are generated with this source packet
4. Update the connexion

The decoding algorithm is run each time a packet is received (incremental decoding)

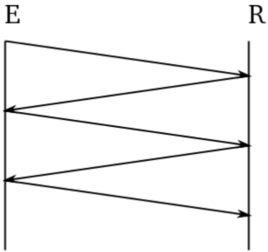
# TCP vs LT codes

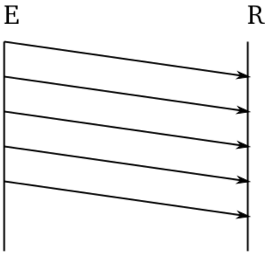
## TCP

- Reliability
- Low latency
- Unicast
- Rate depends on loss rate
- Flow control

## LT codes

- Reliability
- High latency
- Multicast aware
- Universal
- Absence of flow control



# Challenges

## Cross Layer Design

- New bottleneck is in the link layer
- Allow corrupted frames to send to the application layer
- $\Rightarrow$ Propagation of errors during LT decoding process

In order to maintain the quality of service, decoding process have to be modified:

- Estimate the quality of each packet
- Send the information to the application layer
- Modify the decoding process in order to take into account this new parameter

Thanks!

# Universal routing protocol implementation that can be used in simulator and software router

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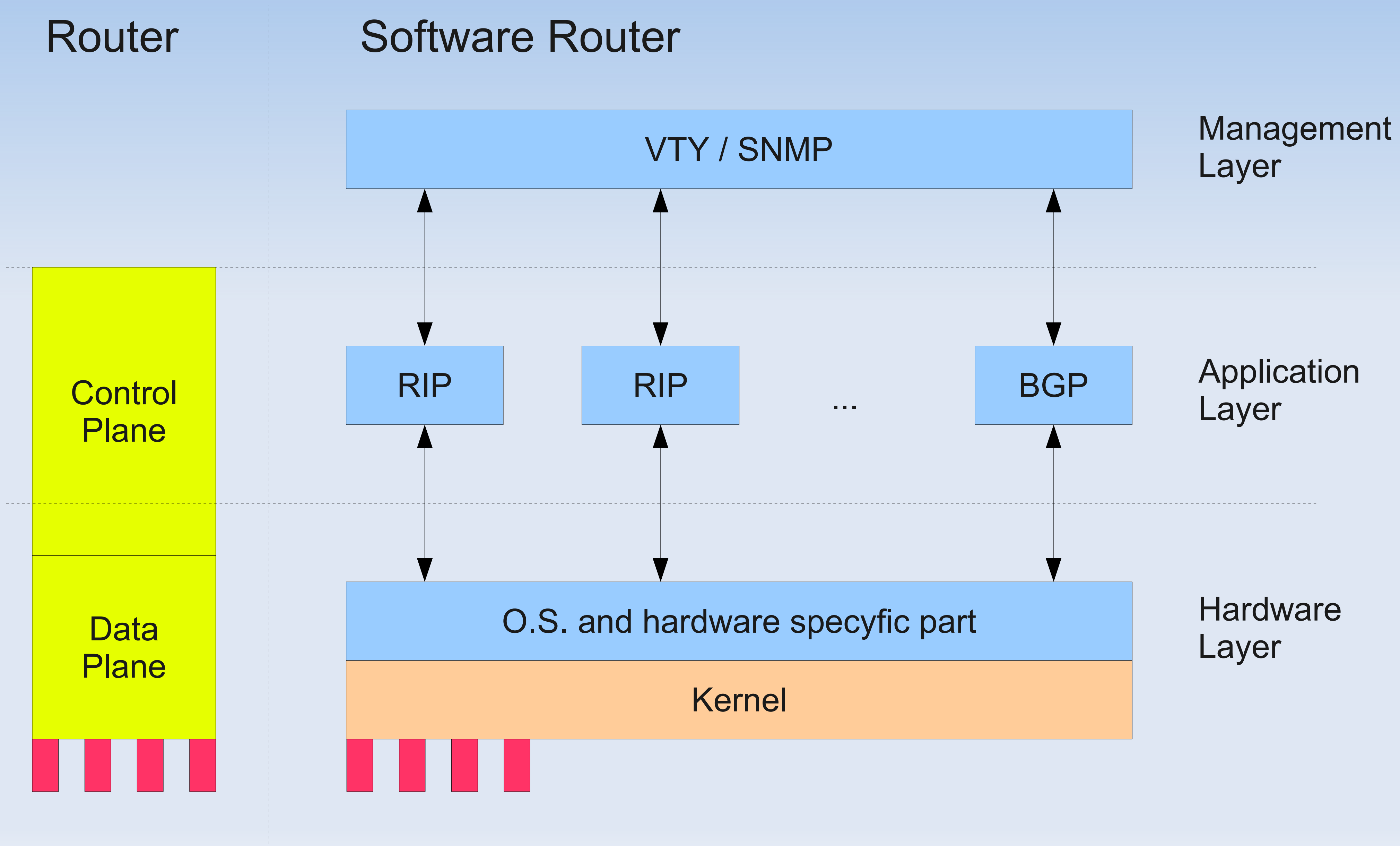
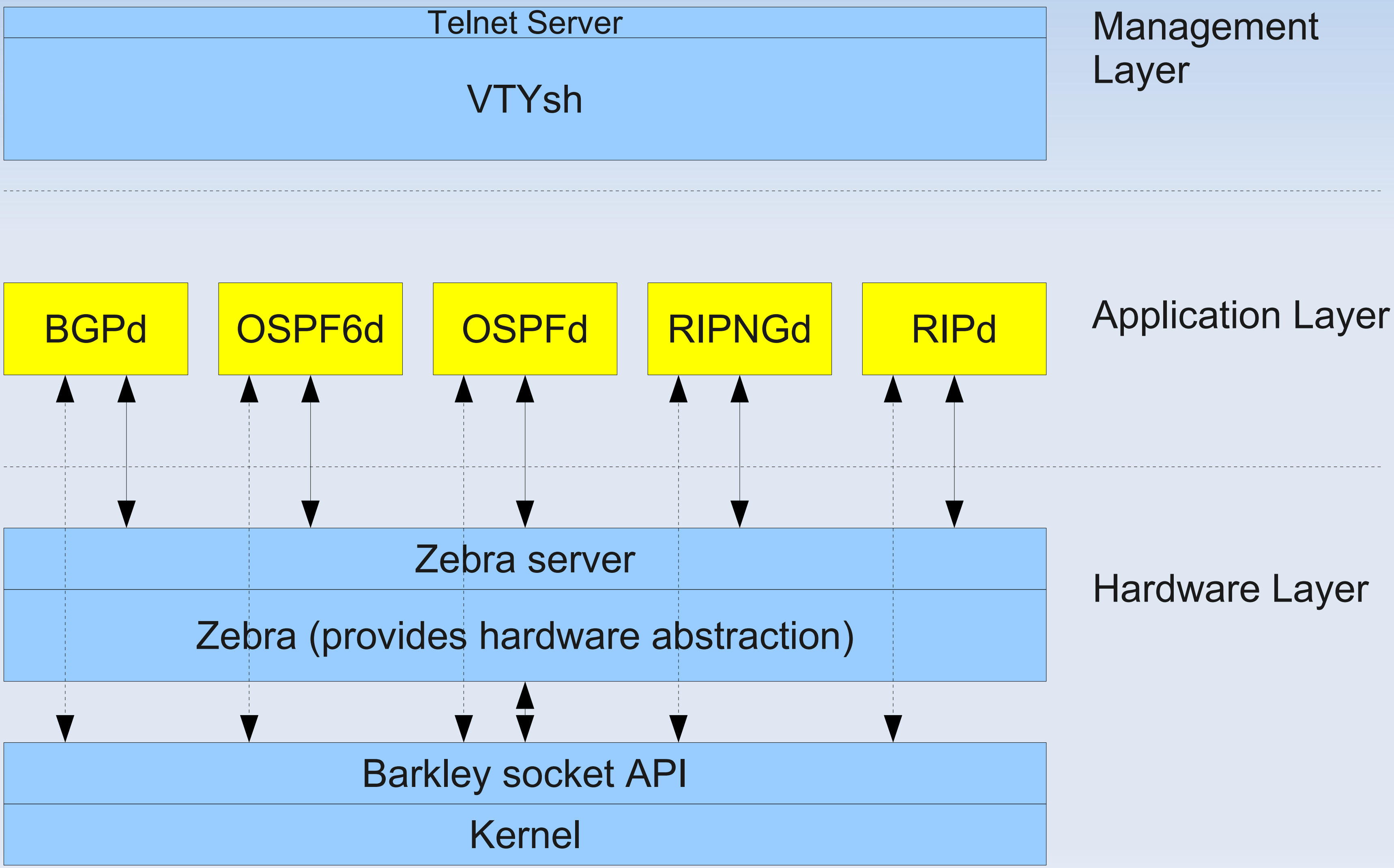
# Router vs Software router architecture

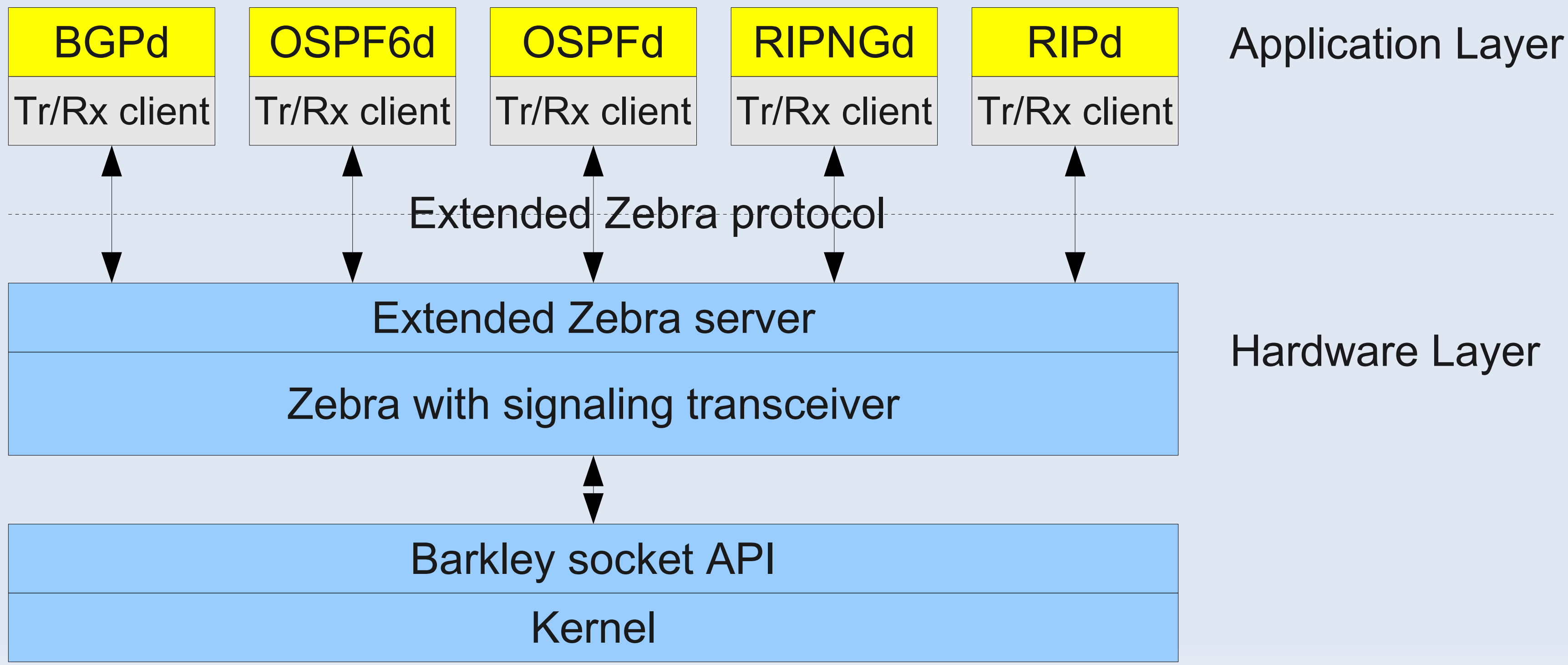


# The architecture of Quagga router

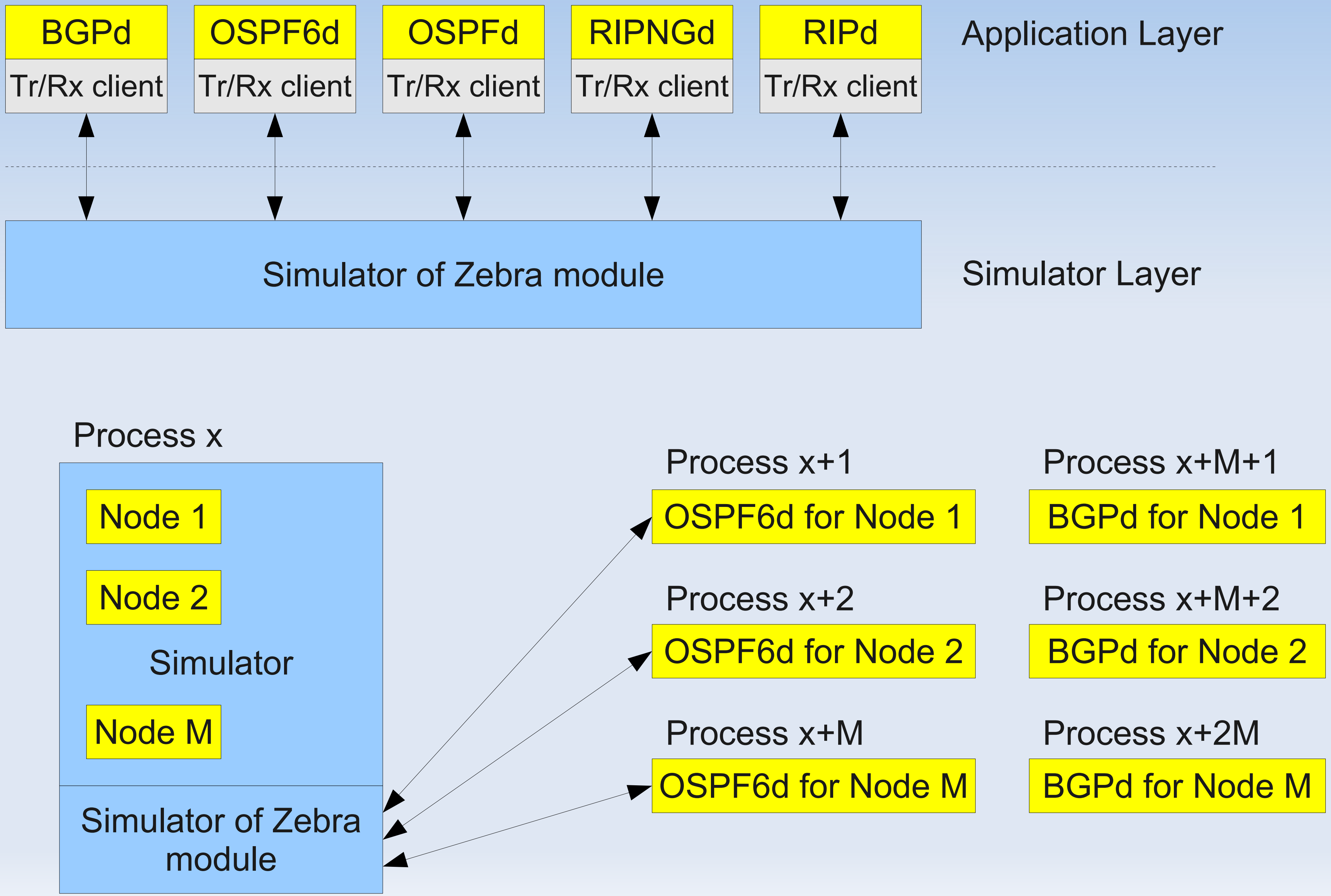


# Modified architecture of Quagga router

- Application layer modules can not send message directly:
  - Sending message to Zebra module
  - Message includes in data field whole packet to send
  - Message include Data Plane interface index that have to send the packet



# Simulator module, that cooperates with CP modules



# Questions and potential problems

- Communication between simulator of zebra module and CP modules
  - Using physical interface, CP on dedicated machine
  - Using loopback
  - Using interprocess communication
- Performance:
  - Possible of distribution (CP on separate machines)
  - Required real time simulation
- Colecting the simulation results
  - Adding special command to zebra protocol to write statistics

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IARIA

# Energy-aware optical communications: current status and possible approaches

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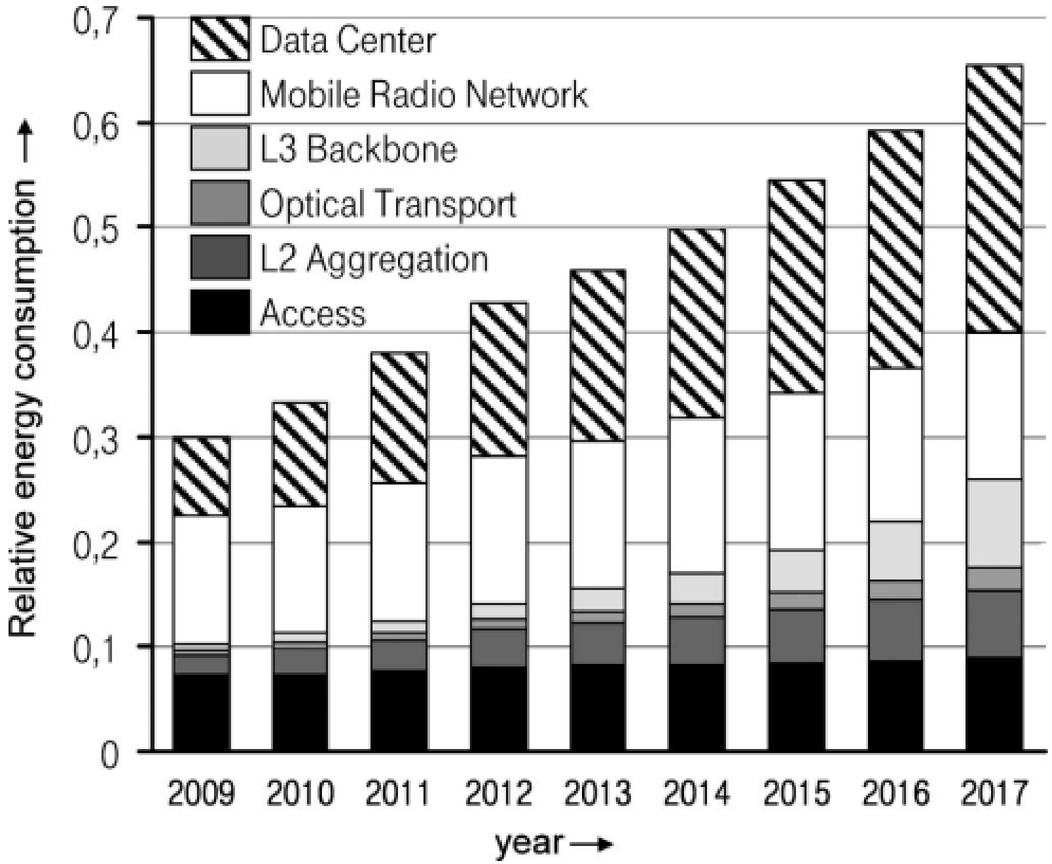
RINCE | Research Institute for Networks and Communications Engineering

sfi science foundation ireland fondúireacht eolaíochta éireann

DCU

# Current Status and Challenges

ICTs will be responsible of the 8% of the global electricity consumption!



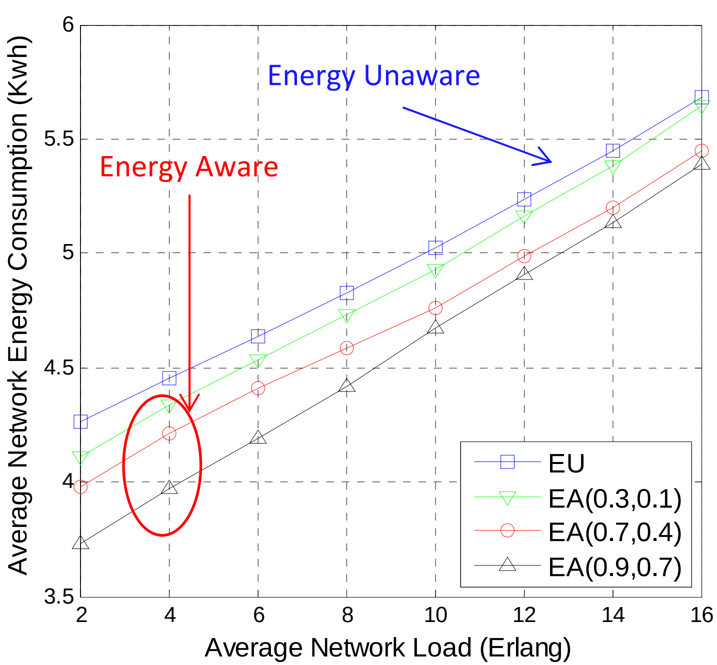

It is estimated a 20x increase of the wired network Carbon Footprint over the next 10 years!

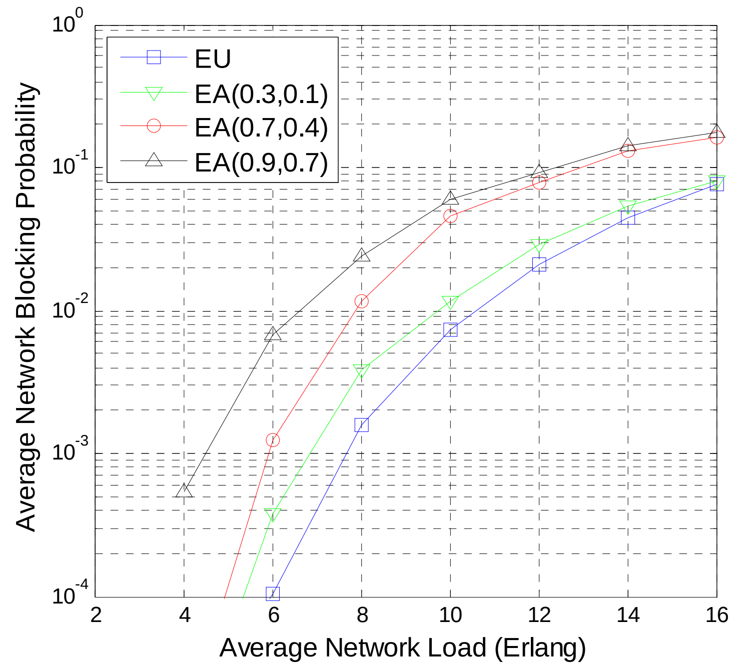
Access networks are the major contributors in energy consumption in wired communication networks (approx. 70% of overall Internet energy consumption).

**Source**: C. Lange et al., "Energy Consumption of telecommunication networks and related improvement options", IEEE JSTQE, March/April, 2011

# Possible Approaches (Core Network)

- Energy-efficient Network Design
- Limit energy consumption at IP layer (efficient forwarding)
- Green Routing
- Power-saving mode of network elements (example below)




**Source:** D. Tafani, B. Kantarci, H. Mouftah, C. McArdle, L. P. Barry, "Energy-efficient Lightpaths for Computational Grids", Proc. ICTON 2012, Coventry UK

# Possible Approaches (Access Network)

Of all different access network technologies, Passive Optical Networks (PONs) are the most energy-efficient.

| | | | PER USER ACCESS RATE | | |
|---|---|---|---|---|---|
| **Technology** | **Per user power consumption [W]** | **Technology limit [Mb/s]** | **Energy per bit [nJ/b] @ 10 Mb/s** | **Energy per bit [nJ/b] @ 75 Mb/s** | **Energy per bit [nJ/b] @ 1Gb/s** |
| **DSL** | 8 | 15 | 816 | NA | NA |
| **HFC** | 9 | 100 | 900 | 120 | NA |
| **PON** | **7** | **2400** | **745** | **99** | **NA** |
| **FTTN** | 14 | 50 | 1416 | NA | NA |
| **PtP** | 12 | 1000 | 1201 | 160 | 12 |

POSSIBLE STRATEGIES

- **IEEE 802.3ah/802.3av EPON** and **ITU-T G.sup45 GPON** standards
- Put ONU to sleep (10x power savings than in active mode)
- Shedding of power/speed in UNI/ANI

**Source**: J. Baliga et al., "Energy Consumption in Wired and Wireless Access Networks", IEEE Communications Magazine, June 2011

# Thank you for your attention!☺

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Panel on Advances in Telecommunications

# Advances in Cognitive Radio

Mohamed El-Tarhuni
American University of Sharjah
Sharjah, United Arab Emirates

May 29, 2012

# Cognitive Radio

A disruptive technology where the sky is the limit towards a new wireless world of about 100 billion wireless devices by 2025

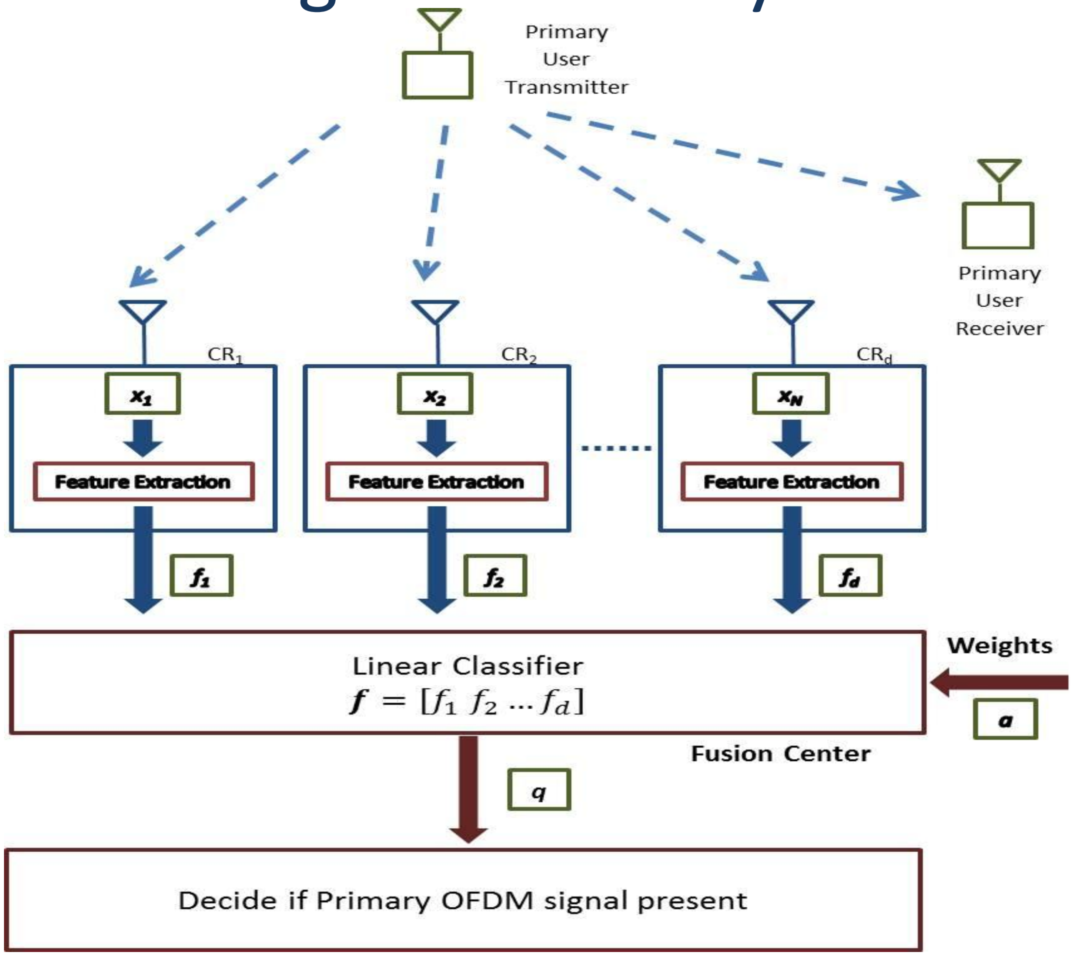
# What is going on?

- Research and Development
  - New spectrum sensing and sharing algorithms
  - Prototype and test-beds
- Market Drivers
  - New services based on spectrum-on-demand, e.g. civil and public safety, defense, etc.
  - Spectrum brokering
- Regulators
  - Awareness of the need for a new spectrum allocation paradigm
  - New devices and licenses awarded with CR in mind

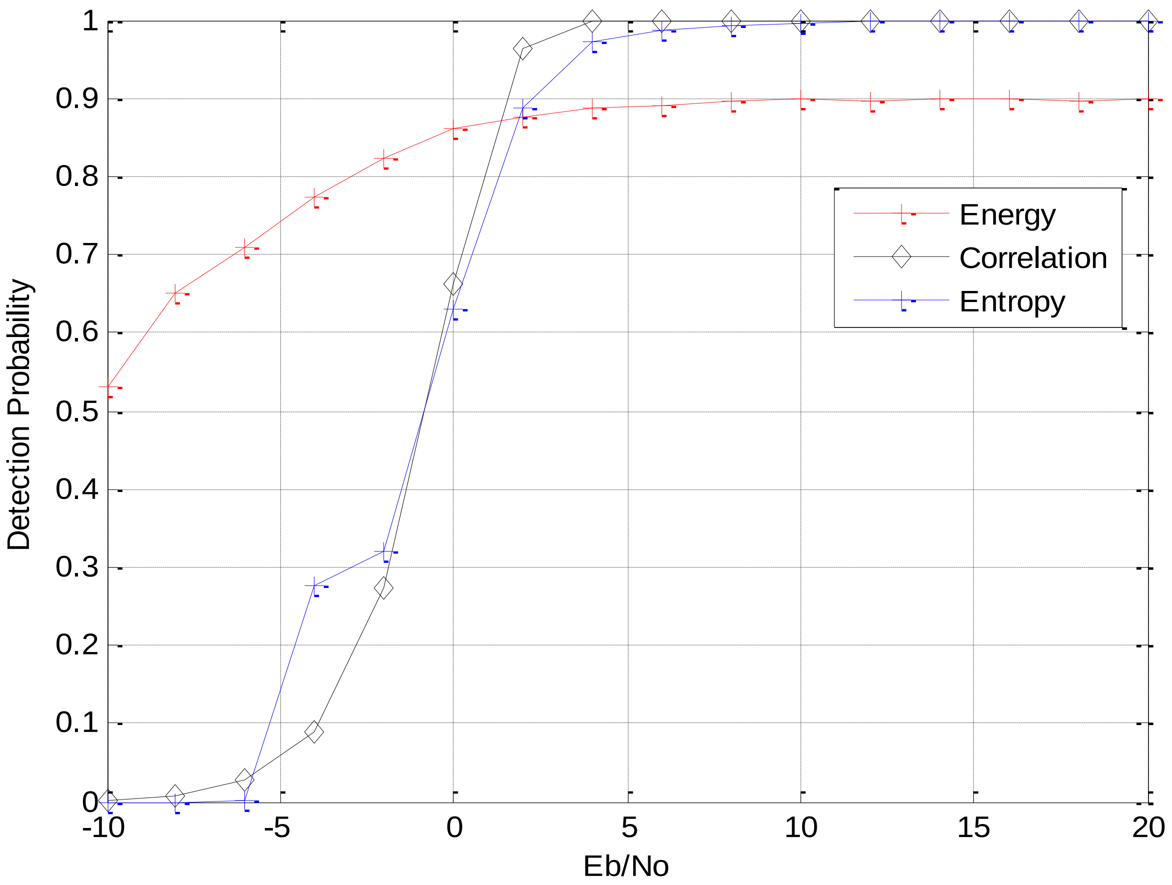
# Spectrum Sensing Vs. Overlay

- Cooperative and Learning Based
- Overlay Architecture

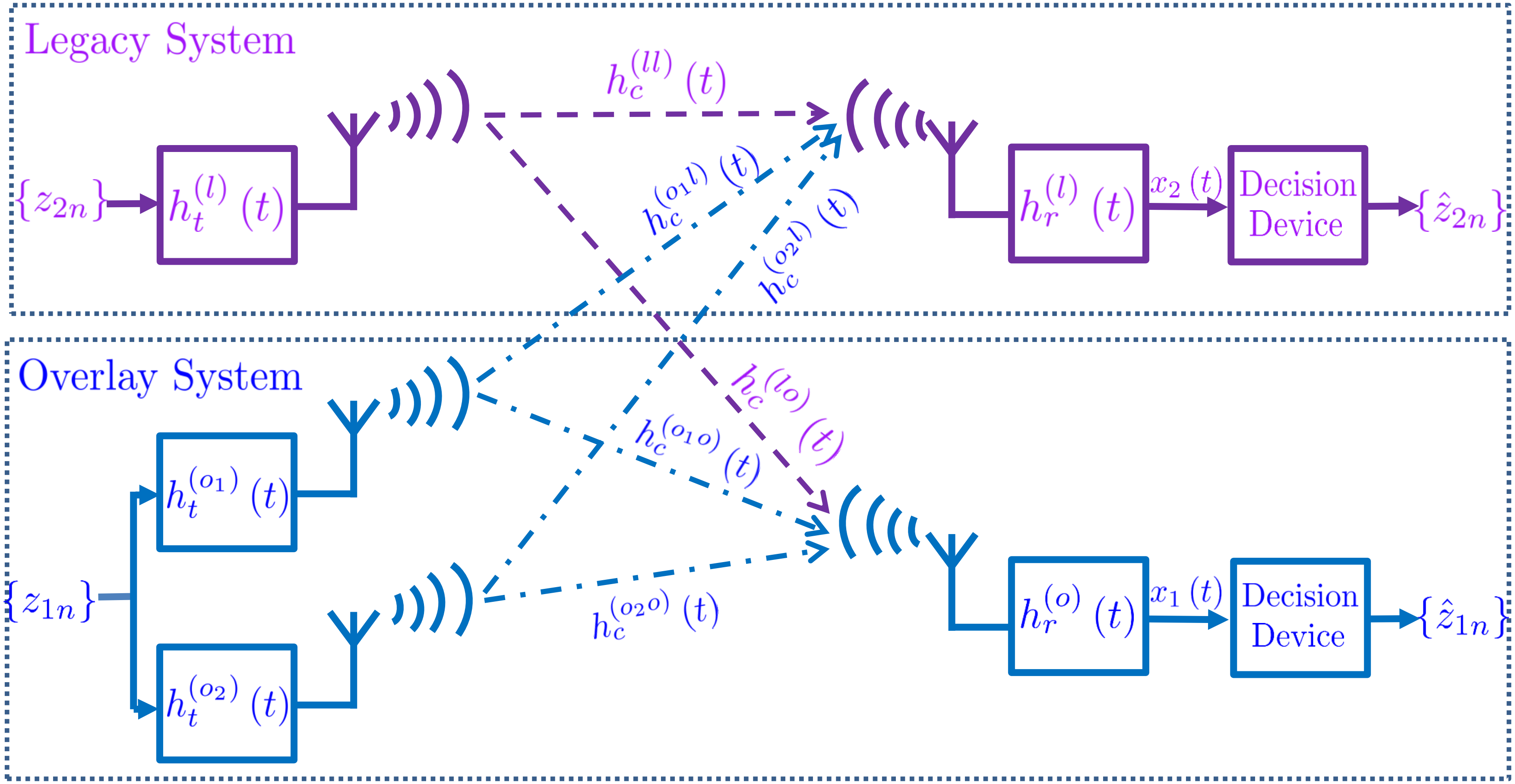
# Cooperative Learning-Based CR System Architecture



# Sensing Performance with 5 CR

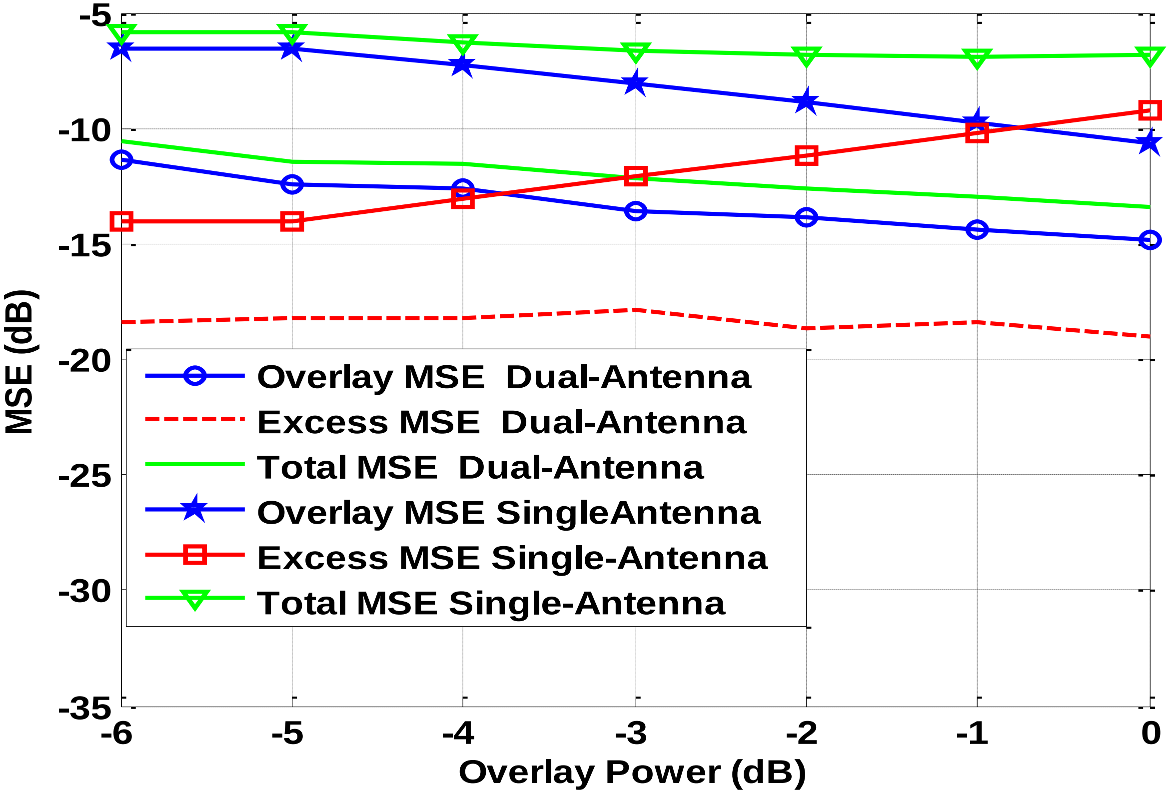


# Overlay CR Architecture



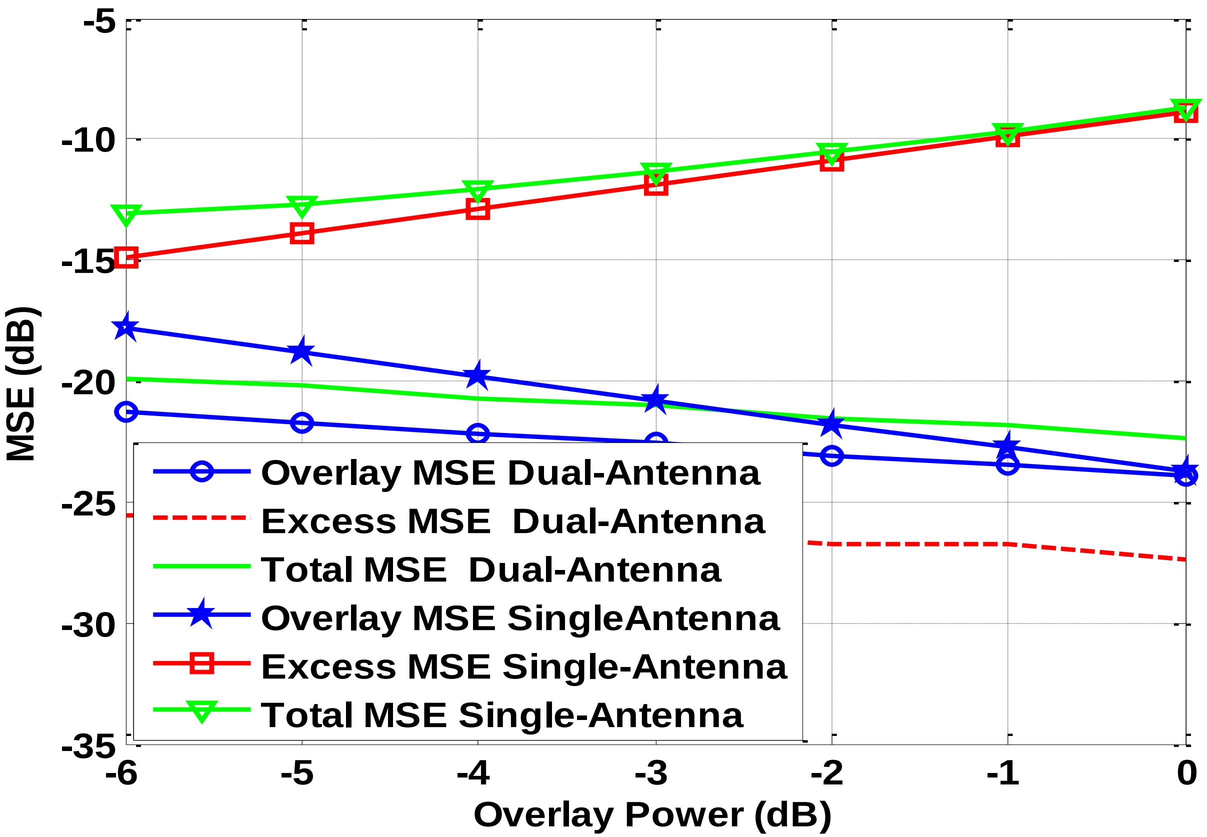
# MSE Performance

***Case 1:*** *Both* systems under *strong* interference



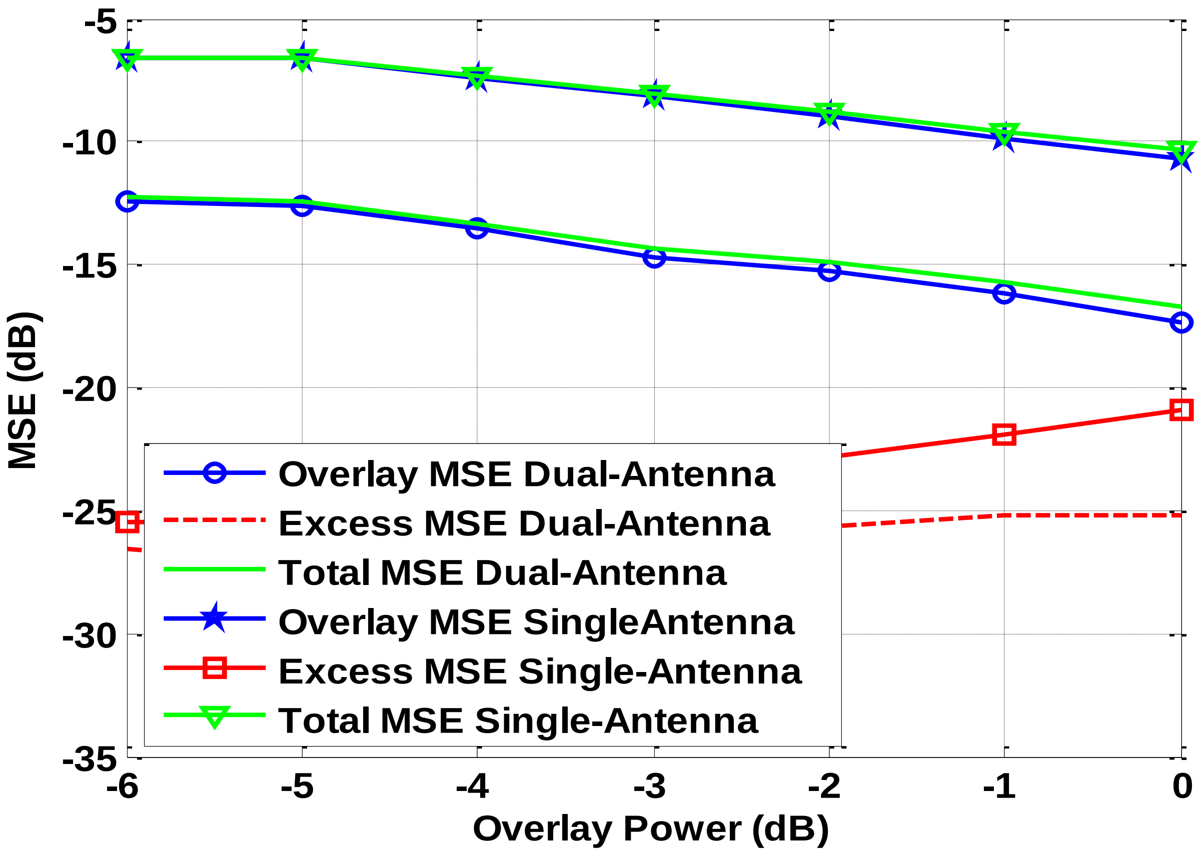
# MSE Performance

***Case 2:*** *Legacy* under *stronger* interference

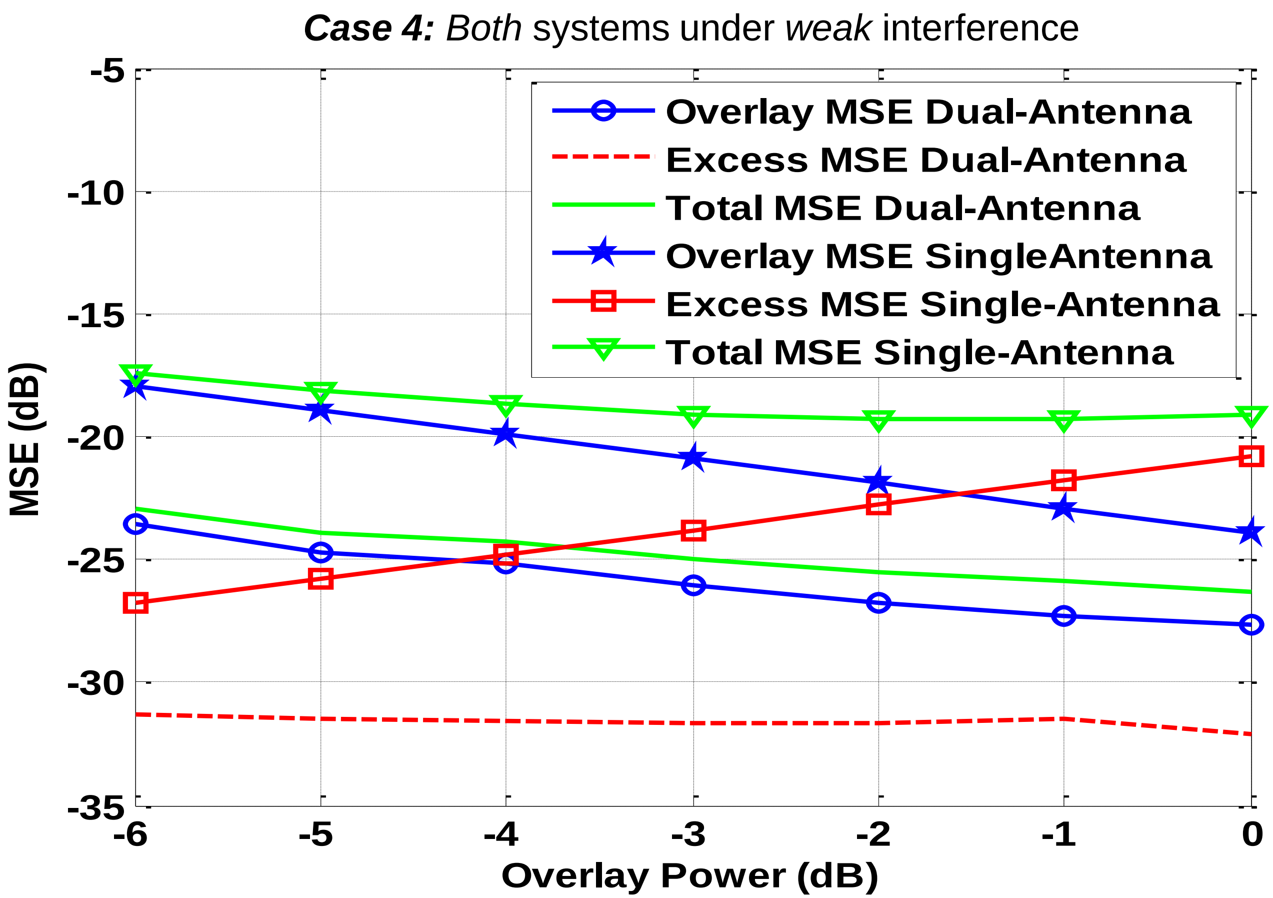


# MSE Performance

***Case 3:*** *Overlay* under *stronger* interference



# MSE Performance



# CR Challenges:

- CR RF frontends
  - Wideband, linear adaptive filters and amplifiers
- Interference in large scale networks
- Learning primary user behavior
- Security Issues – Silence the Jammer