Cross-layer Optimization with Real-time Adaptive Dynamic Spectrum Management for Fourth Generation Broadband Access Networks

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Overview

- **Introduction**
- **Approach**
- **Current state**
- **Summary**

In the beginning, we had few kbit/s

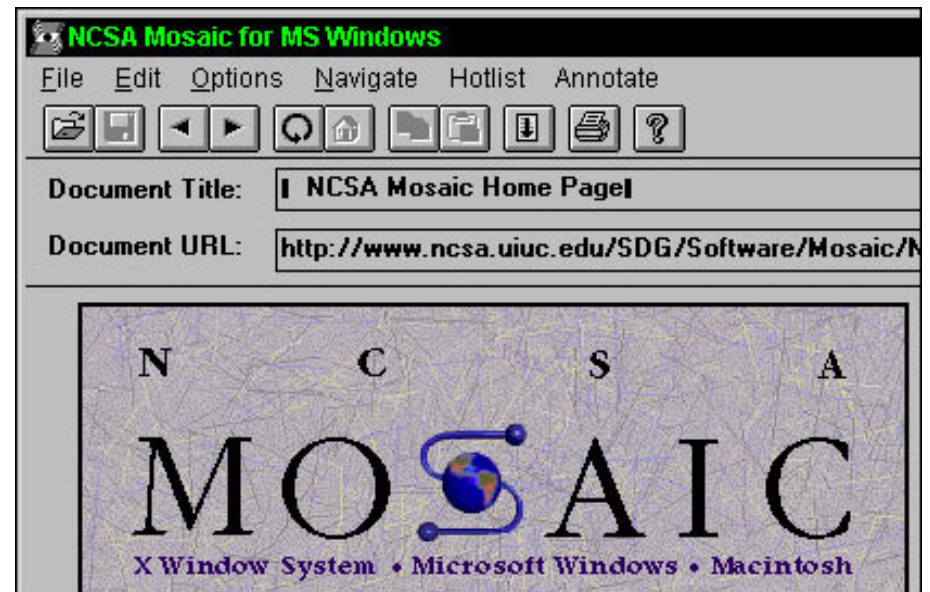**And it was slow**

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Introduction

- **Technology evolved, offering higher bandwidths, and demands increased**
  - 56k dial-up
  - ADSL
  - ADSL2, ADSL2+
  - VDSL

Introduction

- **Technology evolved, offering higher bandwidths, and demands increased, requiring technology ...**
    - 56k dial-up
    - ADSL
    - ADSL2, ADSL2+
    - VDSL

Better!

Faster!

Stronger!

Introduction

- **Current DSL generation allows rates of up to only 100 Mbps**
- **This is mainly due to**
    - copper wire length
    - crosstalk

Introduction

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    - Bring Fiber to the Home: FttH! For all!

    - Get on with it!

      Yeah, get on with it!

  - crosstalk

Introduction

- **Current DSL generation allows rates of up to only 100 Mbps**
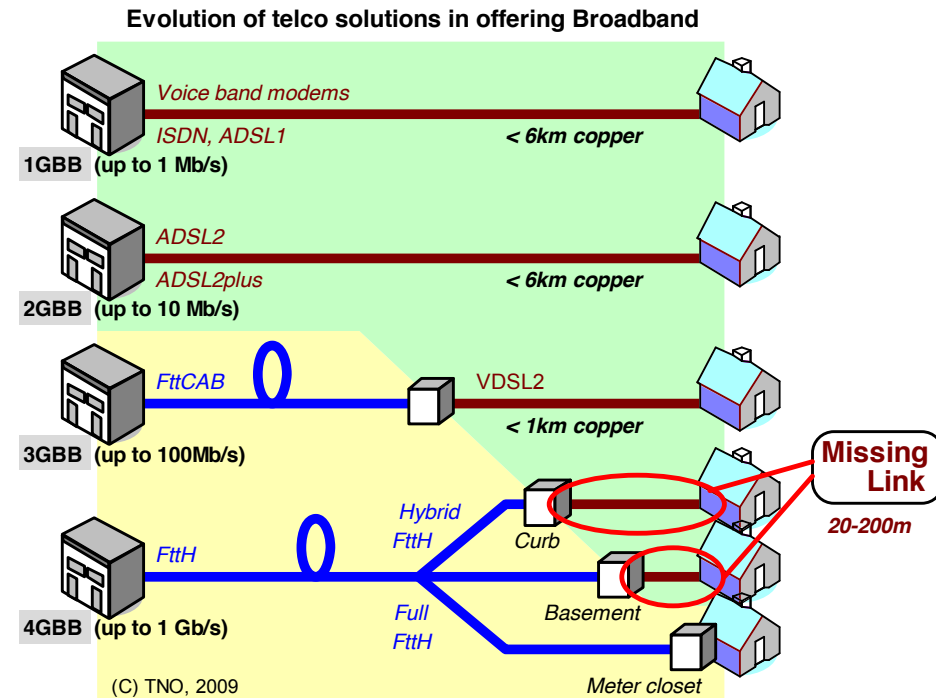
- **This is mainly due to**

  - copper wire length

   - Bring Fiber to the Home: FttH! For all!

    - $$$$ == ☹

    - Intermediate step
   - Fiber to the Curb: FttC!

  - crosstalk

Evolution of telco solutions in offering Broadband

Voice band modems	
ISDN, ADSL1	< 6km copper
1GBB (up to 1 Mb/s)	
ADSL2	
ADSL2plus	< 6km copper
2GBB (up to 10 Mb/s)	
FttCAB	VDSL2
	< 1km copper
3GBB (up to 100Mb/s)	
FttH	Hybrid FttH — Curb
	Full FttH — Basement
4GBB (up to 1 Gb/s)	Meter closet
(C) TNO, 2009	

Missing Link

20-200m

Introduction

- **Current DSL generation allows rates of up to only 100 Mbps**

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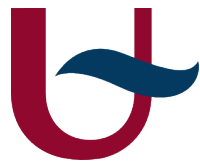   - electromagnetic coupling between wire-pairs
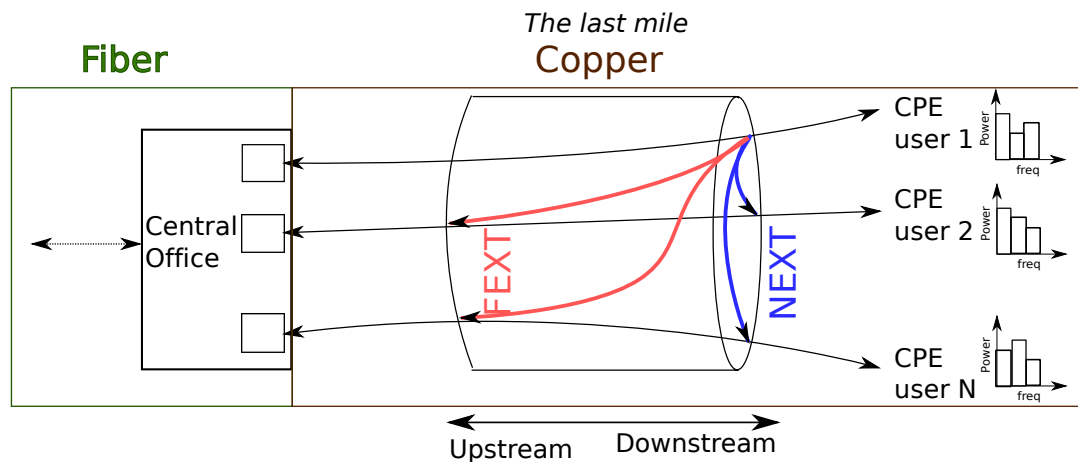
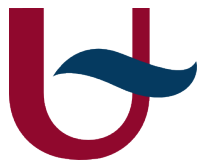

    - And there are many wire-pairs!
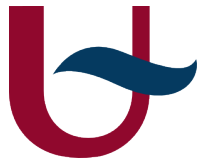
What is this about?

- **Cross-layer Optimization with Real-time Adaptive Dynamic Spectrum Management for Fourth Generation Broadband Access Networks**
  - Dynamic Spectrum Management
    - Physical allocation resource techniques

    - Spectrum Management
    - Vectored transmission

What is this about?

- **[...] Real-time Adaptive Dynamic Spectrum Management [...]**
    - DSL already has DSM
    - *Dynamic* refers to different scenarios
    - Worst-case is envisioned, thus very conservative

    - Use available information to adapt in *real-time*

What is this about?

- **Cross-layer Optimization** **with Real-time Adaptive Dynamic Spectrum Management for Fourth Generation Broadband Access Networks**

  – OSI: standardized reference model for communication

  – Layer provides service to layer above

Image: http://upload.wikimedia.org/wikipedia/commons/2/2b/Osi-model.png

What is this about?

- **Cross-layer Optimization [...]**
    - Cross-layer: interaction between any layer
        - Unidirectional or bidirectional
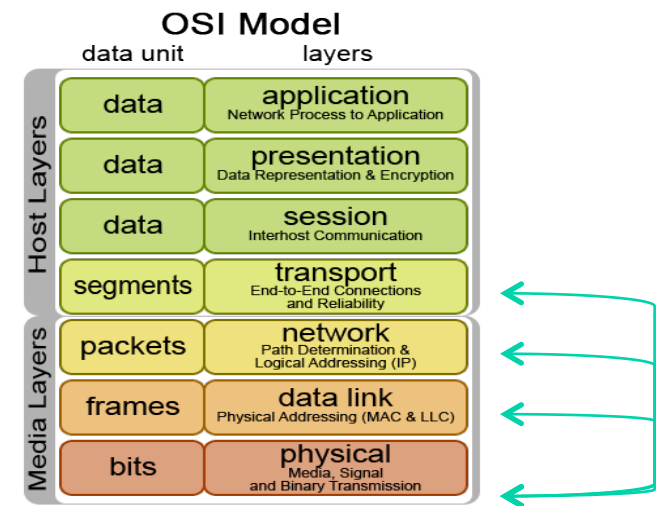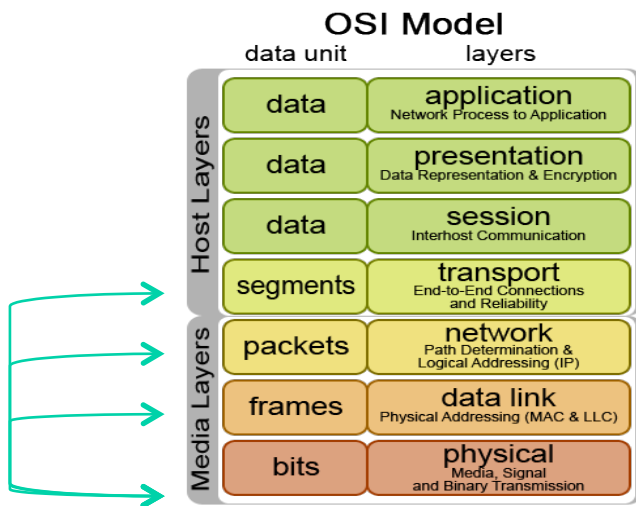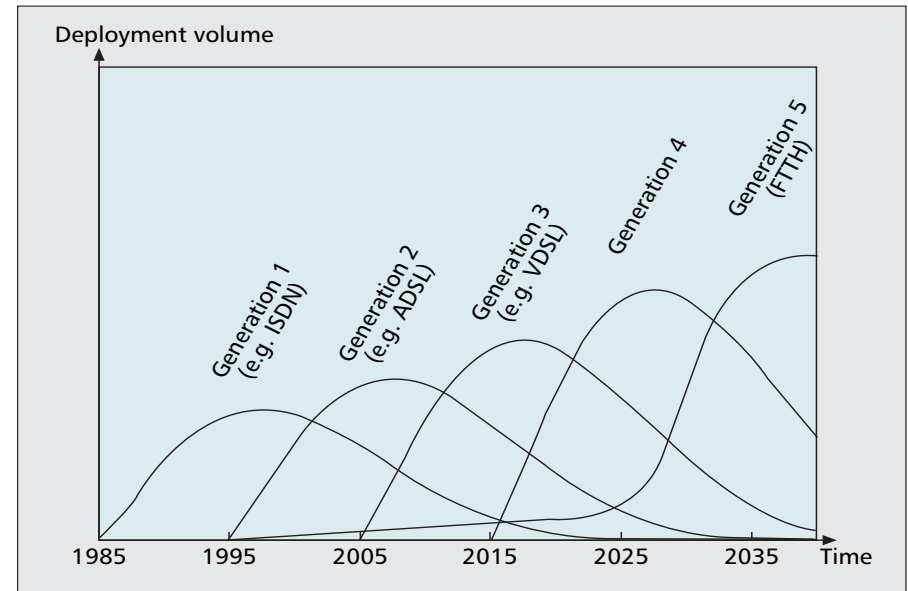   - Use extra information to our advantage!

Image: http://upload.wikimedia.org/wikipedia/commons/2/2b/Osi-model.png

What is this about?

- **Cross-layer Optimization with Real-time Adaptive Dynamic Spectrum Management for Fourth Generation Broadband Access Networks**

  – 4GBB, the intermediate step between DSL and FttH

What is this about

- **So ...**

- **Cross-layer optimization of physical layer and upper layers**
  - Faster data rates
  - Stable networks
  - Green devices

- **Intermediate solution while waiting for economic feasibility of our FttH**
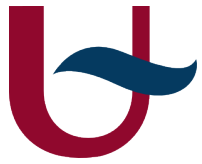
APPROACH

Approach

1. Construct a flexible and general cross-layer system model

2. Cross-layer optimization

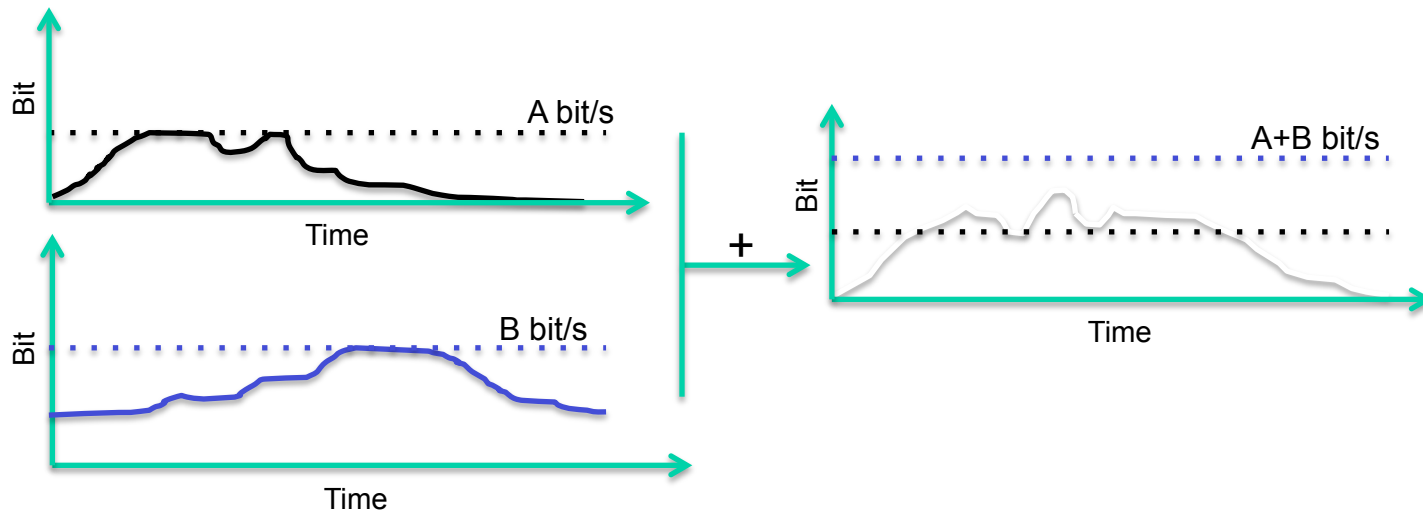3. Development of a realistic 4GBB simulator and performance evaluation

Approach

1. **Construct a flexible and general cross-layer system model**
   - We will focus on the upper layers (i.e. L2 and up)
   - What layers will be involved?
   - What are our degrees of freedom for each layer?
   - What types of traffic will we consider?
   - What metrics are important for us?
   - What new interfaces do we create?
   - For up- and downstream

2. **Cross-layer optimization**

3. **Development of a realistic 4GBB simulator and performance evaluation**

Approach

1. **Construct a flexible and general cross-layer system model**

2. **Cross-layer optimization**

   – Upper layer scheduling & statistical multiplexing


   – taking the multi-user environment into account

   – Prediction of data and channel behavior

3. **Development of a realistic 4GBB simulator and performance evaluation**

Approach

1. **Construct a flexible and general cross-layer system model**

2. **Cross-layer optimization**

3. **Development of a realistic 4GBB simulator and performance evaluation**

    – Implementation of physical model and cross-layer optimizations

    – Perform simulations with stochastic channel models

      • Realistic and worst-case
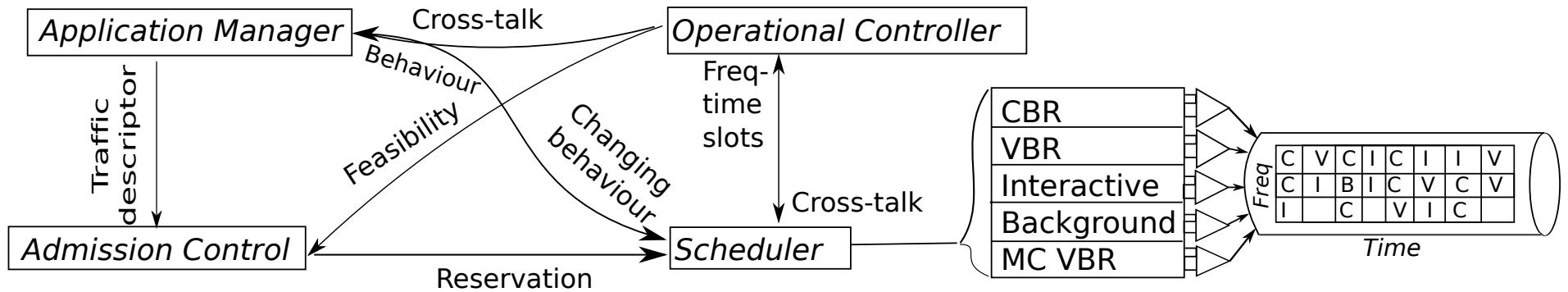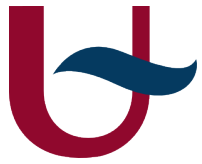
    – Compare against G.fast standard
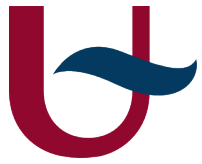
CURRENT STATE

High-level overview

QoE → QoS (delay, loss, IPDV), power usage, retransmission probability

SUMMARY

Summary

- **FttC is intermediate step to FttH**

- **Physical layer transmission techniques in DSL are configured for fixed, worst-case scenarios**

- **Cross-layer optimization allows for real-time adapting of physical layer, resulting in faster data rates, stable networks and green devices**

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The End

- **Thank you for your attention**