Modeling and Simulation of 3G UMTS in OPNET

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Outline

- Introduction and motivation
  - Introduction to UMTS networks
  - Goal of simulations
  - OPNET Simulator
- Modeling Framework
  - Modeling scope
  - Requirements and challenges
- Modeling of UMTS and its evolution in OPNET
  - Rel99 ATM-based UTRAN
  - Rel5 IP-based UTRAN
- Performance Evaluation
- Future Work

Introduction

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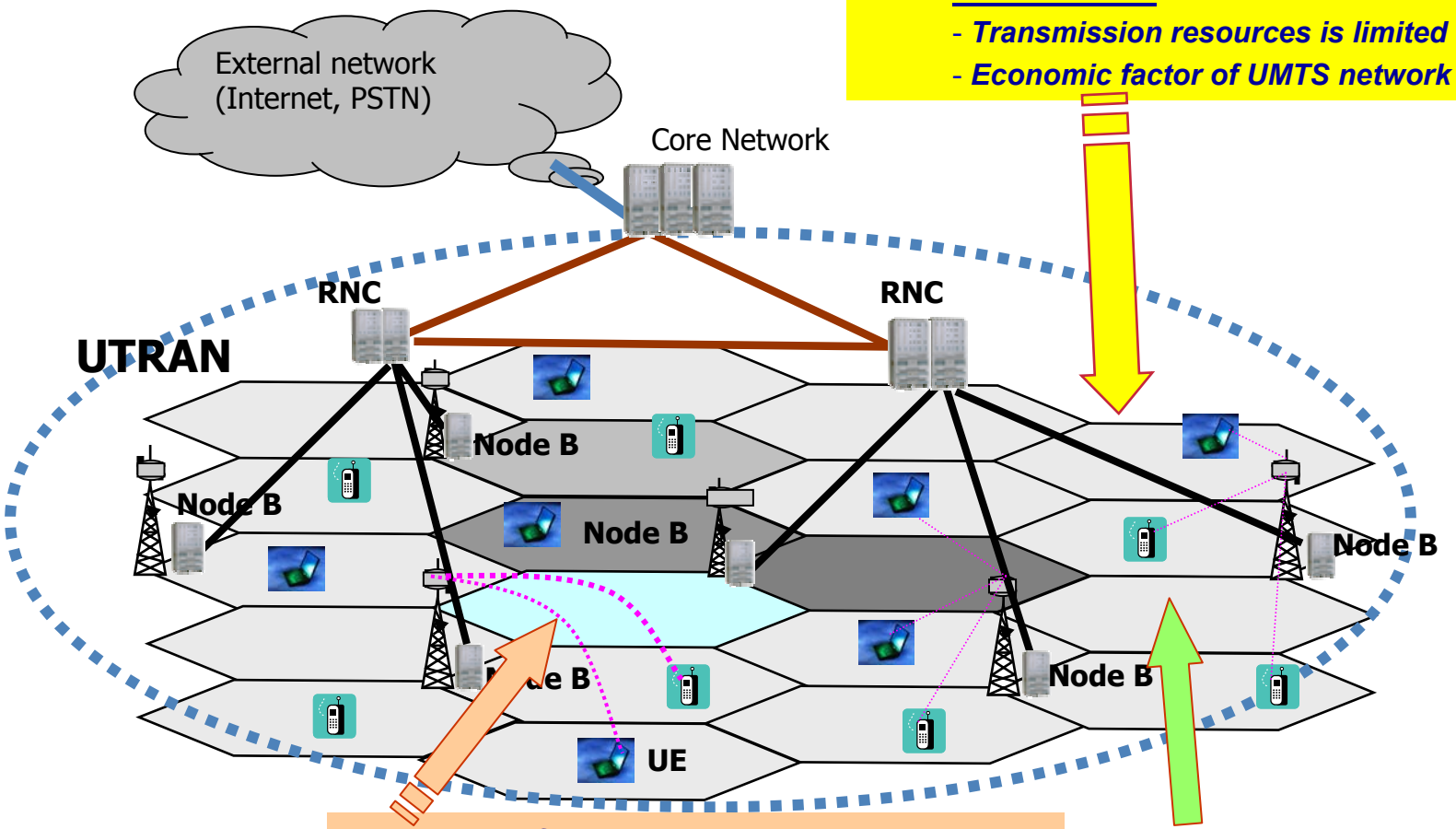


Iub Interface

- *Transmission resources is limited and costly*
- *Economic factor of UMTS network design*

Uu Air Interface:

- *WCDMA (Wideband Code Division Multiple Access)*
- *Data sent at every TTI*
- *Invokes strict delay requirements of transport of radio frames on Iub interface*

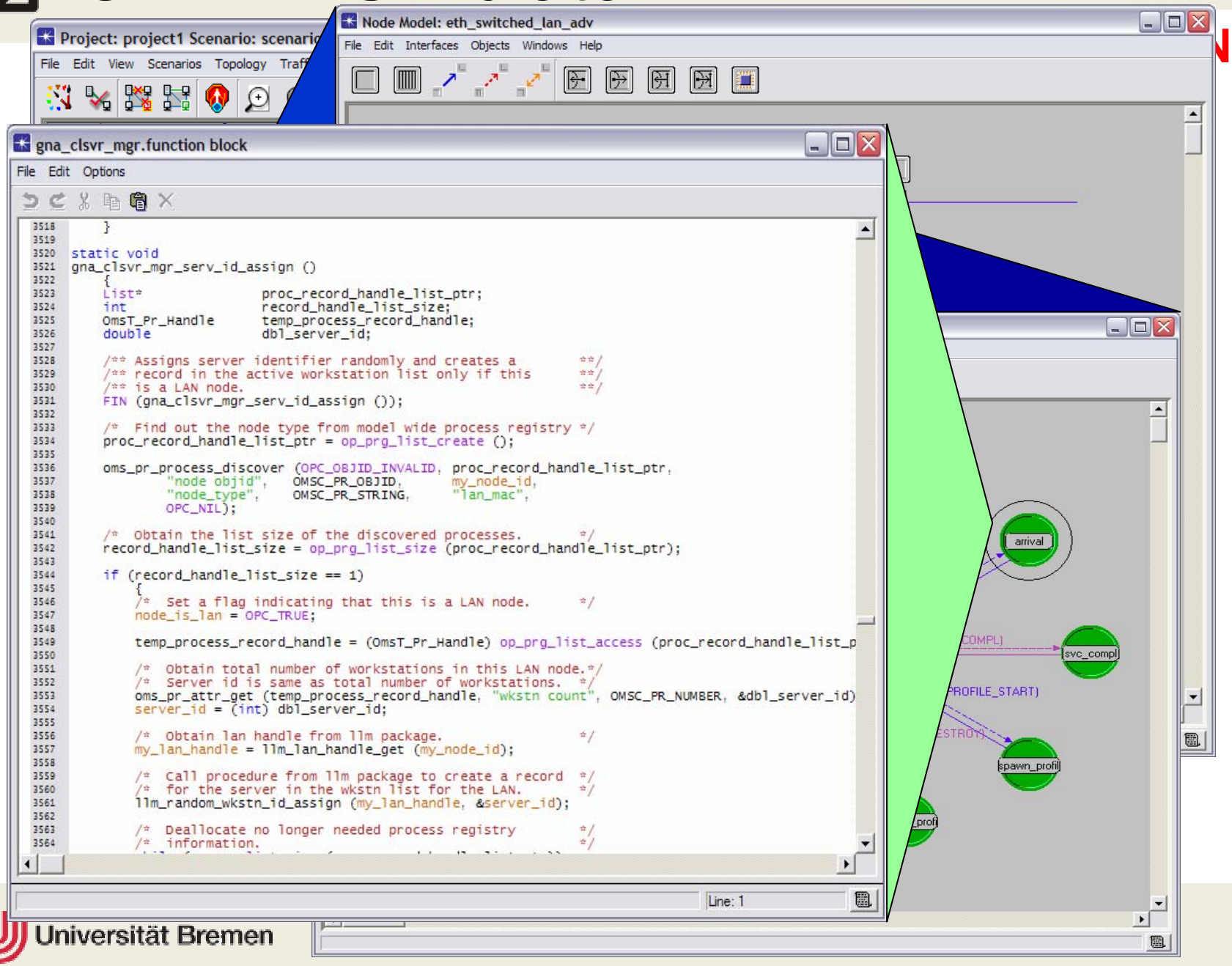
Performance Evaluation

- *Delay and jitter*
- *Connection reject ratio*
- *Packet discarding due to congestion and excessive delay*

Why Simulations?

- Performance Evaluation by simulations
- New feature modeling and testing
- Parameter and network optimization
- Traffic generation and characterization
- Network capacity planning and dimensioning
  - Derive the dimensioning rules from the simulations
  - Validate the analytical dimensioning models
- Focused on the UTRAN Iub interface
  - Transport resources management
  - Dimensioning of the Iub interface

OPNET Simulator



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Modeling Scope

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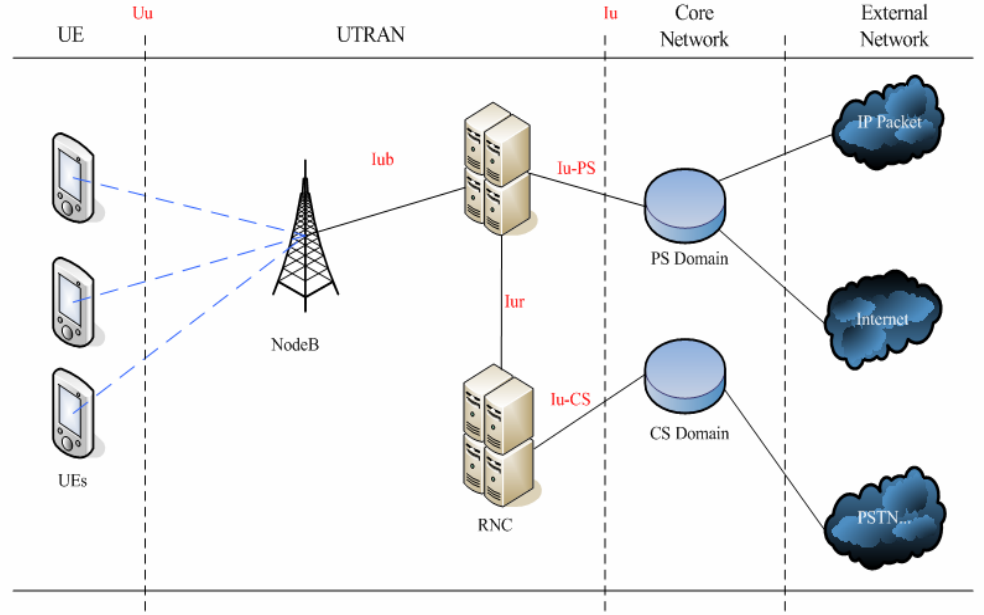

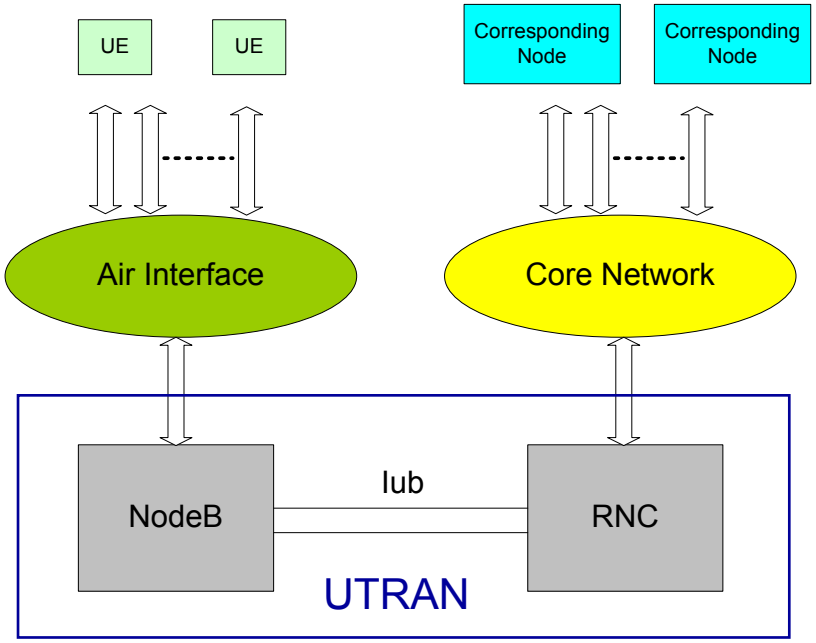

- Groups of UEs and their corresponding nodes as traffic source and sink
- Air interface: WCDMA
- UTRAN: NodeBs, RNC, Iub interface, underlying transport technology (e.g. ATM, IP/Ethernet)
- Core network: Packet Switched (PS) and Circuit Switched (CS) domains

Modeling Requirements (1)

- Physical Layer
  - WCDMA
- Traffic QoS classes in UMTS network
  - Background
  - Conversational
  - Interactive
  - Streaming
- Network Architecture
  - UE: User Equipment
  - NodeB: Base stations
  - RNC: control and serve multiple base stations
  - Core network: provide gateways to UTRAN
- Transport Technology
  - ATM
  - IP

Modeling Requirements (2)

- Logical Channels
  - Dedicated channel (DCH)
  - Common channel (RACH, FACH)
- Protocol modeling
  - Radio Link Control (RLC)
  - Medium Access Control (MAC)
  - Frame Protocol (FP)
  - Transport network layer, e.g. AAL/ATM, IP/Ethernet
- Resource management
  - Radio Access Bearer (RAB) setup/release
  - Call Admission Control (CAC)
  - Channel Type Switching (CTS)
  - Bit Rate Adaptation (BRA)
- Traffic management
  - Packet classification
  - Buffer management
  - Scheduling
  - Shaping

Challenges for modeling

- Quality of Service (QoS) provision and differentiation
  - ATM defines five QoS classes: CBR, UBR, VBR-rt, VBR-nrt, ABR
  - IP: e.g. DiffServ, IntServ, RSVP
- Traffic Engineering
  - Congestion control, flow control
- Traffic Separation
  - Rel99 with HSPA (HSDPA/HSUPA)
- UMTS Evolution
  - HSDPA/HSUPA
  - LTE (Long Term Evolution)
- Mobility Modeling
  - Soft/Softer HO
  - Hard HO

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UTRAN Model Concept

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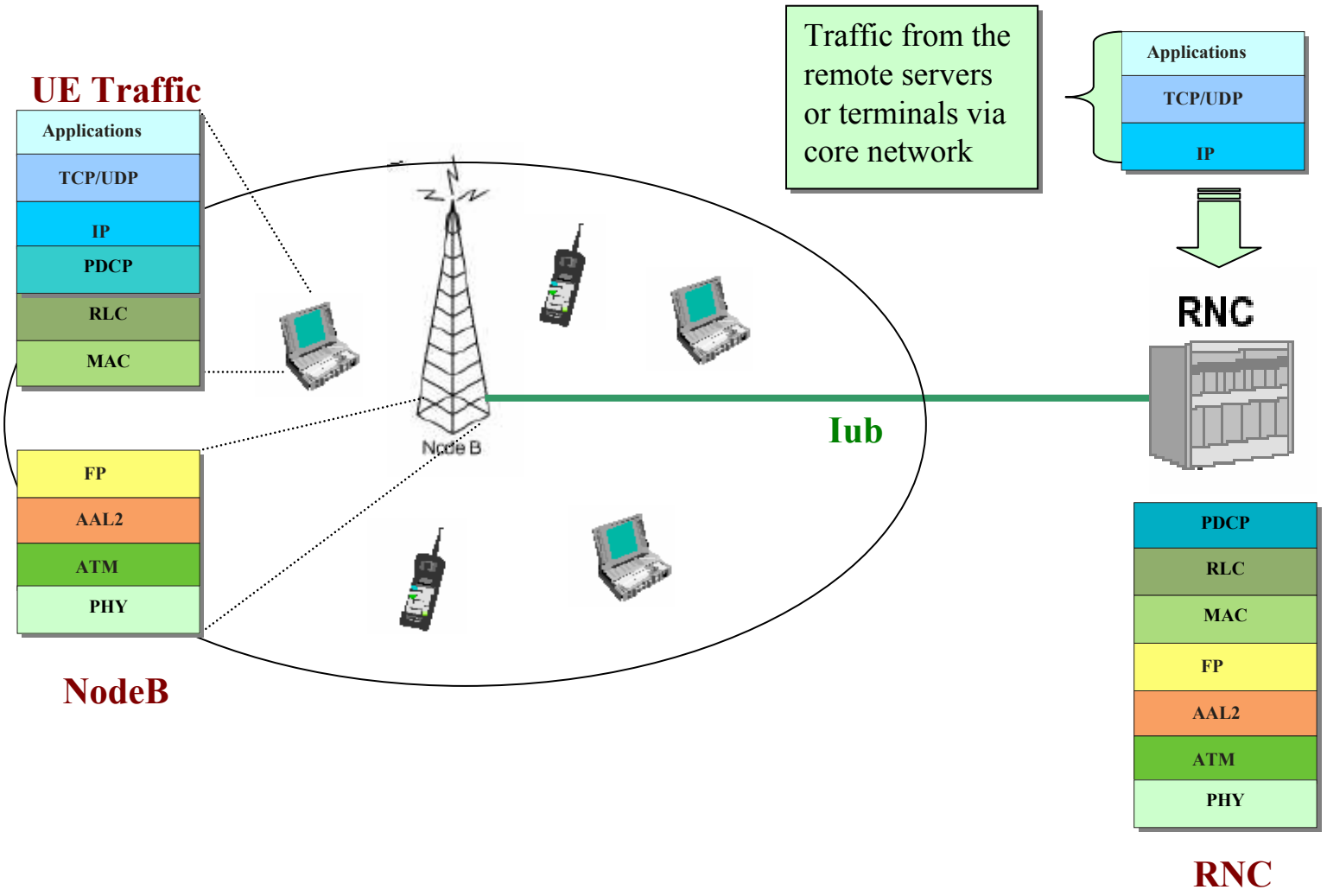

Modeling of UMTS Rel99 in OPNET

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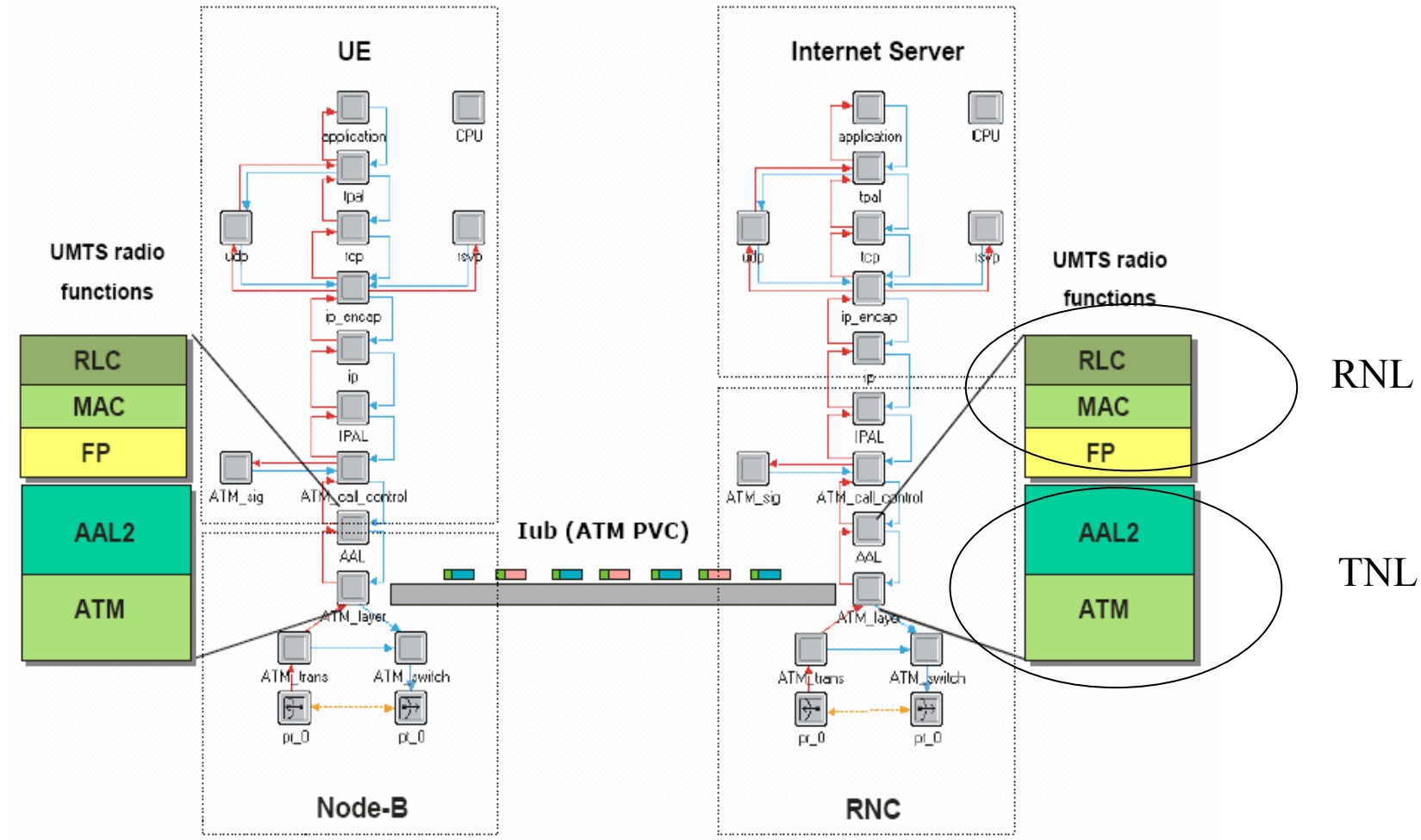
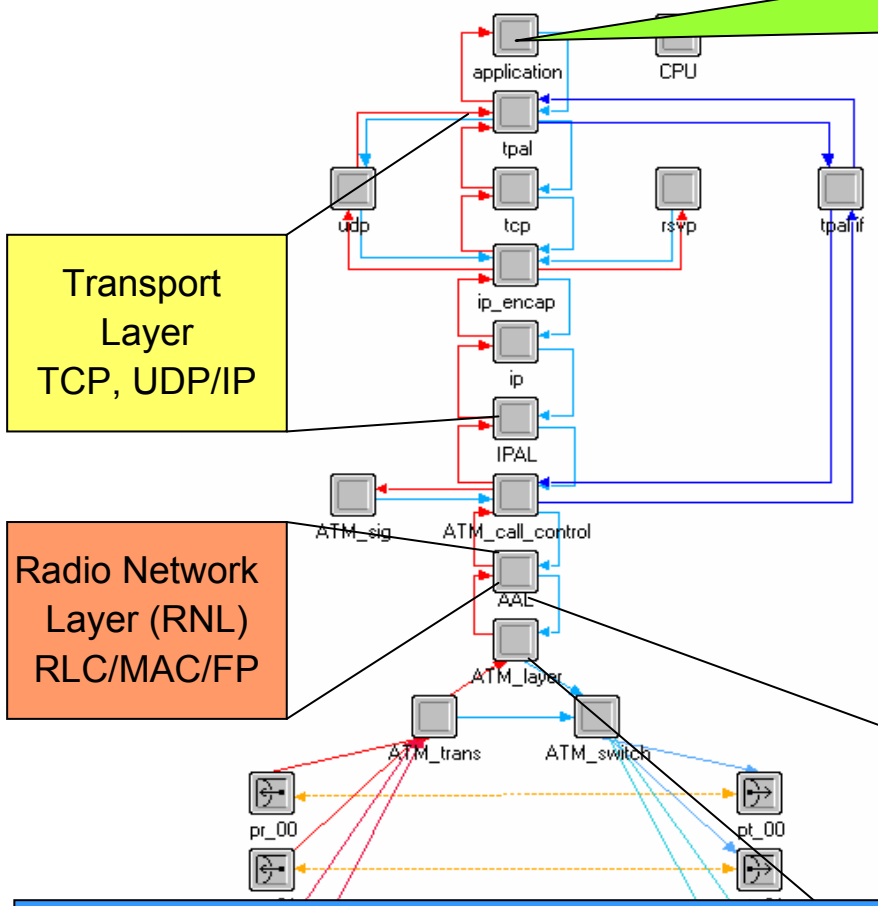


Based on the OPNET ATM library (workstation/server)

Main Functions



App. layer:
Each user is represented by one app. instance
define Traffic models
e.g. web, voice, ftp

Nets

Transport Layer
TCP, UDP/IP

UE UE UE UE .....

RAB

Radio Network Layer (RNL)
RLC/MAC/FP

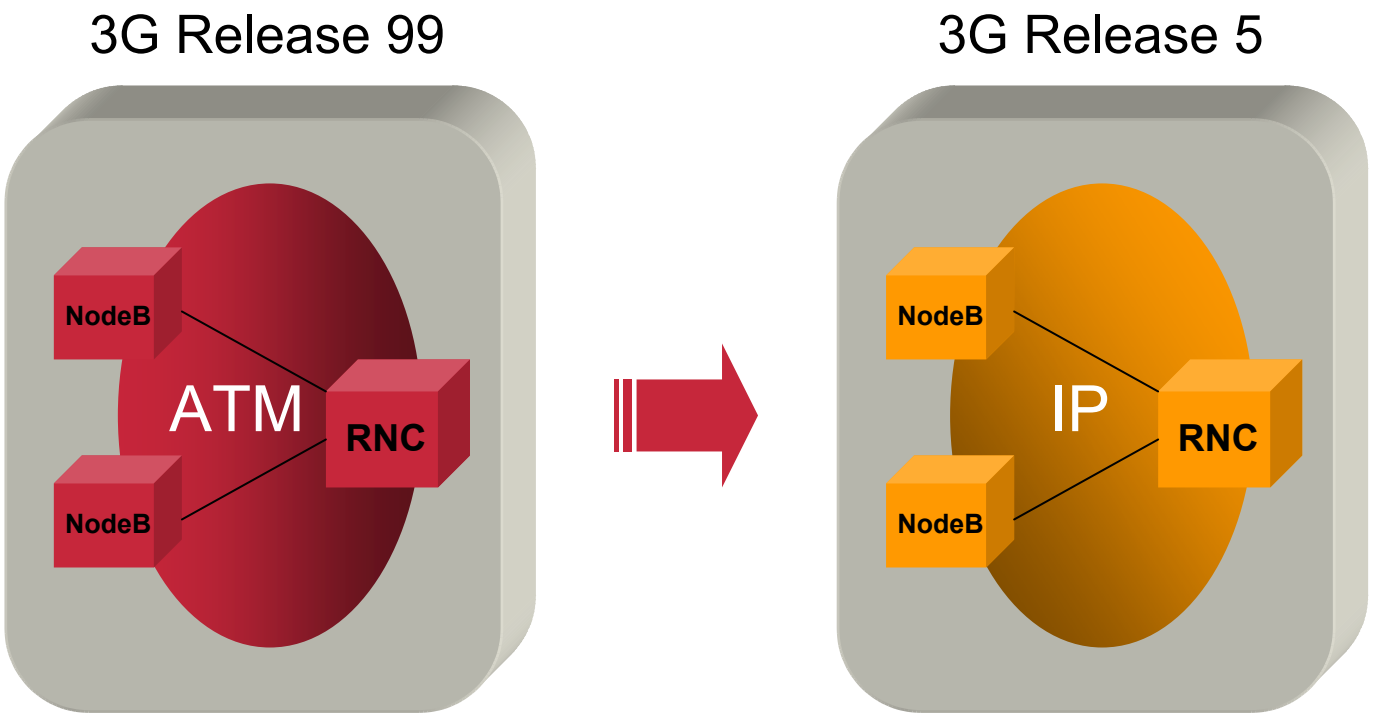
Channel assignment DCH (DTCH/DCCH), FACH/RACH

RRM
(CAC, CTS, BRA)

Transport Network Layer (AAL/ATM)
AAL2 QoS prioritization (BE and RT)
AAL2 shaping based on PCR rate (VP/VC shaping)
limited waiting time at the AAL2 buffer of RNC
ATM VC, VP setup (CBR, UBR, etc.)

Air interface modelling, e.g. propagation delay, radio frame loss due to bad channel conditions, etc.
Core network and Internet delay
Each NodeB serves up to three cells

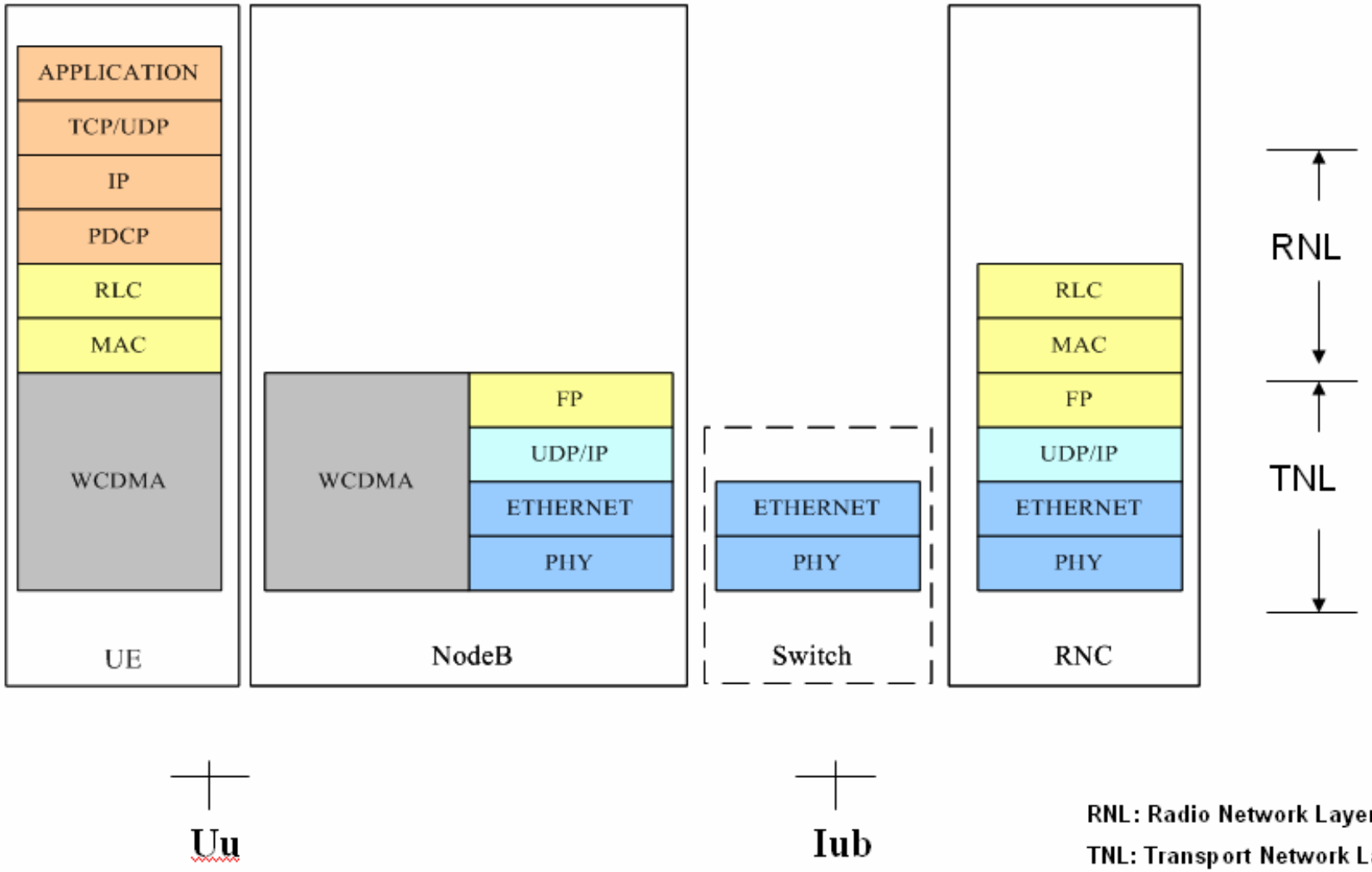
ATM → IP based UTRAN



Based on AAL2 / ATM

Based on UDP / IP

Rel5 IP-based UTRAN



Modeling of Rel5 IP-based UMTS

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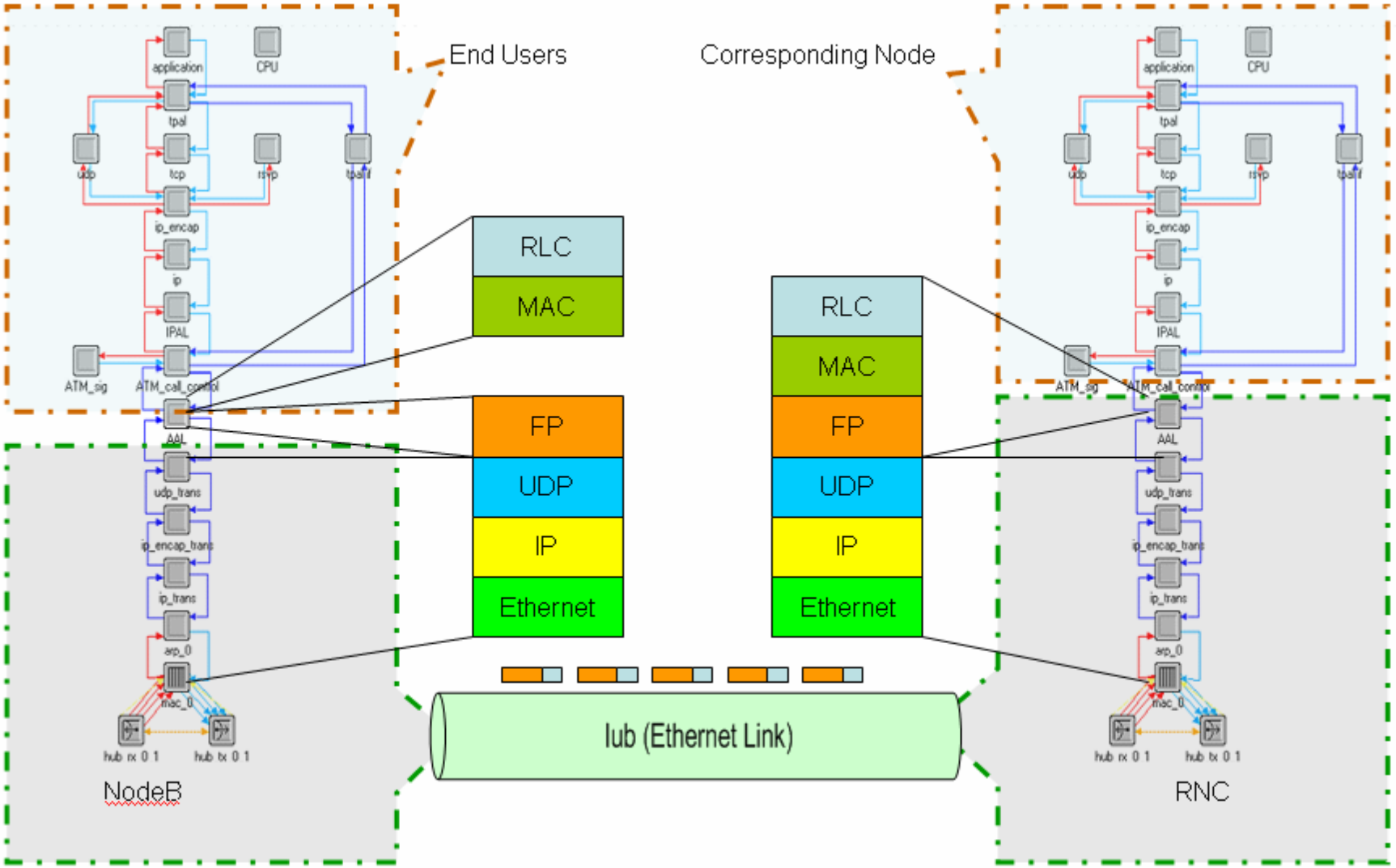

- Multiplexing, e.g. LIPE, CIP, to enhance the transport efficiency
- QoS provisioning and differentiation, e.g. DiffServ, IntServ

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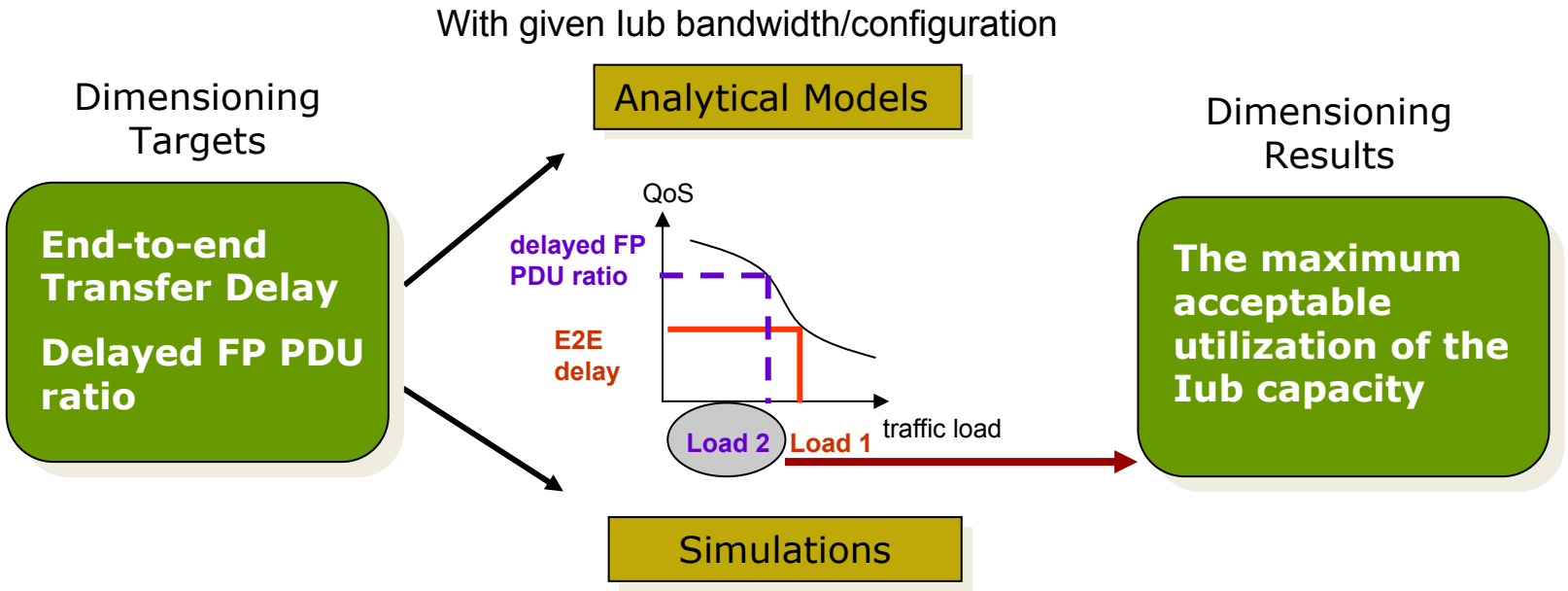
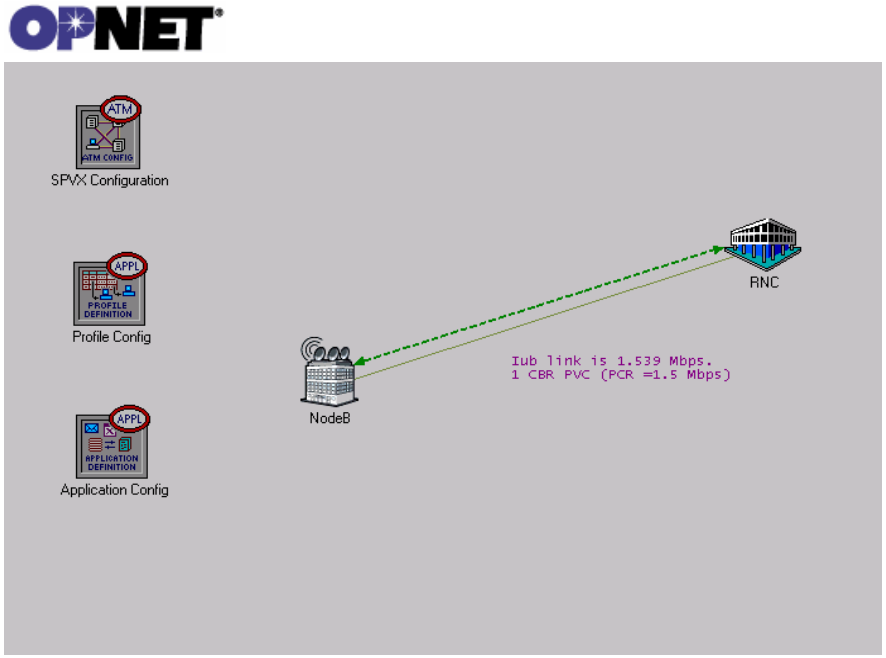
Dimensioning Task

- The properly dimensioned Iub has to achieve two main targets:
  - Ensure a given level of application performance (guarantee a maximum end-to-end transfer delay)
  - Allow only a certain percentage of discarded radio frames or FP PDUs, referred to as “delayed FP PDU ratio”, the FP PDU is discarded due to excessive delays



Simulation Model



Application: FTP

Iub link: e.g. 1 E1 line (2Mbps ATM link)

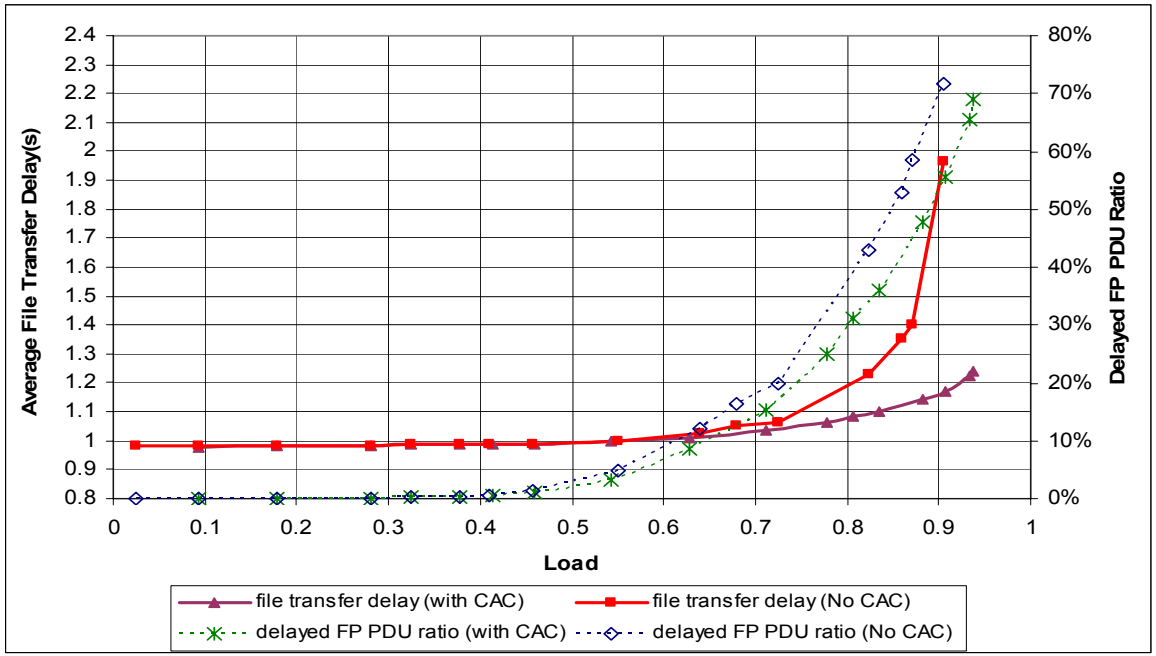
- Modeling of RLC (Radio Link Control), MAC (Medium Access Control), FP (Frame protocol) for UMTS
- Each user session is assigned to a specific RAB type
- AAL/ATM as the transport layer

Dedicated channels - DCHs				
	Uplink		Downlink	
	bit rate (kbps)	TTI (ms)	bit rate (kbps)	TTI (ms)
RAB 1	64	20	64	20
RAB 2	64	20	128	20
RAB 3	64	20	384	10

TTI: Time Transmit Interval

Dimensioning for Elastic Traffic – w./w.o. CAC

Scenario: RAB 128kbps, Iub = 1 E1 line (2Mbps), FTP (file size: constant 12kbyte)

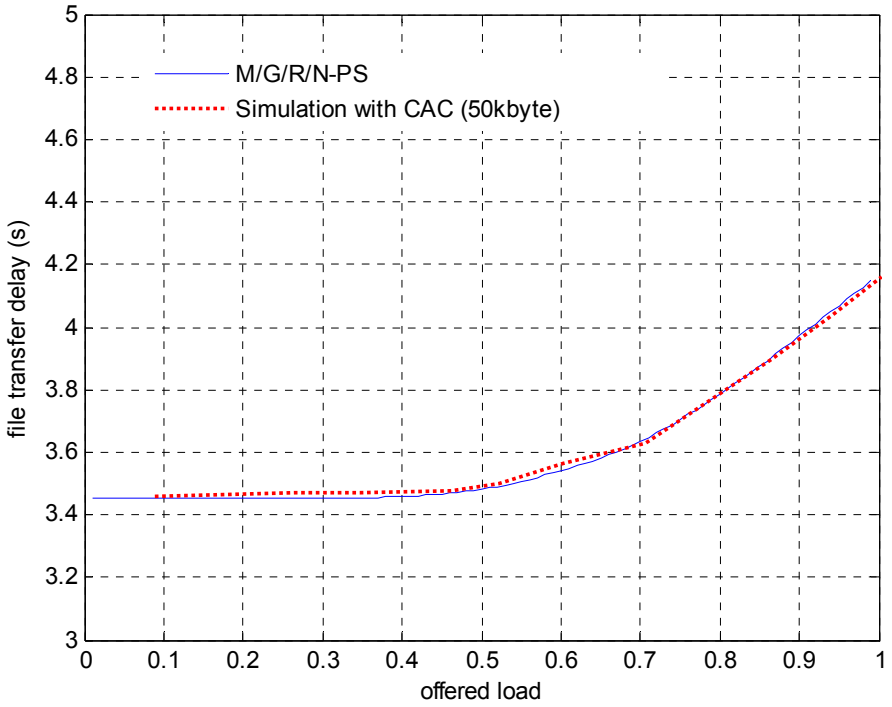


- When employing the admission control in the system, the application performance is stabilized by limiting the number of active user connections simultaneously on the link.
- But due to the bursty Internet traffic, the performance of the FP layer is only slightly improved.
- FP layer performance is the more critical restriction.

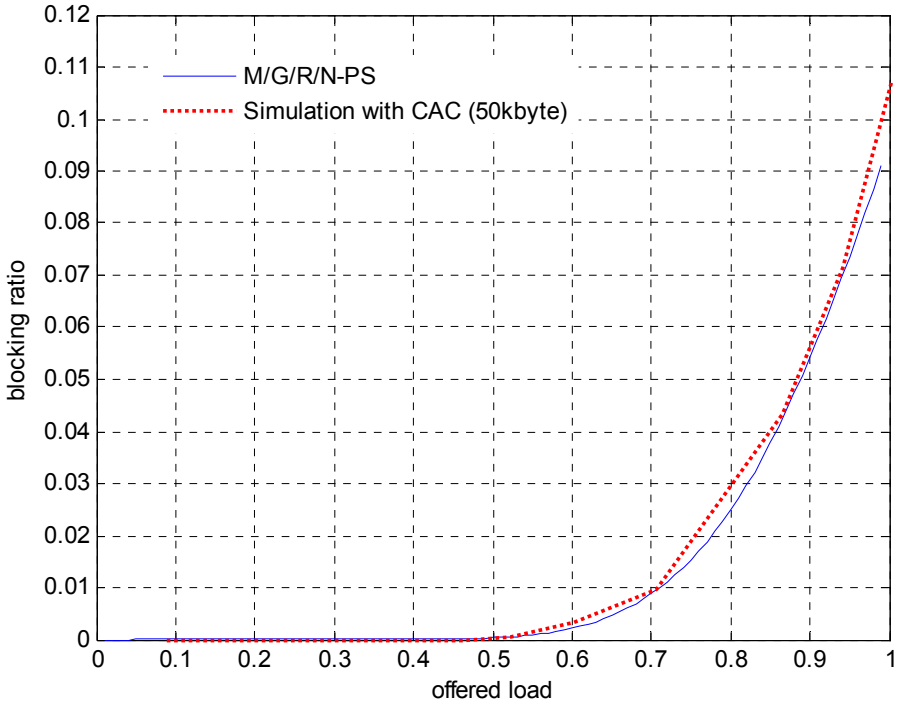
Source: X. Li, R. Schelb, C. Görg and A. Timm-Giel, "Dimensioning of UTRAN Iub Links for Elastic Internet Traffic." in Proc. 19th International Teletraffic Congress, Beijing, Aug/Sept. 2005, 2005.

Validate analytical model via Simulations (I)

Scenario: RAB 128kbps, Iub = 1 E1 line (2Mbps), FTP (file size: constant 50kbyte)



file transfer delay

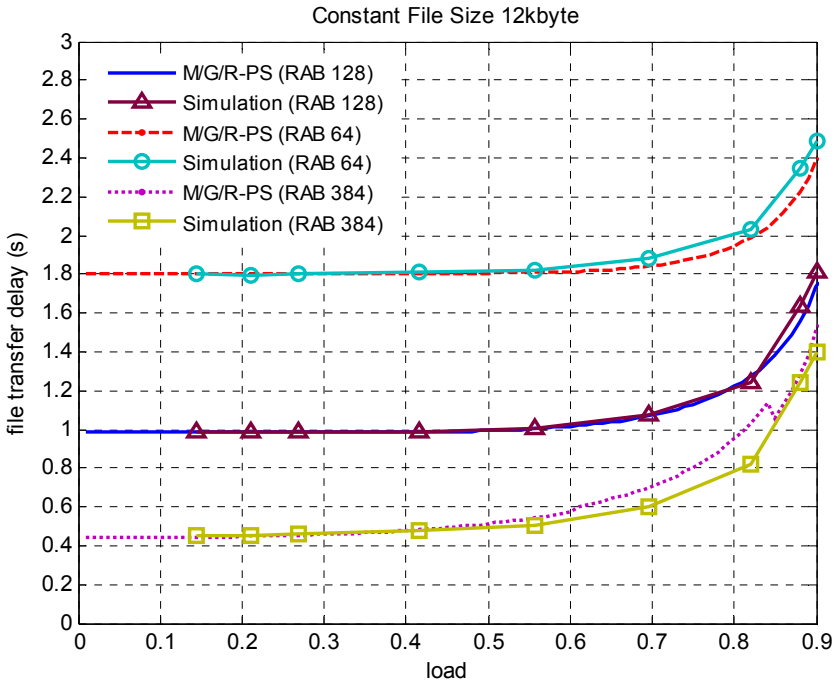


blocking probability

Source: X. Li, R. Schelb, C. Görg and A. Timm-Giel, "Dimensioning of UTRAN Iub Links for Elastic Internet Traffic." in Proc. 19th International Teletraffic Congress, Beijing, Aug/Sept. 2005, 2005.

Validate analytical model via Simulations (II)

Multiple RAB Types



- The transfer delay dependent on the bearer type
- Analytical results matches the simulaitons in the low load
- In high load, the flows with the small peak rates achieve longer transaction times than calculated with the M/G/R-PS model, while the high-peak-rate flows experience a somewhat higher QoS than calculated
- The delay for a common file size among the different traffic classes tends to converge in the high load as none of them can utilize its peak rate and thus a fair share of the available resources is available among different RAB types

Source: X. Li, R. Schelb, C. Görg and A. Timm-Giel, "Dimensioning of UTRAN Iub Links for Elastic Internet Traffic with Multiple Radio Bearers," in Proc. 13th GI/ITG Conference Measuring, Modelling and Evaluation of Computer and Communication Systems, Nürnberg, March 2006, 2006

Main Research

- Dimensioning for Iub link for supporting various traffic scenarios for different UMTS releases (Rel99, IP-based UTRAN, HSDPA, HSUPA)
  - Derive the dimensioning rules from the simulations
  - Validate the analytical dimensioning models
- Iub Overbooking in multi-NodeBs scenario
- Combine HSPA and Rel99 traffic with traffic separation

Future Work

- UMTS Evolution
  - Internet HSPA or I-HSPA, a flat architecture that provides the first step towards Long Term Evolution (LTE)
  - 3GPP Long Term Evolution (Evolved UTRA and UTRAN) accompanied by 3GPP System Architecture Evolution (SAE)
- New Services, e.g. VoIP, IPTV, etc.
- Validate with real word scenario

References

- *X. Li, R. Schelb, C. Görg and A. Timm-Giel, "Dimensioning of UTRAN Iub Links for Elastic Internet Traffic." in Proc. 19th International Teletraffic Congress, Beijing, Aug/Sept. 2005, 2005.*

- *X. Li, R. Schelb, C. Görg and A. Timm-Giel, "Dimensioning of UTRAN Iub Links for Elastic Internet Traffic with Multiple Radio Bearers," in Proc. 13th GI/ITG Conference Measuring, Modelling and Evaluation of Computer and Communication Systems, Nürnberg, March 2006, 2006*

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Thanks for attentions!

Questions?