Cross-Layer und Inter-Service Optimierung zukünftiger Mobilkommunikationssysteme

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Outline

- Mobile Networks at the IKR
- Challenges for Future Mobile Networks
- Cross-Layer Interferences
- Inter-Service Interferences
- Issues and Methods of Treatment
- Example: HTTP Page Loading over UMTS
- Conclusions and Outlook

Problem Statement

Problem Treatment

Mobile Networks at the IKR

IKR: Institute of Communication Networks and Computer Engineering

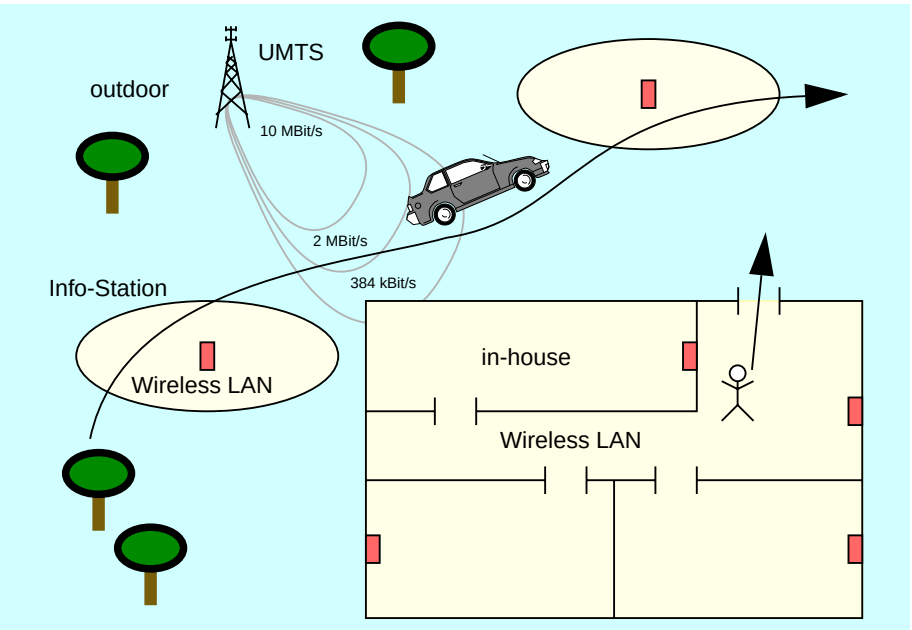
- **Head: Prof. Dr.-Ing. Dr. h. c. mult. Paul J. Kühn**
- **25 research staff members**
- **5-6 non-scientific staff members**

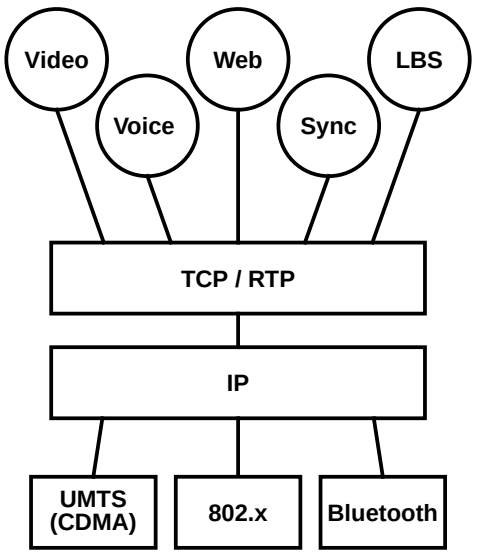
Mobile Networks

- **6 research staff members**
- **Funding**
  - German Research Foundation
  - European Commission
  - Companies
- **Main Focus**
  - architectures and performance of 3G and beyond 3G mobile networks (Layer 2+ view)
  - mobile Internet: Nexus, a system platform for context based services

Coping with the Heterogenity

- **Aim for new wireless technologies (IEEE 802.11x, WiMAX, Bluetooth)**
- **Aim for rich tele-services (applications)**
- **Highly dynamic environments ... including user mobility**





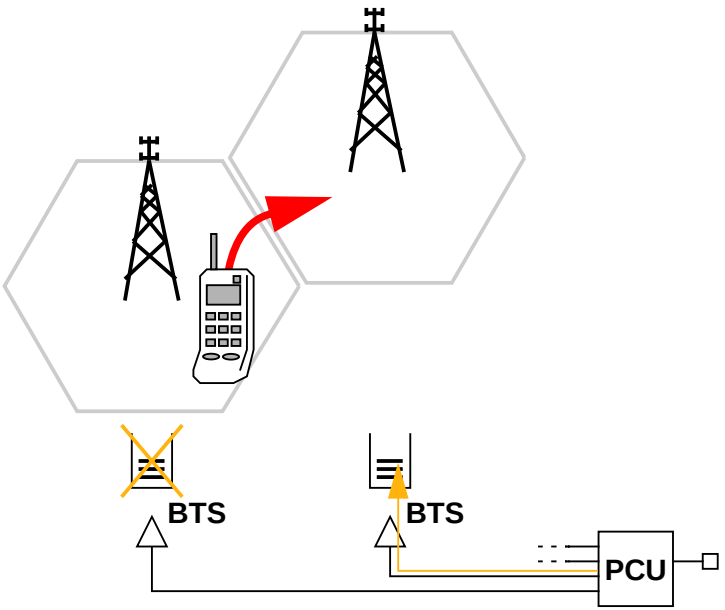
➥**integration !?**

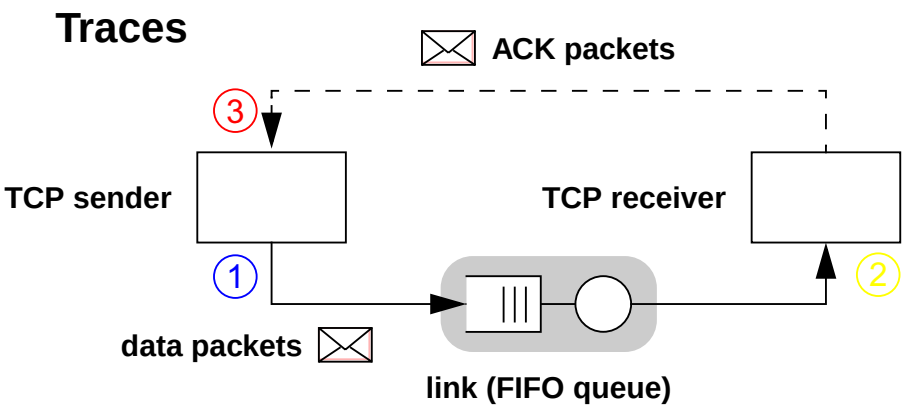
- **Highly complex systems**

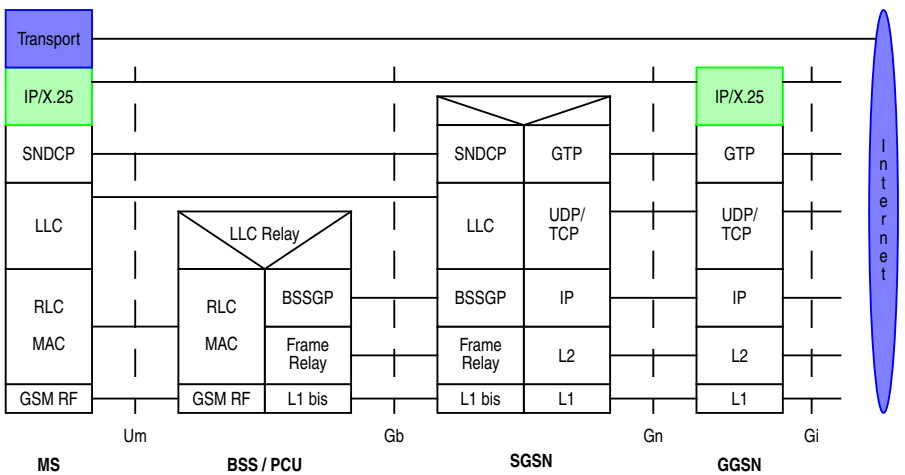
Examples for Cross-Layer Interferences

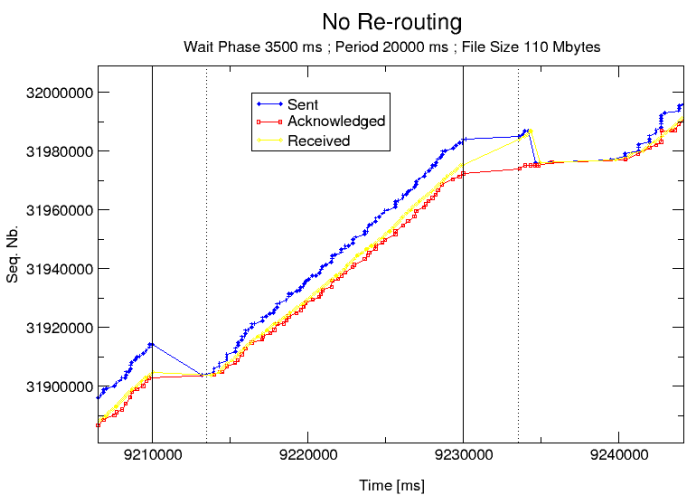
Layer 2 / Layer 4 Interferences

- **TCP transmissions with intra-technology handover**

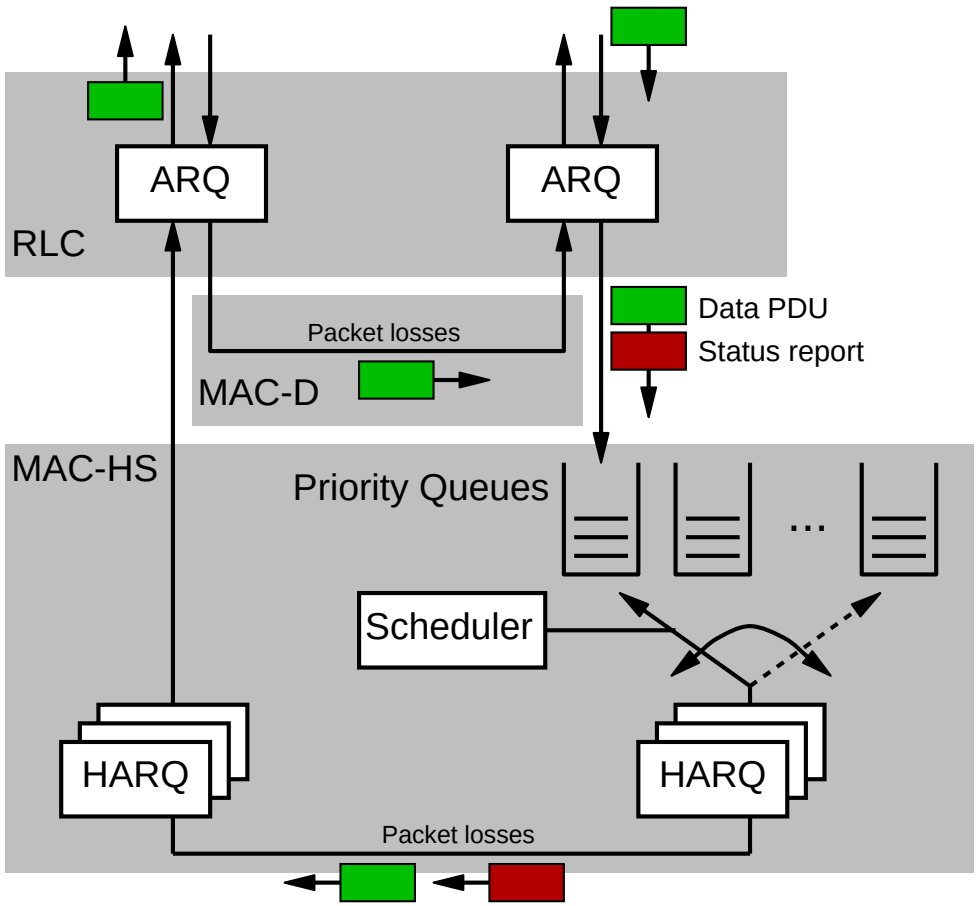








Interfering Control Loops – ARQs of MAC and RLC

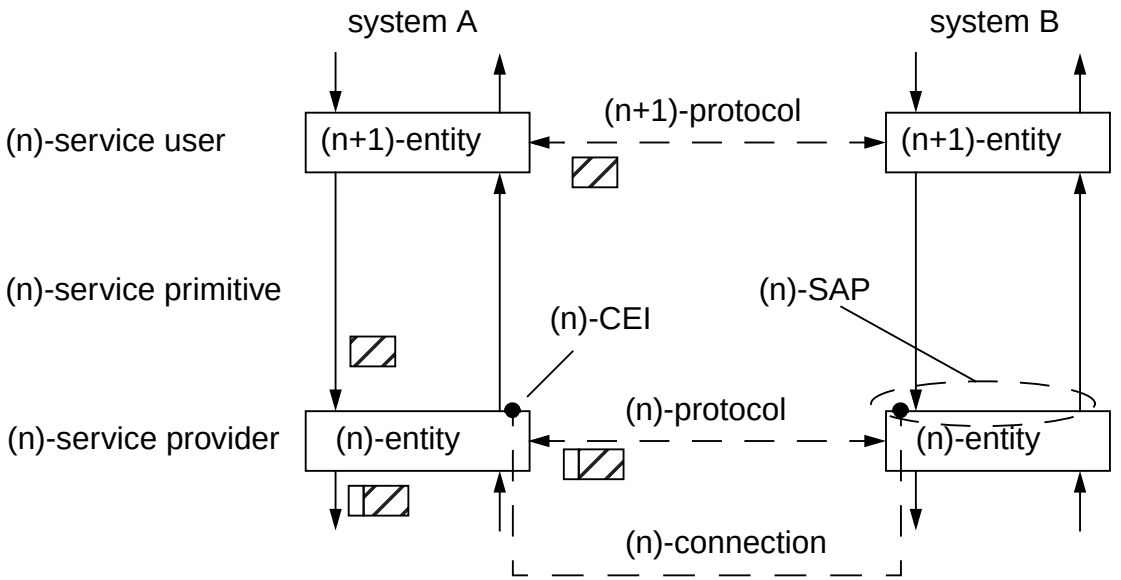


- Loss of UL data PDU causes DL status report
- Retransmission only after reception of status report by UE
- DL MAC-HS scheduler highly affects UL behavior
- may degrade UL performance
- UL performance directly affects DL TCP performance

Reasons behind Cross-Layer Interferences

Classical OSI Layering Paradigm

- **Each layer acts independent of each other**
- **Each layer is designed and optimized by itself**



- **Functional properties are well defined by service primitives**

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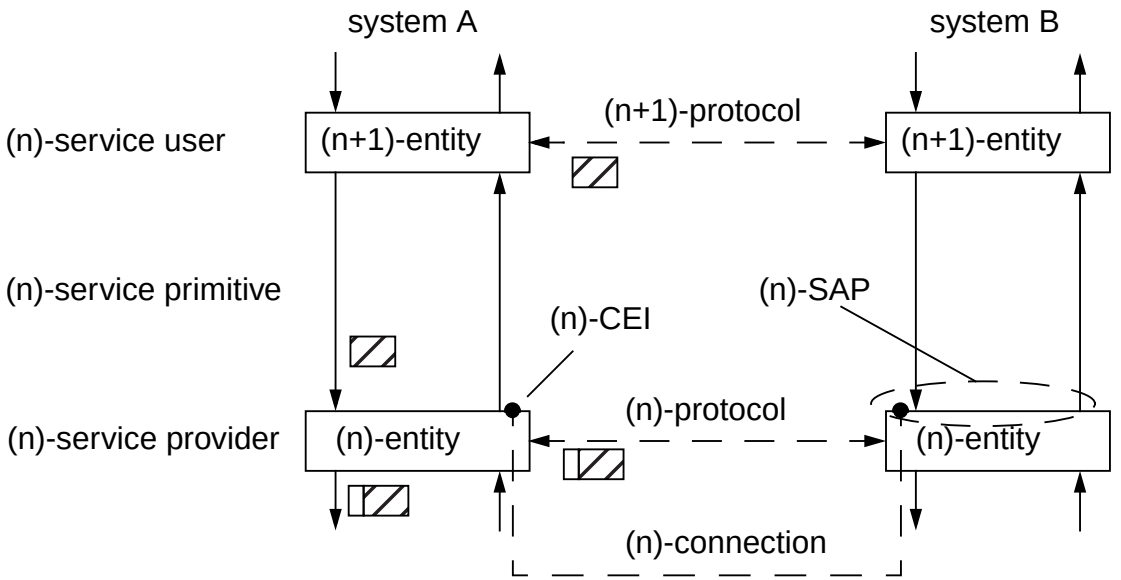
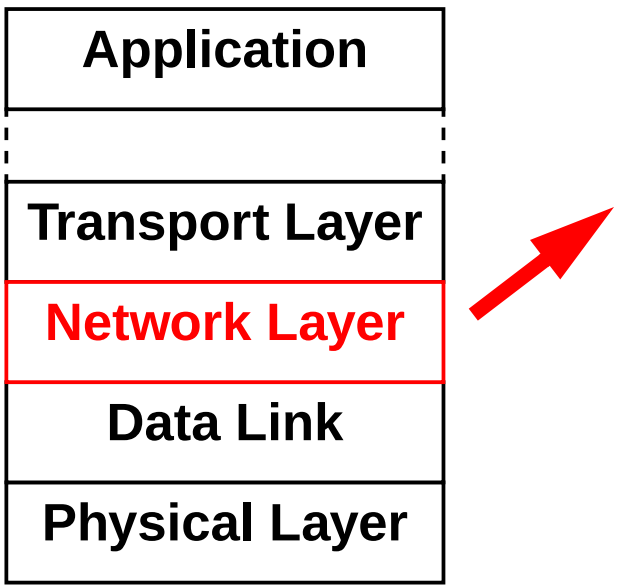
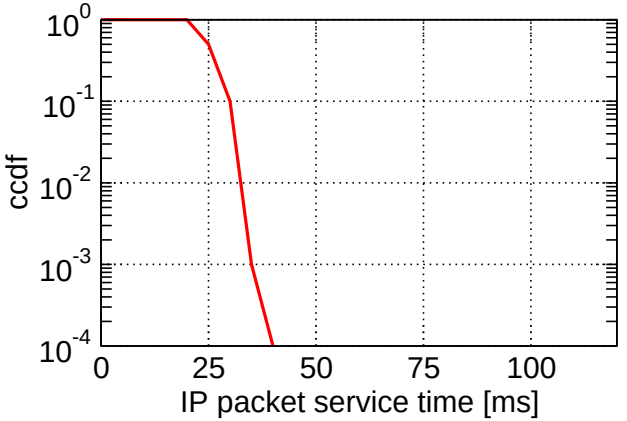


- **Functional properties are well defined by service primitives**
- **Non-Functional properties many times are neither specified nor are they available to higher layers**

Reasons behind Cross-Layer Interferences (2)

Examples for non-Functional Layer Properties





Fixed Access

- **Short RTT**
- **Small delay jitter**

Reasons behind Cross-Layer Interferences (2)

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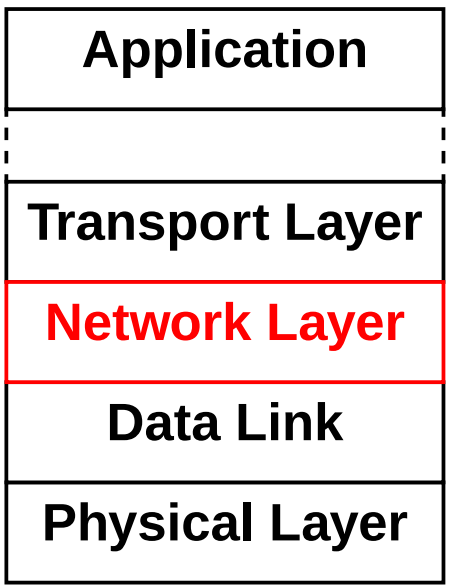

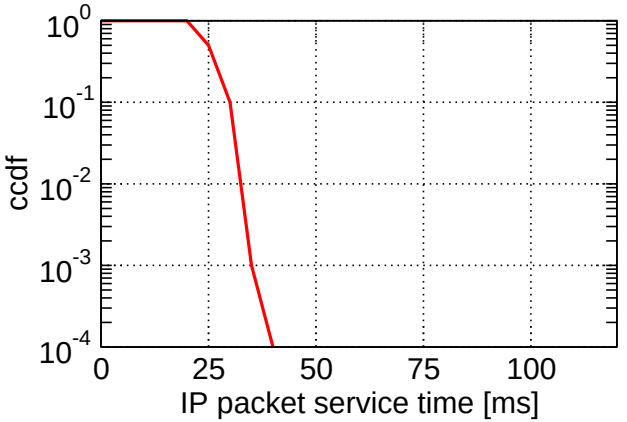

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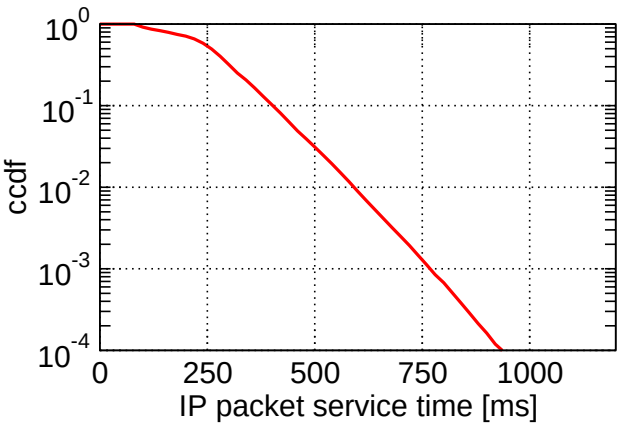
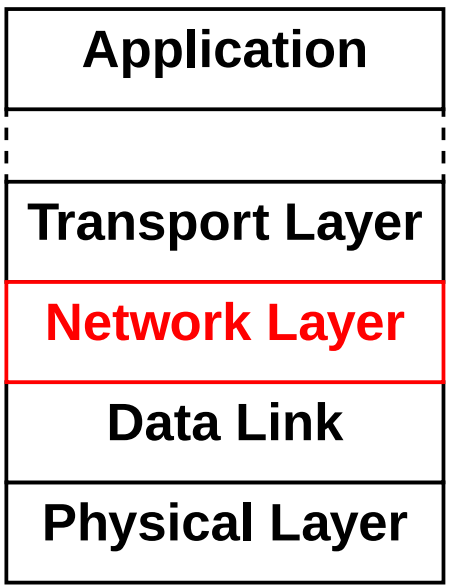


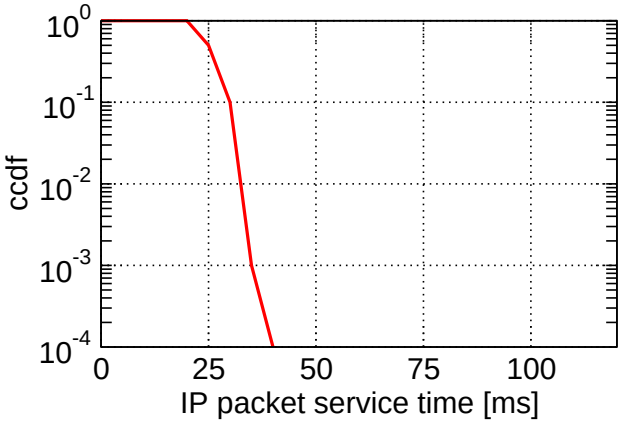
Mobile Access

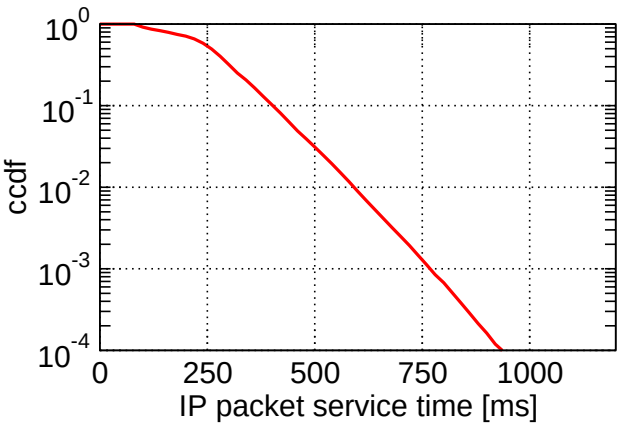
- **Large RTT**
- **Large delay jitter**

Reasons behind Cross-Layer Interferences (2)

Examples for non-Functional Layer Properties







Fixed Access

- **Short RTT**
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Mobile Access

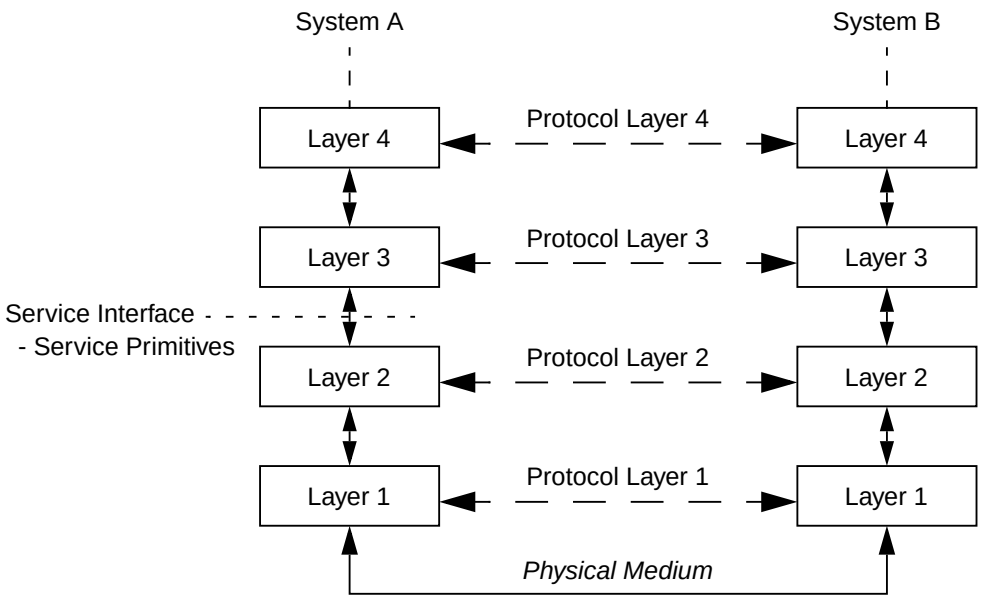
- **Large RTT**
- **Large delay jitter**

More properties

- loss rates and loss reasons
- buffer sizes and drop strategies
- presence of control loops

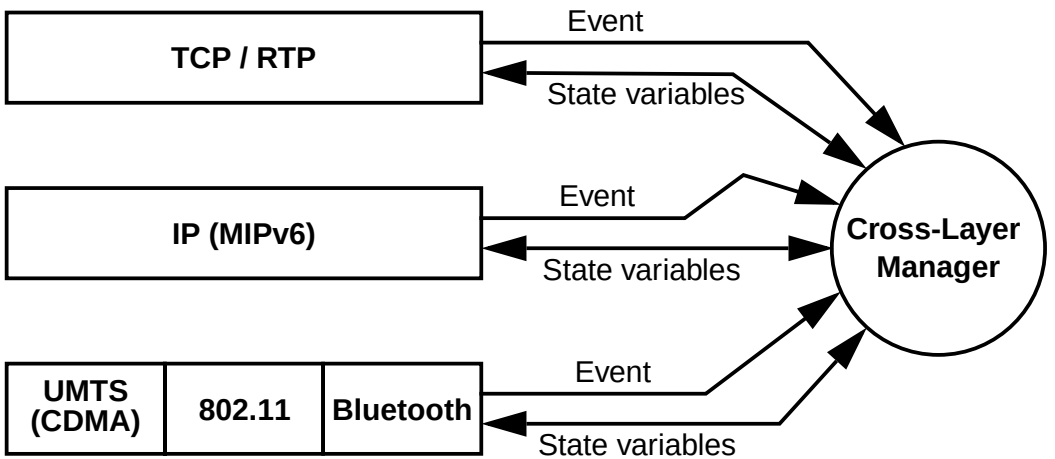
More Cross-Layer Issues

- **QoS treatment**
- **Mobility management / mobility treatment**
- **Application / service adaptation**
- **(Encryption in multiple layers)**



New Architectures

➥ **Is there a need for such an approach?**



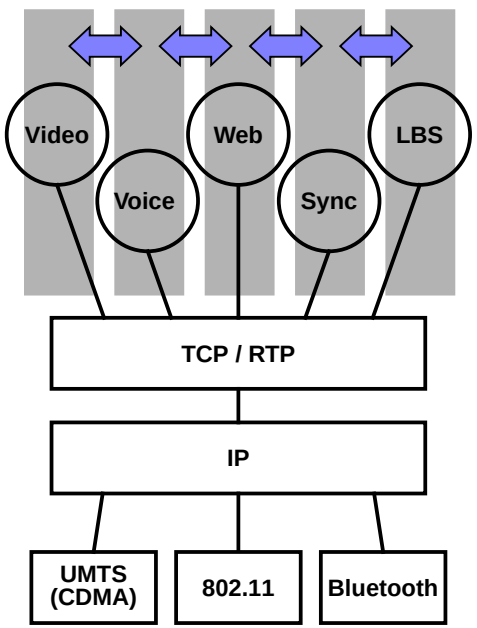
Inter-Layer Coordination Model

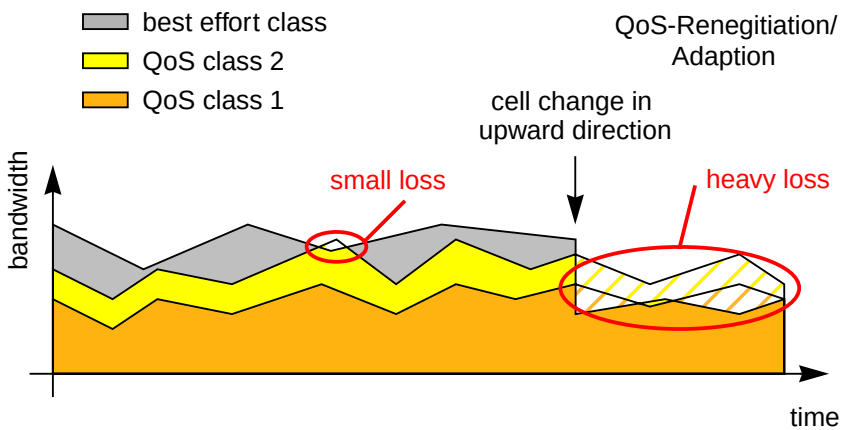
Gustavo Carneiro, "Cross-Layer Design in 4G Wireless Terminals", IEEE Wireless Communications, April 2004

Inter-Service Interferences

Same Problem in Horizontal Dimension

- **Non-functional horizontal interferences of services**
  - within a mobile node
  - within an access network
  - across access networks
- **Lack of coordination! Need for intelligent QoS-brokers, advanced schedulers, high level mobility management, ...**



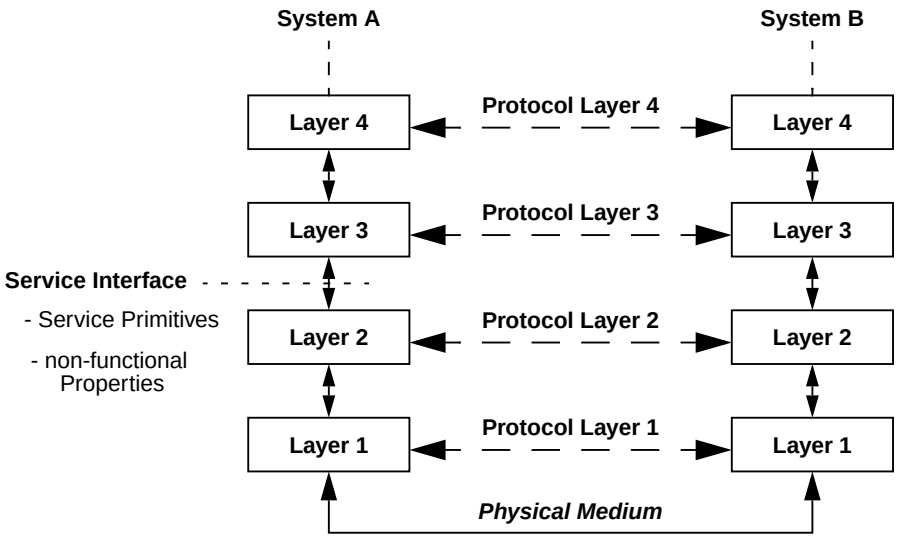


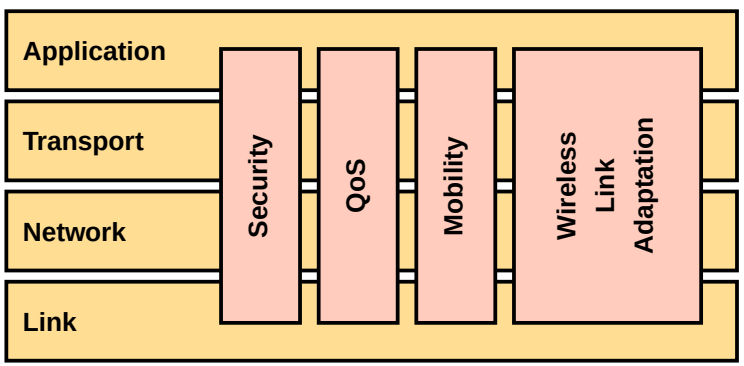
Treatment at the IKR

Tasks for Treatment

Research Issues

- **Research in non-functional properties of architectural layers**
  - service characteristics of UMTS-OFDM (DL), HSDPA, ...
  - timings and control loops of protocol mechanisms, i. e. handover control, ARQ, link adaptation, ...
  - application properties





Cross-layer coordination planes
Source: Gustavo Carneiro, "Cross-Layer Design in 4G Wireless Terminals", IEEE Wireless Communications, April 2004

- **System parametrization and tuning**
  - buffer and timer dimensioning
  - standard interpretation e.g. packet re-routing, algorithm design, ...
- **Architectural changes**
  - e. g. introduction of cross-layer coordination planes

Methods of Treatment

Simulation

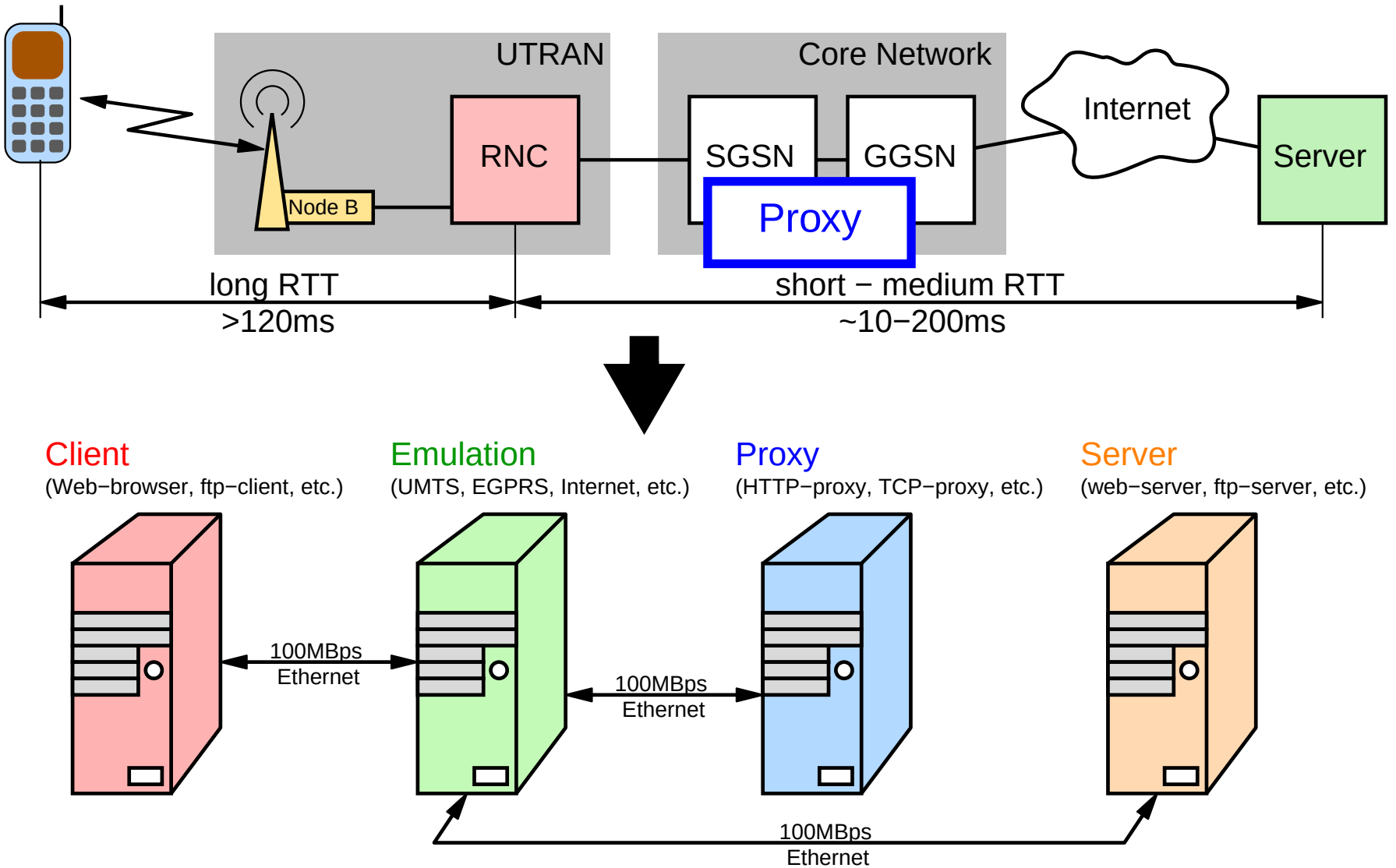
- **Event driven simulation-environment based on *IKR SimLib***
  - ➥ quickly explore vast parameter spaces
  - ➥ rather simplistic traffic models

Emulation

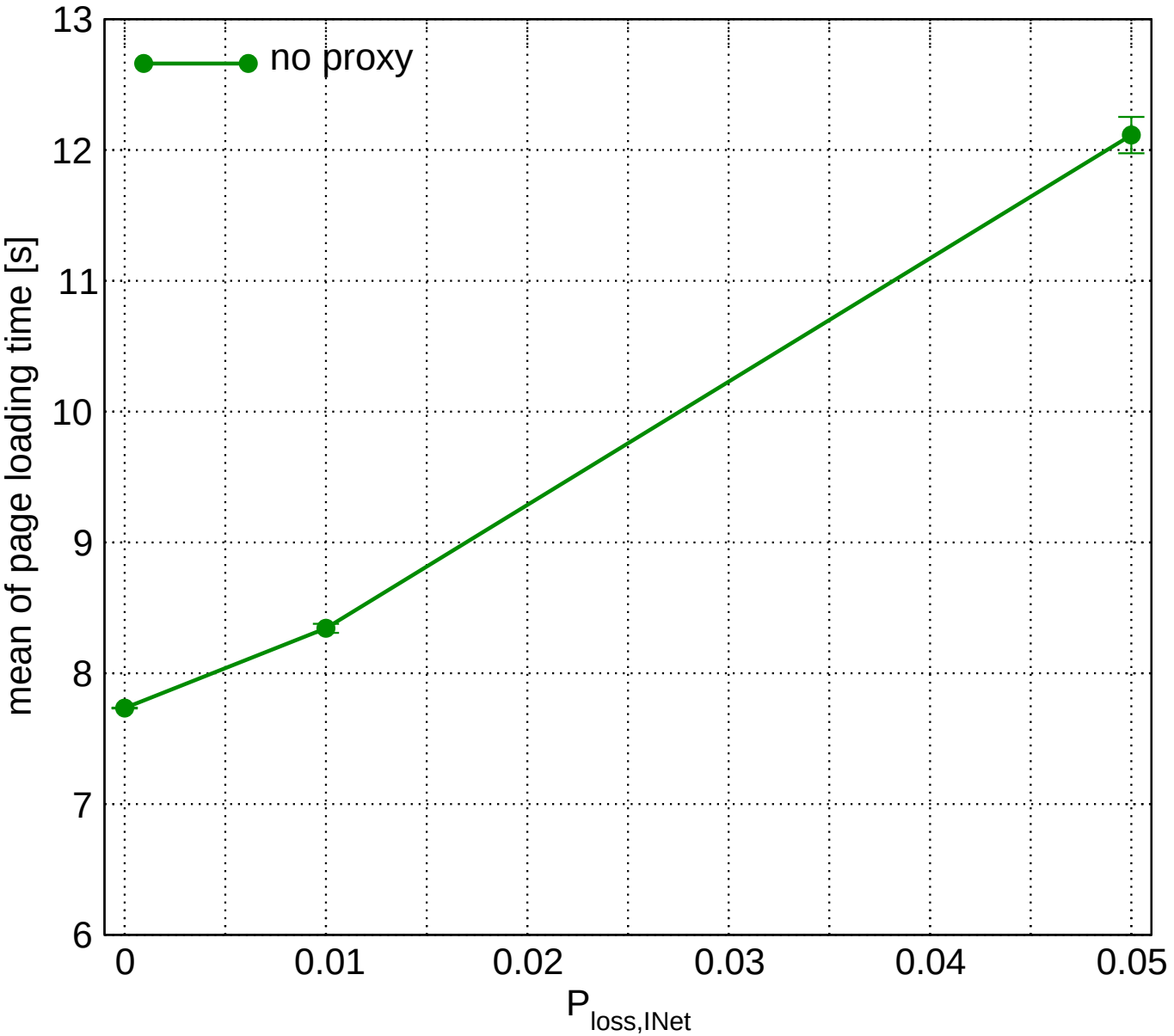
- **Extension of simulation environment using *IKR EmuLib***
  - ➥ use the same simulation model within an emulation environment
  - ➥ easy analysis of sophisticated real-world traffic
  - ➥ inclusion of real-world components (e.g. servers, TCP-stacks, ...)

Example: UMTS-Emulation Environment

UMTS Scenario



Example: HTTP Page Loading Times



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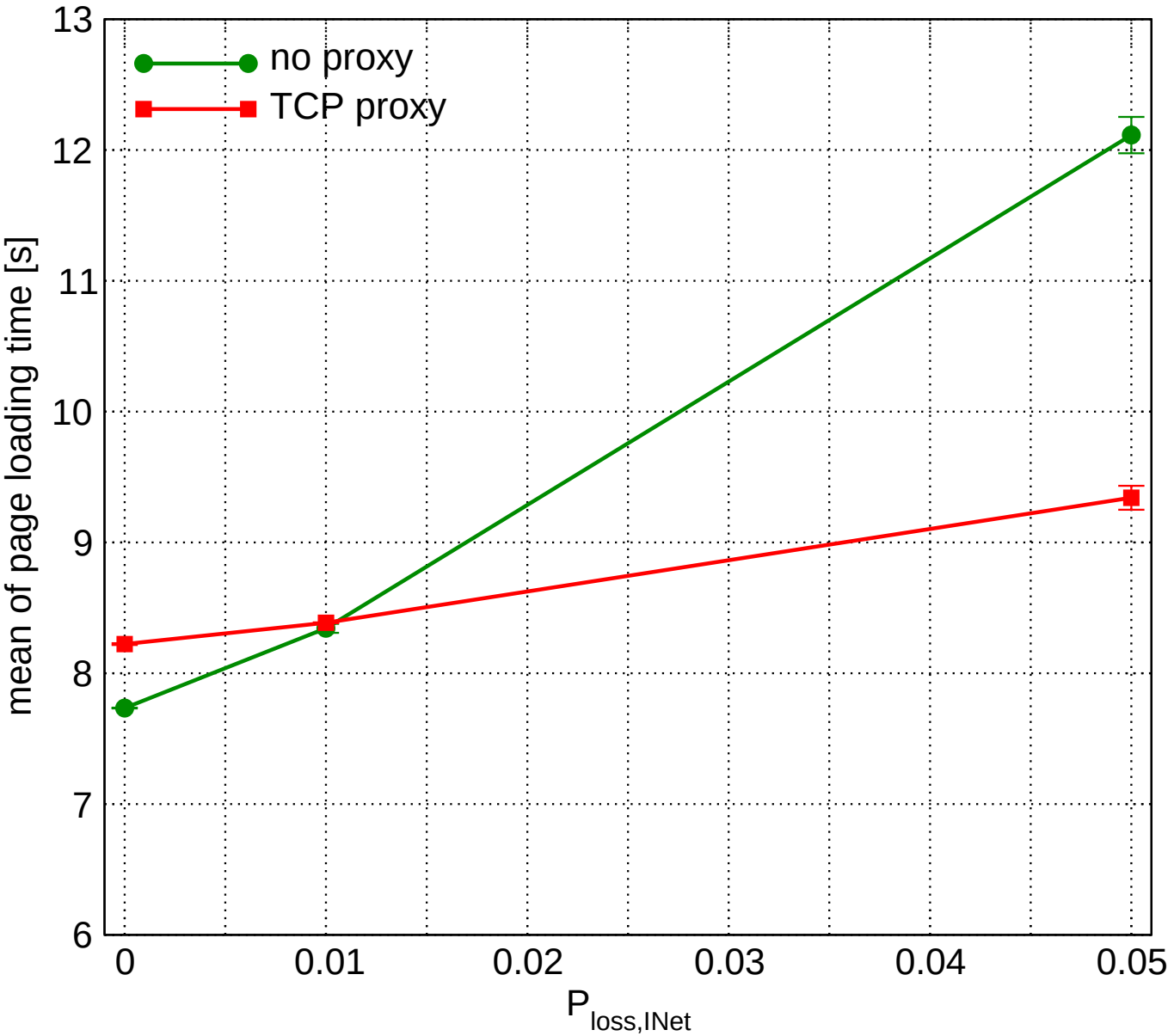

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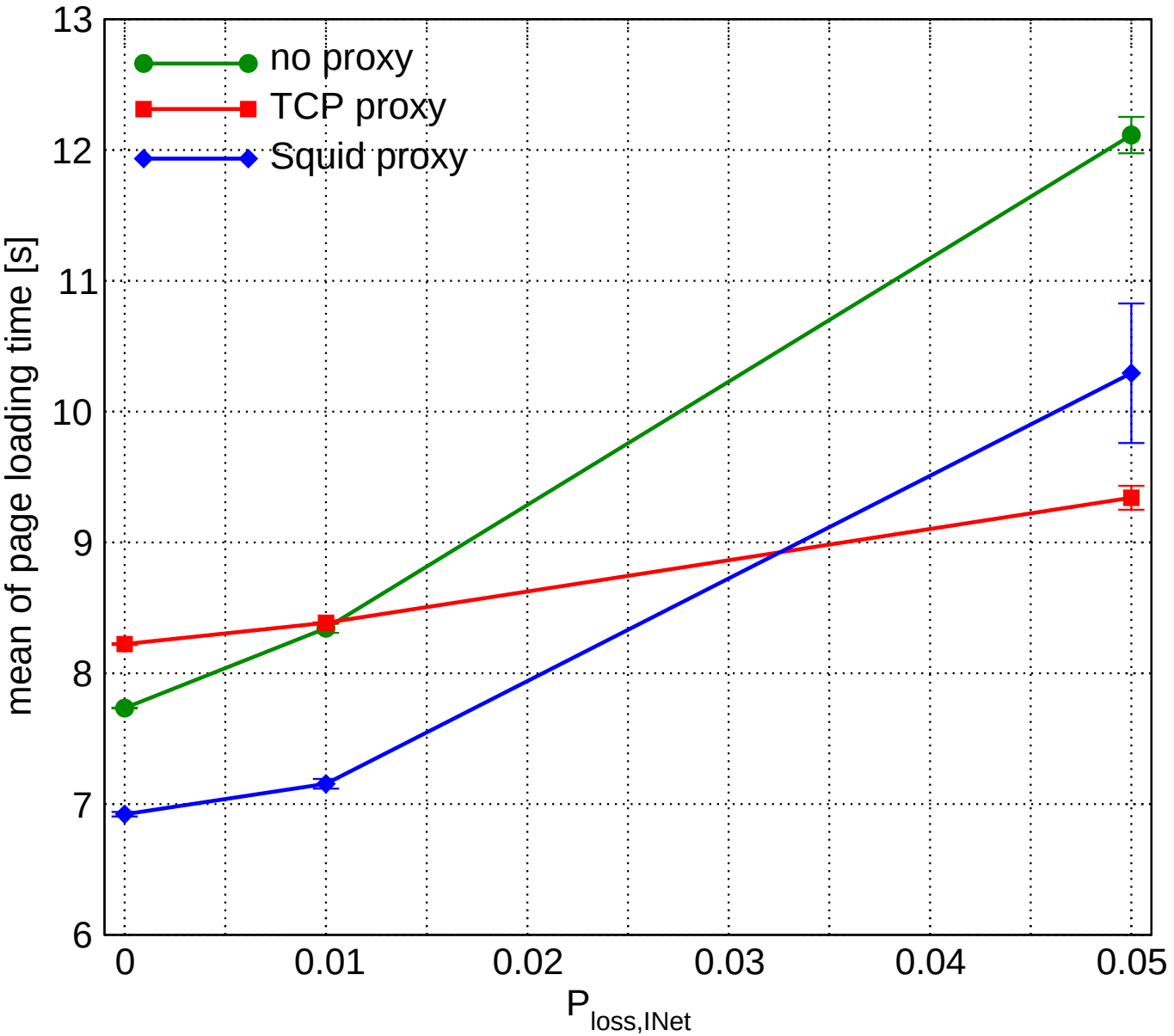

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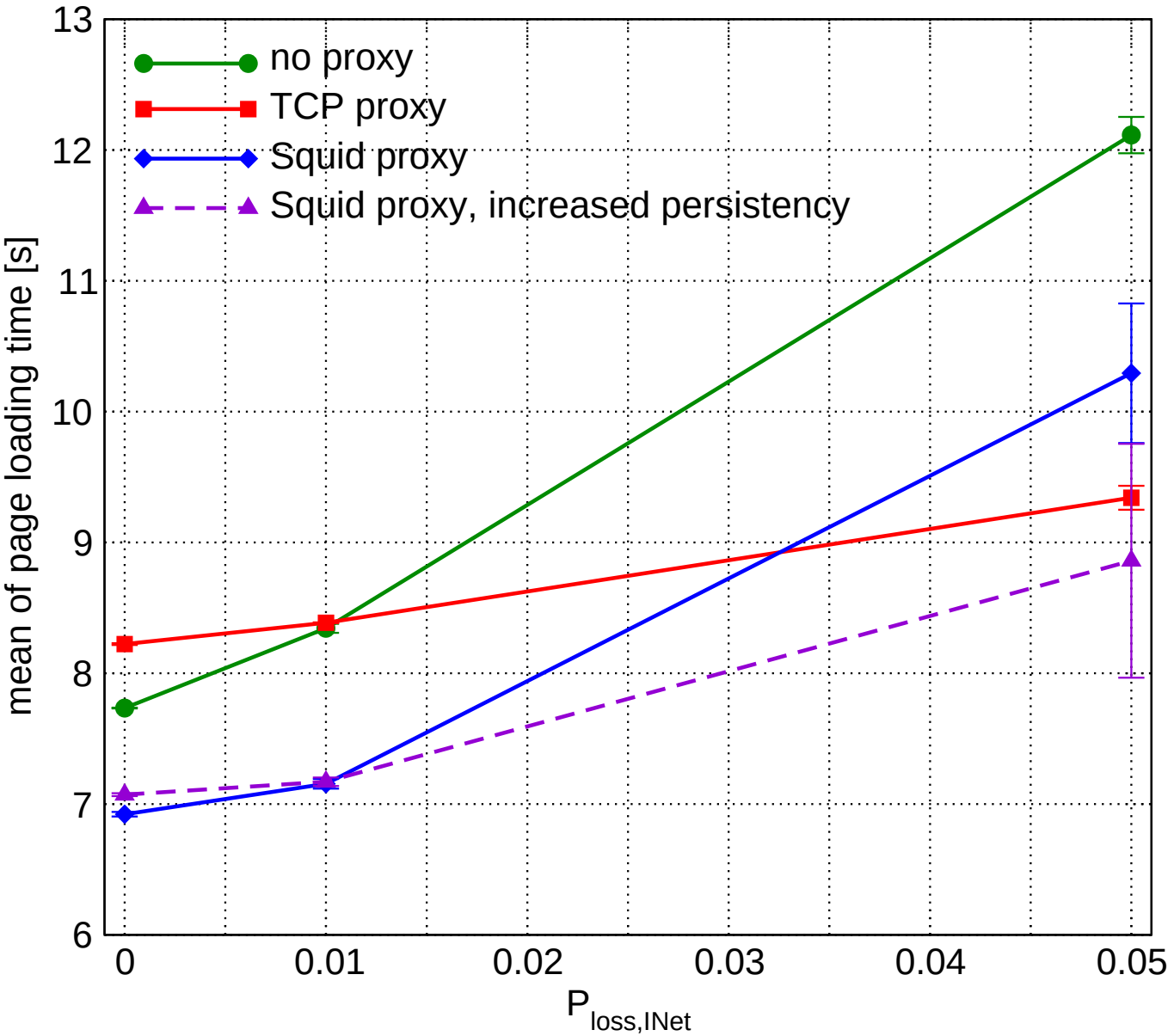

Conclusions and Outlook

Need for Methods and Tools

- **Simulation models (and tools) of wireless technologies and systems**
- **Testbeds for emulation studies**

Research Results

- **Modelling and understanding of non-functional properties of future mobile communication systems**

  ➥ fundamental basis for future system development
- **Understanding the interferences**
- **Ways of handling the interferences**

Outcome

- **Improvements for existing systems (probably patent relevant issues)**
- **Architectures for cross-layer optimization**

  ➥ new solutions for publication / project partners

  ➥ as contributions to standardization processes