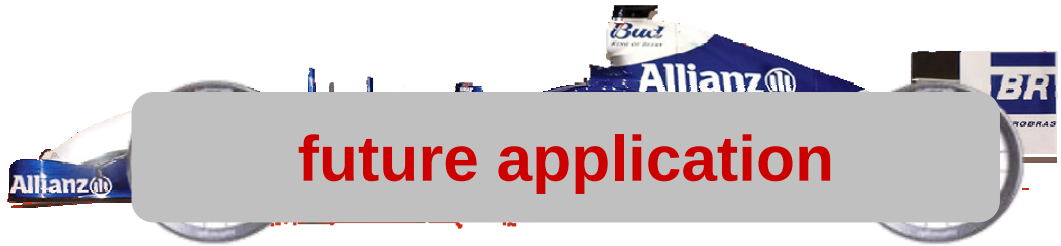
University of Würzburg
Institute of Computer Science
Prof. Dr. P. Tran-Gia

Service Design Evolution in Future Internet

Phuoc Tran-Gia

www3.informatik.uni-wuerzburg.de

Today's Scientific Work in Telecommunications



future application

Internet constraints

science or repair shop ?

Service Design Evolution in the Future Internet

1. **Trends of Future Services**
   - Intelligence Placement at Edge and User Initiated Service
   - Multi-Network Service and Multi-Platform Service
2. **Edge-Based Service Design & Deployment**
   - Overlay self-organizing control structure & dynamics
   - User Behavior: selfish and altruistic users
   - Functional Scalability & Stochastic Scalability
   - QoS Issues and Example: VoIP-Signaling Platform on Chord Ring
3. **Challenges**
   - From QoS to Quality-of-Experience
   - Trendscouting, Network Dimensioning, Adjustment and Management
   - Performance and Monitoring Issues

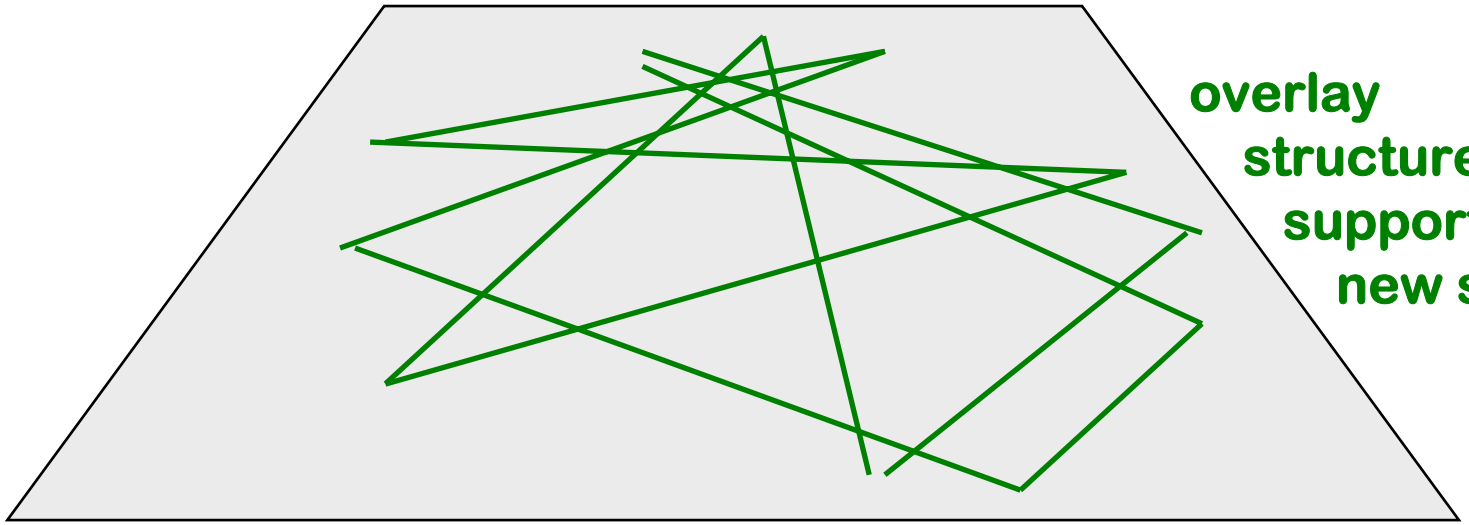
Trends observed and Questions

- Boundary between providers and users is disappearing
- Network dimensioning or reaction scheme design
- Stochastic scalability and network resilience
- Quality of service (QoS) or quality of experience (QoE)

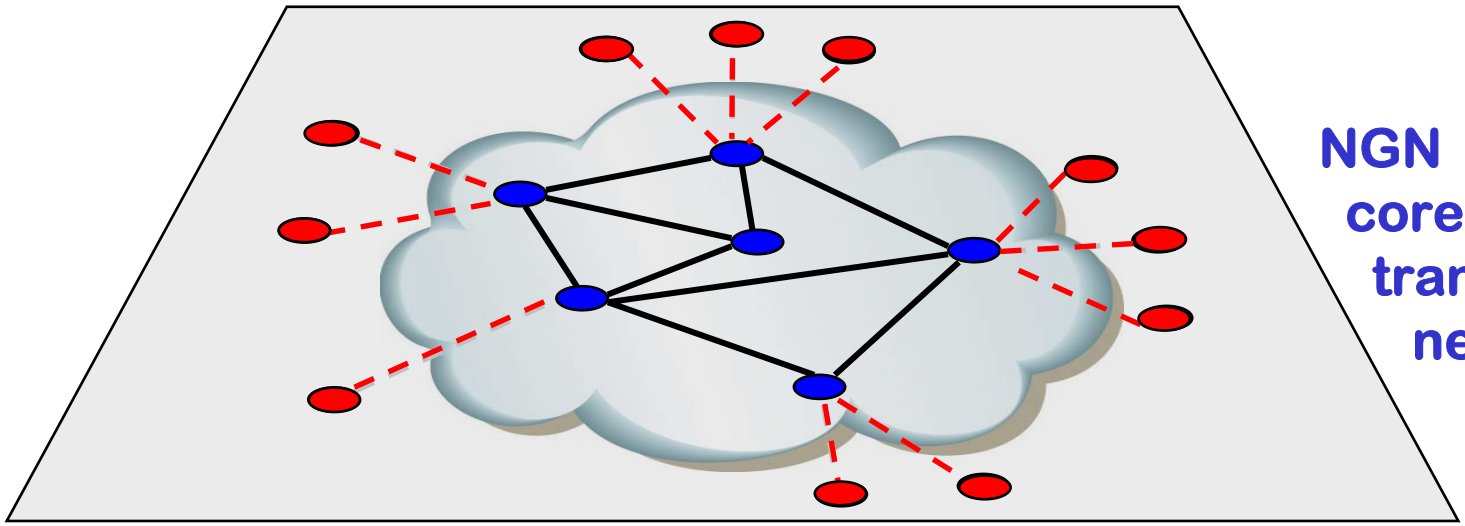
Trends in Services and Platforms

- Who designs services?
  - Service design by network provider
    - classic way to design service, provider and platform-dependent
  - Edge-based service design
    - designed and deployed by user groups
    - transition from disruptive technology to business cases
    - edge-based intelligence & application-driven overlay structure
    - example: P2P content delivery

Overlay Control Structure

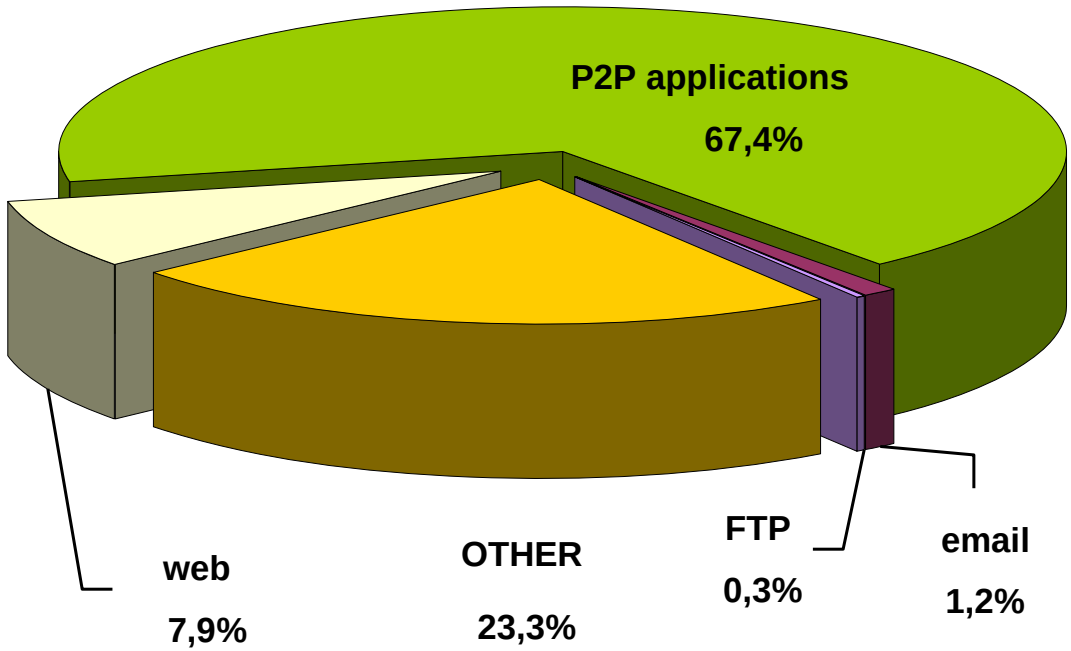


overlay
structure
supporting
new service



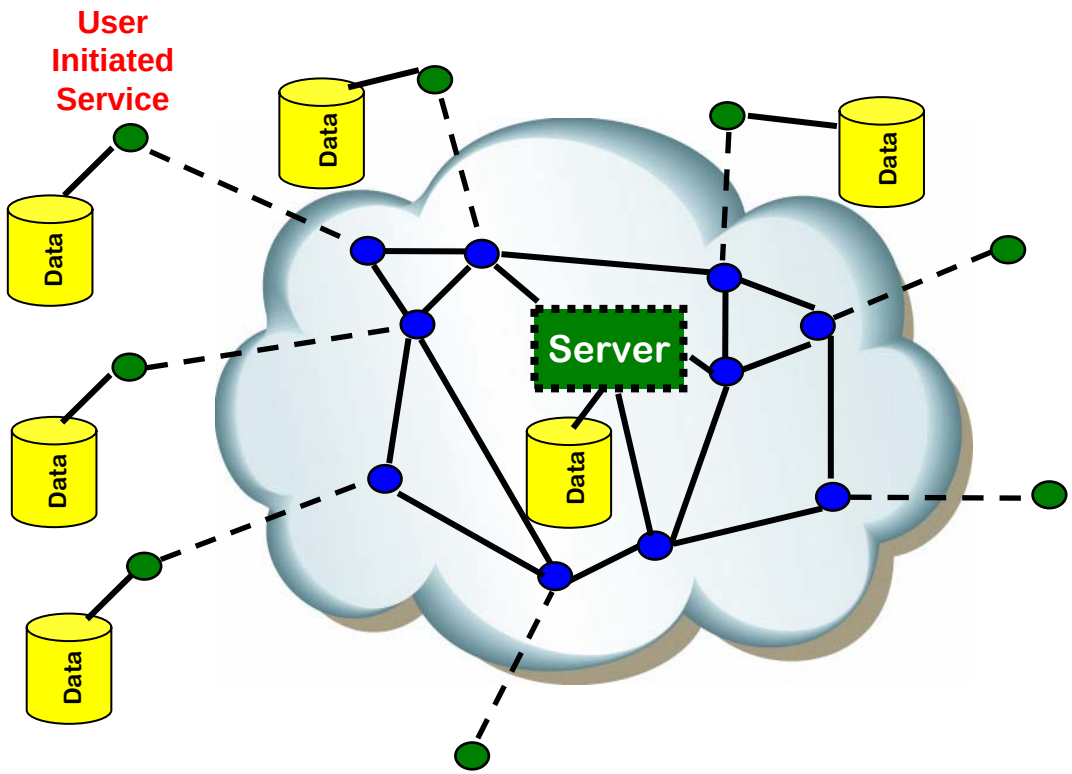
NGN
core
transport
network

Stepwise Traffic Change

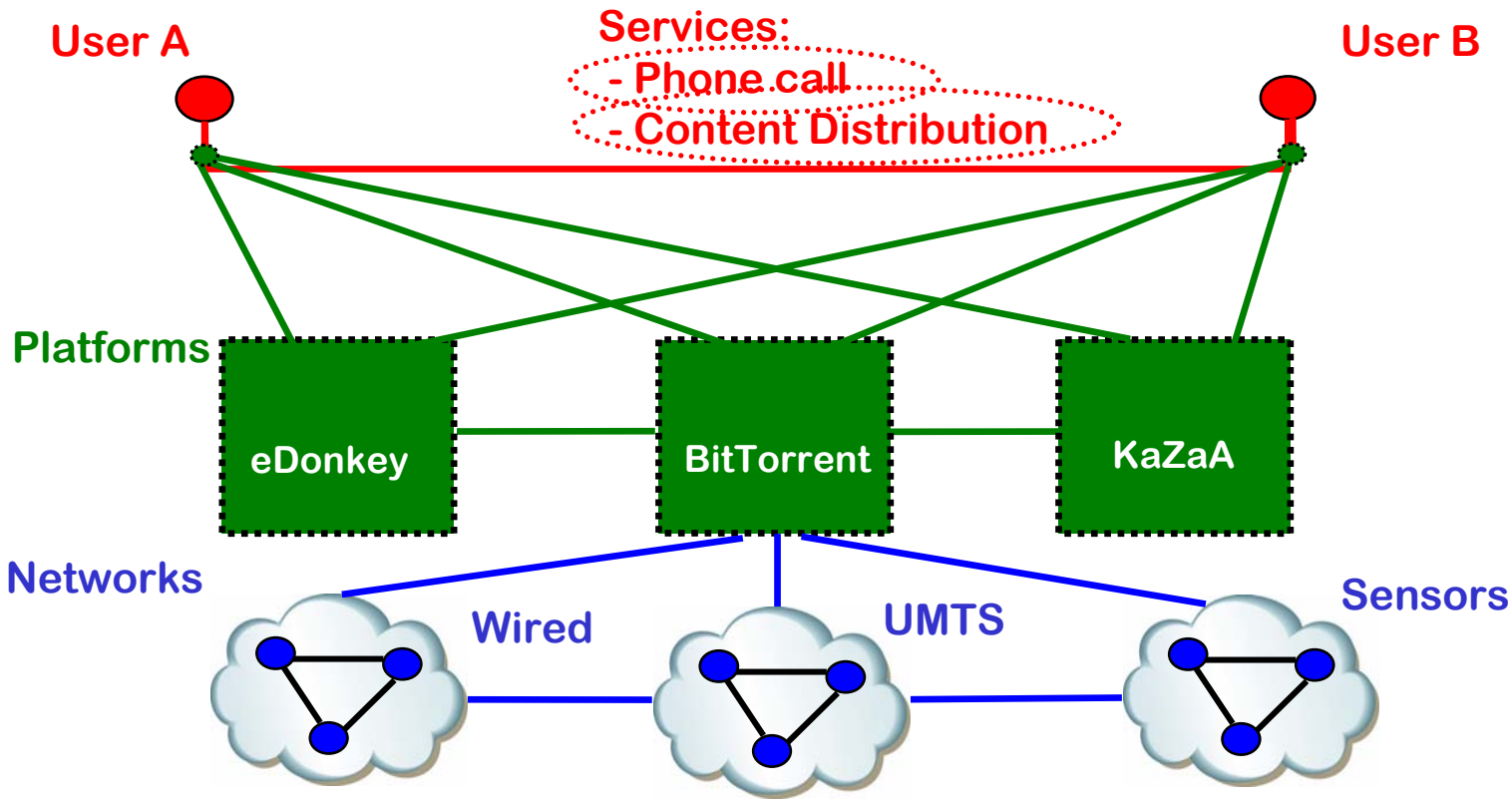


source:
Telefonica 2004
Jose Enriquez
COST 279, Rome: traffic observed in a transit router

Intelligence Placement & Service



Services, Platforms and Networks

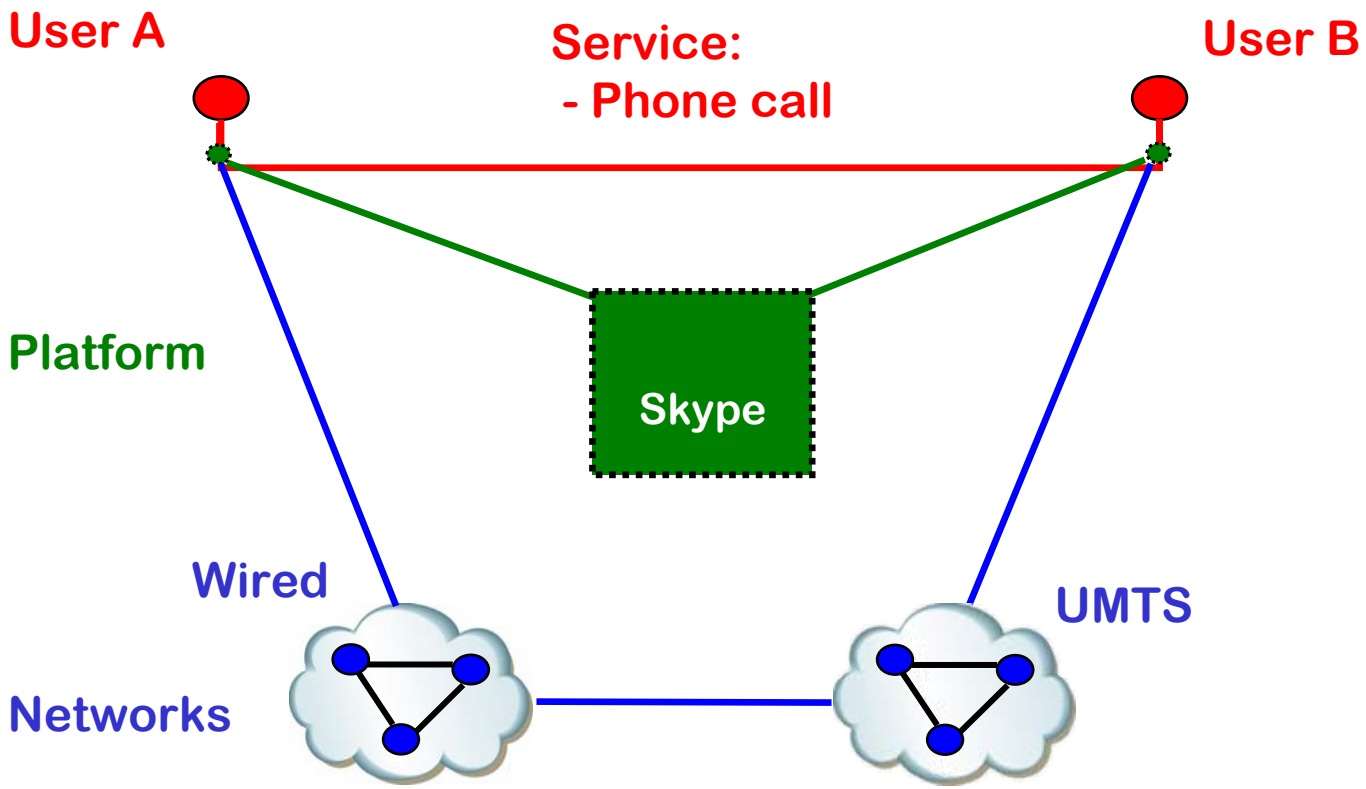


Trends in Services and Platforms

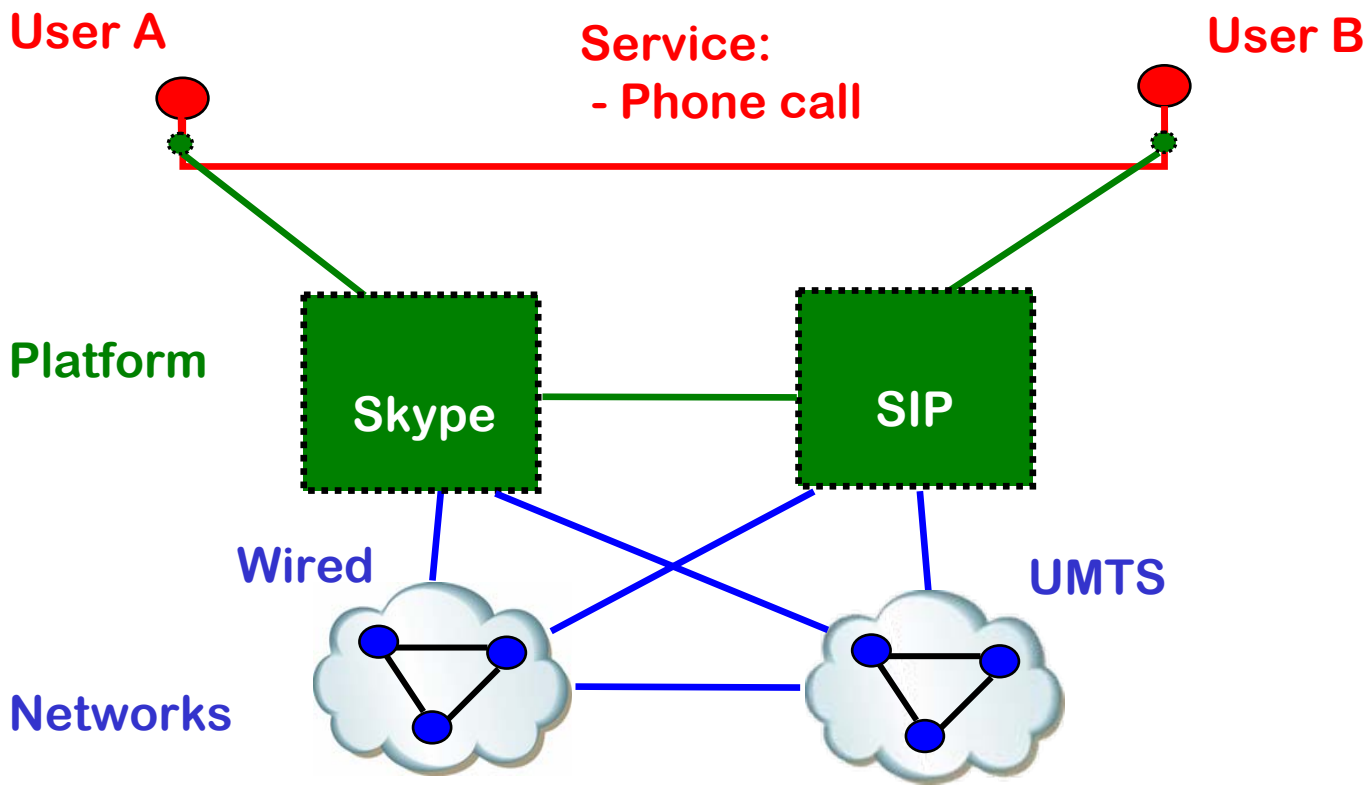
- Who designs services?
  - Service design by network provider
    - classic way to design service, provider and platform-dependent
  - Edge-based service design
    - designed and deployed by user groups
    - transition from disruptive technology to business cases
    - edge-based intelligence & application-driven overlay structure
    - example: P2P content delivery

- Transition to Multi-Network Services & Multi-Platform Services
  - highly dynamic network topology and traffic growth
  - customer behaviour changed, selfish users and applications
  - QoS issues unclear: customer perceived or network provider defined QoS

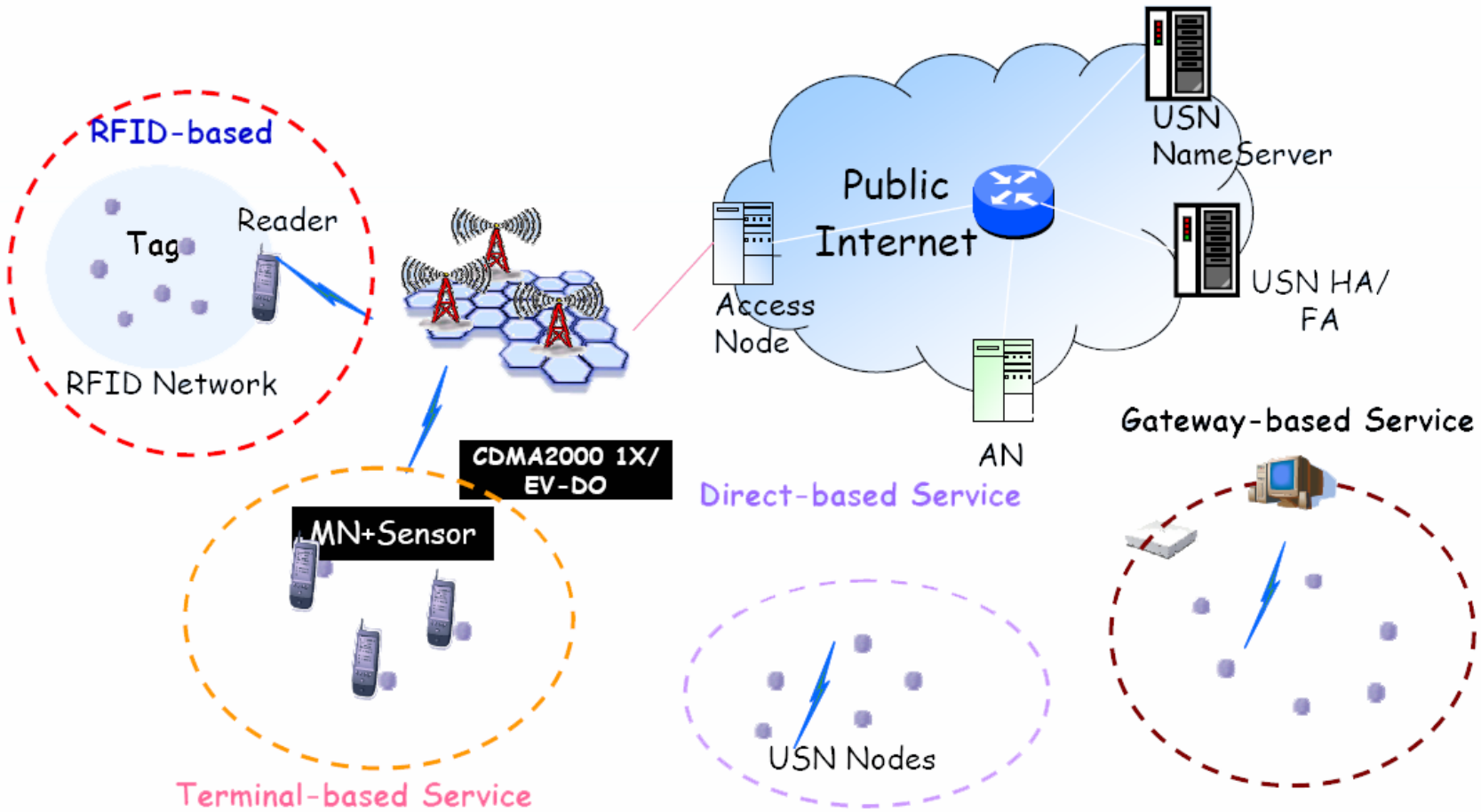
Multi-Network Service



Multi-Platform Service



Multi-Platform: Interconnection of USN and Internet

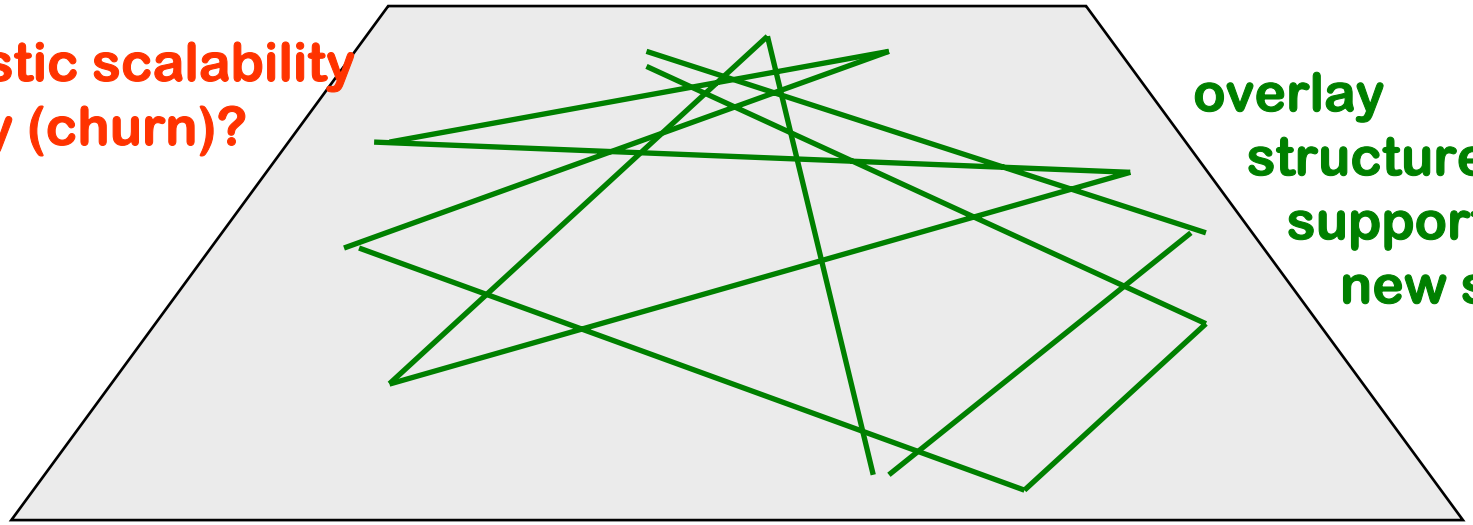


Service Design Evolution in the Future Internet

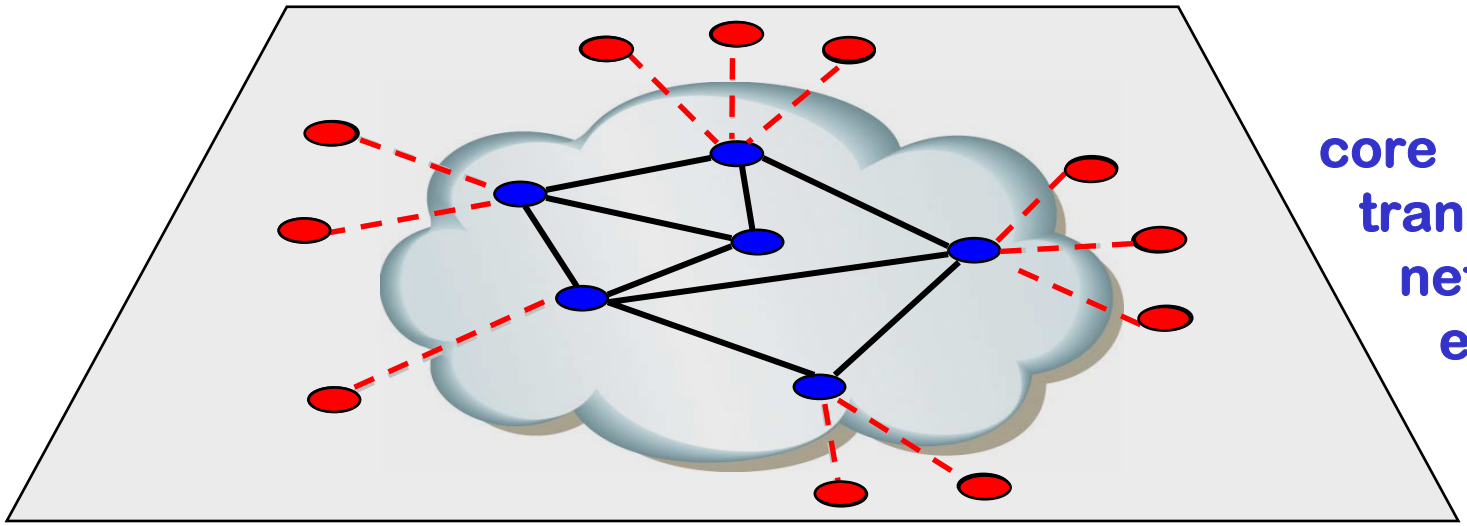
1. **Trends of Future Services**
   - Intelligence Placement at Edge and User Initiated Service
   - Multi-Network Service and Multi-Platform Service
2. **Edge-Based Service Design & Deployment**
   - Overlay self-organizing control structure & dynamics
   - User Behavior: selfish and altruistic users
   - Functional Scalability & Stochastic Scalability
   - QoS Issues and Example: VoIP-Signaling Platform on Chord Ring
3. **Challenges**
   - From QoS to Quality-of-Experience
   - Trendscouting, Network Dimensioning, Adjustment and Management
   - Performance and Monitoring Issues

Overlay Control Structure

stochastic scalability
stability (churn)?



overlay
structure
supporting
new service

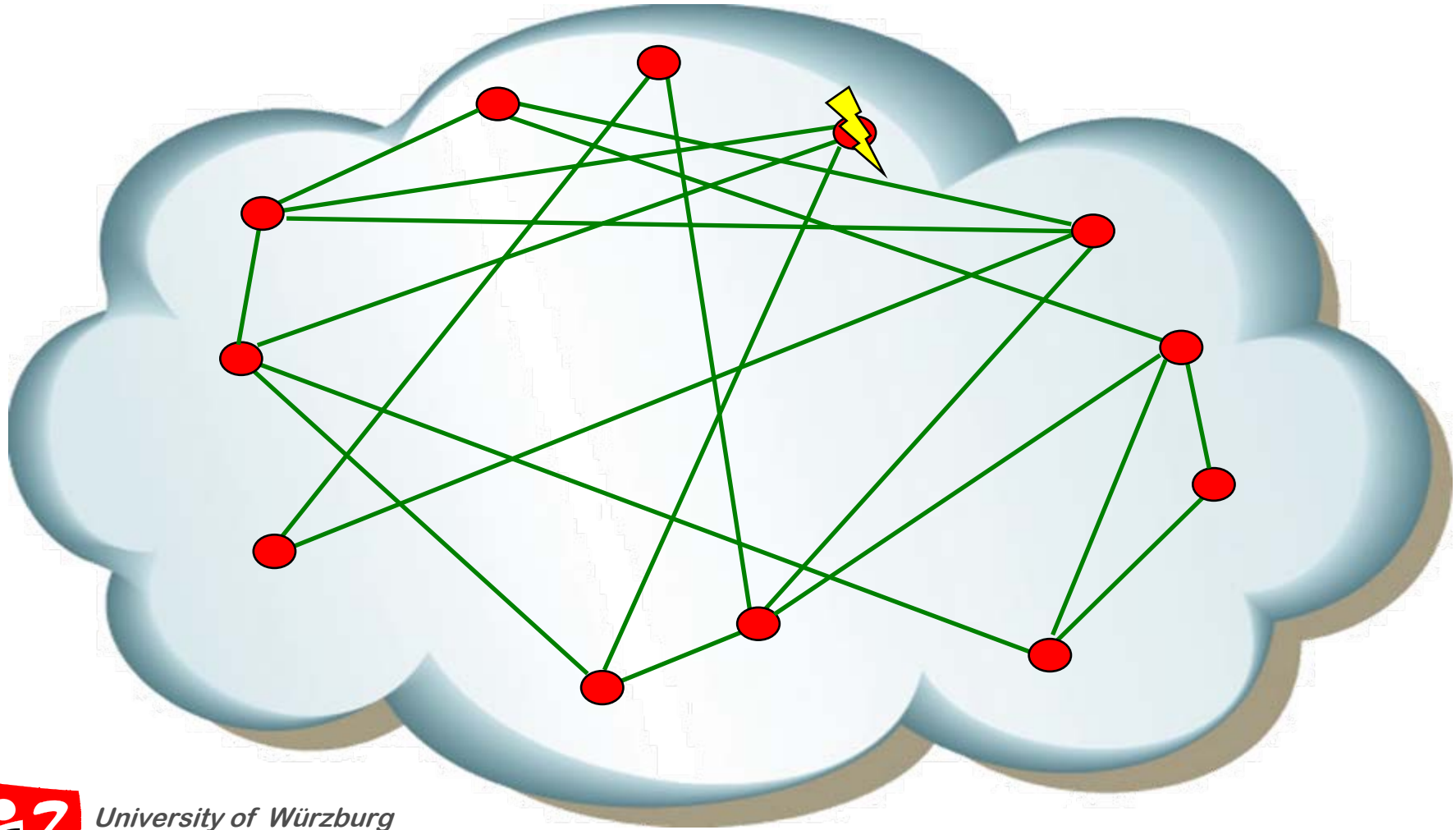


core
transport
network
e.g. IP

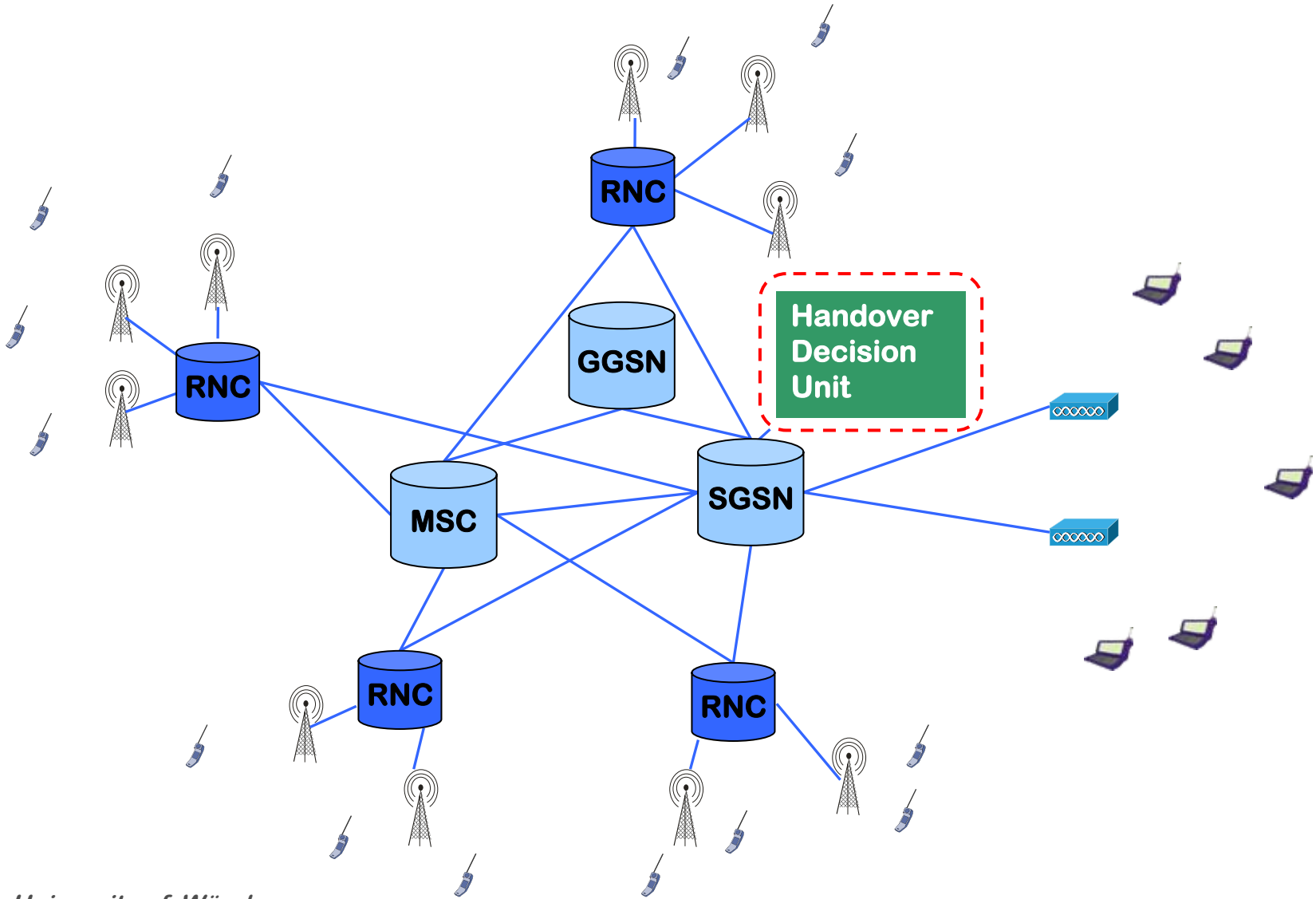
Self-Organizing of Service Support

Node failure/leave
⇨ self-repair structure

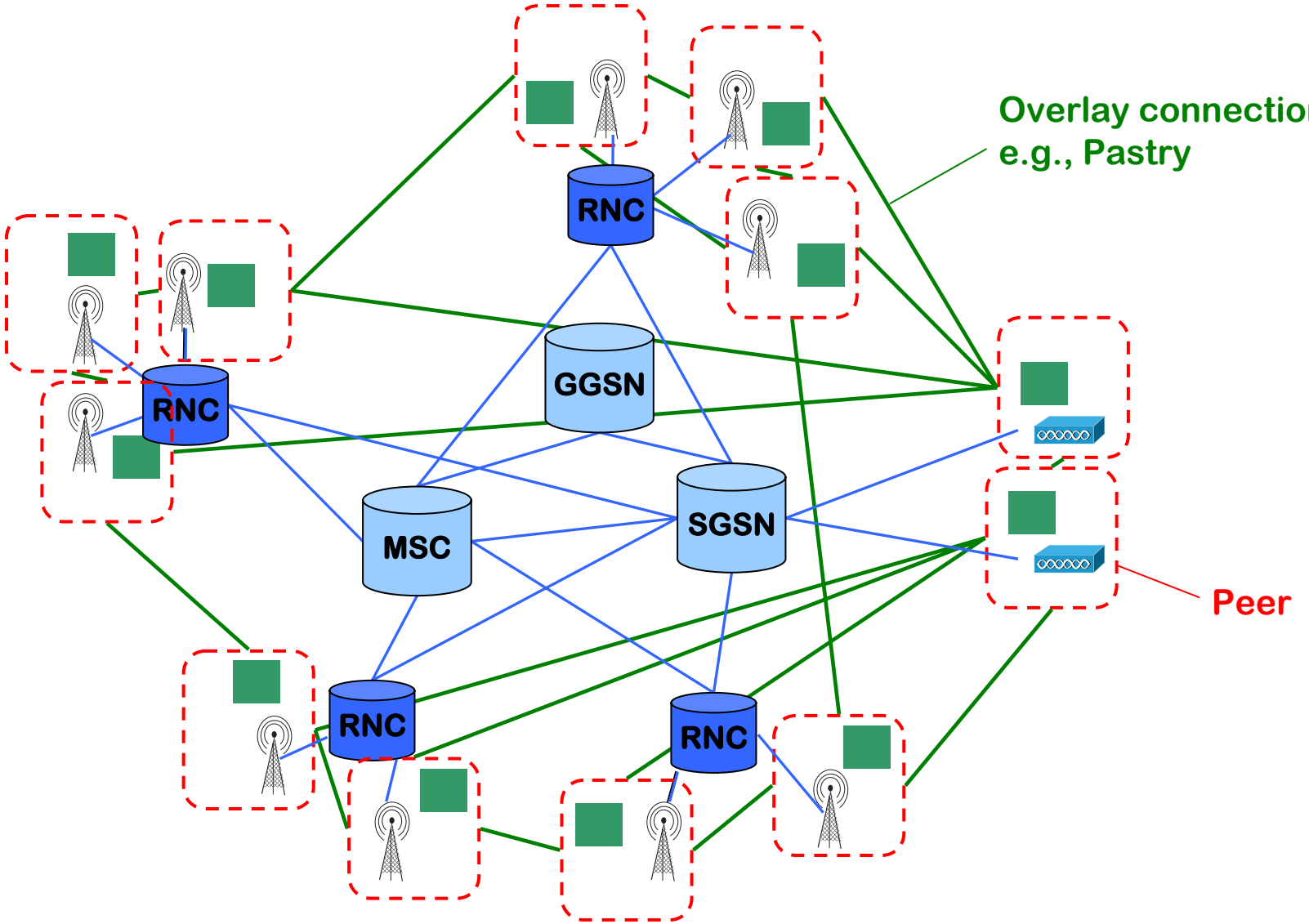
Node joins
⇨ self-adapt structure



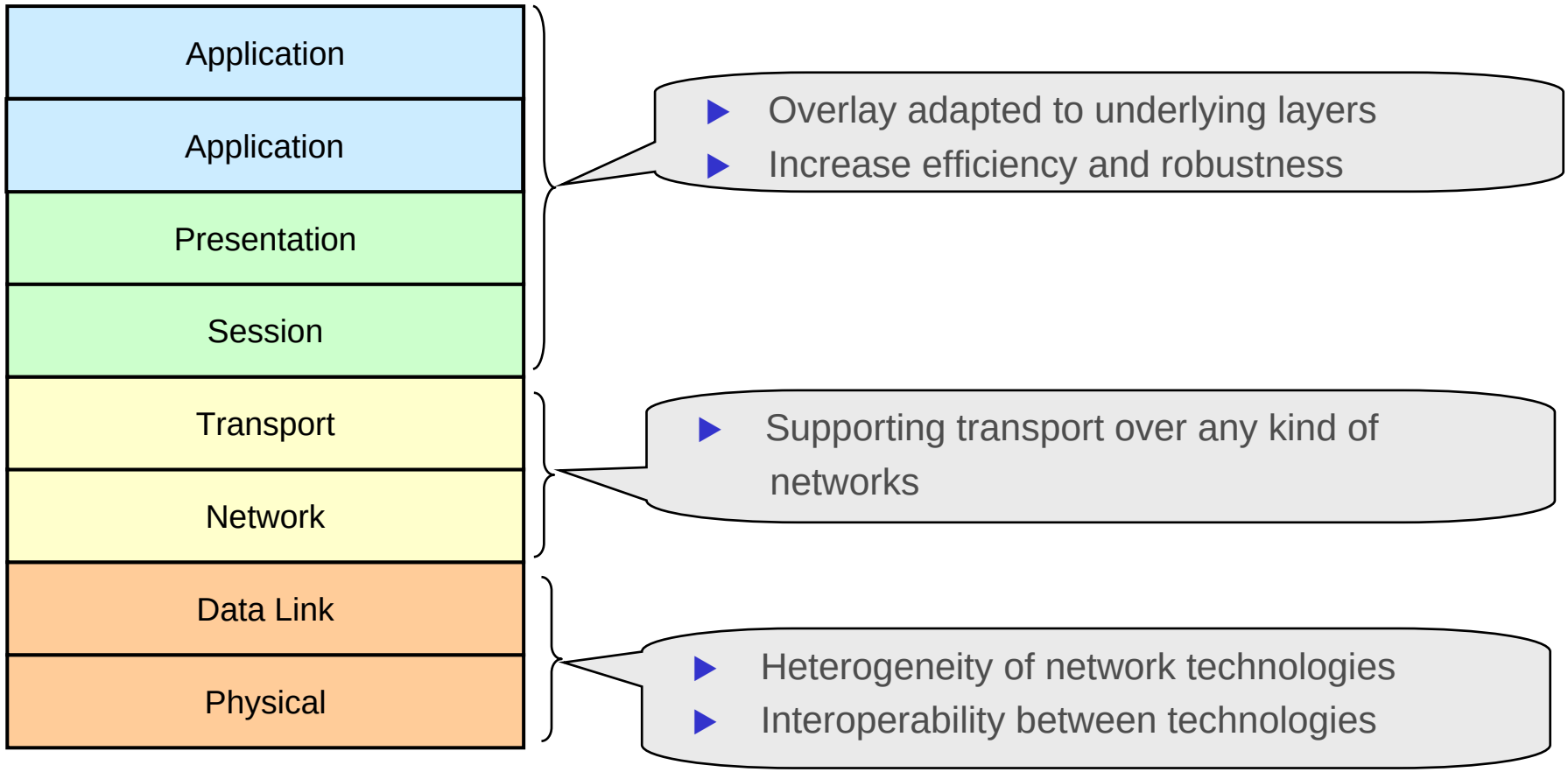
Example: Multi-Network (Vertical) Handover



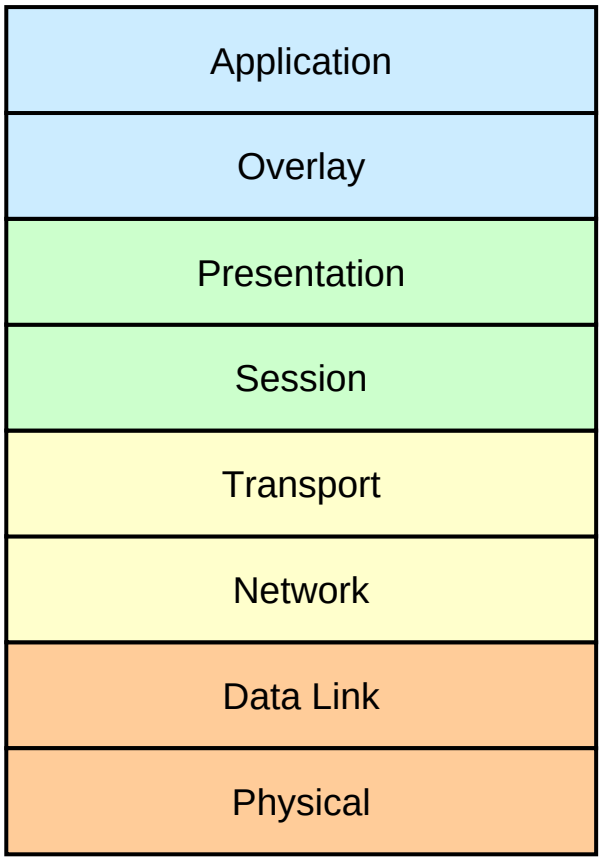
Example: Multi-Network (Vertical) Handover

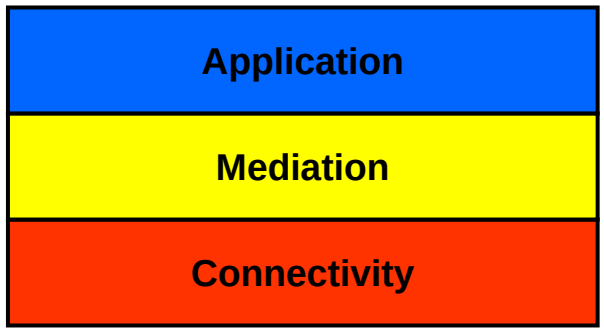


Thinning the protocol architecture



Thinning the protocol architecture





Thinning the protocol architecture

Application

- user-centric, context aware, QoS, Quality of Experience
- allows multi-network-services with edge intelligence
- application-layer routing / content-based routing

Mediation

- self-organized routing and distributed resource access
- autonomic network management
- allows dependable direct communication

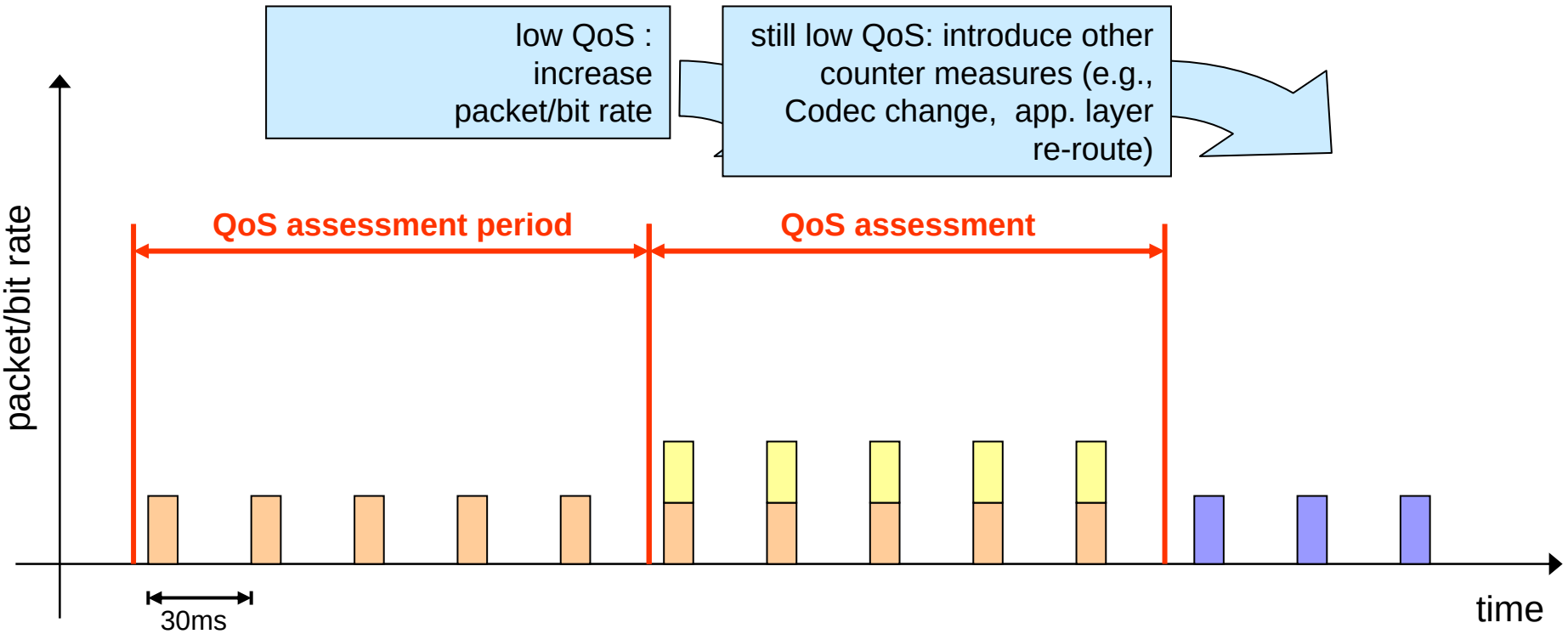
Connectivity

- optimized for individual access network
- allows mobility of users and handover between technologies

Service Design Evolution in the Future Internet

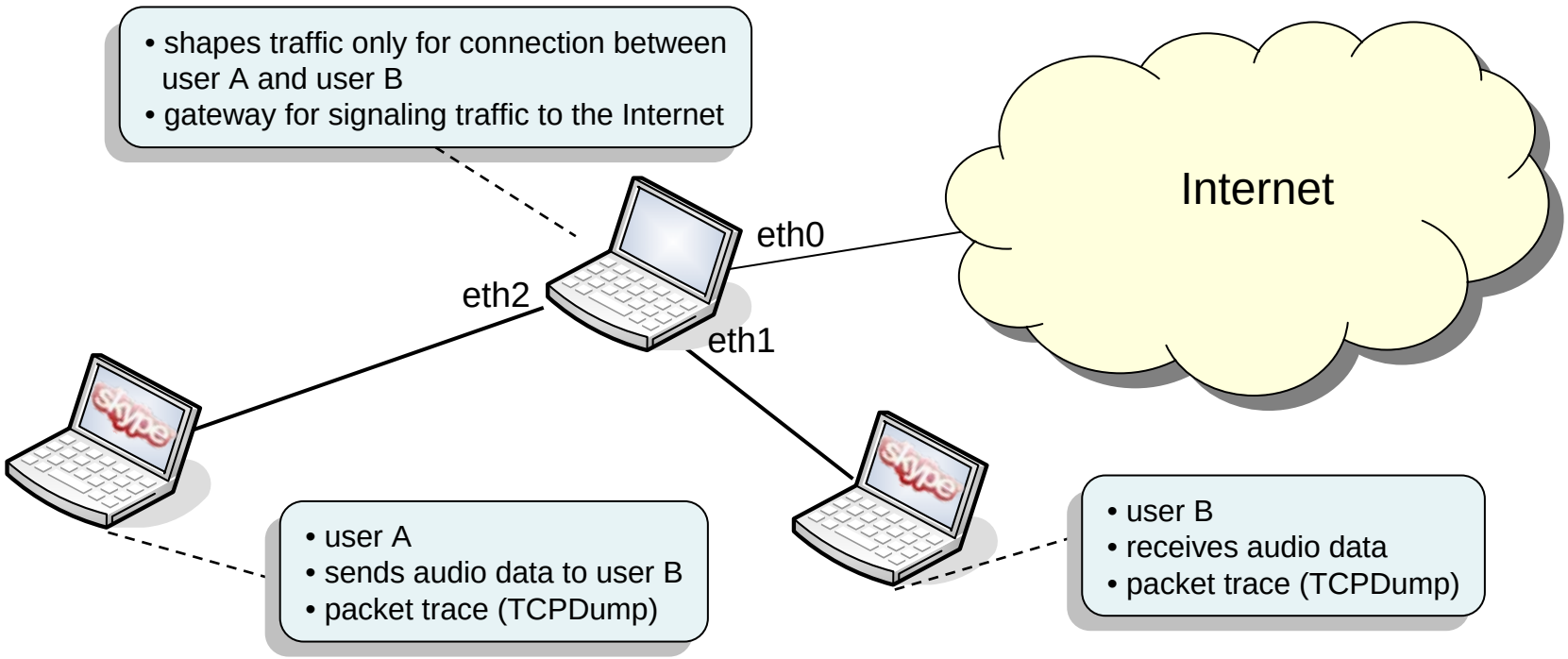
1. **Trends of Future Services**
   - Intelligence Placement at Edge and User Initiated Service
   - Multi-Network Service and Multi-Platform Service
2. **Edge-Based Service Design & Deployment**
   - Overlay self-organizing control structure & dynamics
   - User Behavior: selfish and altruistic users
   - Functional Scalability & Stochastic Scalability
   - QoS Issues and Example: VoIP-Signaling Platform on Chord Ring
3. **Challenges**
   - From QoS to Quality-of-Experience
   - Trendscouting, Network Dimensioning, Adjustment and Management
   - Performance and Monitoring Issues

Selfish application: positive feedback bitrate



Selfish application: some measurements

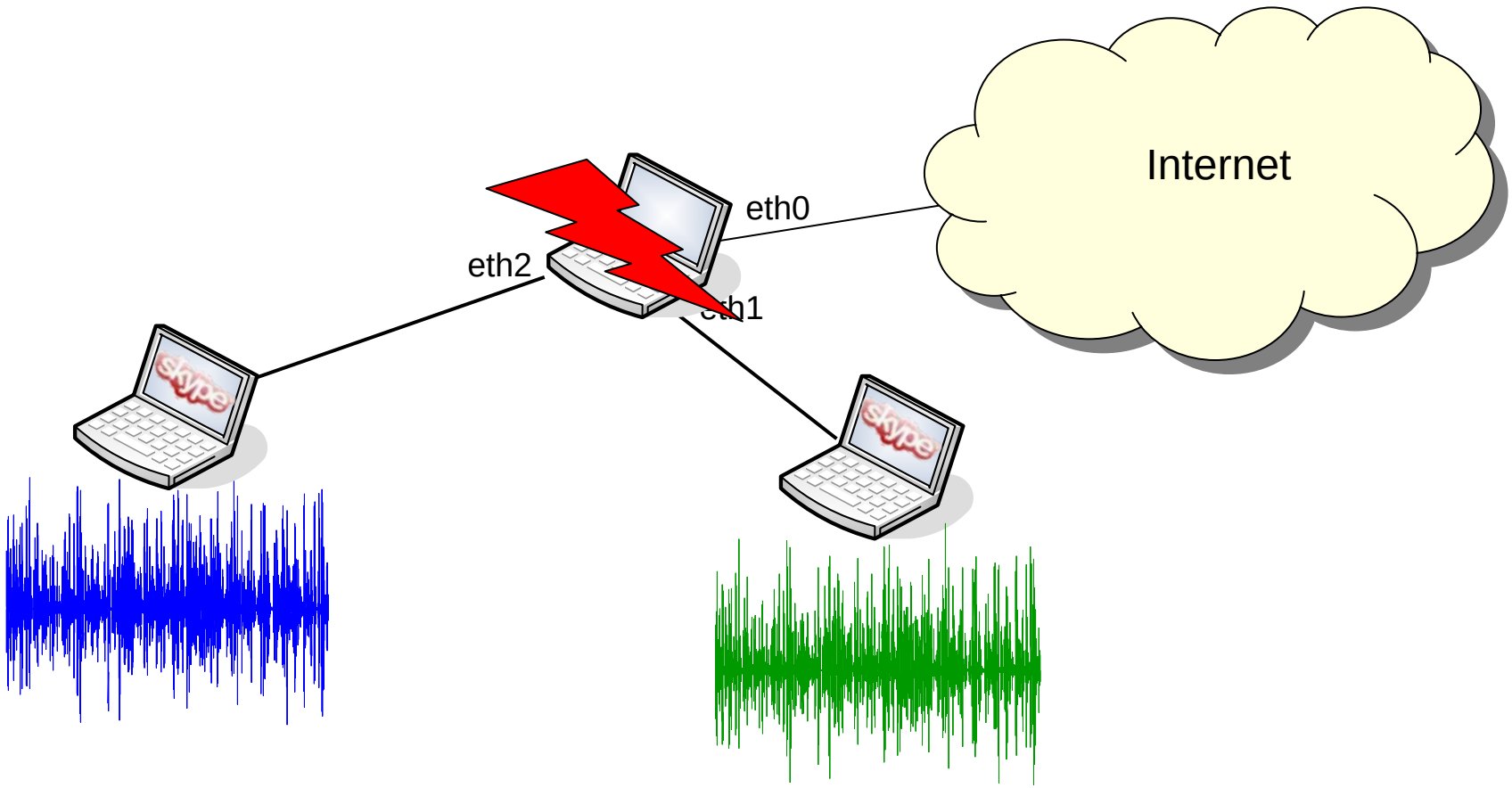
- Use NistNet to emulate network dynamics
- Test case: Skype VoIP application



- Audio file (51s) is repeated with a pause of 5s in between
- End-to-end QoS measured in terms of PESQ value (computed for intervals of 56s)
- Network characteristics (e.g. packet loss) evaluated using moving average (of 5min)

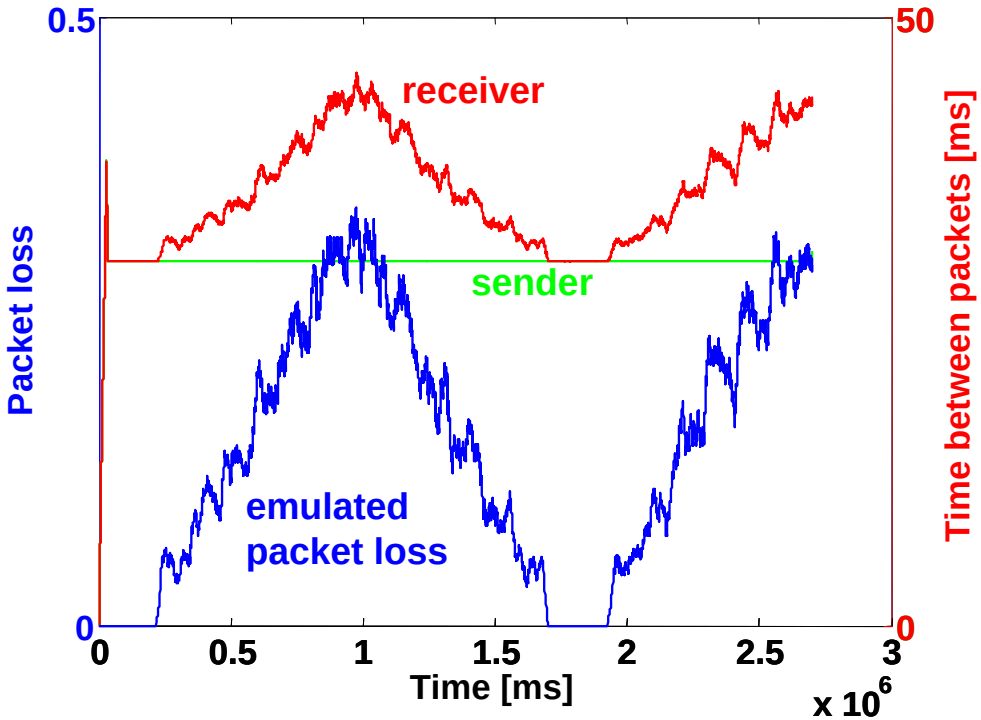
Emulating Dynamic Changes

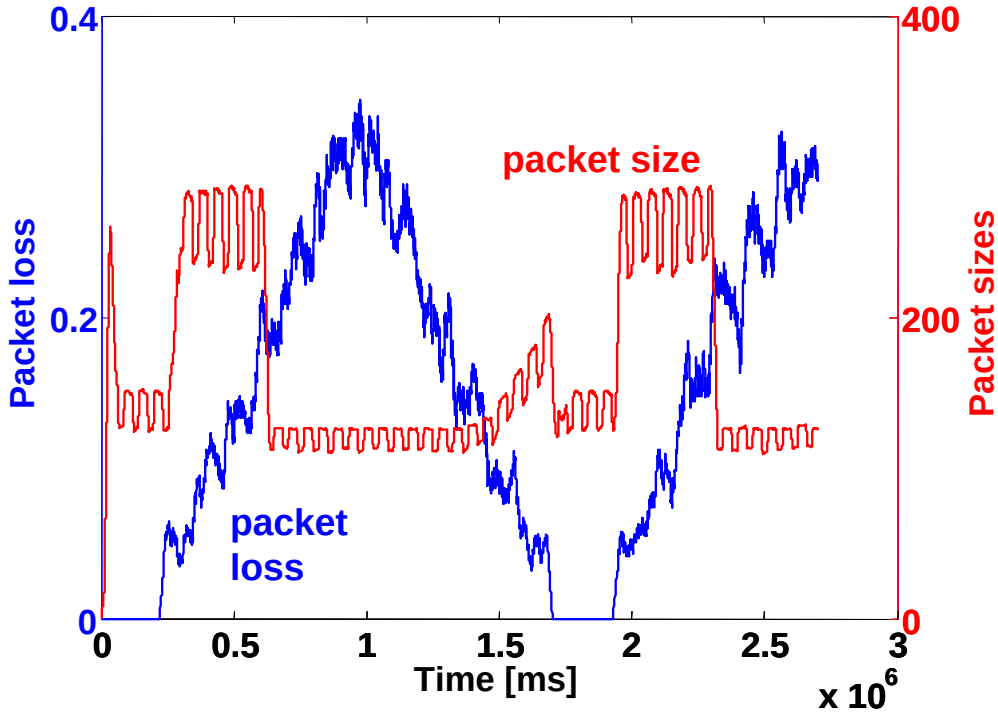
packet loss



Bandwidth Adaptation Based on QoS

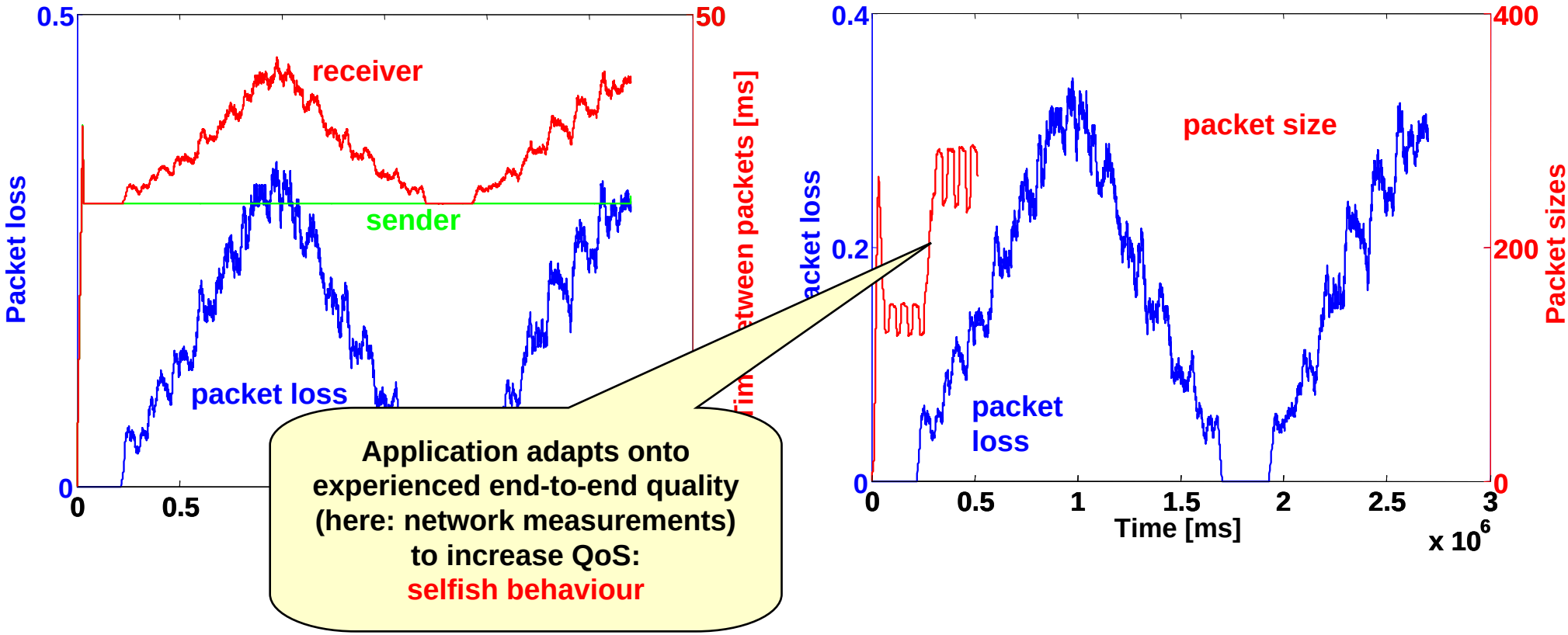
- Packet sent times depend on codec, independent on packet loss
- Variable bit rate by increasing packet size, i.e. more audio data





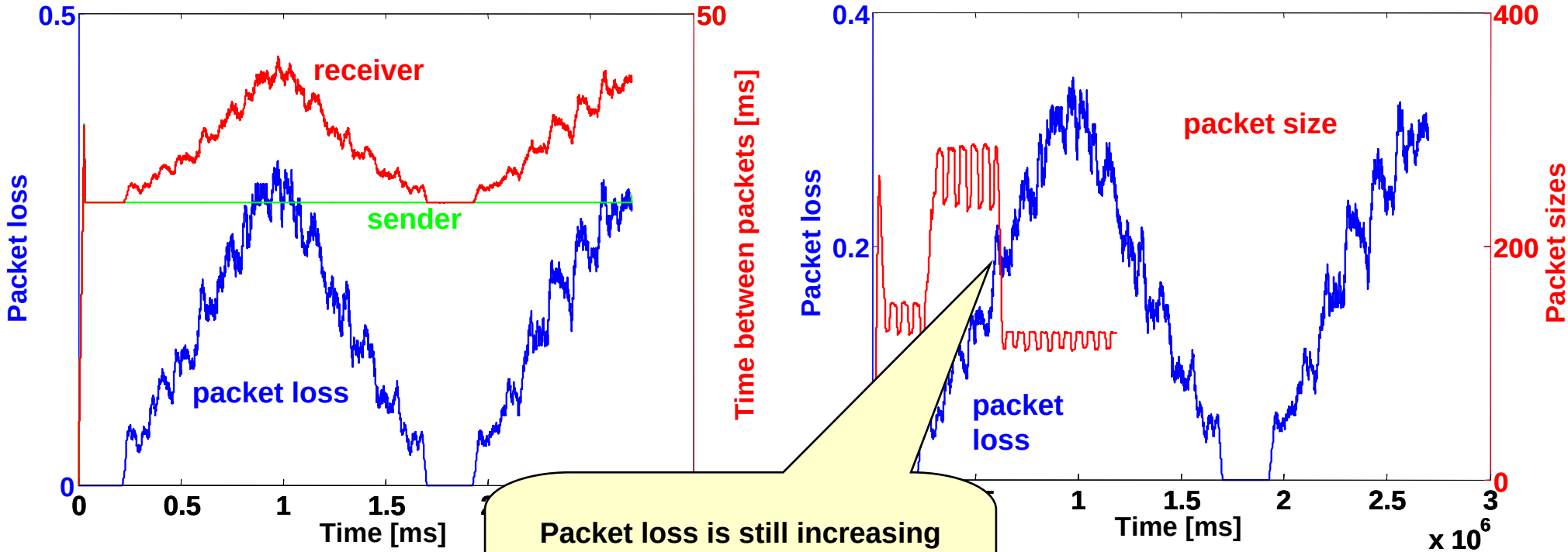
Bandwidth Adaptation Based on QoS

- Packet sent times depend on codec, independent on packet loss
- Variable bit rate by increasing packet size, i.e. more audio data



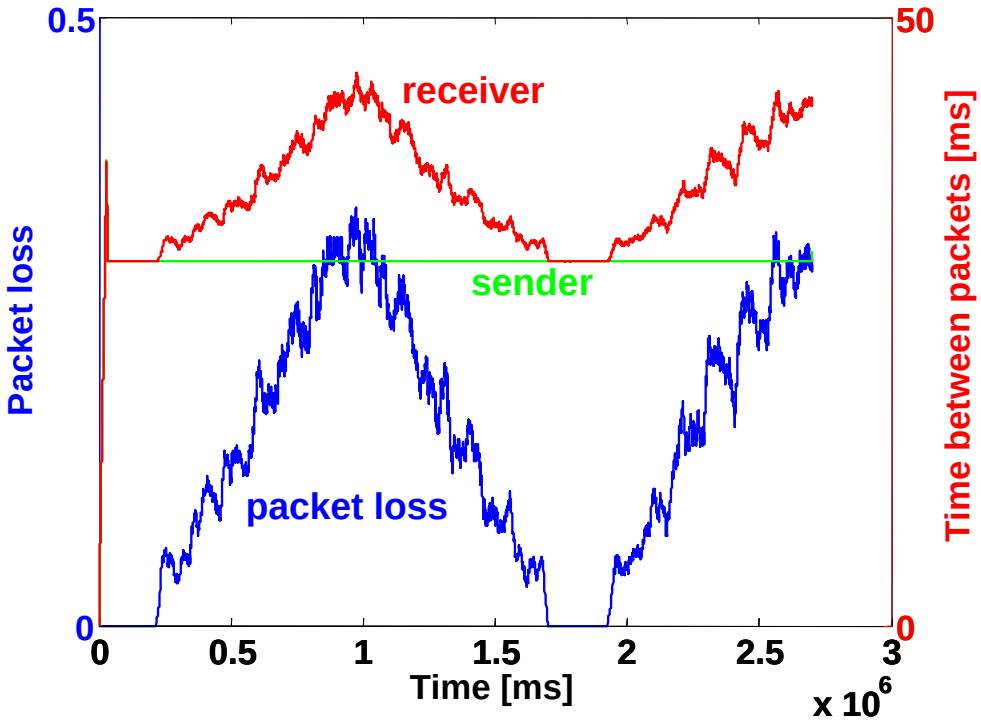
Bandwidth Adaptation Based on QoS

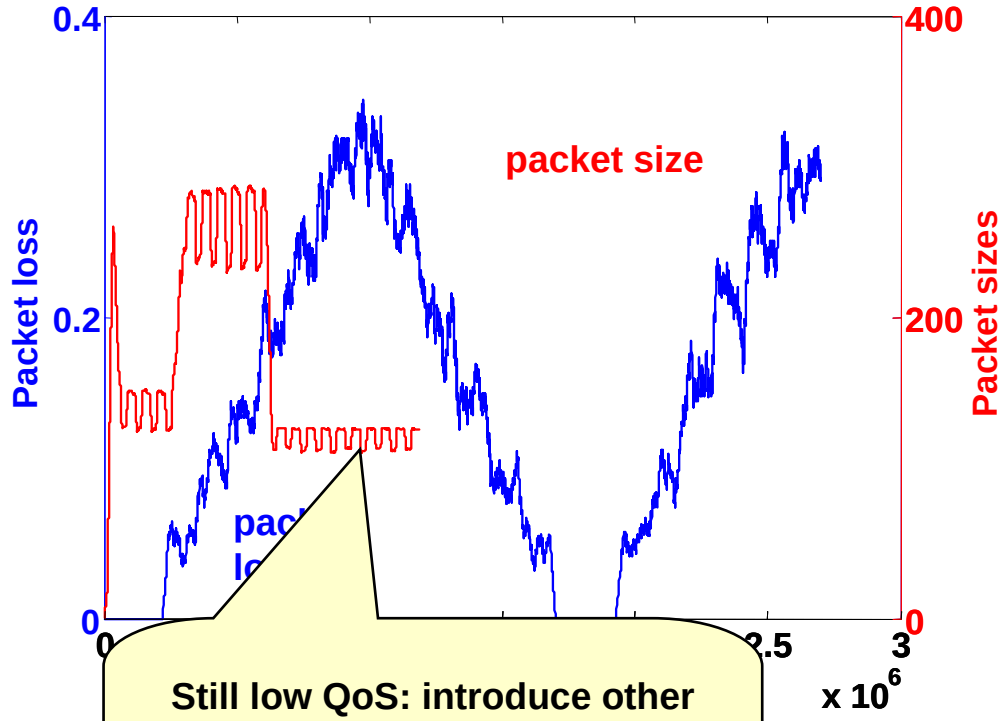
- Packet sent times depend on codec, independent on packet loss
- Variable bit rate by increasing packet size, i.e. more audio data



Bandwidth Adaptation Based on QoS

- Packet sent times depend on codec, independent on packet loss
- Variable bit rate by increasing packet size, i.e. more audio data

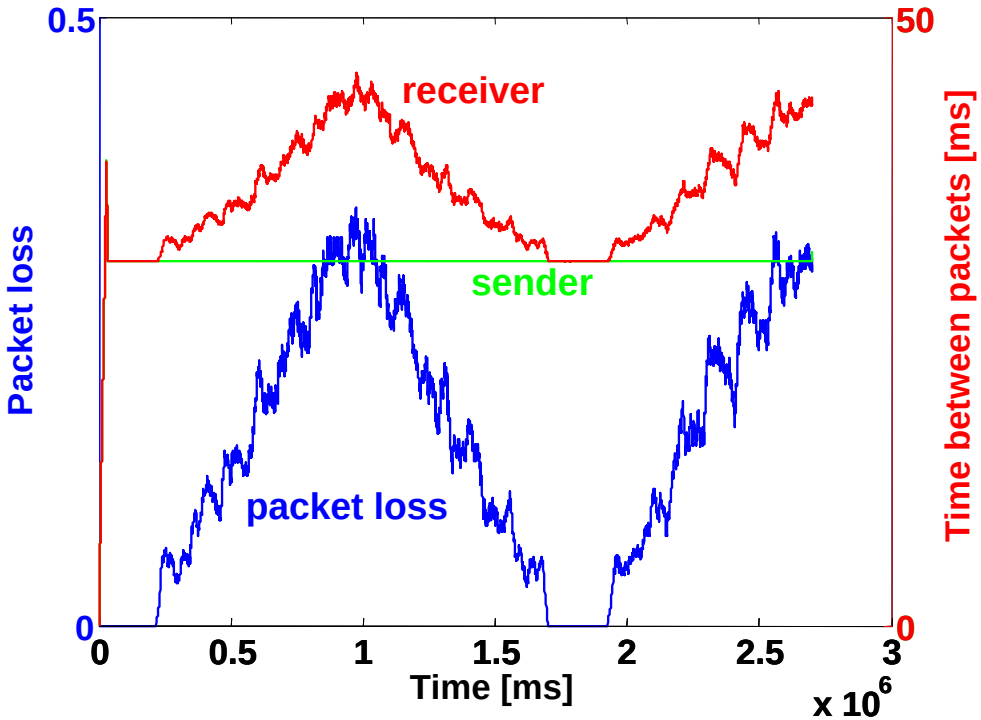


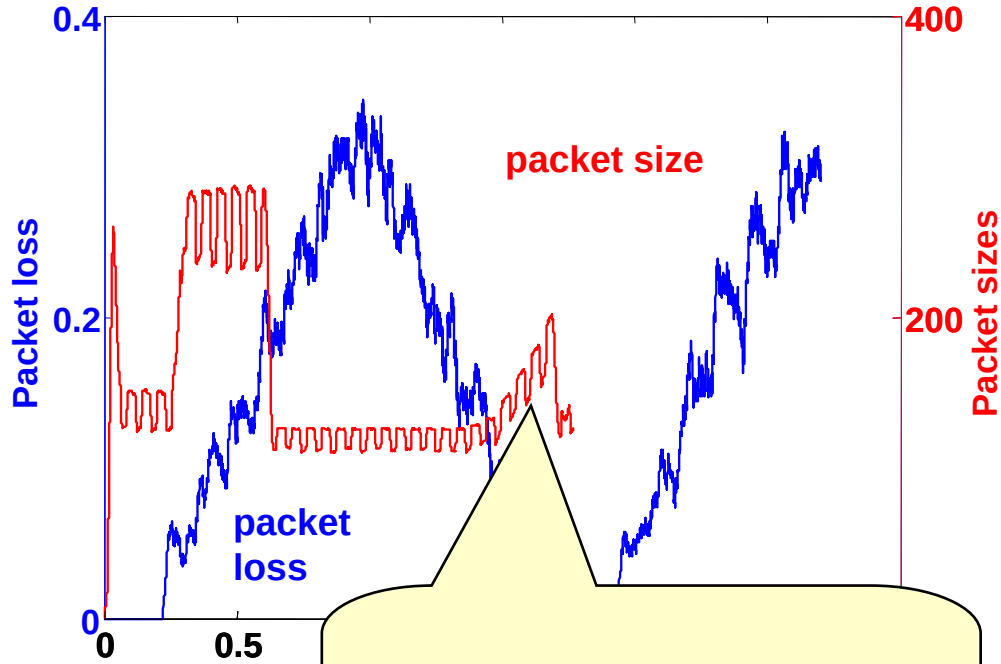


Still low QoS: introduce other counter measures, here another voice codec is used (with smaller packets)

Bandwidth Adaptation Based on QoS

- Packet sent times depend on codec, independent on packet loss
- Variable bit rate by increasing packet size, i.e. more audio data

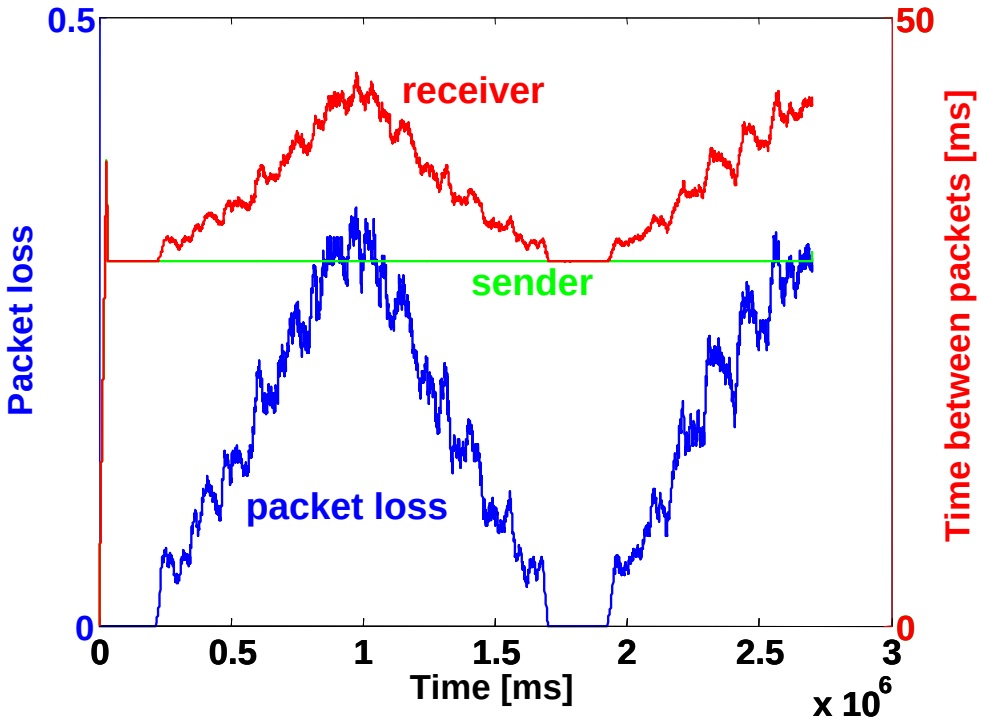


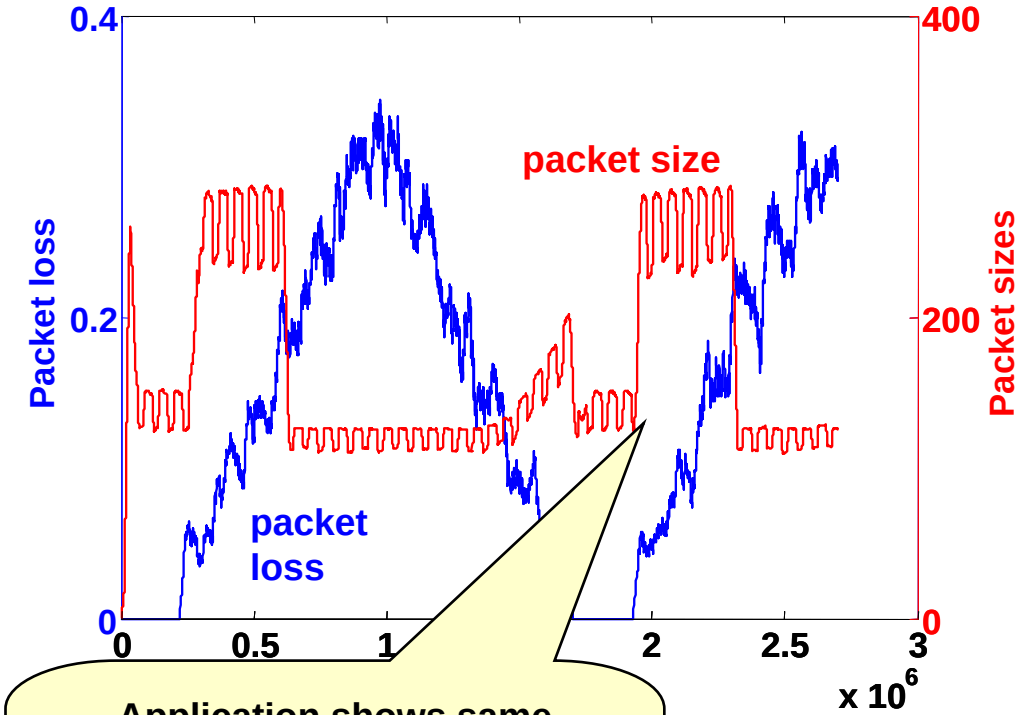


Application measures end-to-end QoS and reacts on it, i.e. edge-based intelligence

Bandwidth Adaptation Based on QoS

- Packet sent times depend on codec, independent on packet loss
- Variable bit rate by increasing packet size, i.e. more audio data

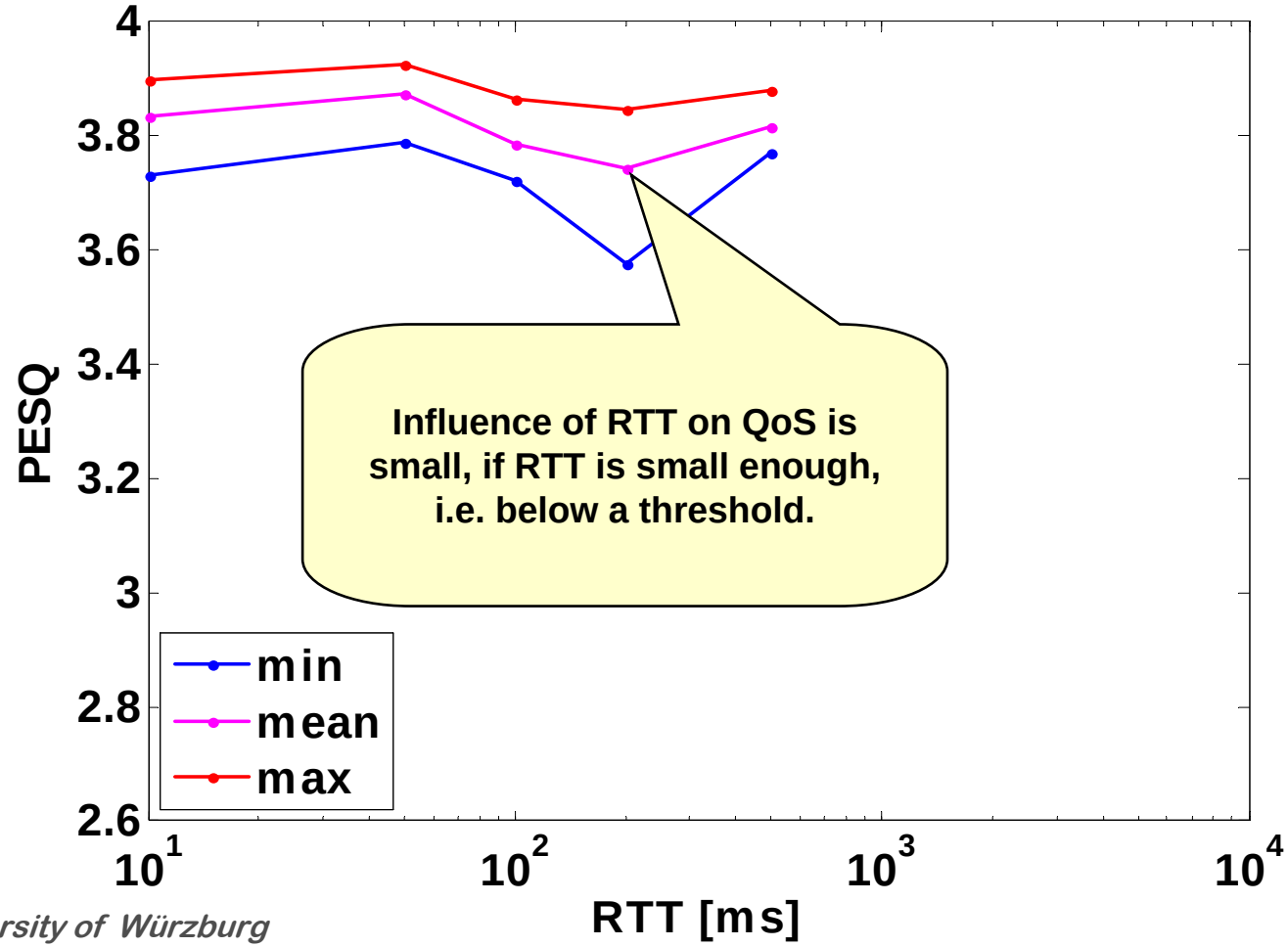




Application shows same behavior when restarting the experiment, i.e. intelligence managed by measurements and thresholds/states

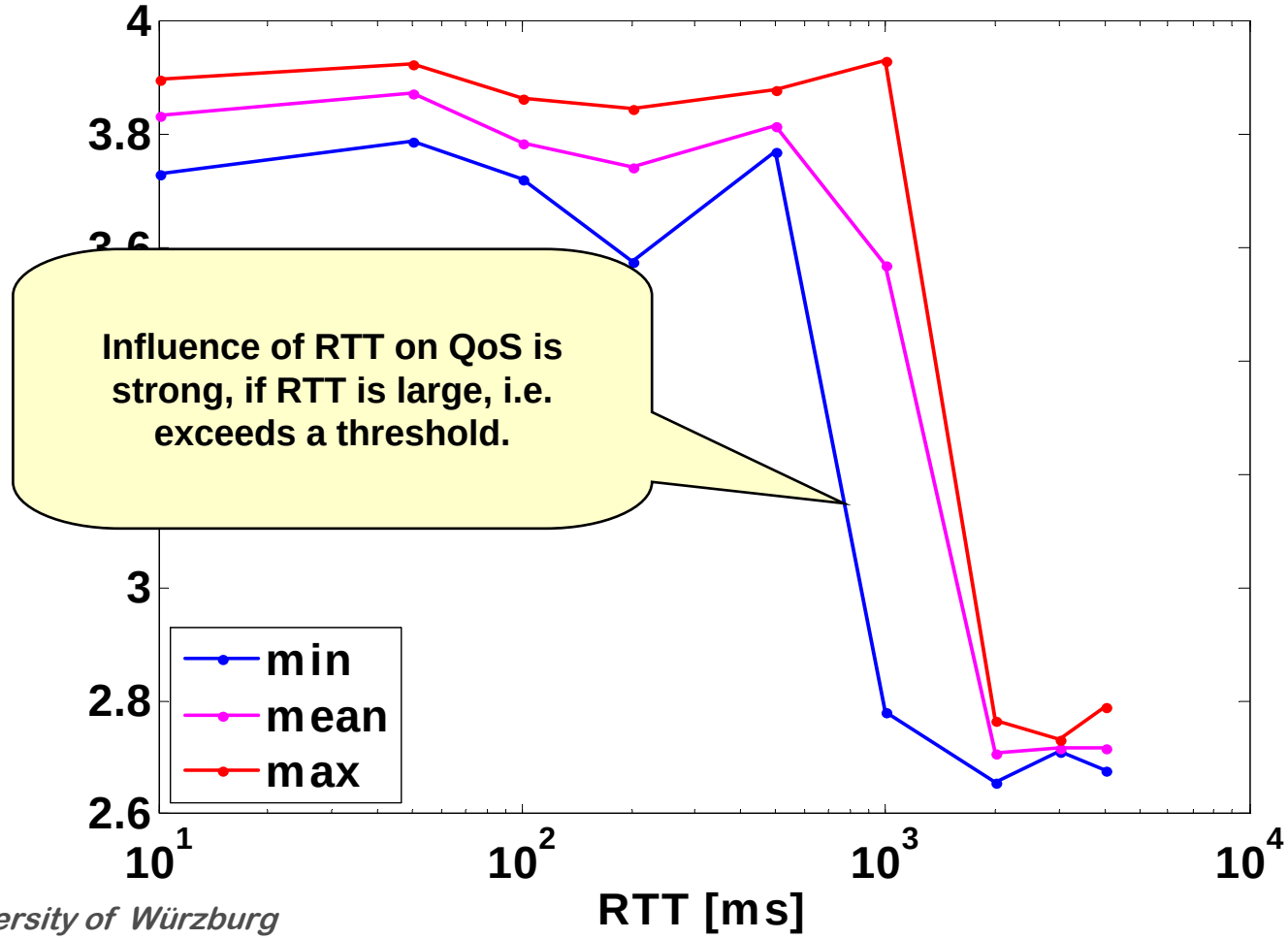
Application-Driven Routing Based on QoS

- RTT>500ms results in strong PESQ degradation
- If RTT>4s Skype relays connection over third party machine



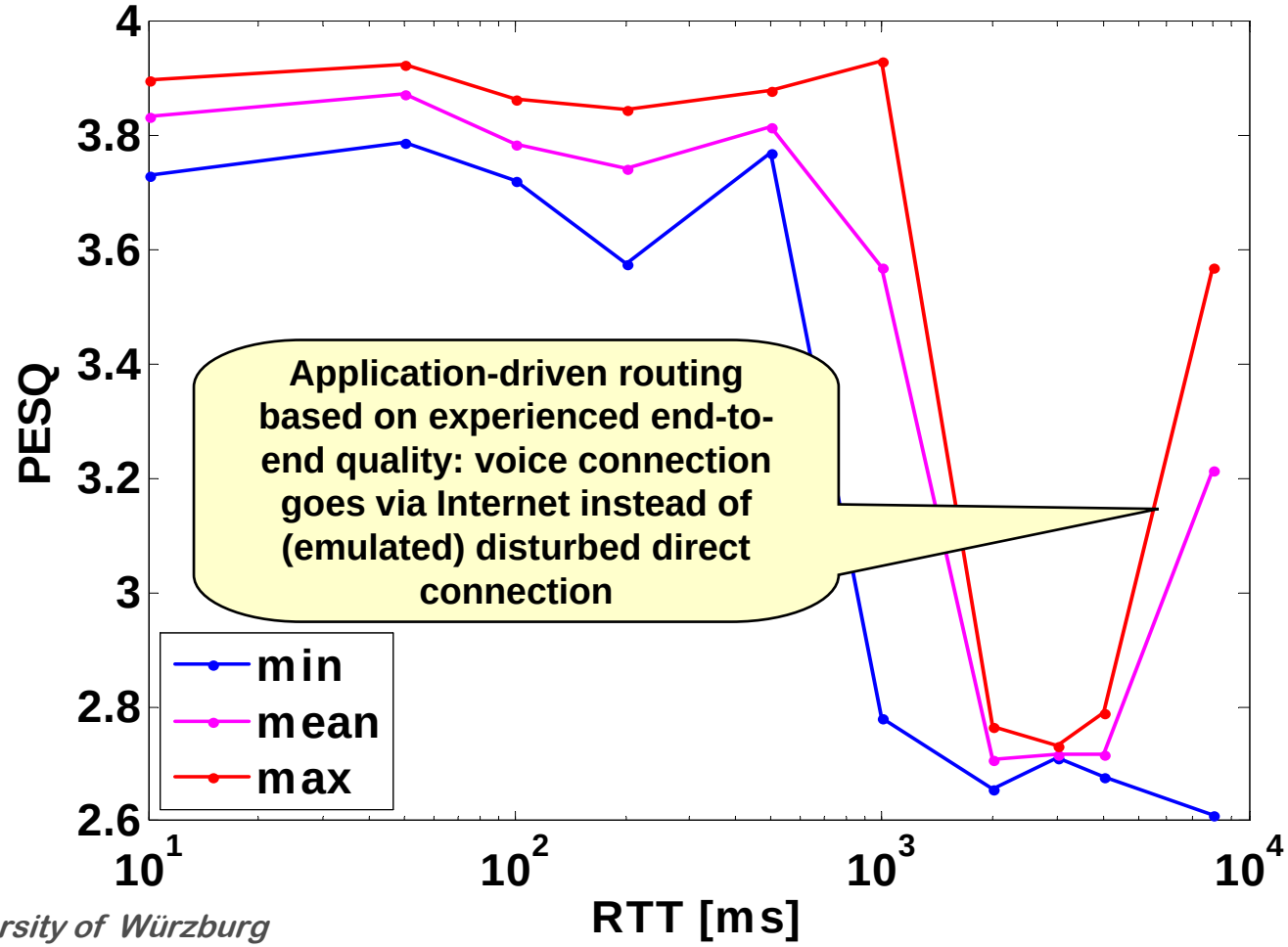
Application-Driven Routing Based on QoS

- RTT>500ms results in strong PESQ degradation
- If RTT>4s Skype relays connection over third party machine



Application-Driven Routing Based on QoS

- RTT>500ms results in strong PESQ degradation
- If RTT>4s Skype relays connection over third party machine

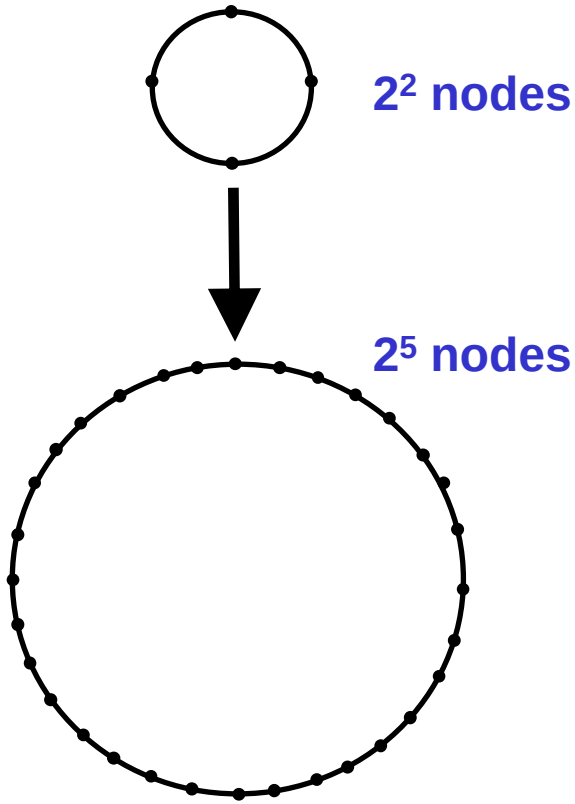


Service Design Evolution in the Future Internet

1. **Trends of Future Services**
   - Intelligence Placement at Edge and User Initiated Service
   - Multi-Network Service and Multi-Platform Service
2. **Edge-Based Service Design & Deployment**
   - Overlay self-organizing control structure & dynamics
   - User Behavior: selfish and altruistic users
   - Functional Scalability & Stochastic Scalability
   - QoS Issues and Example: VoIP-Signaling Platform on Chord Ring
3. **Challenges**
   - From QoS to Quality-of-Experience
   - Trendscouting, Network Dimensioning, Adjustment and Management
   - Performance and Monitoring Issues

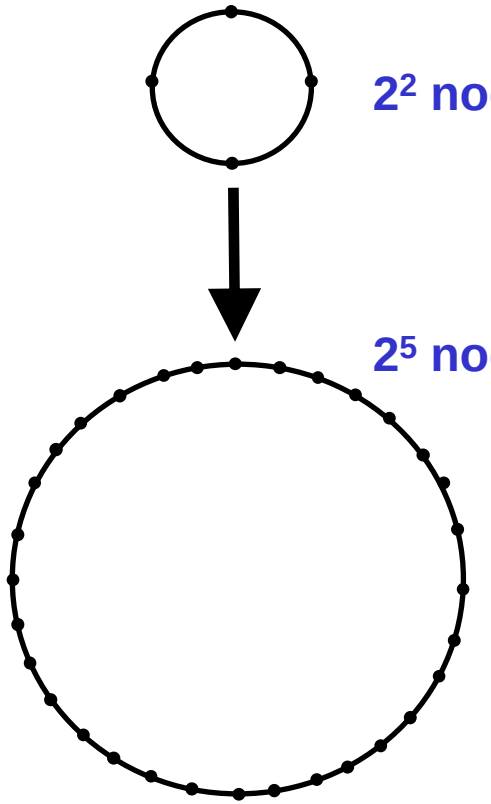
Functional Scalability

Functional Scalability



Functional Scalability & Stochastic Scalability

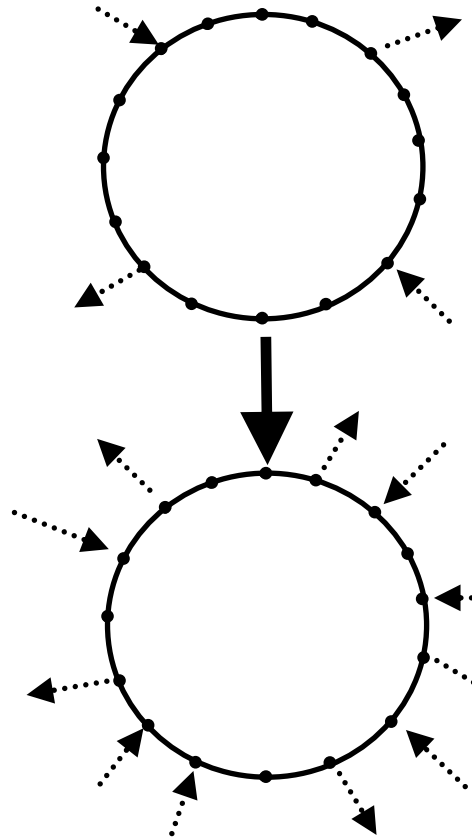
Functional Scalability



2^2 nodes

2^5 nodes

Stochastic Scalability



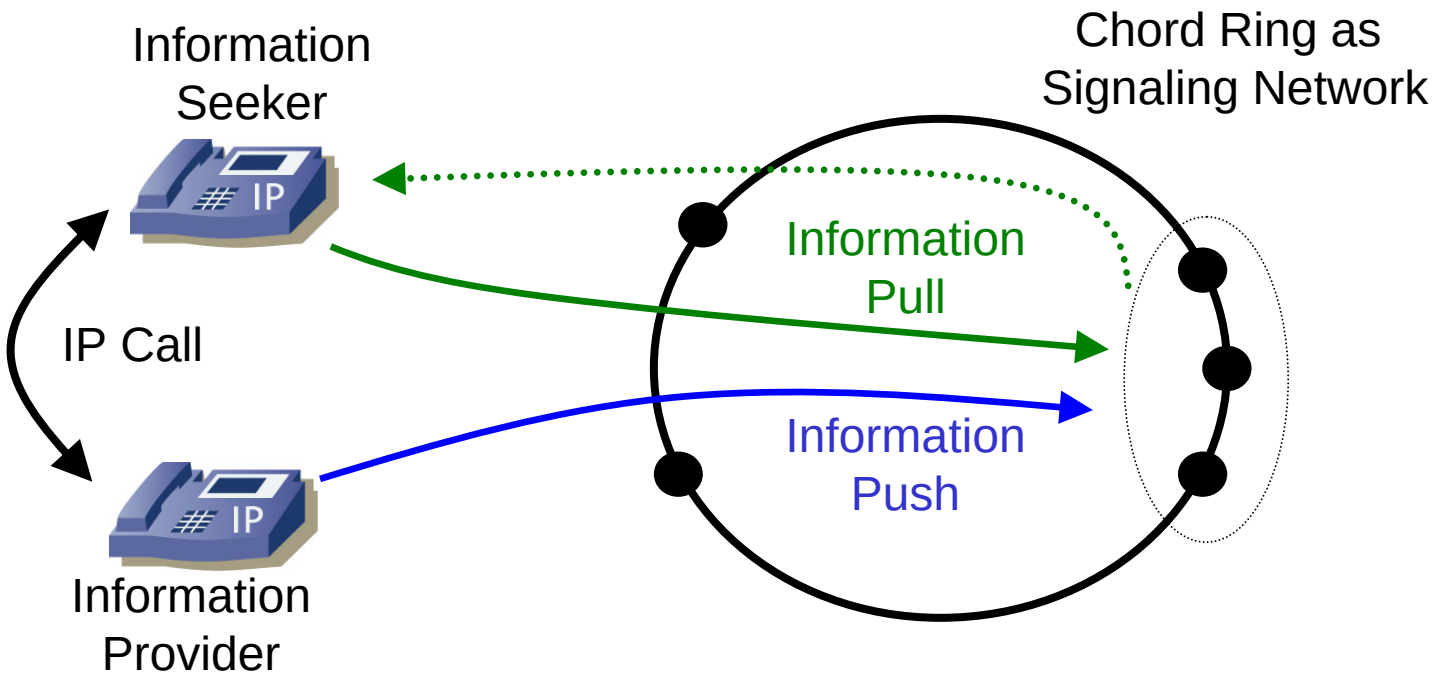
2^4 nodes, stable stationary structure

2^4 nodes, higher churn rate (joins and leaves)

Stochastic Scalability

- **Functional Scalability**
  - **If a solution works for 10 customers, does it also work for 100, 1000, …, customers ?**
  - scalable for slowly changing network size and structure
- **Stochastic Scalability**
  - **If a solution works for X=100 customers, does it also work if the network size X is a stochastically varying random variable?**
  - overlay network with high “churn rate”, fast changing network size and structure
  - networks resilience & survivability in case of stochastic breakdowns
- **Self-describing Networks?**

Example: P2P Voice-over-IP Signaling using Chord



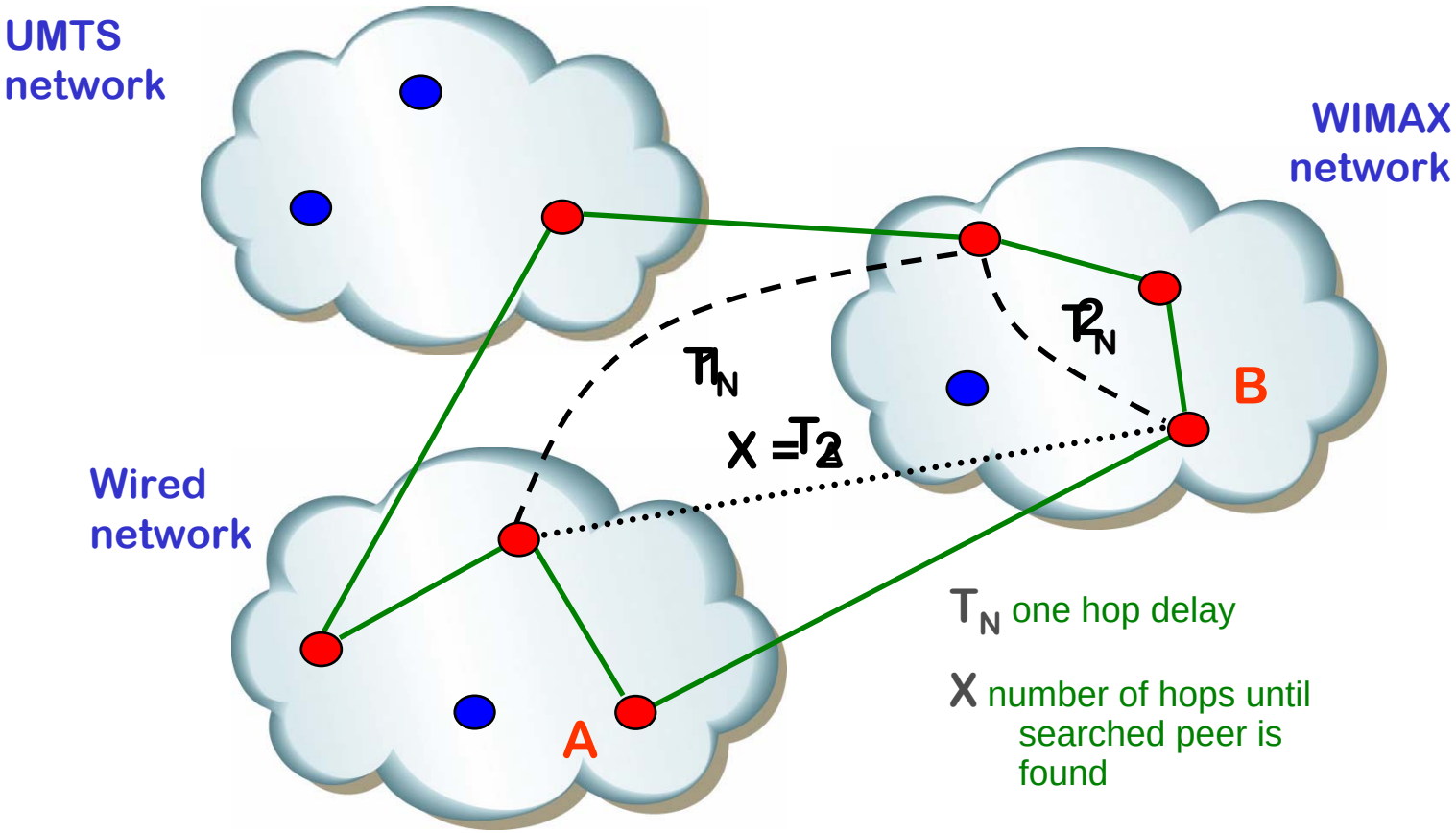
Information:
- nick-name
- current IP-address
- user profile

Performance analysis of a VoIP Signaling Platform

- Voice-over-IP application with distributed P2P-based directories
  - Architecture: Signaling platform using Chord ring with distributed hash table
  - Scalability: how many customer can be supported by stochastically varying ring size due to “churns”
  - Service Level: 99% of directory searches need less than 1 sec

- Performance analysis with stochastic modeling approach
- Research cooperation with Siemens

Model parameters



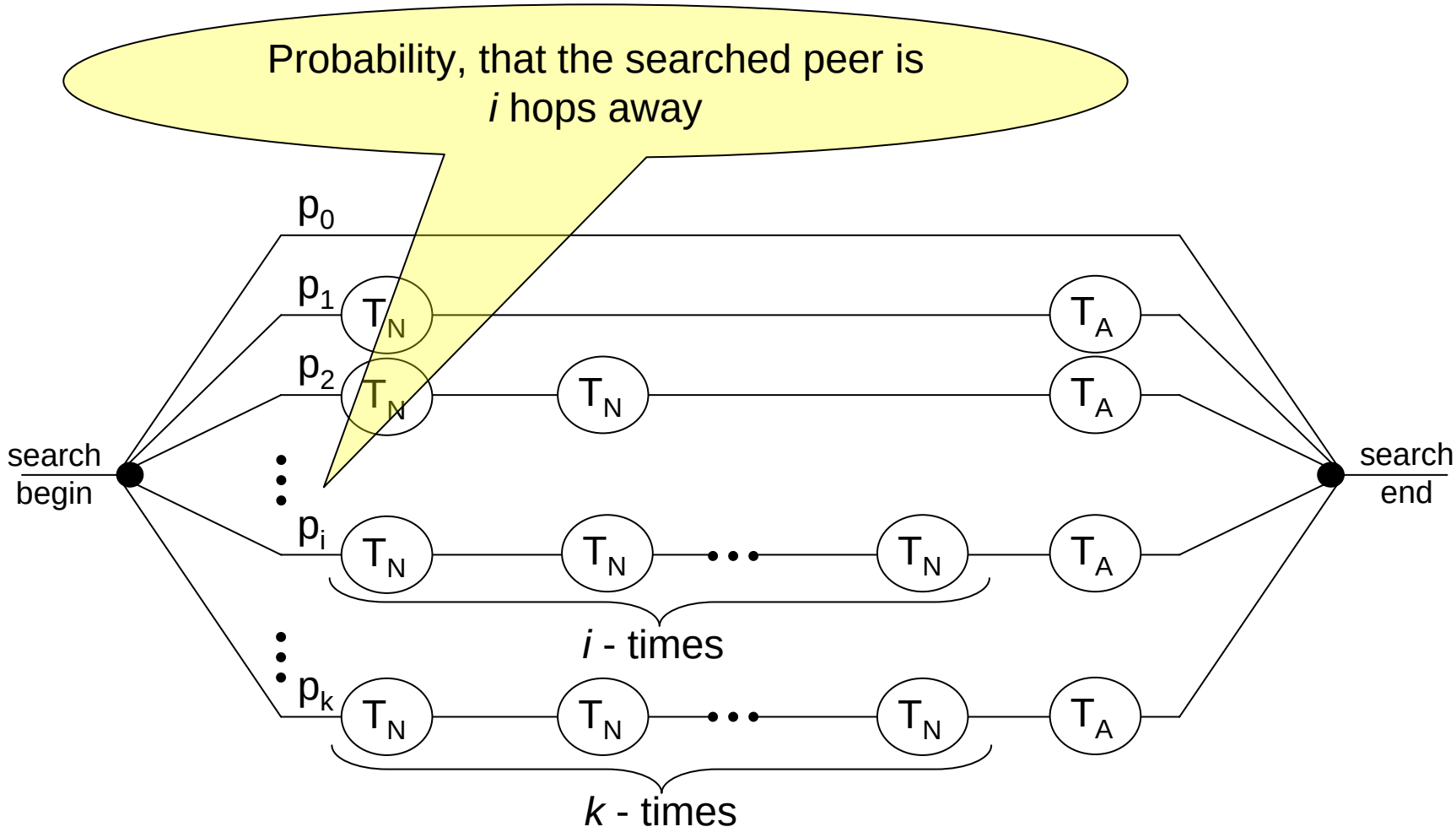
T_N one hop delay

X number of hops until searched peer is found

T_A delay of the answer

T total search duration

Phase Diagram of a Search Process



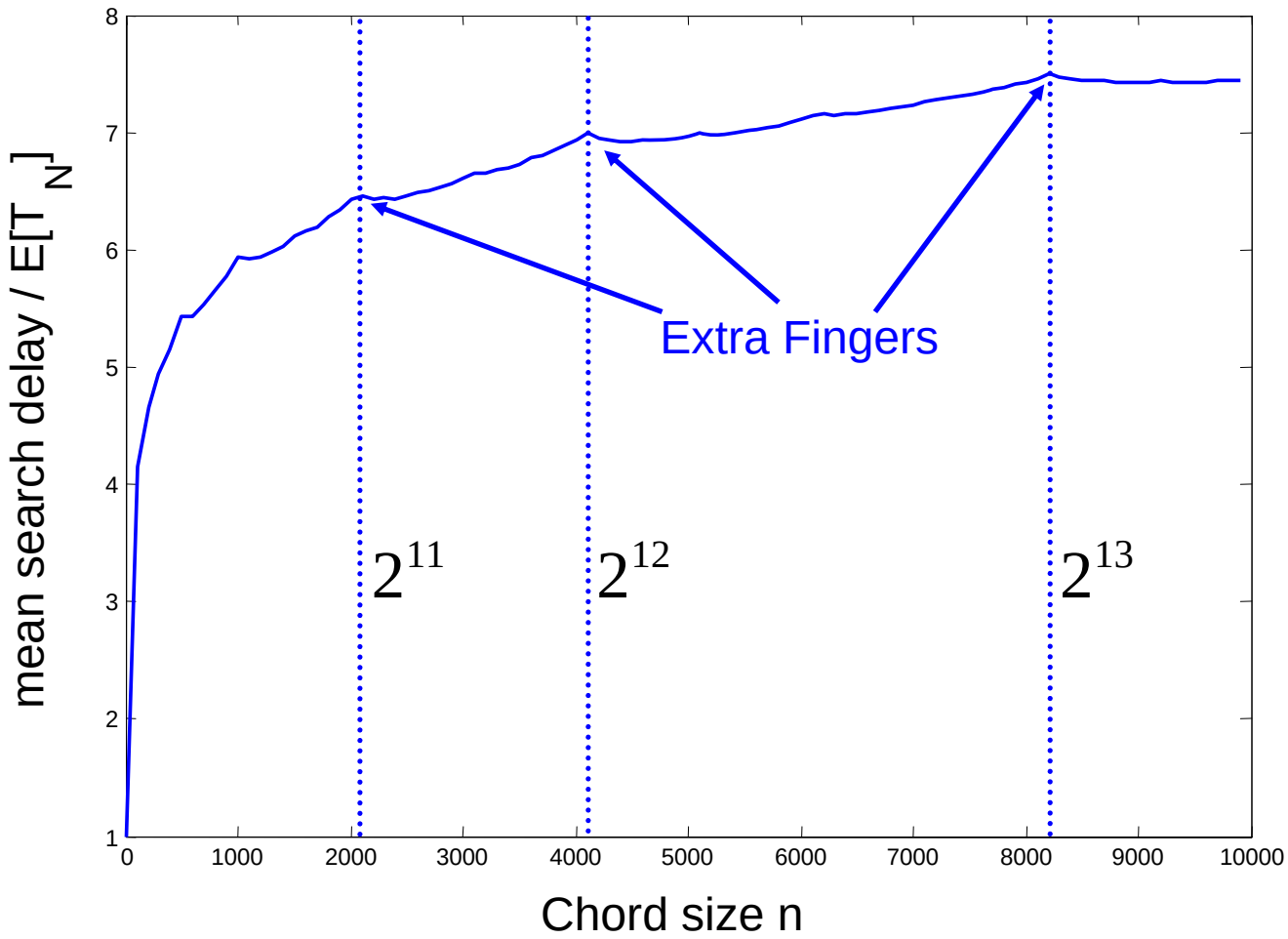
Functional Scalability

$T_N = T_A$

T_N: negative-binomially distributed

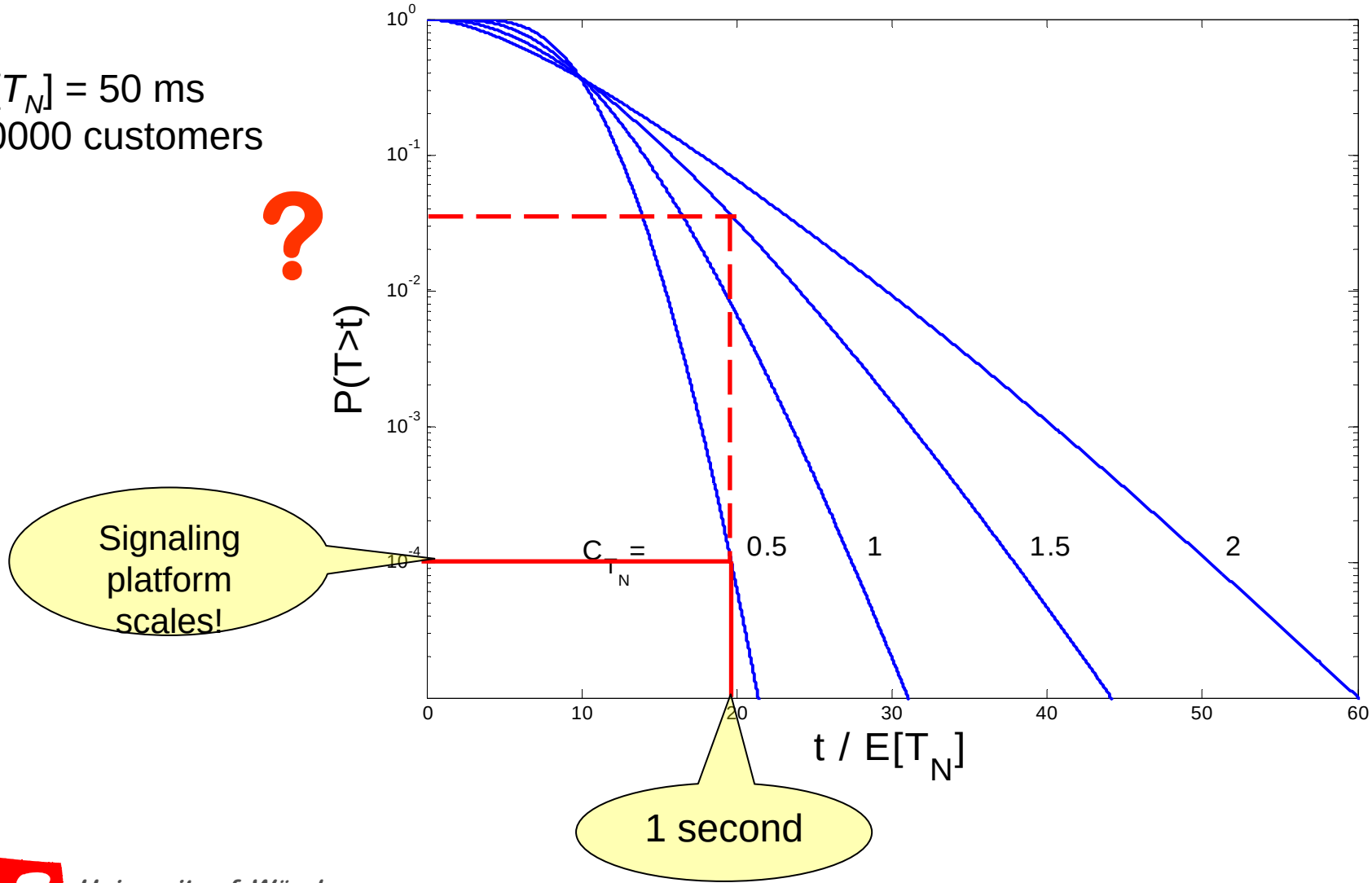
$c_{T_N} = 1$

$E[T_N] = 50$ ms

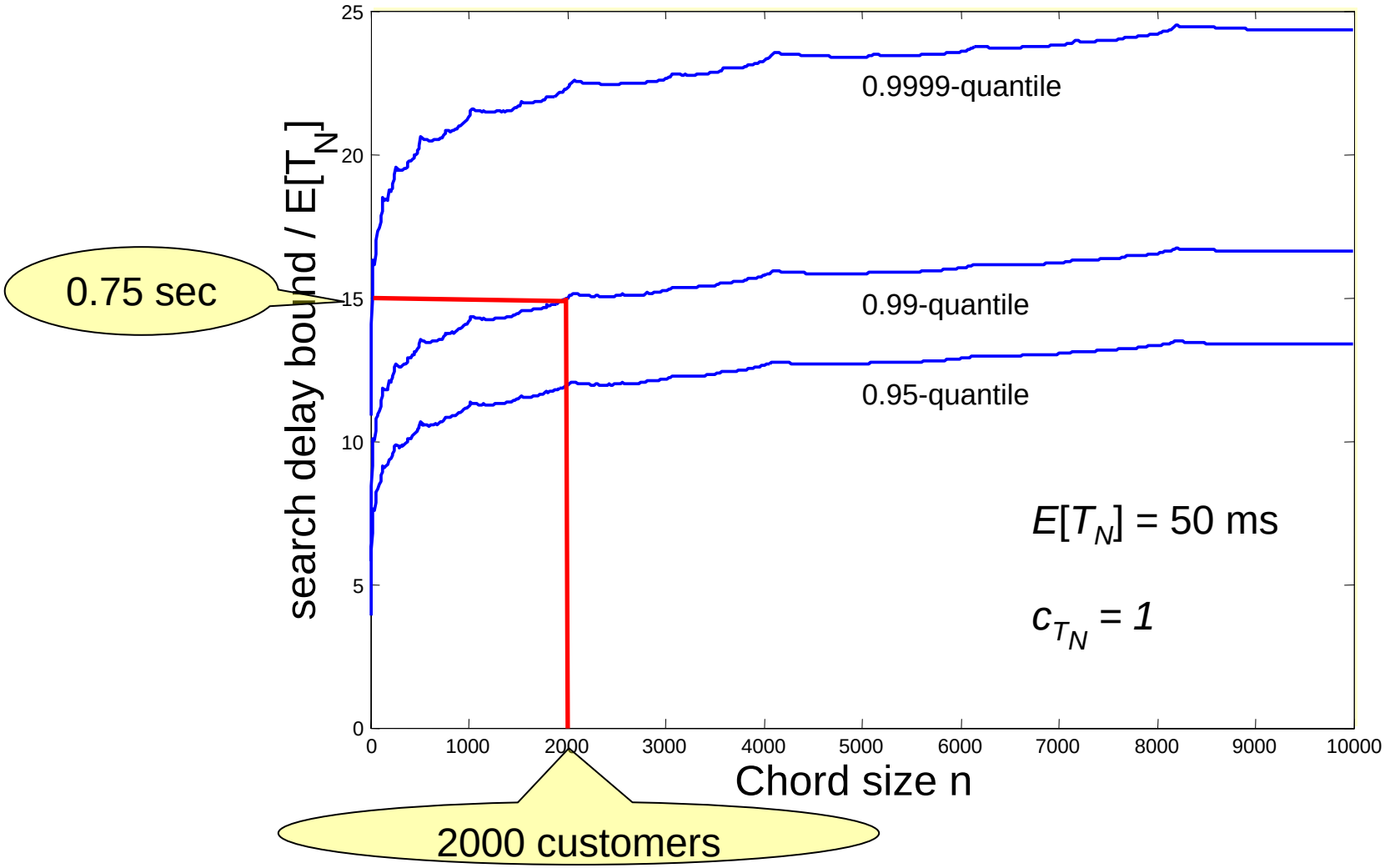


Stochastic Scalability

$E[T_N]$ = 50 ms
10000 customers



Quality of Service: Delay Quantile



Service Design Evolution in the Future Internet

1. **Trends of Future Services**
   - Intelligence Placement at Edge and User Initiated Service
   - Multi-Network Service and Multi-Platform Service
2. **Edge-Based Service Design & Deployment**
   - Overlay self-organizing control structure & dynamics
   - User Behavior: selfish and altruistic users
   - Functional Scalability & Stochastic Scalability
   - QoS Issues and Example: VoIP-Signaling Platform on Chord Ring
3. **Challenges**
   - From QoS to Quality-of-Experience
   - Trendscouting, Network Dimensioning, Adjustment and Management
   - Performance and Monitoring Issues

Trends observed and Questions

- Boundary between providers and users is disappearing
- Network dimensioning or reaction scheme design
- Stochastic scalability and network resilience
- Quality of service (QoS) or quality of experience (QoE)

End of Talk

Thank you !