Evolution der Dienste im zukünftigen Internet

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Impossible to see the future is.
(Master Yoda)

Tools to find the Future Internet
IP & Post-IP

future application

Internet constraints

science or repair shop?
Projects toward Future Internet

- GENI: Global Environment for Network Innovations (USA)
- u-IT839: Future of the Internet for Korea (Korea)
- EIFFEL: Evolved Internet Future for European Leadership (EU, Framework 7)
- IKT 2020 (BMBF, Germany)
- Overlay Networks (Japan)
1. Trends and Observations
   - 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 changes: 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

- From Multi-Service Network to Multi-Network Service
- Edge-based Intelligence
- Content placement: boundary between providers and users is disappearing
- From Quality of service (QoS) to Quality of Experience (QoE)
Network-centric: Multi-Service Networks

- Application
  - Browser
  - Instant Messenger
  - Soft Client
  - PSTN

- Service
  - WebServices
  - Other Services
  - Internet Telephony
  - PSTN Telephony

- Service Provider
  - Internet Service Provider A
  - Internet Service Provider B
  - Telephony Service Provider XY

- Network Provider
  - Carrier A
  - Carrier B
  - Carrier X
Application-centric: Multi-Network Service
Services, Platforms and Networks

User A

- Phone call
- Content Distribution

User B

Platforms
- eDonkey
- BitTorrent
- KaZaA

Networks
- Wired Sensors
- UMTS

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Trends

- From Multi-Service Network to Multi-Network Service

- Edge-based Intelligence
  - Boundary between Content Providers and Customers is disappearing
  - User behavior changes: selfish users emerge

- Content placement: boundary between providers and users is disappearing

- From Quality of service (QoS) to Quality of Experience (QoE)
Overlay Control Structure

overlay structure supporting new service

NGN core transport network
Stepwise Traffic Change

- P2P applications: 67.4%
- Web: 7.9%
- Other: 23.3%
- FTP: 0.3%
- Email: 1.2%

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

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- From Quality of service (QoS) to Quality of Experience (QoE)
Intelligence Placement & Service
Skype

- Free Voice-over-IP (VoIP) Software
  - voicemail
  - video-conferencing
  - calls to POTS (SkypeOut)

- First version July 2004

- Bought in September 2005 by eBay
  - price: 4.1 billion dollar

- More than 6 mio. users online at the same time
  - more than 277 mio. downloads (own report, 28.03.2006)

Youtube

- Platform for sharing and viewing video clips
- Founded in February 2005
- Takeover by Google in October 2006
  - price: 1.31 billion dollar
- app. 45% share in the video provision service
- App. 65,000 new clips daily, 100 mio. clips viewed

Flickr

- Website to upload and comment pictures
- Development company founded in 2002
- Bought by Yahoo! in March 2005
  - no monetary details disclosed
- App. 3 mio. registered Users, app. 5000 hits per minute (own data)

MySpace

- Web community to manage profiles, blogs, groups

- Community founded in July 2003

- Purchase in July 2005 by Rupert Murdoch
  - price: 580 mio. dollar

- More than 105 mio. members (own data)
  - 500,000 new members per week

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
Service Design Evolution in the Future Internet

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Example: Multi-Network (Vertical) Handover
Overlay connection, e.g., Pastry

Example: Multi-Network (Vertical) Handover
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Thinning the protocol architecture

- Overlay adapted to underlying layers
- Increase efficiency and robustness
- Supporting transport over any kind of networks
- Heterogeneity of network technologies
- Interoperability between technologies
Thinning the protocol architecture

Application
Overlay
Presentation
Session
Transport
Network
Data Link
Physical

Application
Mediation
Connectivity
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Selfish application: positive feedback bitrate

- Low QoS: increase packet/bit rate
- Still low QoS: introduce other counter measures (e.g., Codec change, app. layer re-route)

QoS assessment period -> QoS assessment

<table>
<thead>
<tr>
<th>Packet/bit rate</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>30ms</td>
<td></td>
</tr>
</tbody>
</table>
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

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
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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)
Example: P2P Voice-over-IP Signaling using Chord

Information Provider → Information Seeker

IP Call

Chord Ring as Signaling Network

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 customers 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

- **TA**: delay of the answer
- **TN**: one hop delay
- **T**: total search duration
- **X**: number of hops until searched peer is found

Wired network

UMTS network

WIMAX network
Probability, that the searched peer is $i$ hops away
$T_N = T_A$

$T_N$: negative-binomially distributed

$c_{T_N} = 1$

$E[T_N] = 50$ ms
Stochastic Scalability

$E[T_N] = 50 \text{ ms}$

10000 customers

Signaling platform scales!

1 second
Quality of Service: Delay Quantile

\[ E[T_N] = 50 \text{ ms} \]
\[ c_{T_N} = 1 \]

0.95-quantile
0.99-quantile
0.9999-quantile

Chord size \( n \)

search delay bound / \( E[T_N] \)

0.75 sec

2000 customers
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Scenario

- Users
- Altruistic
- Selfish
- Traffic adjustment
- QoE notification
- Observe QoE for period
IQX Hypothesis: Exponential Relation between QoE and QoS

\[ QoE = 3.0819 \cdot e^{-4.6446 \cdot p_{loss}} + 1.07 \]
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End of Talk

Thank you!