The Development of the Next Generation Network (NGN)

Horizontal and Vertical Integration, Fixed-Mobile Convergence, and Ambient Communication

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Outline

1. Development of Network Technologies and Services
   1. Digital Telecommunication Networks
   2. Packet Networks
   3. Mobile Communication Networks
   4. Services and Applications

2. Network Convergence
   1. Horizontal and Vertical Integration
   2. Towards IP-Based Networks
   3. Ambient, Ubiquitous and Nomadic Communications

3. Technical Challenges of NGN
   1. Architectures and Platforms
   2. Component Technologies
   3. Quality of Service and Traffic Engineering
   4. Network Management and Self-Organization
   5. Security

4. Conclusions
1200 Million Subscribers (Fixed Network) Annual Growth 10%
1400 Million Subscribers (Mobile Networks) Annual Growth 50%
Intelligent Network Services (IN)
Computer Communication Networks

- Probably more than 100,000 Subnetworks and more than 700 Million Users
- Services: Electronic Mail, Database Access, File Transfer, Internet Telephony, Multimedia Communication, World Wide Web, Peer-to-Peer
Development of User Numbers

Source: ITU News 2/2002

- Mobile Users
- Fixed Telephone Network Subscribers
- Internet Users

Million Users

- 0
- 500
- 1000
- 1500

Application Areas and Communication Services

**Telecommunication**
- Telephonie
- Multimedia-Mail
- Telefax
- Videoconference
- E-Mail
- Telecooperation
- Home Working

**Information**
- Electronic Newspaper
- Stored Multimedia Access
- Data Base Access
- Tele-Education

**World Wide Web**
- Peer-to-Peer Application
- Video-on-Demand
- Advanced Pay-per-view
- Distributed Video Games

**Entertainment**
- Telecooperation
- Home Working
- Tele-Education
- Videoconference

**Data Communication**
- Computer Communication
- Remote Login

**Context**
- Location Based Services
- Context Awareness
- Sensor Applications

**Business Applications**
- e-Business
- Portals

**Focused Advertising**
- Telecooperation
- Home Working

**Application Areas and Communication Services**
Peer-to-Peer File Sharing

Overlay Network

Underlying unreliable Internet (TCP/IP)

Server + Client (Servent)

Autonomous System

Request (Query)

Query Hits
Application Scenario

Electronic Ticket

1. Railway Customer uses PDA + Mobile Phone to communicate with BSS.
2. BSS communicates with MSC.
3. MSC communicates with Trust Center.
4. Trust Center communicates with Bank.
5. Conductor uses PDA to check railway ticket.

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Network Convergence

Users may have access to networks of different technologies
Communication across networks of identical / different technologies
"Always best connected"
Wide spectrum of services
Horizontal and Vertical Integration

Statements: Existing networks: ISDN, Mobile Networks, Internet, ...
Future trend: IP-based networks

Questions: Transition from existing networks to future IP-based networks
Architecture, protocols, migration

Horizontal and Vertical Integration

Fixed Networks 1 Op. #1
ISDN

Conventional coupling

Fixed Networks 2 Op. #2
ISDN

Media Gateway

Fixed Networks 3 Op. #2
SIP

Fixed Networks 4 Op. #3
SIP

Horizontal Integration

Vertical Integration

SIP
Ambient, Ubiquitous and Nomadic Communications

**Ambient Communications**
- Location and Context Awareness
  - Examples: Location Based Services, Context Aware Services

**Ubiquitous Communications**
- Distribution of Computer and Communication Functions in many devices ("smart its")
  - Examples: Body (Personal) Area Networks, Sensor / Actor Networks

**Nomadic Communications**
- Communication from any place including use of local / distant facilities
  - Extension of the Mobile Communications Paradigm
New Mobile Services

Communication Services ➔ Emerging Topics

- information services
  - location/context aware services, navigation services, ...
- classical information services
  - MMS, e-mail, ...
- stream-oriented services
  - speech and video telephony, ...

➔

- new services
  - minimalistic user interface
- new requirements to the networks
  - mobility management/support
  - resource reservations
  - support for hundreds of niche applications
- business models
Heterogeneous Access Networks

- wireless network technologies are designed for special environments
  - e.g. indoor/outdoor, slow/fast users, low battery consumption, ...

- change of paradigm: from \textit{anytime-anywhere} to \textit{sometime-somewhere}
- critical: network transitions in vertical direction
- users always want to use the best available network
  - but without manual interactions

\textit{research topic: Always Best Connected (ABC)}

Quelle: U. Kubach (IPVR/AS), Universität Stuttgart, 2001
Challenge: Adaptation of Networks and Applications

- inter-technology mobility support
- abstraction of networks and technologies

- fair and adequate resource sharing
- control of communication costs
Project Aims (Interdisciplinary)

- platform for the support of context-aware services
  ➥ open system platform
- "world model" for context aware systems

technology assessment
  ➥ security and privacy aspects, social acceptance, ...

applications
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ASTN Functionality

- **Provisioned/hard permanent connection (PC)**
  - controlled by management system
  - long provisioning times
• **Switched connection (SC)**
  - uses control plane with user-network-interface (UNI) and internal/external network-network-interface (I-NNI/E-NNI)
  - dynamic information exchange

• **Soft permanent connection**: SC only within network, no UNI
• Circuit switched transport network
• Evolutionary extension of current core networks
• Optimal combination of
  - optical transport
  - electronic aggregation and traffic engineering
Optical Burst Switching

- Burst assembly in edge node, mostly variable length
- WDM-based transmission
- Separation of control and data

- *Fast* optical switch
- Separation of control and data

edge node

OBS network

core node

control-channel

data-channels

edge node

OBS network

core node

control-channel

data-channels
Contretion Resolution in OBS

• Burst loss possible due to bufferless statistical multiplexing
• Application of OBS in high-speed metro/core networks
  ➣ lost data has to be retransmitted on end-to-end basis not locally
  ➣ very low burst loss probability required (e.g., $10^{-6}$)
  ➣ Need for highly effective contention resolution

• Wavelength domain wavelength conversion
  - very effective as all WDM channels shared among all bursts
  - but: low burst loss probabilities only for $\geq 100\,\lambda$s
  ➣ additional schemes necessary

• Time domain fiber delay lines (FDLs)
• Space domain deflection/alternative routing

⇒ Optimized combination of these schemes
Contestion Resolution in OBS

- Potential for resource/performance optimization in OBS node
- Different selection strategies for converters and FDLs
  - minDelay minimizes delay at cost of higher converter usage
  - minConv minimizing converter usage at cost of higher delays
NGN Service Platforms

Open Interfaces

**Application Platform**
- Voice, Video, Streaming
- Business Applications
  - e-XYZ, m-XYZ, ...

**Service Platform**
- Web Services
- Middleware
- SIP
- Roaming
- AAA

**Access & Core Transport**
- ISDN, DSL
- GSM
- GPRS
- UMTS
- WLAN
- WiMax
- DVB

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# Technical Challenges of NGN

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Example 1: Telecommunication Services

Traditional Solution is not feasible for many new applications due to:

- Variable bitrate sources (burst traffic)
- Overhead for connection management (delay, state management, ...)
- Integration of many services with quite different characteristics
- Inflexibility with respect to adaptation to application requirements
- Cost

Connection: Reservation of Bandwidth

Admission Control  Circuit Switching
Traditional Solutions

Example 2: Internet

"Best Effort Service": No admission control
No resource reservation
Unpredictable delays and losses

BES is not feasible for many new applications due to:
• No guarantees on QoS
Internet Routing

- **RIP**
- **BGP**
- **OSPF**

Diagram:
- **Domain 1 (RIP)**
- **Domain 2 (RIP)**
- **Domain 3 (OSPF)**

- **Domain Router**
- **Edge Router**
- **RIP** (Routing Information Protocol)
- **OSPF** (Open Shortest Path First)
- **BGP** (Border Gateway Protocol)
Traffic Classes in the IntServ-Model

- Guaranteed Service (similar to CBR and rt-VBR)
- Controlled Load Service (similar to nrt-VBR)
- Best Effort Service (similar to UBR)

Use of RSVP

Traffic Classes in the DiffServ-Model

- Expedited Forwarding (Premium Service)
- Assured Forwarding with different Priorities

Hop-by-Hop Control
Flow Description by

Flow Specifications (FlowSpec)
- Service Class
- Reserve Specification (RSpec)
- Traffic Specification (TSpec)

Filter Specification (FilterSpec)
Negotiation of max. Bitrate between User and ISP for Aggregated Traffic Volumes
Classification of Traffic Class by Access Routers

Premium Service: Separate Queues and Prioritized Transport provide virtual leased Line Service
Policing Function by Border Router

Assured Service: Use of Priority to provide QoS for short Bursts
Policing Function and Packet Dropping by Border Router
Appropriate Dimensioning of Transmission Resources by ISP

Per Hop Behaviour (PHB) Routing, Marking of IP Packets within DS-Field
Tag Switching

- Detection of flows
- Assignment of flow labels
- Fast switching along pathes

State-based switching
Challenges of NG Internet with Respect to QoS

- Tremendous increase in bandwidth demand in mobile and fixed networks for new applications
  Ahead: Japan and Rep. of Korea (70/60 % mobile Internet users; US/Europe < 10%)
  Asia-Pacific Region leading in broadband penetration
- Rapid decrease of internat. bandw. pricing from 111 TUSD (1998) to 10 TUSD (2002) for US-Japan 1Mbps link per year
- NG Internet Technology and broadband access
- Fast routing algorithms
- Convergence of Internet and Mobility
- Adaptive traffic control (e.g., for Peer-to-Peer applications)
- Negotiable QoS Levels and QoS guarantees
- Accounting and charging for highly variable bitrate services
- Ubiquitous computing and ad hoc communication networks
- Adaptation of source coding and network traffic control
- QoS across multiple layers and heterogeneous network technologies
### Technical Challenges of NGN

#### Topics

1. **Architectures and Platforms**
   - Control of Dynamic Transport Networks
   - Optical Burst Switching
   - NGN Service Platforms

2. **Quality of Services and Traffic Engineering**
   - Traditional Solutions
   - QoS in the Internet

3. **Communication & Security**
   - Architectures and Protocols
   - Mobility
   - Security and Privacy
Architectures & Protocols

- Unified Communication based on IPv6
- Communication across different Networks
- Mobility Management based on Mobile IP Concepts
- Dynamic Address Management
- Horizontal and Vertical Handover
- Integration of Ad Hoc Networks (infrastructureless)
- Middleware Concepts
  Abstraction from Underlying Network Infrastructures
- Design & Implementation
- Standardization
Mobility

- Modelling of Mobility of Users and Data
- Modelling of (Communication) Traffic - spatial and temporal
- Disconnected Operation (information Caching and Fuelling)
- Predictive Information Provision (Hoarding)
- Simulation Methods for Mobility
- Performance
Example

- Tracking of Location May Cause Severe Privacy Problems
- Similar Problems Arise from Recording of User Activities
Research Topics - Security & Privacy

• Protection Against Concatenation between Location Data and User Identity

• Methods:
  • Pseudonymization
  • Authentication
  • Multilateral Security concepts:
    Negotiation of Protection Aims and Strengths
  • Accountability and Non-Repudiation
  • Integrity

• Security Protocol Design
Conclusion (1): General Observations

- **Change of Paradigms in the Communication Sector**
  - heterogeneous network technologies, broad spectrum of applications
  - trend directs to IP-based network and transport protocols
  - technology push and market pull

- **Success Factors**
  - time to market
  - open platforms
  - user acceptance

- **Design Processes**
  - limited development periods
  - specialization and limitation to core competences ("make or buy?")
  - design automation, design platforms and tools

- **Standardization and Quality**
  - proprietary solutions vs. open platforms
  - need for standardization
  - product quality and quality of service
Conclusion (2): Research Areas

- **Integration of the various Network Technologies**
  - fixed, mobile and ad hoc networks
  - internet and photonic technologies
  - support of autoconfiguration and manageability

- **Platforms**
  - advanced middleware concepts
  - service creation support
  - application programming interfaces

- **New Application Paradigms**
  - location and context based services
  - nomadic communications and ubiquitous computing
  - overlay networks

- **New Business Models**
  - micropayment
  - quality of service
  - scalable security