Towards the Next Generation Network

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Outline

- Introduction: What is the NGN?
  - The Basics
    - QoS
    - Fast Failure Recovery
    - Traffic Engineering
  - Resource Management
  - Automated Network Control
  - Conclusion
<table>
<thead>
<tr>
<th>Content is king</th>
<th>Connectivity is king</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users are willing to pay for high-quality services</td>
<td>Users want simple, affordable services; quality is secondary</td>
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<tr>
<td>Flat rate</td>
<td>Pay per use</td>
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<tr>
<td>Wireless voice will cannibalize or even displace wireline voice</td>
<td>Wireless will stimulate growth of wireline voice</td>
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<tr>
<td>Wireline's main value-add is fast Internet – voice will move to wireless</td>
<td>Wireline will remain the primary delivery system for voice</td>
</tr>
<tr>
<td>New services like Video on Demand help providers move up value chain</td>
<td>Cost of deploying new services is high, fast RoI unlikely</td>
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</table>
Options for providers

The valley of commodity
- Video
- Online gaming
- Web hosting
- E-commerce
- IP VPN

The battlefield of differentiation
- QoS
- Availability, reliability
- Customer service
- Security
- Ease of use

The garden of value-added services
- IP Transport
- Operational efficiency

Value today
Value tomorrow

Information and Communication Networks
What is the Next Generation Network?

- One network infrastructure for all services
  - Voice, video and data
  - Benefit from data network investment
  - Capex reduction through resource sharing
  - Opex reduction
- Enable new (converged) services
- Overcome TDM network limitations
- Ride the technology cost curve
- Carrier-grade properties
Next Generation Network Overview

Applications
- Presence
- Video Collaboration
- Gaming
- ... and more Applications

Switching & Control
- NGN Control
- Media Gateways
- PSTN / PLMN
- 3G-Mobile Network

Backbone
- IP/Optical Backbone
- Multiservice Packet Switch
- Metro Optics

Access
- Access Gateway
- Multi-Service Access
- Residential Customers
- Triple Play
  - Voice, Video, Data

Information and Communication Networks
The variety of convergent services will be based on carrier-class IP core networks.
QoS-Requirements to an IP Network for NGN for Voice Traffic

- One way end-to-end requirements:
  - Latency: \(< 100 \text{ ms end-to-end} \) (ITU-T Rec. Y.1541)
  - Jitter \((t1 \neq t2)\): \(< 50 \text{ ms} \) (Y.1541)
  - Packet loss: \(< 10^{-3} \) (Y.1541)

- Duration of Interruption (also for logical IP failures): \(< 2 \text{ sec} \)
NGN: a convergence platform for existing services, service evolution and future new services

Internet service evolution
- more bandwidth (e.g. high speed web surfing)
- service differentiation (e.g. gold, silver bronze)
- additional requirements (e.g. reliability, security, ...)
- multitude of short-lived data flows

Telecommunication service evolution
- more bandwidth (e.g. high quality video, ´virtual presence´)
- true real-time, interactive (dialogue) communications
- ´carrier grade´ network properties and behaviour
- predictable number of long-lived data flows

Convergence on a highly flexible and scalable QoS enabled high speed network with ´open´ architecture.
NGNs and existing networks

Will NGNs replace existing networks?

* interoperability is not critical due to similarity and commonality of principles and mechanisms
* fast growth of internet traffic leads to very short turnaround times of related equipment
* ´better service´ and reduction of operational cost are also desireable for the internet

* Internet

NGN technology will absorb and replace the traditional (best effort) internet within less than a decade.

* Telecom Network

  * a huge base of telecommunications equipment is installed and operating satisfactorily
  * introduction of NGN technology has to be justified by new service capabilities (broadband?) and/or significant reduction of operational cost
  * interoperability is provided through (voice) gateways

* PSTN equipment will coexist for a considerable time
Why is NGN taking longer than expected?

- General reduction of carriers’ capital spending
- Underestimation of business aspects
- Speed of xDSL roll-out resulted in network congestion relief
- Skepticism concerning NGN quality, reliability and security
- Marketing new applications is taking longer than expected
- In some markets: Absence of real competitive pressure on incumbents
- Regulatory & standardization issues
Objectives of RESIP:
Siemens-Juniper Cooperation

- Coordinate NGN activities
- Next Generation Network solutions with quality of service, reliability, security, management and efficient utilization of voice, video and data transmission over a packetized network infrastructure
- Set up a joint laboratory to validate end-to-end NGN solutions and demonstrate them ("Proof-of-concept lab")
- Establish a QoS benchmark for resilient IP networks ("RESIP"), based on existing standards (ITU, IETF, …)
The goal of the research project KING* is to establish a comprehensive carrier class solution that complies with the three major requirements:

- Quality of Service
- Network Reliability
- Efficient Network Management

- KING started in October 2001 with term of 3 years
- KING is carried out by Siemens AG jointly with 2 research institutes and 5 universities
- KING is partially funded by the German Ministry of Education and Research (BMBF)

* Key Components for the Internet of Next Generation

Information and Communication Networks
NGN requires both QoS and resilience in the IP core network

- **QoS**
  - Support for broadband, real-time, interactive service
  - Qualified SLA
  - In case of failure, preserve QoS (subsecond range)

- **Resilience**
  - Network support for fast fail-over and service differentiation
  - Additional configuration parameters
  - Automated network control

- **Convergent services**
  - IP core network
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Fast fail-over in OSPF/IS-IS networks

shortest path to dest.
Fast fail-over in OSPF/IS-IS networks

Fast fail-over in OSPF/IS-IS networks relies on fast failure detection mechanisms, such as BFD (Bidirectional Forwarding Detection), which can detect failures in the network within approximately 50 ms. This rapid detection allows for a switchover to a backup path to maintain connectivity.

In the network diagram:
- **Source 1** and **Source 2** represent the primary and backup sources, respectively.
- The network routes with solid lines represent the shortest path to the **Destination** in the event of a failure.
- The network routes with dashed lines represent alternative paths in case the primary path fails.

BFD (Bidirectional Forwarding Detection) is a protocol used to detect failures in point-to-point or multipoint link connections. It helps in quickly identifying network failures, which is crucial for maintaining network reliability and performance.
Fast fail-over in OSPF/IS-IS networks

- Fast failure detection, e.g. BFD (~ 50 ms)
- Fast routing by next gen routers (<1 s)

Source 1 → Router 1 → Router 2 → Destination
Source 2 → Router 3 → Router 4 → Destination

BFD Bidirectional Forwarding Detection
Traffic Engineering by optimizing link metrics

- Optimized link cost metric ➔ Improved traffic distribution
- Routing ambiguities removed by ECMP
- KING algorithms provide solutions for complex networks
- Autonomous failure reaction (re-routing) is fully maintained

A Siemens project supported by BMBF
Traffic Engineering by optimizing link metrics
Example: the “COST 239” Network

- hop count based routing
  - mean link load = 24.38%
  - max. link load = 71.35%

- optimized routing metrics
  - mean link load = 24.69%
  - max. link load = 38.75%
Traffic Engineering by optimizing link metrics

- given network (COST239) and traffic matrix
- comparison of maximum link loads
  - hop count metrics, normal operation 0.714
  - hop count metrics, single failures 0.854
Traffic Engineering by optimizing link metrics

- given network (COST239) and traffic matrix
- comparison of maximum link loads
  - hop count metrics, normal operation 0.714
  - hop count metrics, single failures 0.854
  - optimized metrics, normal operation 0.388
  - optimized metrics, single failures 0.663
Traffic Engineering by optimizing link metrics

- given network (COST239) and traffic matrix
- comparison of maximum link loads
  - hop count metrics, normal operation: 0.714
  - hop count metrics, single failures: 0.854
  - optimized metrics, normal operation: 0.388
  - optimized metrics, single failures: 0.663
  - failure opt. metrics, single failures: 0.567
  - failure opt. metrics, normal operation: 0.450
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Admission Control provides efficient resource management

Admission control (AC):
- checks if required QoS resources in forwarding direction are available.
- if positive, it admits the QoS request and stores a reservation state.
- if negative, it rejects the QoS request
Connection oriented resource reservation keeps states along the path

connection oriented resource reservation
Restoration of Reservation States slows down Fault Recovery

Recovery speed in case of failure is limited by the necessary update of reservation state information
**Characteristics:**

- Network admission control at the edges assures QoS
- NAC budgets also include reserves for resilience
- Fast fail-over enabled:
  - QoS reservation states at borders only
    -> flows' paths through the network can change
  - Diffserv-like forwarding locally preserves QoS traffic in all routers
Network Admission Control

- QoS and resilience requirements are combined
  - highest QoS class will have best resilience
  - resilience supported by strict priority queueing/scheduling
  - NAC budgets include reserves for resilience

- no QoS / bandwidth configurations at transit nodes
Four Fundamental Methods for Admission Control

- **LB NAC** (Link Based Admission Control): Link-based budgets.
- **IB/EB NAC** (Ingress/Egress Based Admission Control): Ingress and egress based budgets.
- **BBB NAC** (Border-to-Border Admission Control): Border-to-border budgets.
- **ILB/ELB NAC** (Ingress and Link/Ingress and Egress Based Admission Control): Ingress and link / egress and link based budgets.

![Diagram](image-url)
Network Admission Control introduces a combinatorial component

- Resource utilization for different NAC schemes

- IB/EB NAC is flexible but inefficient
- BBB NAC is simple and efficient
Resilience can be included in Network Admission Control

- Resilience is best included in BBB budgets

11 nodes COST239 Network
20 nodes Lab Network

Resource Utilization vs. Offered Load $a_{b2b}$ [Erl]
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Efficient Network Operation by Network Control Server

- Non real-time environment
- Real-time environment

Network Management
- Network Control Server
- Calculation of NAC budgets and optimized link metric
- Budget utilization
- Topology, link loads
- Budgets
- Optimized link metric

Stateless core with Diffserv, fast routing and ECMP

Network Admission Control (NAC)
Network control server initializes and operates the network

**Network initialization**

- **Operator:** provides traffic relations and operator policies
- **NCS:** calculates and configures **NAC budgets** for traffic classes with resilience and **optimized link metric**
  - **NAC**
  - **Routers**

**Network operation**

- **NCS:**
  - Evaluates received network data
  - Evaluates alternative network scenarios (calculation of alternative NAC budgets and link metric)
  - Decides whether to change network parameters
  - If yes, configures alternative parameters. If desired, by operator confirmation only.
- **Routers:** provide budget utilization
  - **NAC**
  - **Routers**

**NAC:**
- Provide budget utilization
  - Provide info on topology and link loads

**Routers:**
- Provide info on topology and link loads
The NCS reduces blocked traffic effectively

- blocking is minimized through traffic monitoring and re-adjustment of budgets and routing

<table>
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<th>Relative Blocked Traffic</th>
<th>Gain from Budget Adaptation</th>
<th>Gain from New Link Metrics</th>
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<tbody>
<tr>
<td>after change in traffic matrix</td>
<td>-63.5%</td>
<td></td>
</tr>
<tr>
<td>after adaptation of NAC budgets</td>
<td></td>
<td>-74.5%</td>
</tr>
<tr>
<td>after adaptation of link metrics</td>
<td></td>
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The NGN will continue to gain strong momentum:

- The underlying cost advantages are solid
- Addresses the issues of tomorrow's network demands
- The technology has matured and will be the prevailing technology in the next round of major new network deployments
- Can bring new sets of applications to the market