Deutsche Telekom Corporate R&D
Evaluation of Next Generation Network Architectures and Further Steps for a Clean Slate Networking Approach

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Deutsche Telekom

DISCLAIMER

Motivation

Change of (technical) paradigms

- Services converge to packet-based solutions (VoIP, IPTV) at the customer edge
- Transport becomes ever more cost-efficient
- Optics in the access – broadband everywhere

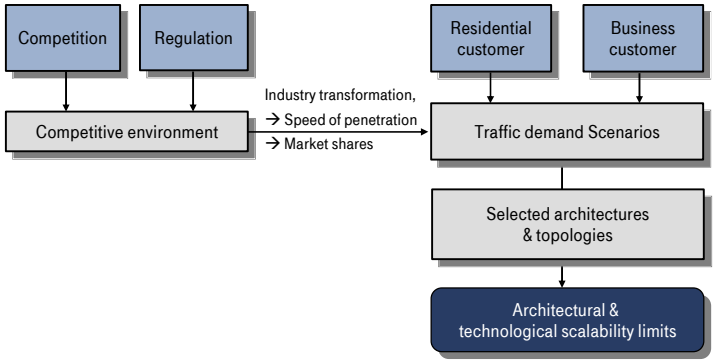
Analysis & implications

- Implementation of converged networks offering seamless services
- Investigation of the trade-off between packet- and circuit-based solutions
- → How scalable are different network architectures?
- → Which role do transport solutions in future core networks?

Objectives

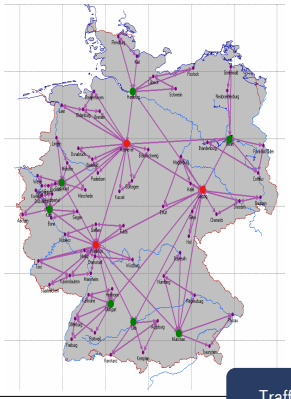
- Investigation of 3 typical architectures with respect to node throughput, link and tunnel size for a DT related network architecture
- → Extend technical discussion to further aspects ...
- → Some contributions to the 'Clean Slate' discussion regarding future network research direction

Embedding of Architectural and Traffic Demand Scenarios Considering Future Competitive and Regulatory Impact



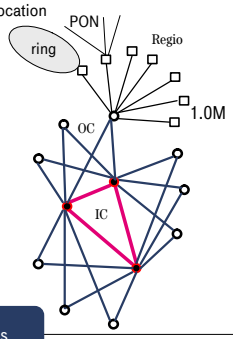
Topological Scenario

DT IP network topology



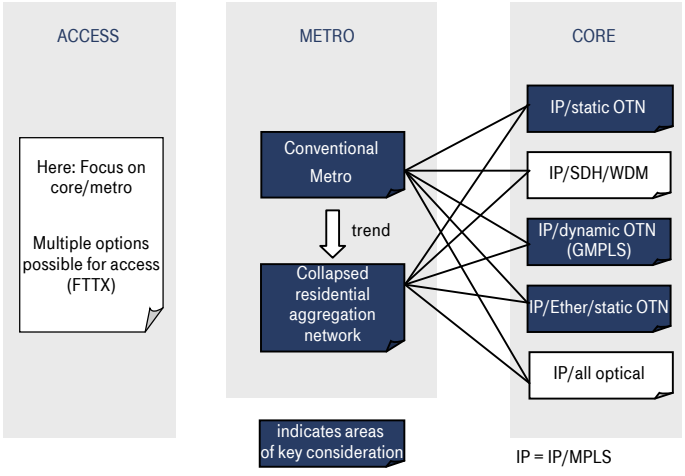
Abstracted topology

- 75-node (3 inner core, 9 outer core, 63 regional nodes)
- Inner/outer core triangles
- 7 regio networks connected to each outer core location



Traffic demand: 1 – 100 Tbit/s

Important Combinations of Architectural & Technological Alternatives



Brief Description of Three Considered Architectural Scenarios

IP/MPLS

- IP/MPLS routers in the metro and backbone area interconnected by fixed OTH systems
- Common management of IP and OTH

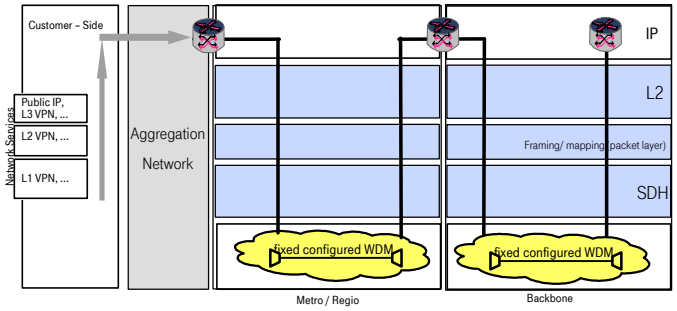
GMPLS

- IP/MPLS routers with fixed OTH systems in the metro, and reconfigurable OTH systems in the backbone
- Common control and management (GMPLS)

Ethernet

- IP/MPLS routers and/or L2 switches in the metro and backbone interconnected by fixed OTH systems
- Interconnection of routers / switches via L2 or L3 possible – the functional separation needs further investigation
- Managed by common or separate IP and Ethernet control planes

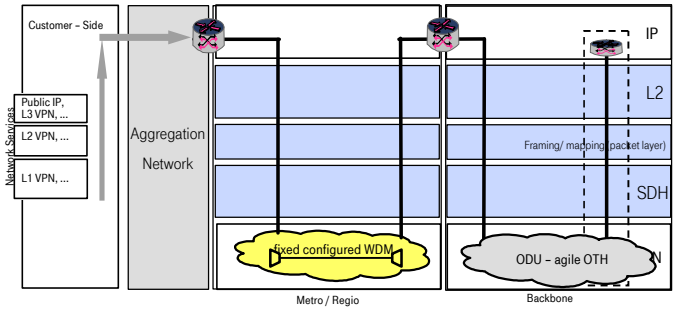
Scenario I: All IP/MPLS



Description & Assessment

- Efficient traffic grooming and cost effective transport of coarse granular traffic streams in backbone
- Offers IP/L3 services and emulates L1 and L2 services
- Increased data plane complexity
- Scalability of integrated multilayer control may be limited
- Acceptable migration path from MPLS to GMPLS

Scenario II: IP/MPLS – GMPLS



Description & Assessment
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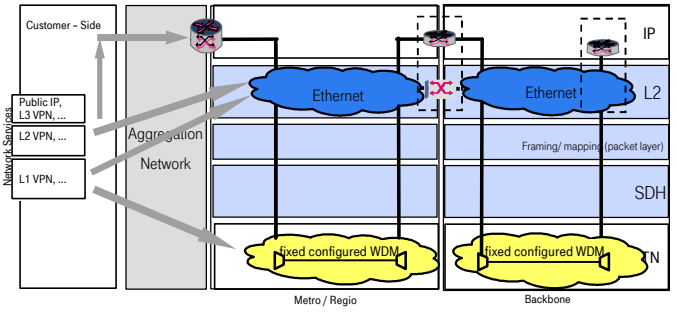
Scenario III: Dominant Ethernet



Description & Assessment
▪Leased line brutto bandwidth high because LLs' low filling factor (20%): migration of LL to Ether production offers high packet gains ▪Offers IP/L3 and L2 services and emulates L1 services ▪Simplified data plane but continuing cost advantage of Ethernet switching over IP/MPLS routing unclear ▪Currently high complexity of Ethernet configuration, fault and performance management ▪Unresolved tension between view of Ethernet as a low-cost fabric versus the rich fabric for tomorrow's services

Assessment of Nodal Throughput, Link Load and Tunnel Bandwidth

	IP/MPLS	GMPLS	Ethernet
Nodes	IP/MPLS routers reach a maximum > 10 TBit/s throughput	A) ODU begins at regio: Router throughput max. 3 TBit/s ODU switch max. 30 TBit/s B) ODU begins at outer core: Router throughp. max.20 TBit/s ODU switch max. 30 TBit/s	IP routers process data in regio (and outer core) with maximum of 3 TBit/s (20 TBit/s)
	→ achievable today → But, highest transport cost	→ data processing in inner- and outer core ODU based with reduced cost → Trade-Off: reduced packet gain due to lower filling degree in inner- and outer core, leading to increased ODU brutto load	→ Ethernet switches in (outer core and) inner core reduce costs But, a number of unresolved issues exist for Ethernet technology → Achievable today → But, high transport cost
Links	Multiple channels per link required		
	→ requires inevitably link bundling on IP level for all load scenarios	→ aggravates the problem identified for IP/MPLS scenario	→ requires inevitably link bundling on IP level for all regarded load scenarios
Tunnels	Full mesh outer core: higher than 10 GBit/s on all channels Full mesh regio: mostly below 10 GBit/s per channel		

The choice of transport or packet technology depends on the incremental cost, the meshing and the resulting tunnel bandwidth

Critical Issues Identified ... Leading to a more Thorough Investigation of Future Issues

Multiple channel interfaces in Core & Regio
- Link loads expected to exceed the capacity of a single physical channel (multi-wavelength interface operated as one single logical interface)
- Load balancing is a basic requirement

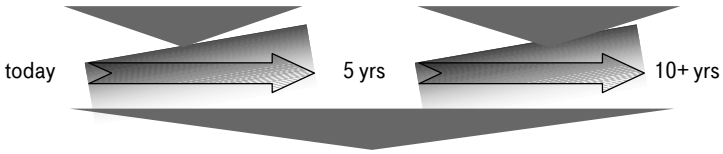
Efficiency in the Regio and Backbone
- Paket vs transport efficiency
- ODU vs. transport

Distribution of functionality between Regio and Access
- First versions of multi-wavelength interfaces are still in the process of being standardized, but not implemented yet
- Business customers might have different requirements

Expected scalability limitations in the backbone
- Limited due to technical constraints of limited sharing capabilities
- Power consumption and heat dissipation in single shelf devices will be the most severe limitation factors
- Logical scaling limitations?

Future Network Evolution and Research Directions – The Big Picture

Industry (carriers, vendors)	Academia
The entire industry undergoes both commercially and technically a deep transformation – a change even more profound than during the bubble years and completely changing the face of the industry	Academia undertakes a rigorous evaluation of the existing network architectures and protocols – and prepares for a radical redefinition of architectures, protocols, and technologies which are truly suited for a knowledge-based society



Long-term impact on architectures& technologies, value chains & business relationships

Architectural Implications

Investigated in Detail

- IP and the optical core
- Topologies and routed networks
- Router development and IP architectures
- Issues in routing architectures
- Future applications
- The role of Ethernet