

Commercial Optical Research Roadmap

Objectives:

- Understand what technology developments will happen naturally outside of GENI.
- Overview of current research activities for optical transport, switching, and advanced networking.
- Report drivers for the research from a commercial/economic perspective.
- Describe future commercial network trends.



What Network Operators answer...

...when being asked

"What technology and/or network trends do you see on a 5+y time horizon?"

or rephrased

"What [technologies] would you like to have for your network in 5+y?":

- "Hm...difficult..."
- "If society and economy rely more and more on services – even critical services like telemedicine, homeland security, or time-critical business transactions – provided by an ubiquitous telecommunication infrastructure **the network better does not fail.**"
 - ☛ **Network resilience, [cross-layer] protection, end-to-end...**
- "Like it or not, **energy efficiency** becomes an important issue – and be it for the sole reason of cost savings."
 - ☛ **Complexity reduction, parallelization, advantage "all-optical" ...**
- "**Guaranteed data integrity** might be mandatory or at least a competitive advantage."
 - ☛ **Unaltered, unobserved, untapped... quantum communication?**



What Network Operators care...

...about when looking 5+y into the future:

- “In total the traffic growth in the core network will result in link loads exceeding the capacity of 40 Gbit/s and probably even 100 Gbit/s within the next 10 years...”
- “...with router interfaces being the foreseeable drivers for the deployment of 100 GbE systems.”
- “Due to increasing ‘on-demand services’ (video, TV), will servers become a more integral part of the network? Or should their locations at least become part of network design considerations?

☛ **“Network = edges + nodes + servers
= transmission + switching/routing + storage?”**

- More flexible mapping/adaptation of client signals
- G.709 cross-connects and OADMs
- Protection and restoration



The usual Suspects (“Drivers”)...

...but only those who've already been caught in the act – examples and trends:

- New services, more services, unpredicted services – each one demanding higher bandwidth:
 - IPTV / HDTV / HDTV video conferences*
(* recently announced by Cisco which also predicts 100-200% IP-traffic growth per year)
 - High-speed / high-definition peer-to-peer networking/services
 - Etc.
- More subscribers, higher bandwidth per subscriber:
 - Fixed: “Fiber-(closer)-to-the-Home” (FTTx, xDSL)
 - Mobile: Ubiquitous high-speed wireless access
(cellular networks, WLAN “hotspots”* using IEEE802.11, WiMAX, UMTS)
(* the “spots” won't be “spots” any longer...)
- And many more as we will learn from our colleagues from Computer Sciences:
 - High capacity mass storage systems operated by authorities, universities generate bandwidth requirements for back-ups which can easily exceed 100 Gbit/s.



Technology Integration

vs.

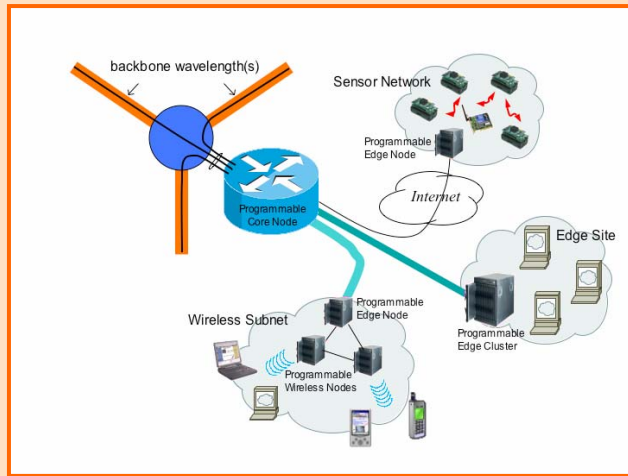
Market/Business Diversification

On the one hand various efforts suggest the integration of previously separated technologies:

- Optical/physical \leftrightarrow transport \leftrightarrow IP
- Fixed optical interconnection networks



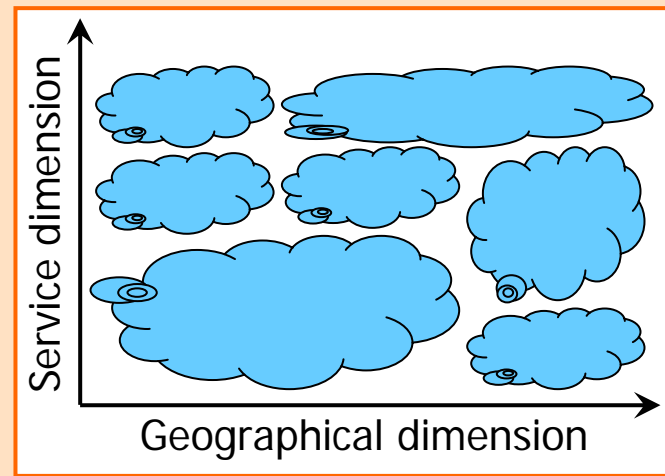
Mobile wireless access networks



On the other hand deregulation of almost all global markets leads to a broader variety of players:

- Content, service, access, transport providers
- Local, regional, national, global players
- **Not 'the' single master-planned**

network



Standardization

Standardization activities concerning 100 GbE are currently under way:

- The IEEE Higher Speed Study Group (<http://grouper.ieee.org/groups/802/3/hssg/index.html>) as well as
- the ITU-T Study Group 15 (<http://www.itu.int/ITU-T/recsaap/search/aatable.asp?varSG=15>) is working on solutions for “beyond 10 Gbit/s Ethernet.”
- However, serious efforts are still required to evaluate proposed alternatives from a scientific and technological point of view as well as from the system development and finally the economical perspective.
- In that respect, the ITU-T strengthens its efforts to include the expertise from the research community into the standardization processes.

