Where is the Internet heading to?

CHEP'2009 conference

Praha (24/3/09)

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Disclaimer

- The opinions expressed in this talk are independent of my former affiliation with CERN and do not, by any means, represent the past and/or current position of CERN.
- This presentation is derived from an article with the same title written following a presentation given at the NEC'2007 conference in September 2007 in Varna (Bulgaria)
- This article is available from: http://www.ictconsulting.ch/reports/NEC2007-OHMartin.doc

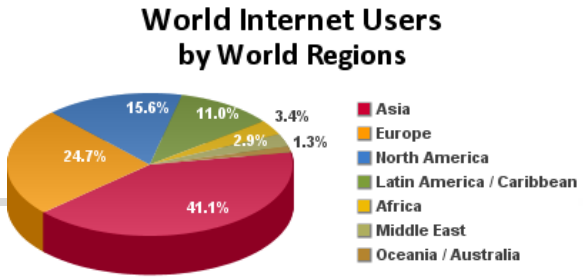
Outline

- Internet Traffic Statistics
  - Impact of P2P & Internet Video to PC
- State of the Internet
  - Research & Education
  - Commercial
- IPV6 Deployment Status & Issues
- Internet Governance
- Ongoing Internet Rescue Initiatives
  - The “clean-slate” temptation
- Conclusions

Acknowledgments

- Brian Carpenter (University of Auckland)
- Steve Goldstein (ICANN)
- Tomonori Aoyama (Keio University, NICT)
  - (ITU Kaleidoscope presentation, May 2008)

Internet World Statistics (2007)



Source: Internet World Stats - www.internetworldstats.com/stats.htm
1,581,571,589 Internet users for December 31, 2008
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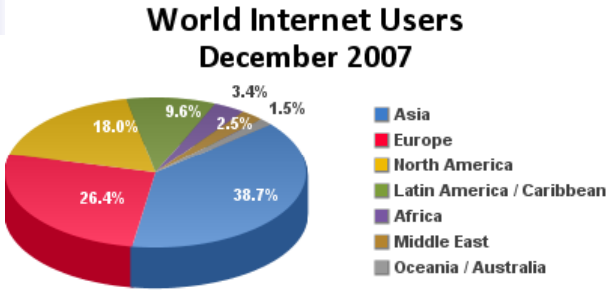

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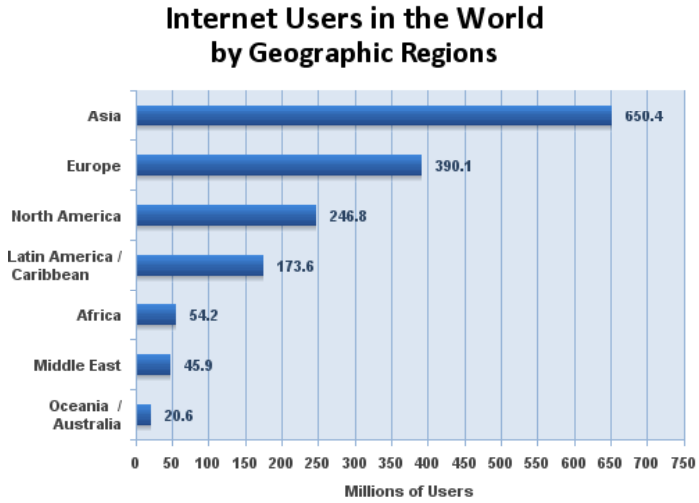

Source: Internet World Stats - www.internetworldstats.com/stats.htm
Estimated Internet users are 1,581,571,589 for year 2008
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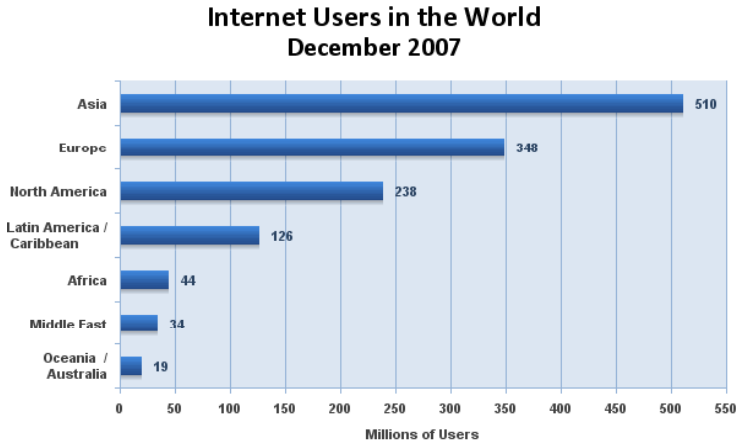
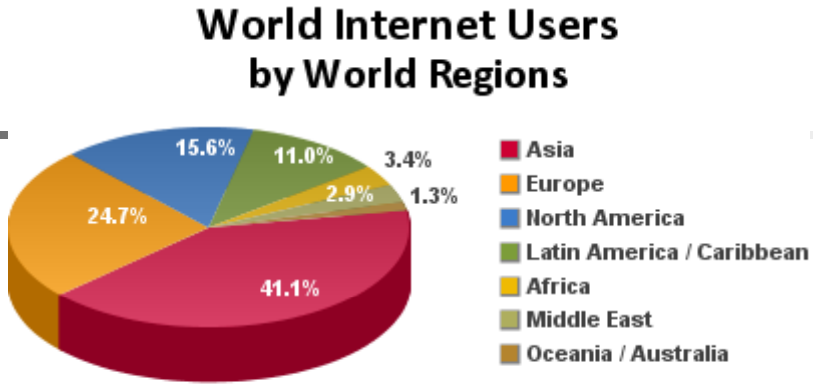


Note: Total World Internet Users estimate is 1,319,872,109 for year-end 2007
Copyright © 2008, Miniwatts Marketing Group - www.internetworldstats.com

Internet World Statistics (2008)



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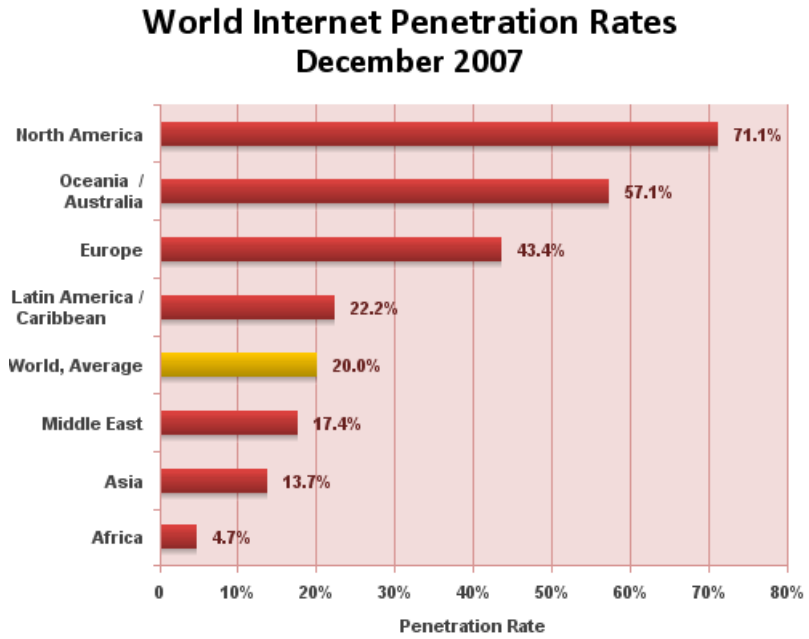

Source: www.internetworldstats.com
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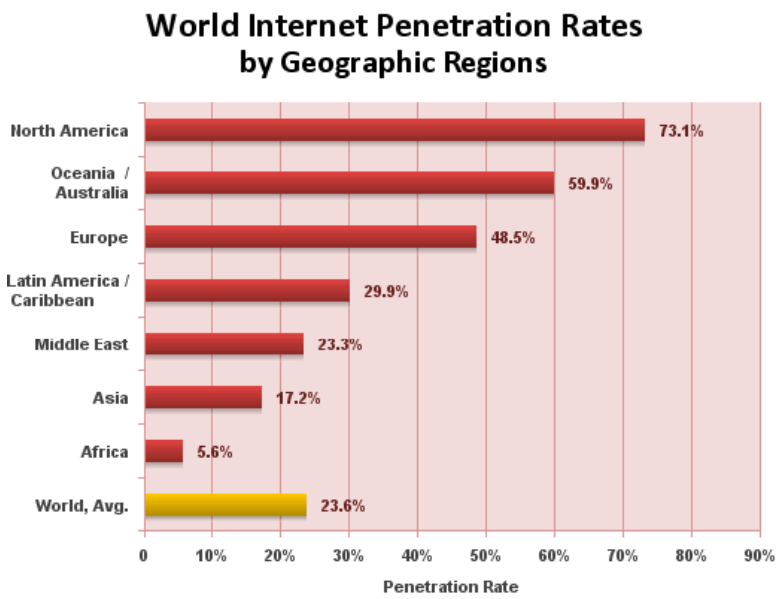

Source: Internet World Stats - www.internetworldststs.com/stats.htm
Penetration Rates are based on a world population of 6,710,029,070
for full year 2008 and 1,581,571,589 estimated Internet users.
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Internet Traffic Projections by Applications (1)

Customer Internet Traffic 2006-2012								
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**CAGR** 2007-2012
By Sub-Segment (PB per month)								
Web, email, data	509	731	1,039	1,396	1,865	2,452	3,253	35%
P2P	1,358	1,764	2,361	3,070	3,857	4,280	5,980	28%
Gaming	91	131	187	252	324	399	490	30%
Video communications	16	25	37	49	70	103	154	44%
VoIP	23	39	56	72	87	101	114	24%
Internet video to PC	269	654	1,359	2,064	3,079	4,374	6,069	56%
Internet video to TV	14	118	736	1,405	1,405	2,288	3,458	97%
Total (PB per month)								
Consumer Internet traffic	2,280	3,462	5,372	7,638	10,686	14,536	19,519	41%

Source Cisco Visual Networking Index – Forecast and Methodology 2007-2012, June 2008

Internet Traffic Projections by Region (2)

Customer Internet Traffic 2006-2012								
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**CAGR** 2007-2012
By Geography (PB per month)								
North America	605	894	1,249	1,687	2,174	2,729	3,296	30%
Western Europe	530	821	1,359	2,135	3,229	4,688	6,584	52%
Asia Pacific	890	1,374	2,207	3,044	4,182	5,618	7,653	41%
Japan	114	158	226	308	406	526	644	32%
Latin America	60	98	163	246	363	516	721	49%
Central Eastern Europe	65	91	127	178	247	341	463	38%
Middle East and Africa	15	26	41	60	86	118	159	43%
Total (PB per month)								
Consumer Internet traffic	2,280	3,462	5,372	7,638	10,686	14,536	19,519	41%

Source Cisco Visual Networking Index – Forecast and Methodology 2007-2012, June 2008

Peer-to-Peer Networking (P2P)

- The P2P technology suffers from its early pioneers, e.g. Napster, and is sometimes synonymous to: illegal distribution of copyrighted material!
- BitTorrent, eDonkey, Gnutella distribution techniques are both very impressive but also very effective, but are seen by some as a violation of basic Internet principles!
  - Files divided into chunks
  - Multiple source downloads
- Peer-2-Peer Traffic
  - Significant percentage of total Internet traffic (up to 40-50%)
  - Raises network neutrality issues (traffic throttling)
- P2P projects:
  - P2P-Next, Smoothit (EU)
  - P4P forum (USA)
- P2P standardization (very recent, i.e. 2008):
  - P2P WG (IRTF), ALTO WG (IETF))

State of the Internet

- There are really two Internets that have very little in common, namely:
  - Academic & Research Internet (GEANT & NRENs in Europe, Internet2 & NLR in the USA, etc.)
  - Commercial, also dubbed, commodity Internet
- The academic & research Internet is bandwidth-rich and is looking for solutions to not so well established requirements and/or problems!
- The commercial Internet is plagued by a number of very serious “ills” that are threatening, if not its existence, at least its long-term stability as listed below:
  - IPv4 address space exhaustion predicted to occur within the next 2 years!
  - Routing
  - Security
  - Inter-domain Quality of Service (QoS)
  - Domain Name System (DNS)

GEANT2

- Over time, an extremely impressive network construction with many good things: e.g. links to Africa, Asia, America, Black Sea (Caucasian countries), etc.
- Monopoly style organization that is too much politics driven and not enough user driven
- Price/performance ratio questionable
- The (too) strong emphasis on bandwidth on demand (BoD) is puzzling
- Degenerated from a single global pan-European backbone into multiple Mission Oriented Networks:
  - e.g. DEISA, JIVE, LHC
  - i.e. back where we were some 30 years ago with HEPnet, Decnet, NSI, MFEnet and many other networks!
- The original building assumption, back to the early 1990, "economy of scale" has become invalid:
  - The 10Gb/s bandwidth limit forced this evolution as the old rule "4 times the capacity for 1/3 to 1/2 of the price" no longer holds as pricing became linear, hence the wide adoption of "dark fibers".
  - Wide-scale commercial 40Gb/s deployment really started in 2008 (e.g. ATT, NTT)
  - 100Gb/s technology is still some years away.
- Not clear at all what the future of GEANT as a single pan-European backbone for academic & research networks is?

Commercial Internet (1)

- Commercial Internet is booming with traffic growth rates around 40% or more per year due to:
  - Peer to Peer applications & overlay networks
    - BitTorrent, CAN, Gnutella, JXTA
  - Video-on-demand, Video-sharing
  - IPTV, TriplePlay, Skype
  - Social networking & Web 2.0
  - Sophisticated Search Engines and Content Distribution Techniques

Commercial Internet (2)

- However, it is plagued by many problems:
  - Exhaustion of IPv4 address pool coming soon (see next slide)
  - No clear sign of significant IPv6 rollout raising serious doubts about the operational future of IPv6!
    - "The path of least resistance for the industry appears to be that of standardizing NATs" (Geoff Houston)
  - Routing stability and continuous growth of routing tables
  - Security
    - Spamming
    - Phishing (fraudulent activities, e.g. stealing credit card numbers, passwords)
    - Identity theft
    - DDoS (Distributed Denial of Service Attacks)
  - Lack of inter-domain QoS
    - particularly annoying for real-time applications (e.g. TV, Video, Telephony, Conferencing)
  - DNS overload
    - Often due to misconfigured servers.
    - Extension to the Internet of "Things" unthinkable?
  - Last mile bandwidth constraints, extensive use of Network Address Translators (NAT) & Firewalls

IPv4 Address Reports
(1/4/08 – 21/3/09)

- Compared to almost one year ago the prediction for the date of exhaustion of IPv4 addresses did not change (2011/2012)
- Projected IANA Unallocated Address Pool Exhaustion:
  - 03-Apr-2011 (2008)
  - 8-May-2011 (2009)
- Projected RIR Unallocated Address Pool Exhaustion:
  - 27-Jun-2012 (2008)
  - 4-Sep-2012 (2009)
- A rough estimate of the additional time provided by using the unadvertised address pool is 5-Sep-2012.
  - http://www.potaroo.net/tools/ipv4/index.html
- An IPv4 trading model has been developed by the IANA
  - Did not appear to have any effects on the deployment of IPv6!
- There are some signs that IPv6 uptake may happen in 2010?

Will IPv6 be deployed soon?

- Network World 20/3/09
  - *"Business incentives are completely lacking today for upgrading to IPv6, the next generation Internet protocol, according to a survey of network operators conducted by the Internet Society (ISOC)."*
  - http://www.isoc.org/pubs/2009-IPv6-OrgMember-Report.pdf
- Special Network World Issue 21/1/09 (sponsored by NTT)
  - IPv6: Not If, When?

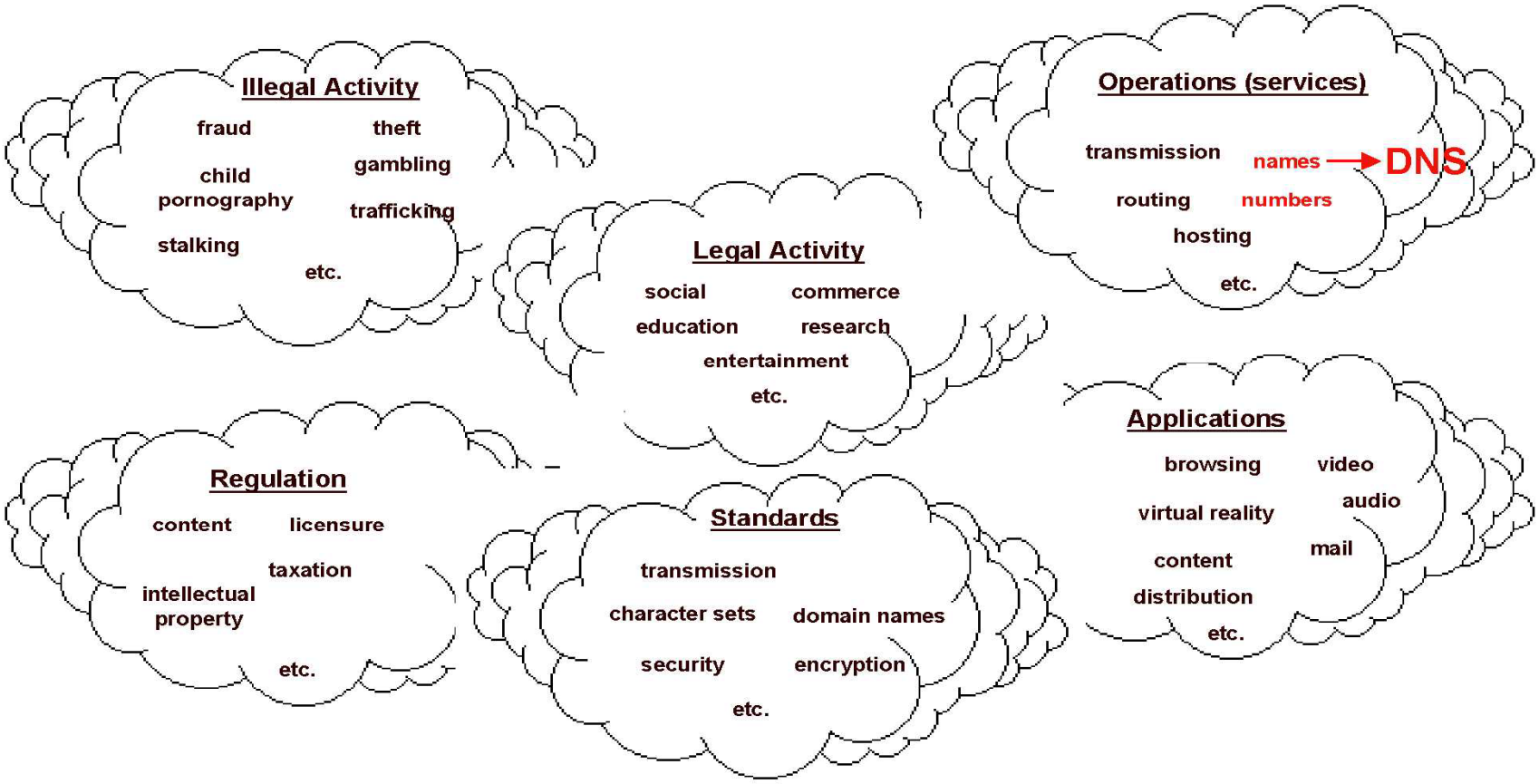
Some statements on IPv6

- Are NATs for IPv6 a necessary evil?
  - Russ Housley (IETF Chair)
    - "They are necessary for a smooth migration from IPv4 to IPv6 so that the important properties of the Internet are preserved"
    - We need to be pragmatic!
- IVI draft X. Li
  - "The experience for the IPv6 deployment in the past 10 years strongly indicate that for a successful transition, the IPv6 hosts nee to communicate with the global IPv4 networks [JJI07]"

Large scale IPv6 deployment

- For sure, IPv6 migration will NOT happen as envisaged some 10 years ago, i.e. dual stack
  - May even never happen, even so this is rather unlikely!
- Changing paradigms
  - end2end no longer a dogma
  - NATs no longer evils
  - IPv4 only<-->IPv6 only, no longer a taboo
  - Translators needed (Many competing IETF drafts):
    - SIIIT (Stateless Ip/Icmp Translation, the basis)
    - IVI (CERNET)
    - NAT64 & DNS64
    - Dual-stack lite (Comcast)
    - 6rd (6to4 revisited) –free (France)
    - NAT6 IPv6 NAT (Cisco)
    - SNAT-PT (Simplified NAT-PT

Areas of Internet Governance



Internet Governance (1)

- ICANN
  - IANA (technical)
    - IPv6 available in 6 out of the 13 root servers
  - ASO
    - Working with the RIRs to facilitate IPv6 adoption
  - IDN (Internationalized Domain Names)
    - Tests well underway for 11 non-roman Top Level Domains (TLD)
- IGF
  - Apart from the agreement on a multi-stakeholder structure, nothing very concrete has yet happened!
    - However, the annual IGF meetings attracted more than 1000 participants!

Internet Governance (2)

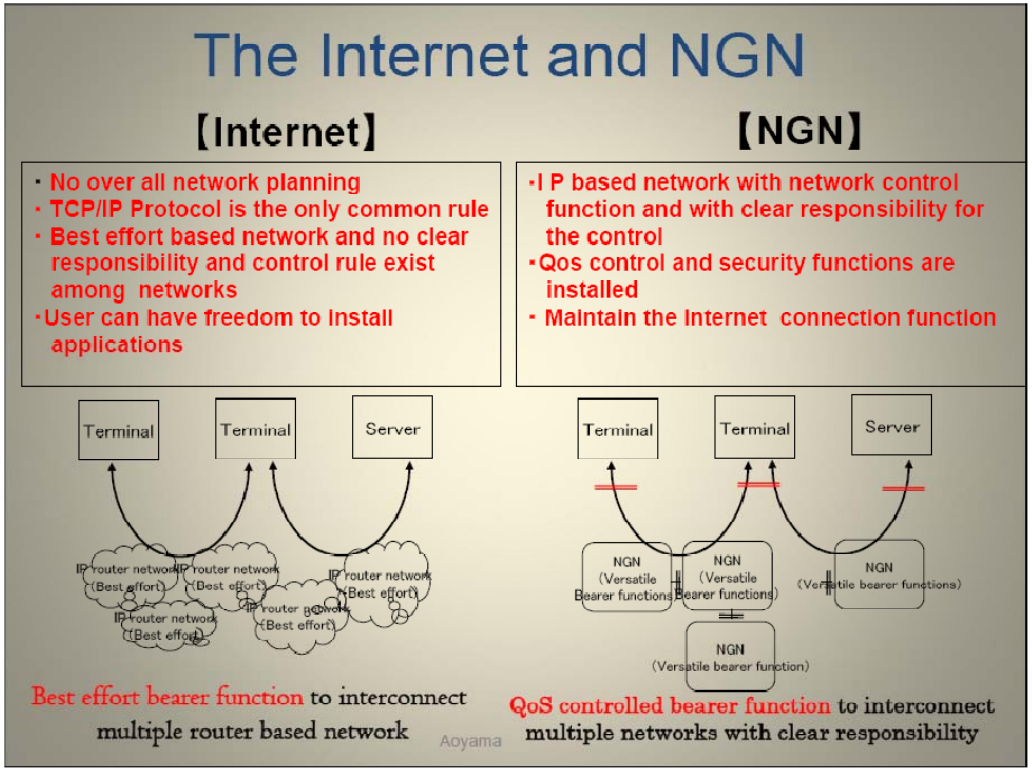
- ISOC
  - IETF
    - Although the “rough” consensus working model has been resisting quite well, it is no longer working as smoothly as before because of the many conflicting commercial interests at stake.
  - IAB
    - The guardian of the Internet orthodoxy
    - Running workshops:
      - State of the network layer (1999)
      - Routing and Addressing (2006)
      - Unwanted Traffic (2006)
- ITU’s NGN + new working group:
  - Focus Group on Future Networks (FG-FN)

Internet Governance (3)

- OECD's STI (Science, Industry & Technology) has been running a number of excellent workshops
  - The future of the Internet (2006)
  - Social & Economic Factors shaping the Future of the Internet (joint with NSF in January 2007)
    - Incremental versus clean-slate
    - NATs versus IPv6
  - Fiber investment & Policy Challenges (April 2008)
  - Ministerial meeting on the Future of the Internet Economy (Seoul, June 2008)

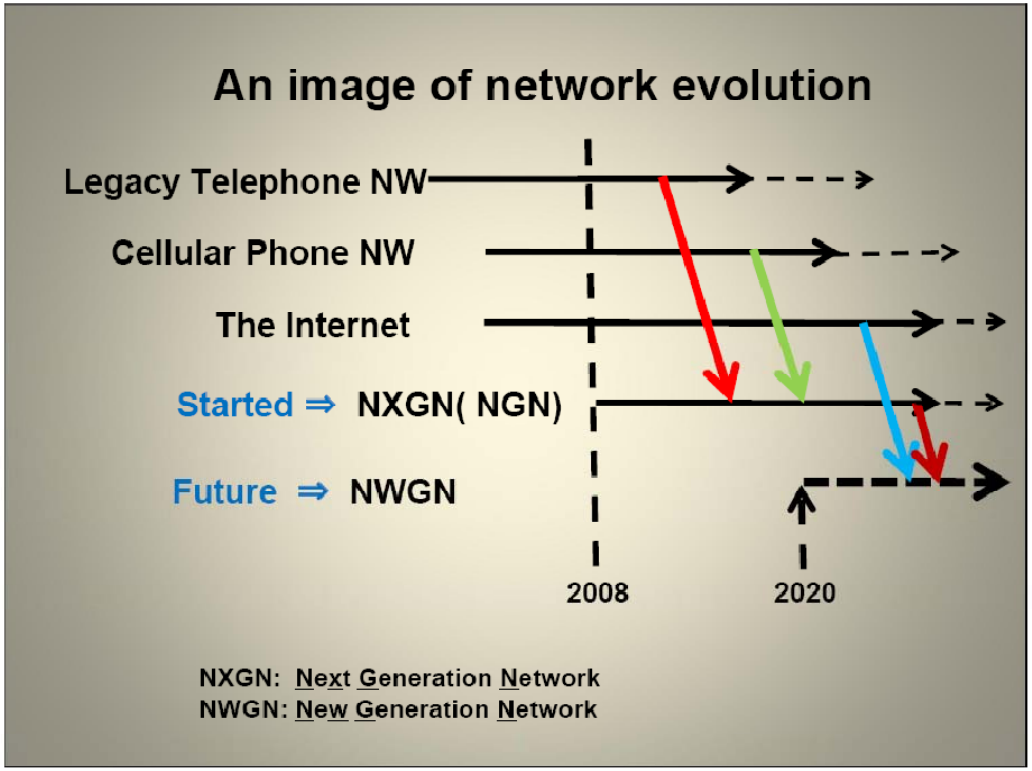
The Internet and NGN

(Tomonori Aoyama - NICT)



A New Generation Network
– Beyond NGN –

(Tomonori Aoyama - NICT)



The “clean-slate” design temptation (1)

- GENI (NSF)
  - Experimental, reconfigurable infrastructure allowing multiple slices to be allocated to different user groups to validate their new architectural proposals
  - With a comprehensive research plan
- NeTS (NSF)
  - FIND (Future Internet Design)
    - Postcatds at the Edges
    - ANR (Anycast Name Routing)
  - NOSS (Networks of Sensors Systems)
  - WN (Wireless Networks)
  - NBD (Networking Broadly Defined)
- Not clear at all which progresses have really been achieved during the last year?

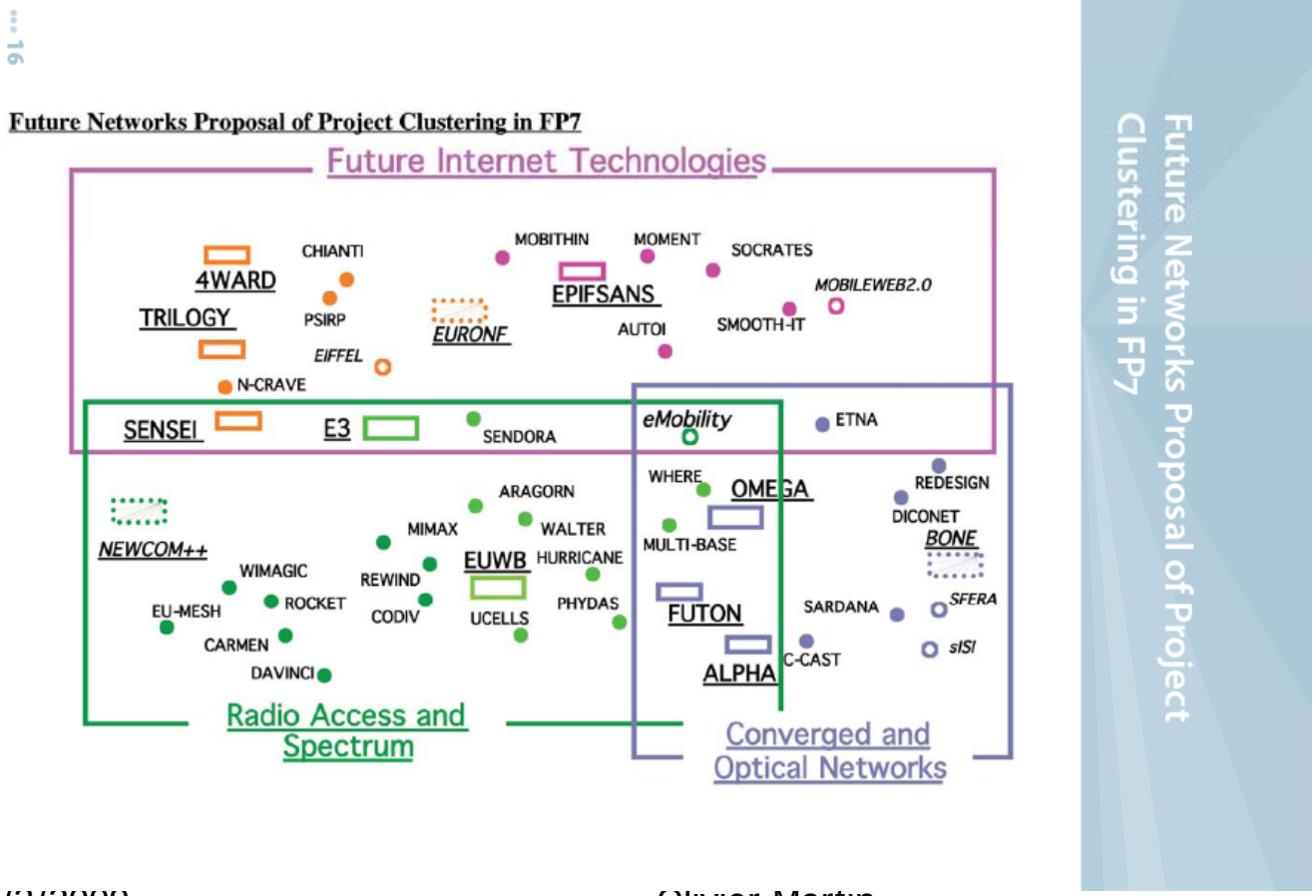
The “clean-slate” design temptation (2)

- DONA (Data Oriented Network Architecture)
  - Based on publish/subscribe paradigm, self-certifying names, similar effort in EU PSIRP project
- Stanford
  - Very little information flowing out!
- MIT’s Communication Future Program (CFP)
  - Sort of private club!
- AKARI (Japan)
- European Union (FP7)
  - Many projects
  - Very open

EU Projects

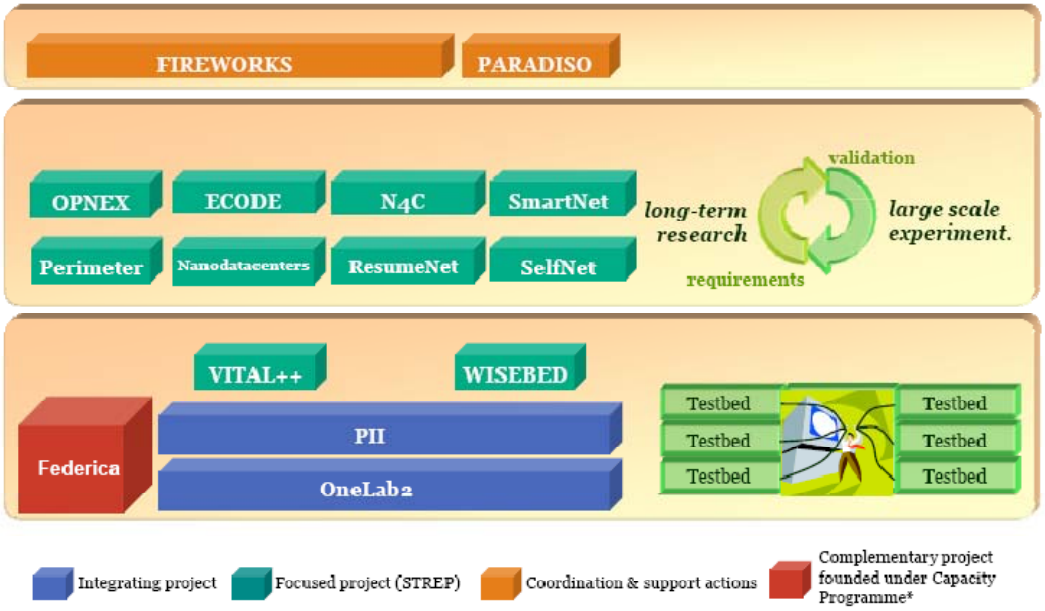
- Clean-slate
  - 4WARD (http://www.4ward-project.eu/)
    - Tenet 1: “Let 1000 networks bloom”
    - Extensive use of network virtualization, including wireless access
    - Netinf
    - Name-based routing (MDHT, LLC)
    - In-network management
    - Generic Path
    - New architecture (stratum)
  - PSIRP (http://www.psirp.org/)
    - Publish/subscribe
    - Strong collaboration with DONA (Data Oriented Network Architecture)
  - Trilogy, ANA, Ambient,….
- FIRE (Future Internet Research and Experimentation)
  - http://www.ict-fireworks.eu/
- Future Internet Assembly (FIA)
  - Started in Bled, continued in Nice, next meeting in Praha in May 2009
  - http://www.future-internet.eu/

EU's "Future Networks" Projects



Future Networks Proposal of Project Clustering in FP7

EU's Future Internet Research and Experimentation (FIRE) Projects



What the Internet may look like

- Need for, so called, Pseudo Wires well established (PWE3) as a way to provide Q0S & layer 2 services (VPN)
  - MPLS/VPLS, sort of frame based ATM, may well be the future (IETF)
  - T-MPLS (ITU), simplified version of MPLS without dynamic signaling
  - PBB-TE (802,1Qay, similar to T-MPLS but Ethernet based)
    - Based on Nortel's PBT (Provider Based Transport) i.e. an adaptation of Ethernet technology to carrier class transport networks.
- Switching in the core, routing at the edges
  - Is it not what we had with ATM yesterday and what we already have with MPLS today?
- Paradigm changing
  - Host based → Content based
- Publish/Subscribe & Content-centric architecture
  - DONA, ANR, PSIRP
  - 4WARD
- Peer-2-Peer networks (P2P)
- Content Distribution Networks
- Streaming versus P2P technology?
- Will QoS ever become real?
  - Badly needed anyway to build new business models!
  - But are customers willing to pay more?

Conclusions

- The IPv4 Internet is growing fast but cannot continue “as is” beyond 2011!
- IPv6 looks “almost” unavoidable but is by no means “guaranteed” to happen!
- Last major architecture change was the introduction of MPLS
- clean-slate solutions are unlikely to be viable before 7-15 years
  - the related work may be dangerous as it could create an even worse political delusion than the “IPv6 cures everything” delusion!
  - A gradual step-wise evolution appears to be much safer
- The instability of the Internet routing system is preoccupying as well as the increasing lack of “network neutrality”, copyright infringements, etc.

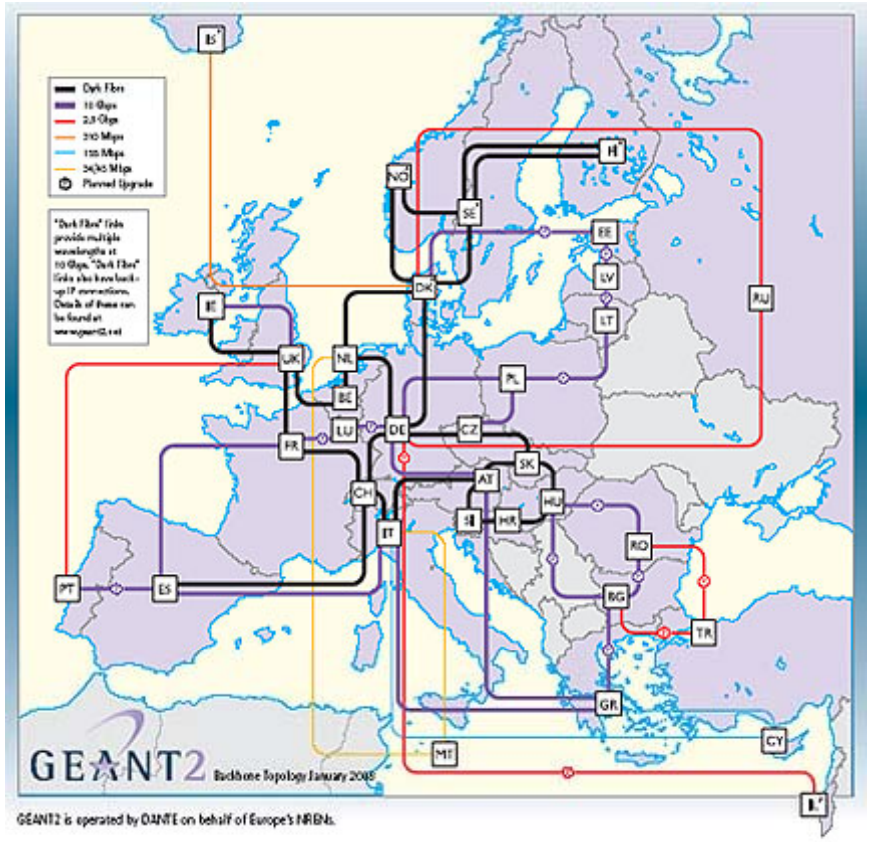
Additional slides

- EU Information Society and Media
- GEANT2 Topology
- The fallacy of bandwidth on demand
- Global Crossing converged architecture
- The Class A, B & C users in the Netherlands (Cees de Laat)

EU “Information Society and Media”

- Directorate D: “Converged Networks and Services”
  - D1: “Future Networks”
    - 4WARD, PSIRP, SmoothIT, etc.
  - D2: “Networked Media Systems”
    - P2P-Next
- Directorate F: “Emerging Technologies and Infrastructures”
  - F1 & F2: Future Emerging Technologies (FET)
  - F3: GEANT & eInfrastructure
    - Grids (EGEE, etc.)
  - F4: New Infrastructure Paradigms and Experimental Facilities
    - FIRE (Future Internet Research and Experimentation)

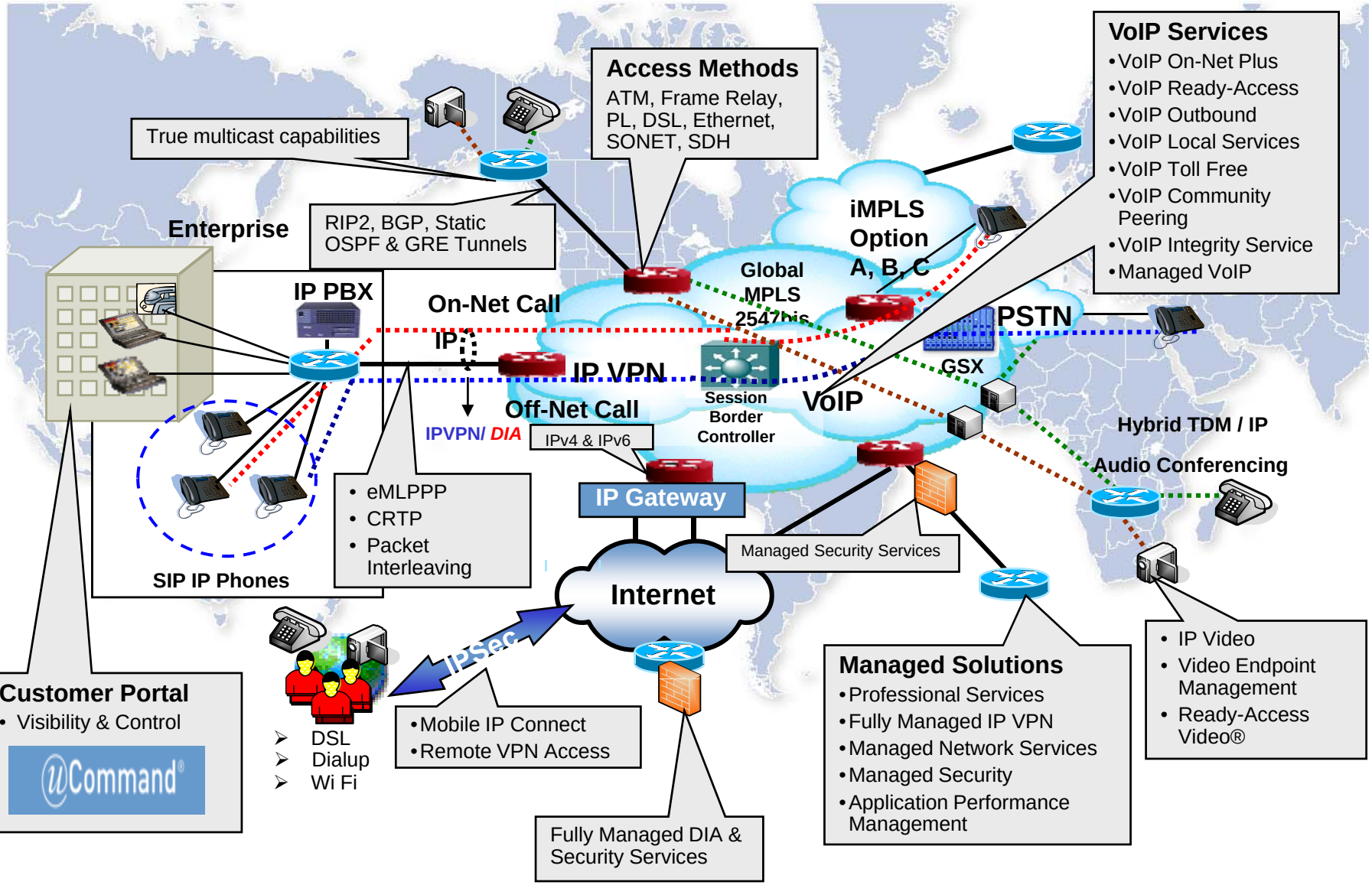
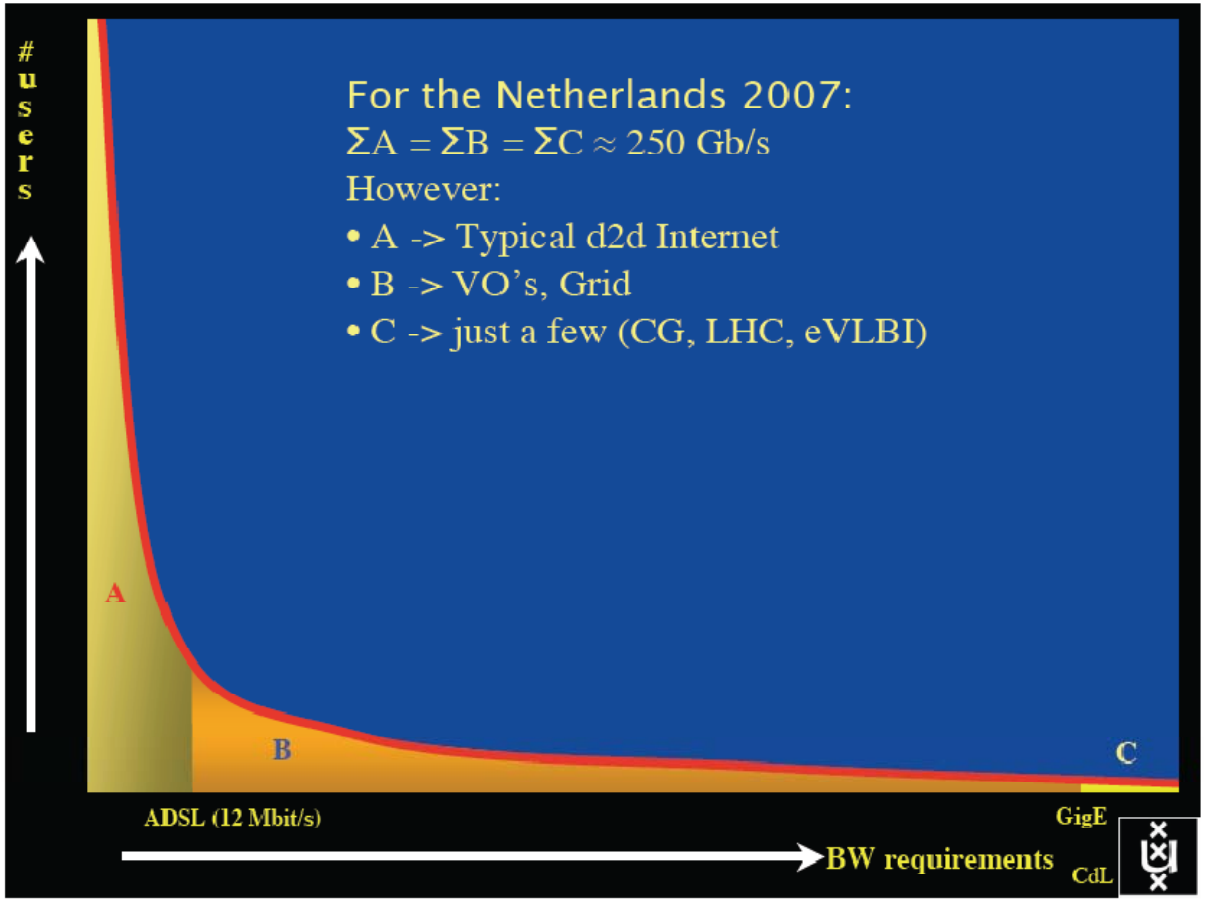
GEANT2 Topology



The fallacy of bandwidth on demand

- *"The fact is, no evidence exists yet that big science traffic volumes, or for that matter Internet traffic volumes, are growing anywhere near what was forecast, even just a few short years ago."*
- *As evidence of this lack of demand for bandwidth, one only need to look at University of Minnesota Digital Technology Center director Andrew Odlyzko's MINTS Website, which tracks traffic volume on various commercial Internet and NRENs around the world.*
- *Traffic volume growth rates on R&E networks have declined significantly over the past decade. For example, Internet2's annual growth is less than 7 percent per year, whereas commercial networks growth rates vary from 25-50 percent per year.*

Global Crossing's converged IP network architecture – one network, any service



A/B/C User Categories (courtesy of Cees de Laat)