Network Research Infrastructure: Back to the Future

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"Research is what I am doing when I don't know what I am doing."

Werhner von Braun
Evolution of Networks

- 1st the Earth cooled
- then we had Dinosaurs
- then we had oil
- then we had Mercedes Benz
- then we had ENIAC
- then we had ARPAnet
- then we had research networks (NSFNET, SURFnet, ESnet,…)
- then we had NGI
- then we had “THE Internet”, BMWs, and IPOs
- then we had the technology market bubble burst
- then the earth cooled – again - or did it?
Evolution of Networks – really

• ARPAnet
• NSFNET/JANET/SURFNET/SINET/ESnet/etc.
• NSFNET II - NAPs, vBNS, ... (circa 1992) - peering & network mgmt R&D
  ➢ Commercialized Internet
• Gigabit testbeds (circa 1992-95) - optics R&D and ATM
• WEB takes off (circa 1994)
• I-WAY (circa 1995) – 1st temporary “GRID”
• Internet2/NGI – Deja vu all over again ala NSFNET (circa 1996)
• Middleware / Globus / GRIDs (circa late 1990s)
• E-Presence / Ubiquitous computing / Nano technologies / PDAs / wireless - all Chaos agents changing way we work and live
• Concurrent network research & production networks (e.g. NLR, CENIC) & GRIDs – idea from 1997 MORPHNET
Network Research Trends

- Intelligent Networks (not just Speed & Feeds)
- Dark Fiber & Waves
- VPNS & Tunneling
- Security, High availability, resiliency
- End to End Capabilities (core is least of our worries)
  - Host, Campus, PAN, LAN, MAN, WAN
- Next Generation TCP & Congestion control
  - E.g. FAST, XCP, HS-TCP, RDMA, etc.
- Convergence of Application, middleware and networks
- Network Research Infrastructures (e.g. NLR)
Intelligent Networks

- Network management
- Dynamic provisioning
- VPNS & Tunnels
- Signaling and control
- QoS
- Policy
- Content and Path optimization
- Security
- Adaptive and agile networks
GGF Network R&D WG

- Congestion Control & scaling of IP & TCP
- Routing: packet size vs TCP scaling
- Multicast
- OSes (end system, kernels, memory copies)
- Light vs heavy weight protocols (e.g., PDA)
- Macroscopic traffic and System considerations
Industry and Researcher Collaboration Opportunities

• All of the prior mentioned network trends provide ample opportunities for REAL Industry and R&E&D collaboration;

• BUT
We Need a New Model for Industry-R&E Collaboration

• Ask not what your industry partner can do for you, rather ask what you can do for your Industry Partner

• It’s the relationship developed not the cheap or free HW & SW which is a value in the future
Technology Transfer & Industry Collaboration MYTH

- The Vast majority of research is never transferred to Industry or commercialized
- Industry collaborators should be more than names proposals
- “Submarine Truths”
  - R&D will develop niche markets which Industry won’t pursue due to lack of markets
  - so Government and R&D community needs to belly up to the bar and pay for it – don’t pass off as TECH XFER
Need New Model of Industry-R&E Relationship

• Quit looking to Industry as cash cows to just fund lunches, conferences, etc.
• Quit asking for free HW and SW
• Look for real partnerships
  - Put real $ on table – pay for somethings – Industry will meet you halfway
  - No AUP – get real industry involved at all layers
  - Adopt real joint research and production infrastructure
    - No Pain No Gain – ie. cannot claim its cutting research when its based on 99.999% up time!
    - Real joint R&D will benefit both Industry and R&D

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CalIREN-2 : Design Methodology

Tier 1 – Commodity Internet
- High Availability
- Aggregated Connectivity
- NxGE, OC-12, OC-48

Tier 2 – High Performance Research
- Research Apps, low latency, GRID
- Advanced Services IPv6, QoS, IPMc
- 10GE, Shared Waves

Tier 3 – Experimental/Developmental
- Bleeding edge services
- Dedicated Waves
- Dynamic λ Provisioning
- 10G, 40G, OC-768
- Network Playground
- Unknown Services

CalIREN

• Fix
• Break and Fix
• Break and Break

XD

HPR

DCP
## NLR networking research use vs. production (aka MORPHNET) – NO AUP!

<table>
<thead>
<tr>
<th>Infrastructure Use</th>
<th>NLR operated</th>
<th>NLR or its production customer or researcher operated</th>
<th>Research use</th>
<th>Production use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production IP service (Cisco COTS routers) - 10GE and 1GE ports</strong></td>
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<tr>
<td><strong>Production Ethernet service (Cisco COTS switches) - 1GE ports</strong></td>
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<tr>
<td><strong>Production point-to-point wave service (Cisco COTS DWDM gear) - 10GE, 1GE, OC192 and OC48 waves</strong></td>
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<tr>
<td><strong>Production fiber (1st pair)</strong></td>
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<td><strong>Production fiber (2nd pair)</strong></td>
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</tbody>
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- Research based on measurements of real user Internet traffic (and not just uni-to-univ traffic) and visibility into Internet BGP for the first time since NSFnet
- Production use for higher ed and K-12
- AUP-free commodity Internet access and inter-GigaPoP transit backup
- Research needing its own L2 links with the capability to do complex topologies but where speed is not the primary focus and 1GE or lower ports are sufficient, e.g., multicast routing
- Production use for cases where shared IP service is not acceptable but also dedicated 10G waves not needed either, e.g., remote instrument control
- Research needing its own L1 links and/or dedicated 10G bandwidth, e.g., very large MTU performance, XTP implementation
- Production use of dedicated (multiple) 10G bandwidth, e.g., DTF/ETF cluster supercomputers "backplane" interconnect, federal agency mission use, international connections transit
- Research needing its own dark fiber full spectrum and/or deployment of breakable L1 gear, e.g., optical packet switching, IP-optics unified control plane, 10GE optics

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Summary

- Application and Network research were coupled on the ARPANET and NSFNET

- WEB grew as result of Application requirements and the existence of a transparently connected network research infrastructure

- Need to go back to the Future and do this again
  - This will only occur when we see a real partnership between Industry and R&D community that goes beyond just getting free HW/SW
  - Programs need to budget accordingly for Networks and other infrastructure and people
OK, Stranger...
What's the circumference of the Earth?..Who
wrote "The Odyssey" and "The Iliad"?..What's
the average rainfall of the Amazon Basin?

Bob, you fool! You can't shoot first and ask
questions later!