The Future (Inter)Network

Challenges and Paradigms

Lawrence H. Landweber
University of Wisconsin

EuroView 2010
Wuerzburg, Germany
August 2, 2010

The Internet Today

- Technologies: **wireless/mobility, cable, optical**, sensors, virtualization, **data centers, clouds**
- Societal: cultural/legal diversity, **privacy**, neutrality, content, censorship, political
- Security/spam
- Social networking
- Address space / routing protocols: IP(v6), BGP
- Scaling / quality of service / app support
- Large-scale research testbeds
- A world-wide client/server system?
- End-end bandwidth is an issue!

Technology Trends: Wireless

- 4G ITU standard – 2011-13 (LTE,WiMax)
- Mobile 100Mbit/s, Stationary 1Gbit/s

- 5G – 2020?
- Details TBD by research
- >1Gbit/s up and down
- Global wireless environment with service(s) equivalent to wired world – pervasive - available everywhere
- Wearable devices with AI capabilities
- Base stations no longer required – fully ad-hoc
- Cognitive radio technology
- IPv6?

Technology Trends: End Point - Wired

- Cable Modem: DOCSIS 3.0 - Data Over Cable Service Interface Specification
  - US – 38/27 Mbit/s down/up per channel (6Mhz)
  - Europe – 50/27 Mbit/s down/up per channel (8Mhz)
  - Multiple data channels to home so >100Mbit/s
  - Typical configuration – fiber to neighborhood
  - IPv6 support
- Fiber: Examples US
  - Verizon FIOS - FTTH - 50/25Mbit/s down/up
  - ATT U-Verse – FTTN/DSL – 24/3 Mbit/s down/up

Next Generation Fiber Optic Systems – 100Gbit/s

- Fit 100 Gbit/s in same 50GHz optical channel as 10 Gbit/s
- Limited transmission reach - no ocean-spanning submarine cables
  - Nortel - 40 Gbit/s for submarine applications
- Issues
  - 100 Gbit/s hardware costs ~10x more than 10 Gbit/s systems
  - Use on backbone where more capacity needed to avoid new fiber
  - Lower cost needed to make 100 Gbit/s attractive for routes with adequate capacity
- Cienna/Nortel (8.8Tbit/s? with DWDM), Alcatel-Lucent, etc
- Future: Data rates above 400 Gbit/s in a 50 GHz channel.

Data Centers

- 10s-100s of thousands of servers plus peta-exa bytes of storage
- High speed, low latency interconnect (e.g., FC, 10Gb Ethernet)
- Example: Apple – 500K sq. ft. – North Carolina
- Initially metro areas, now near power sources – hydroelectric, gas/oil, biomass
- Data center electricity consumption – today 1-2% of US total

Technology Challenges – Data Centers

- One cow = 100 watt bulb, 10K cows = Megawatt data center

Cloud Computing

- Offload data and processing to commercial data centers
- Virtualized storage / computation resources
- Reinvention of 1970/80s service bureau (IBM Service Bureau Corp.) + virtualization and WAN, LAN, SAN advances
- Non-technical OPEN PROBLEMS
  - Liability in case of failures or loss
  - Ownership of data – e.g., if operator sells or discontinues business
  - Access to data by third parties – e.g., law enforcement or government
  - Cross border data flow and storage – whose laws
  - Privacy, security of data

Privacy

- Individuals have control over access to their personal data
- Cultural differences wrt definition
- But what should be included?
  - Medical/genetic
  - Financial – tax, credit card, bank, investment
  - School
  - Marital
  - Legal / law enforcement
  - Biometric data

Privacy – Already Lost?

- Ubiquitous cameras – Orwell "1984" (1949) – "Big Brother"

The telescreen received and transmitted simultaneously. Any sound that Winston made above a whisper would be picked up by it. …There was of course no way of knowing whether you were being watched at any given moment. How often or on what system, the Thought Police plugged in on any individual wire was guesswork.

  - CCTV - UK 1.5M - 4.2M cameras
  - Computers – HS students lap-top computer
- Searches / cookies / downloads / "free" email
- Location - cell phones – gps – credit card purchases
- Social networking – Facebook, MySpace, Twitter, YouTube
- NOTHING EVER FORGOTTEN!

Privacy – But who Cares?

- Bargains for data!
- Gowalla, Foursquare – tracking (checking in) allowed in exchange for discounts at Starbucks, etc, keep track of friends
- Mint (Intuit) – financial management software, discount from banks or cable in exchange for personal financial data (bank, credit card)
- Bluefly – retailer, e.g., sunglass offers to bathing suit purchaser
- WeShop - access to email to scan for purchases – made available to merchants who send offers
- Bynamite – sell access to your web profile for profit

Security Challenges

- Spam ~90% Email in 2010 (Symantec)
- Attacks: DoS, Virus, Worm, IP Spoofing, DNS, Phishing, Key Logger, etc
- Authentication /Identity Management
- Encryption
- Need better software and defenses – host, network –

OPEN RESEARCH PROBLEM

Social Networking

- Facebook, MySpace, Linkedin, Twitter, YouTube, Geni, Texting plus many many more
- Facebook claims to soon have .5B users
- Will we interact / communicate in fundamentally different way?
- How will society be different in 10-20 years as a result of social media?

OPEN RESEARCH PROBLEM

The Known World - 2020

- Packet Switching: IPv6, BGP, Layer 2 (VLAN, Ethernet, MPLS, OpenFlow)
- Bandwidth / switching not be an issue in backbone or endpoints
- Pervasive wireless mobile systems
- Enterprise Data Centers, virtualization, Cloud Computing
- Ubiquitous information utility accessible from anywhere
- Harvest ambient radio waves – sensors, etc - Powercast
- 3D virtual reality with natural language voice recognition an integral component of many applications

The Less Known World - 2020

- Social networking will fundamentally change how people interact and communicate – HOW?
- The definition of Privacy will fundamentally change - NEW NORMS?
- Reach will extend beyond developed world - HOW?
- Security – PROBLEMS SOLVED?
- New paradigms – UNPREDICTABLE!

The Future World – 2030

- What is the next PARADIGM?
  - Can new paradigms be predicted?
  - Can today's experimental systems be used to invent a new paradigm?
  - How does one recognize a new paradigm?
- Architecture
  - IP will be largely forgotten (XXX, SNA, DecNet)?
  - Layer 2, Circuit switching, packets? Other?
  - Data centric or object oriented network?
  - Humans as network cyber-nodes?
  - Everything integrated with everything?
- An exciting, free entrepreneurial new world or a 1984/Brave New World?

Larry Landweber
lhl@cs.wisc.edu