Trends and Needs in Networking Research

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Outline

• Review: CSTB 2001 Report
• Broad Categories for Networking Research
  – My Personal View
• Trends
• Some Historical Examples
• Needs
CSTB2001 Report

“Looking Over the Fence at Networks: A Neighbor’s View of Networking Research”

- By Computer Science & Telecommunications Board (CSTB), National Research Council of US
- Addresses Three Broad Areas

CSTB 2001 report: First Area

- Measuring: Understanding the Internet Artifact
  - Challenge of Scale
    - How to infer based on incomplete knowledge of configuration
    - How to soundly sample network traffic, and validity of sampling approach
  - Measurement Infrastructure
    - Deployment and operational challenges
  - Nontechnical factors
    - Compose of production commercial systems
      - E.g., Confidentiality and privacy of data
CSTB 2001 Report: Second Area

- Modeling: New Theory for Networking
  - Performance:
    - E.g., What sort of change in the scale and traffic pattern lead to a performance meltdown?
    - Theoretical foundations in flow-level modeling, aggregation/deaggregation, micro/macro level interaction
  - Beyond Performance:
    - Concern for manageability, reliability, robustness, and evolvability—new basic understanding and theory
  - Applying Theoretical Techniques to Networking
    - Understand convergence properties
    - New routing algorithms taking real-world constraints (e.g., absence of complete information)

CSTB 2001 Report: Third Area

- Making disruptive prototypes ("Innovator’s Dilemma")
- "A Disruptive technology can do a few things very well but may not do some very well compared to present technology"
  - Example, RISC architecture (from computer architecture world)
- Developing “disruptive” prototypes that challenge the current Internet
  - E.g. Where should the intelligence in the network reside?
Trouble with Success (CSTB 2001 Report)

**os·si·fi·ca·tion**: The process of becoming set in a rigidly conventional pattern, as of behavior, habits, or beliefs (American Heritage Dictionary)

- Intellectual ossification
  - E.g., it’s not TCP!
- Infrastructure ossification
  - What researchers want may not be deployed in a commercial network (e.g., limited multicast deployment, QoS)
- System ossification
  - Research results judged based on how hard it is to deploy on the Internet

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CSTB2001 Report

- To Summarize
  - Almost five years old!
  - Very well done
  - However, covers networking research to be essentially Internet oriented/related
- What’s Missing?
  - Telephone networking
  - Satellite networking
  - Wireless networking
  - Optical networking
  - Delivery networks (e.g., Cable Networks)
  - Interaction of different networks
  - Network security
  - …
Network Research: My Personal View (2 cents)

• Two Broad Categories:
  – Current networks & related research
  – To imagine future networks/services & related research

• Influence of External/"Overnight" Factors

Current Networks-Related Research

• How to measure/model behavior
• Driven by limitations
• How to “improve”
  – Due to scalability issues, operational problems
  – Traffic engineering
  – Network reconfigurability
Research Trends: Current Networks-related: A Few Examples

- Scalability (in every way thinkable! – routing table lookup, network models, …)
- Internet measurement, sampling
  - Backbone Networks
  - Access Networks
- Protocol extensibility
- Routing: BGP, inter-network traffic engineering
- Impact of number portability
- Integration of IP networks and telephone networks

Future Networking or Services: Research, Technology Concepts & Development

- Some Recent Examples: (~last 20 years)
- Networks:
  - Cellular networks, ATM, MPLS, Optical networking
- Services:
  - 800-number services, WWW, P2P, IM, text messaging
- Associated protocol development, modeling, routing, security, …
- May or may not be commercially successful
Research Trend: “Future” Networks/Services and related research

- Networks/Services:
  - GMPLS
  - Sensor Networks
  - Software Radio
  - 3G/3.5G/4G Networks
  - Service Concept Development
    - IP Multimedia Service
  - Secure Group Communication

Faces issues such as MAC protocol, performance modeling, security as built-in feature, protocol development, performance etc.

External/’Overnight’ Factor

- Something an architecture wasn’t originally intended for, but is forced to handle
What’s next?

• “Overnight” problems
  – To discuss a few historical examples (network-related)
• Relation to current network-related research and future-network related research
• Where NEEDs are

Telephone Switch Overload

• Bruce Springsteen Concert (~1985) – ticket on sales
  – The end-office switch (which was designed for 500,000 calls) received 10 million calls in a 24 hour period!
  – Network became nonfunctional!
• Led to development of new network management controls principles
Limitation of Hierarchical Routing in Telephone Network

- Led to development of dynamic routing (80’s)
- To note:
  - Dynamism is good, but if not handled properly bistability can occur
  - Need for trunk reservation, and when to use restrictive routing, when to use expansive routing

Deployment of Fiber Optics (mid/late 80’s)

- Transport network became too “thin”
- How do you provide survivability
  - Traditional reliability definition wasn’t applicable any more
- Impact on service networks (.e.g. telephone networks, IP networks)
  - 1:N, 1:1 protection switching
  - Need for multi-layered network design for survivability
TCP “Collapse”

- TCP throughput drop (1986)

- Led to new congestion control/timer adjustment approach
  - Key here is on understanding the dynamics
    - Sliding-window, window-adjustment, timer-adjustment, sampling, …

Denial of Service (DoS) Attacks

- Network functionality allowed the possibility for DoS attack
  - First “wave”: Web-server oriented
  - Next “wave”: network impact (e.g. code-red virus)

- Follow-up Research
  - TCP ‘accept queue’, OS implementation etc
  - Source-oriented (‘stop close to the source’)
  - Router-level research: IPprefix lookup
  - …
• Dynamic approach is better than static approach
  – However, dynamism may have pitfalls
    • They must be addressed adequately

• Is dynamism always needed?

Consider IP Network Traffic Engineering

• OSPF/IS-IS: dynamic routing protocol
• Problem: determine link weights in OSPF/IS-IS networks
• However “dynamic” link weight setting/change is discouraged
  – May result in too much traffic shuffling and implied congestion

That is, “dynamism” may not always be good
(at least from an operational point of view)
Needs in Networking Research

- Recap:
  - Current networks-related research
  - Future networks/services-related research
  - External factor that drives research (often for current networks; however, principles might be useful for “future” networks)

- Needs:
  - To highlight a few examples

Needs in Networking Research

- Understanding and Development of Mechanisms for Handling Diverse Networking Interactions
  - To give a few examples (next few slides)

- New Network Communication Mode?
Broadband Access Technology and Service Dynamics

- Broadband access Technology (DSL, Cable Modem) designed for “web” model
  - Lot of download bandwidth
  - Not much upstream bandwidth
- Challenge faced (last few years)
  - P2P services: Napster, …
  - VoIP services

Broadband Access Technology and Service Dynamics (cont’d)

- Can we design an access mechanism that is dynamically adjustable between upstream and downstream
  - Time-Division Duplexing (TDD)? Others?
  - Require solid knowledge of physical, data link, and transport layer?
- Questions:
  - How well will the dynamics work?
  - How does it impact service behavior? Where is the trade-off?
  - Are there possible pitfalls due to dynamism? And How to handle them?
    - (recall: lesson learned from Telephone dynamic routing, TCP congestion, …)
Core Network Interactions: Multi-Layer Networking Dynamics

- If IP layer link setting is dynamically adjustable to address for failure
- If optical networking handles its own dynamic routing (GMPLS)
  - Good for each network, may not be good together?
    - Can the inter-related network go into tailspin?
  - How does ‘DoS’ attack based ‘increase’ in network traffic impact dynamic adjustability?
  - How do we know good from bad traffic (e.g., a new P2P product popularity, or a new DoS attack)?

Need for Medium-Term “Thinking Ahead” Research: Possible Operational Problems

- Historically, we haven’t. Examples:
  - TCP was developed/deployed first in 1981
    - TCP “collapse” identified and improvement in 1986 (and many since then)
  - BGP4, 1994
    - Operational problems/issues identified late 90’s
  - …
- Question:
  - Can we “see” ahead of time what’s out there that needs “help”
    - For example, protocol interaction in IP multimedia services!
      Volumes of signalling messages!
Finally, at a Fundamental Level

- Is there a ‘new’ network communication mode out there?
- Consider time spacing:
  + Between Telegraphy and Telephony: ~50 years
  + Between Telephone and Internet: ~100 years
  + Between Internet and ??
    - Will everything now onward be “incremental”? 
    - Will we get trapped in ossification?