Report from the End-to-End Research Group

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Outline

- What is the End-to-End Research Group?
- Report on a discussion at the E2E RG meeting of January, 2005

The E2E RG

- Existed since 1984
- Chaired by Bob Braden until Nov. 2005
- About 15-20 members (limited)
- Rotating membership
- Meets 2-3 times a year for 1.5 days
- Normally invite some number of others to attend meetings.

- Focus on E2E services and protocols
- Forum for exchange of ideas
- E2E interest list (supported by the Postel Center)
- Sample topics:
  - Transactions (VMTP, SUN RPC, etc)
  - Multicast
  - TCP congestion control
  - Integrated Services
  - New Architectures

The topic of the meeting: Framing the discussion

- Question posed: "*How might the computing and communications world be materially different in 10 to 15 years, and how might we define a research agenda that would get us to that world?*"
- Implies a *vision* of the future Internet
  - The *conception* of the future
  - The *technical approach* to getting there
- Concentrated on the first

10 Visions

1. The influence of increased technology at the edges
2. Universal location system
3. Security architecture
4. Operation in times of crisis
5. Anti-scale: small networks
6. Quantum computing
7. The limitations of the control/data plane dichotomy
8. Physical device presence in cyberspace
9. Reduction of the energy cost of communication
10. The software radio revolution

Computing at the edges

- Trends
  - Applications (mostly) at the edges
  - New, smaller, user interface devices at the edges
  - Much of the economic incentive at the edges
  - 95% or more of processors manufactured do NOT go into “computers”, but in potential edge devices
- Vision: A low cost, open infrastructure suited for communication with low-cost computing devices such as sensors and controllers.

Anti-Scale: Small networks

- Trends
  - Over last 25 yrs, one common thread: seamless scaling over increasing distances and numbers of devices, but…
  - Bluetooth (and others): limited, low-power, low-overhead, increasingly prevalent
  - Demise of the backplane: blurring between very local network and backplane
  - Sandwiching optical or wireless devices on CMOS: imagine information between chips on a card carried by optically or wirelessly, moving termination of network into the center of the chip
- Vision: An architecture to support dozens or hundreds of chips sized devices with price-performance ranging from very low cost to very high bandwidth.

Assume Quantum Computing

- Trend (situation)
  - Not there now, but making progress
  - How do quantum computers communicate: work in qubits, not (binary) bits
    - Are they exchanged?
    - By what technology communicated, since digital technology would destroy their multi-state nature?
    - Do we need qubit routers?
    - How do we interface between qubit and binary bit transmission?
  - Effect on network security: very good at prime factorization: consider effects on numbers and kinds of keys, life-time of keys, etc.
- Vision: In 10 yrs., be prepared for communicating quantum computers, both in terms of communication and security.

Software Radios

- Trends
  - Make all aspects of wireless communication “programmable” including encoding, frequency usage, energy used, media used, etc.
  - Receiver can examine spectrum for utilization to lead to opportunistic use of spectrum
  - New approaches to underlaying encoding on existing used spectrum, without effecting current use
- Vision: In 10 yrs, working SR systems demonstrating revolutionary use and management of spectrum. Demonstration of highly efficient use (and reuse) of spectrum and establishment of a regulatory regime that permits these modes of operation.

Take away (my 2 cents)

- List of topics incomplete. What are your visions?
- What do we do with the visions? Pick one or some
  - Evaluate what is required architecturally
  - Determine what is required technically, and address those things not currently available.
- Propose and explore new architectural features required to enable your vision.
- With value and feasibility explored, consider how to get from here to there.

The paper

Making the World (of Communications) a Different World, Clark, Partridge, Braden, Davie, Floyd, Jacobson, Katabi, Minshall, Ramakrishnan, Roscoe, Stoica, Wroclawski, Zhang, **ACM SIGCOMM CCR 35**(2), July, 2005, pp. 91-96.