On Distributed Communication Networks [Baran64]

- What is the problem that Baran is trying to solve?
  - Create a network that survives massive attack
    - This is the Cold War

- Background
  - Telephone Network: Increase the network reliability by increasing the reliability of individual components

- What is the metric used?
  - Percentage of hosts surviving the attack and stay connected to the largest group of surviving nodes?

Types of Networks

- Which network is more vulnerable?
  - Centralized: Take out central node and node is disconnected
    - Single Point of Failure

- Question answered in this paper:
  - What is the level of vulnerability or robustness of distributed networks

- How to characterize distributed networks?
  - Redundancy Level
**Redundancy Level**

- Network with minimum number of links has R=1
- For R >= 3 can have multiple equivalent ways to construct the network

**Survivability under random attack**

- R=3 produces good results
- Choice of degree depends on expected attack level

**Survivability as a function of node reliability**

- With R=3 even 50% of the links can fail

**Combination of link and node destruction**


The benefit of dynamic routing

- What if we could pre-compute diverse paths?
  - Dynamic routing is again superior

On Future Systems

- The ability to have a large network with dense connectivity is more important than individual component reliability
- [Baran64] also introduces:
  - Packets
  - Dynamic Routing techniques
    - Hot Potato Routing
      - Similar to learning algorithm using by Ethernet switches

Paper extensions

- What else would you like to see?
  - 1.
  - 2.
  - 3.

- What does the Internet today look like?
  - Will come back to this question later
  - How can you find out?

[CK74] A Protocol for Packet Network Intercommunication

- This is the pre-Internet era
  - ARPAnet was created to share computer resources
  - ARPAnet was one of the first packet networks
    - Cyclades
- How do you connect different packet networks?
Network Abstraction
- Network contains hosts and packet switches
- Network Operation
  - Processes on host communicate with each other using app-level protocol
  - First paper advocating the separation of TCP from IP
  - Send packets to the network
  - Switches route packet according to address

Differences among Packet Networks
- Addressing
- Packet sizes
- Services offered by the network
  - Reliability
  - Error conditions are expressed differently

Gateway
- Entity that transforms data units crossing network boundaries
- Implemented as two halves
  - Each half can "speak" the local network language
- What is needed to exchange information among different networks
  - Global Address
  - Mechanism to map address in other network to gateway

Packet Encapsulation
- Local Header
- Internetwork header
  - Source and Destination Addr
- Data and checksum
- Fragmentation may occur
  - Re-assembly should happen at the end-host
- Does it start to look like MAC+IP+data?
Process Level Communication

- Transmission Control Protocol (TCP)
  - Tasks
    - Multiplexing-Demultiplexing
    - TCP level identifiers: ports
    - Segmentation, Reassembly and Sequencing
      - Sequence Numbers, counting bytes, why?
    - Retransmissions and duplicate detection
      - Timers and positive acknowledgements
      - Window-based reliable protocol
    "It is our expectation that the HOST level retransmission mechanism will not be called upon very often in practice"... "However, the inclusion of a HOST retransmission capability makes it possible to recover from occasional network problems."

TCP Tasks (cont.)

- Flow Control
  - Receiver can shrink the size of the advertised window
- Buffering application data
- Connection establishment and teardown

Paper extensions

- What did you think the design missed?
  - 1.
  - 2.
  - 3.
- What about the Internet today?
  - Connecting the Internet to the Cellular network
  - Connecting private network together (Intranets and Portal Servers)
  - Connecting other exotic networks to the Internet
    - Space Networks
    - SensorNets

Class Projects Suggestions
(Overlays)

- Weather Service
  - Use a network of nodes to predict network conditions (e.g. delay, bandwidth)
  - Issues: How many nodes do you need. How accurate can you get. How quickly can you track changes
  - Can be deployed on PlanetLab http://www.planet-lab.org/
Class Project Suggestions (Overlays)

- **Worm Detection, Traceback**
  - How do you detect a spreading worm?
    - Ingress scanning
    - Honeypots/Honeyfarms/Wormholes
    - What is the effectiveness of these techniques?
    - How can we combine these techniques?
  - Once detected, how do you trace-back to the worm's origin?

Class Project Suggestions (P2P)

- **P2P Worms**
  - CodeRed, Nimda propagate through (random) address scanning
  - But potentially we can have worms that spread over P2P networks
    - Communications seem to be normal
  - How do we detect and contain them?

Class Project Suggestions (BGP)

- **Use beacons to do BGP Tomography**
  - BGP Beacons periodically announce and withdraw certain address prefixes
  - Can we use these beacons to detect dynamic characteristics of the AS-Graph in the same way as we use packet probes to detect traffic-level characteristics of the Internet?

- **Root Cause Analysis**
  - Faults are the norm on the Internet. Every day routers and links fail
  - Result is that address prefixes change routes or become inaccessible
  - Can we use different views of the AS-graph to pinpoint the root cause of each problem?
Next Steps

- Pick a project
  - Either from the ones suggested or one you come up with

- Pick a partner

- Submit a one-page project proposal by 2/9
  - The problem you are solving
  - Plan of attack
  - Any special resources you may need