CS644
Advanced Networks

Lecture 2

Background

Andreas Terzis

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

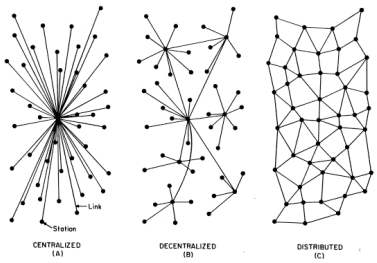


FIG. 1 — Centralized, Decentralized and Distributed Networks

Network Vulnerability

- 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

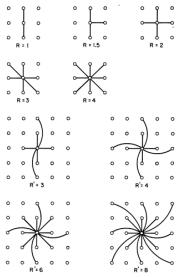


FIG. 2 – Definition of Redundancy Level

Survivability under random attack

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

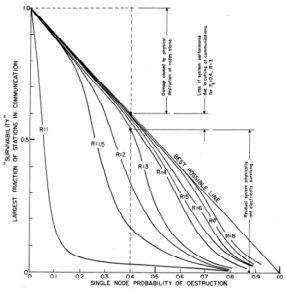


FIG. 4 – Perfect Switching in a Distributed Network – Sensitivity to Node Destruction, 100% of Links Operative.

Survivability as a f(node reliability)

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

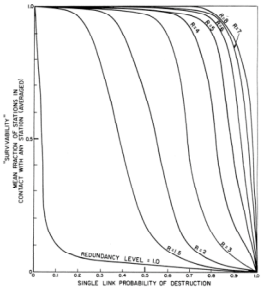


FIG. 5 – Perfect Switching in a Distributed Network – Sensitivity to Link Destruction, 100% of Nodes Operative.

Combination of link and node destruction

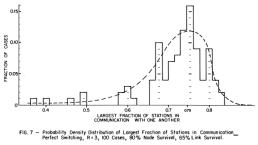


FIG. 7 – Probability Density Distribution of Largest Fraction of Stations in Communication, Perfect Switching, R=3, 100 Cases, 80% Node Survival, 85% Link Survival

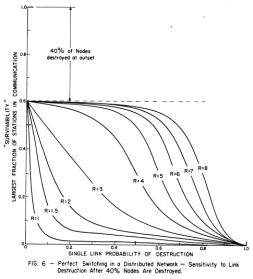


FIG. 6 – Perfect Switching in a Distributed Network – Sensitivity to Link Destruction After 40% Nodes Are Destroyed.

The benefit of dynamic routing

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

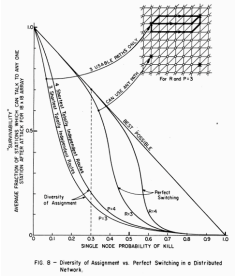


FIG. 8 – Diversity of Assignment vs. Perfect Switching in a Distributed Network.

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

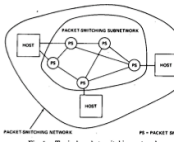
- What else would you like to see?
  - 1.
  - 2.
  - 3.
- What does the Internet today look like?
  - Will come back to this question later
  - How can you find out?

[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
      - Timeouts and positive acknowledgements
      - Window-based reliable protocol
      - "It is our expectation that the HOST level retransmission mechanism will not be call 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 to 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 those 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?

Class Project Suggestions (BGP)

- Load-adaptive BGP
  - BGP routes do not adapt to load
  - Traffic may be sent through a congested path
  - Can we design a load-sensitive inter-domain routing algorithm?
    - Scalable to Intenet size
    - Does not oscillate

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