Characterizing Tradeoffs in Detection and Localization of Network Performance Faults

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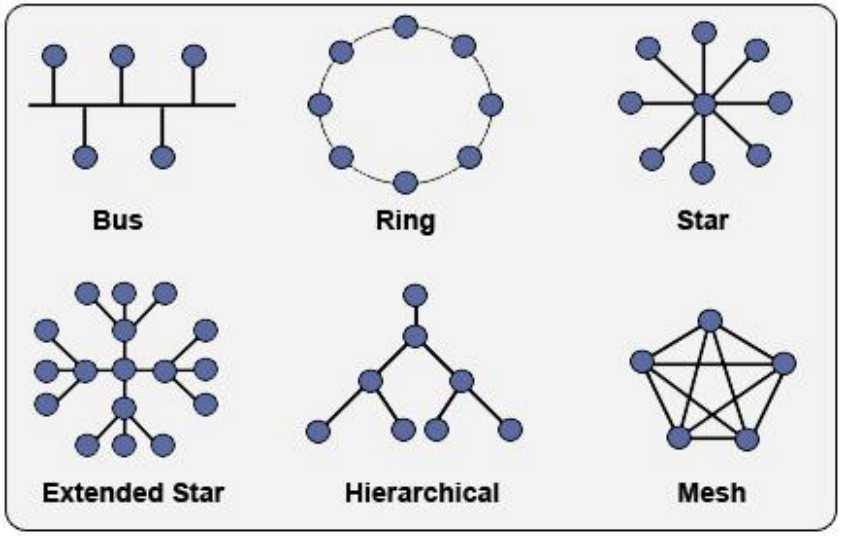
Introduction

- Network operators need to make sure that they satisfy their Service Level Agreements
  - Networks are operating smoothly, no faults
- Standard approach is to monitor network behavior for any faults in performance
- How do we monitor the network behavior?
- Probe-based measures
- Two phases: Detection and Localization

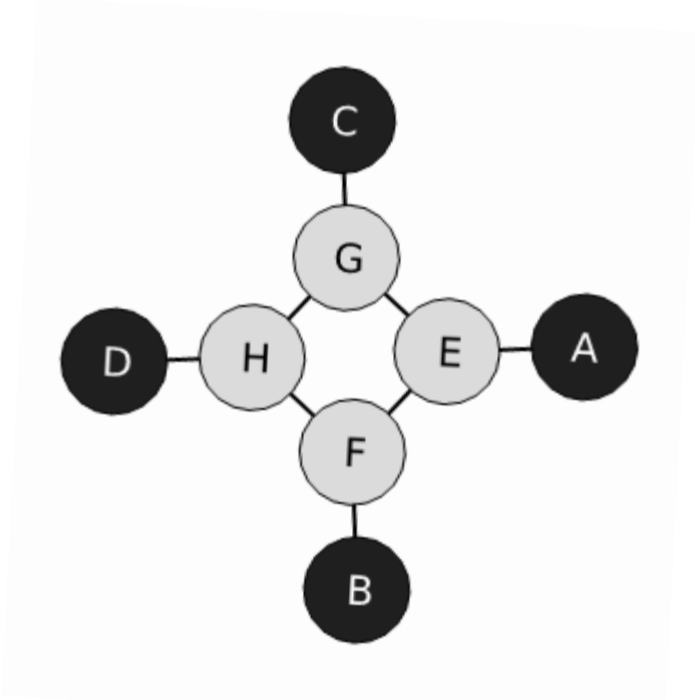
Tradeoffs

- In doing the measurement, there are bound to be tradeoffs that need to be characterized
  - Number of probes to place
  - Where to place the probes
  - Number of messages to send from computer to computer
  - Runtime of the actual algorithm
  - Characterizing necessary overhead vs. optimal overhead

Examples of Network Graphs



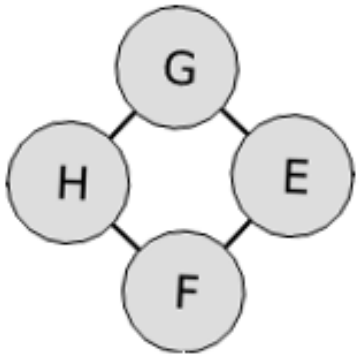
Examples of network graphs



A simple network topology

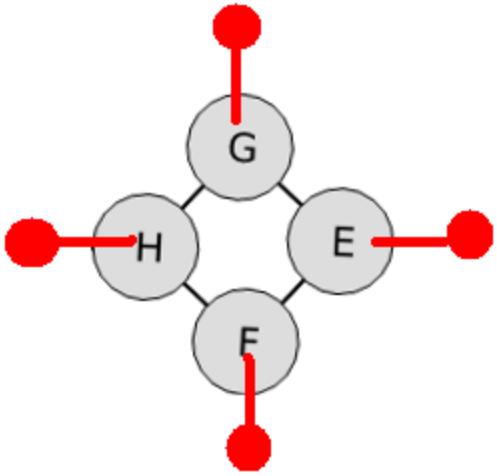
- Each node represents a computer in the network
- We look at directed graphs, because direction and quantity of traffic flow is also important

Detection



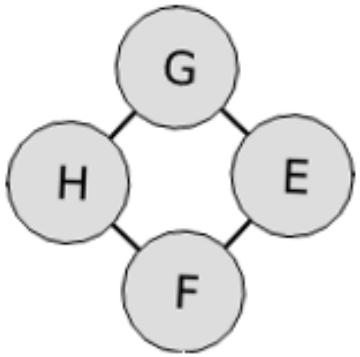
- Need some way of detecting that there is a fault in performance
- Place probing beacons at strategic places in the network
  - Placed at measurement nodes
- Example: Four node ring network

Detection – Trivial Strategy



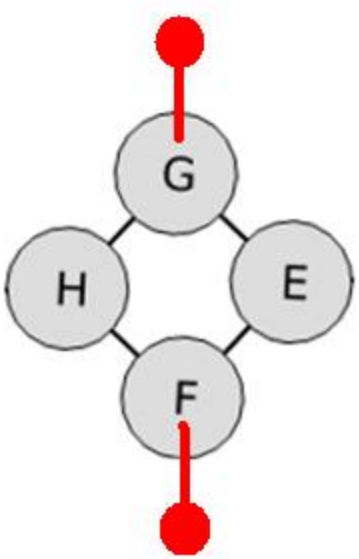
- Every node has a probing beacon
- Follow every path once
  - Pro: covers all cases
  - All faults will be detected, and immediately
  - Con: Generates lot of computational and network overhead

Detection – Other Extreme ☺



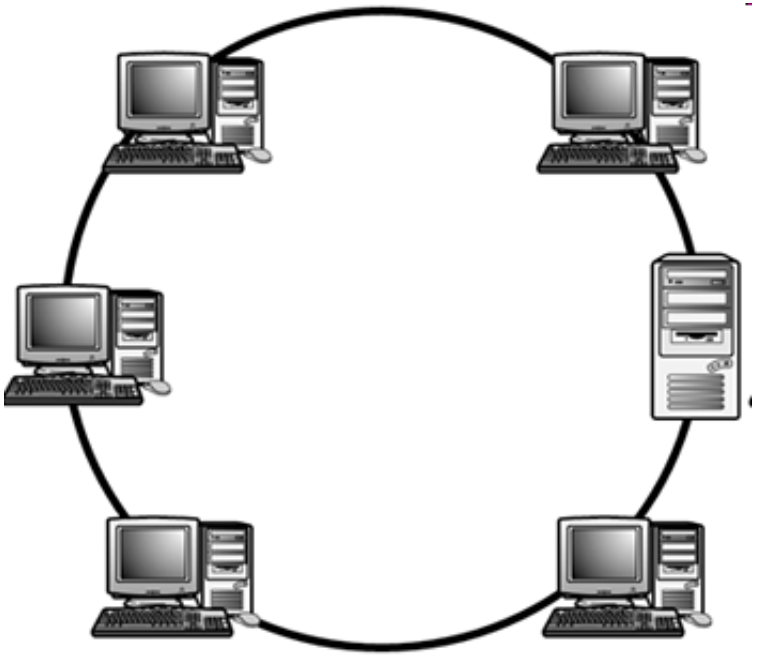
- No probing beacons
  - Pros: no overhead at all!
  - Cons: we forgot to solve the problem

Detection – Less Extreme Strategy



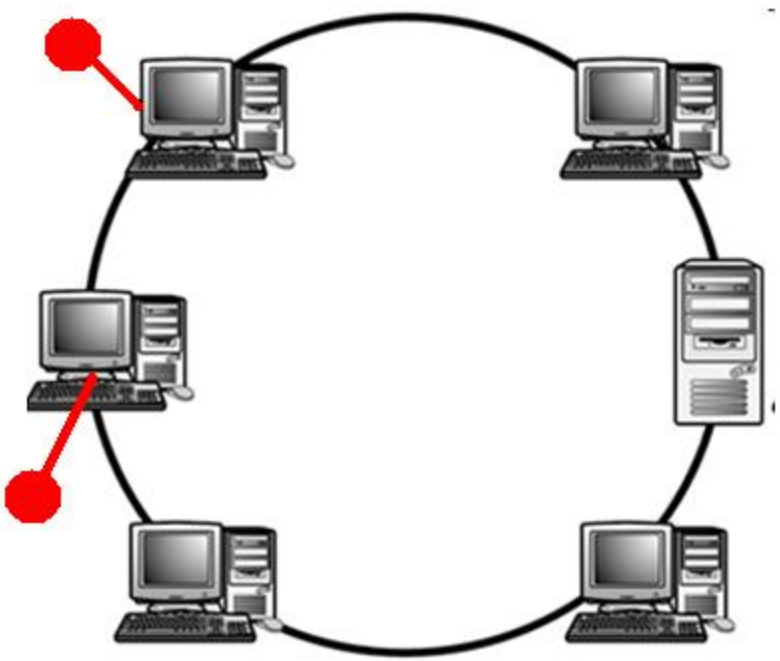
- Two nodes have probing beacons
  - Pro: Much less network and computational overhead
  - Con: May not check every node for faults, will not be able to find the problem immediately

Localization



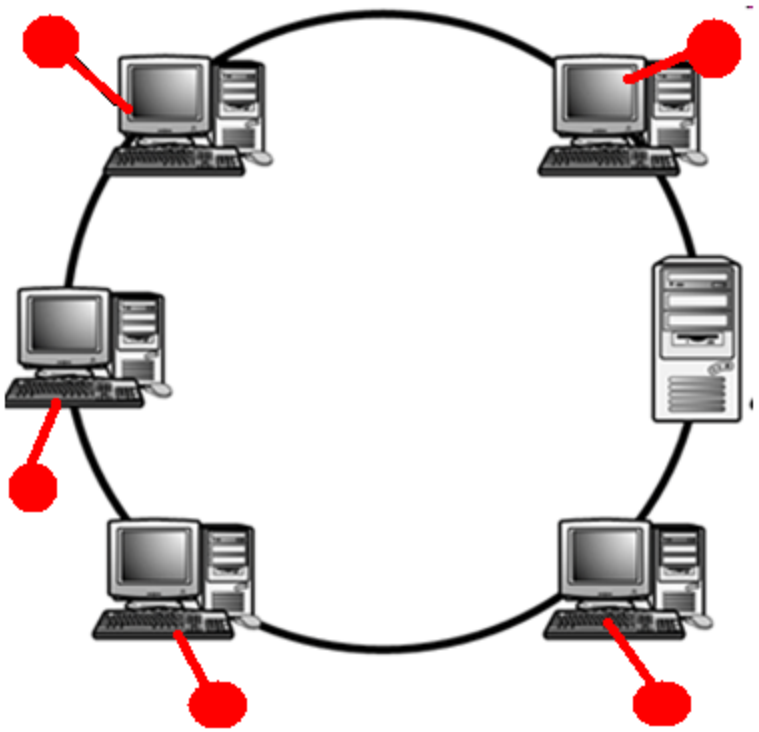
- Once we know there is an anomaly, we need to find which node is causing the trouble
- Example: 5-node ring network

Localization – Example Strategy



- Two probing beacons
  - Pro: Detection will occur with little network overhead
  - Con: Cannot localize the anomalous node

Localization – Another Example



- Multiple probing beacons (e.g., 5)
  - Pro: Can detect and localize the anomalous node immediately
  - Con: Again – more overhead

Problem

- Catch network faults
  - Bound to be tradeoffs in minimizing computational overhead, network overhead, and speed of catching faults
- Given a network topology
  - Where should we place probing beacons
  - Which paths should we probe
- Give an algorithm that does this for a family of topologies

Plan of Action

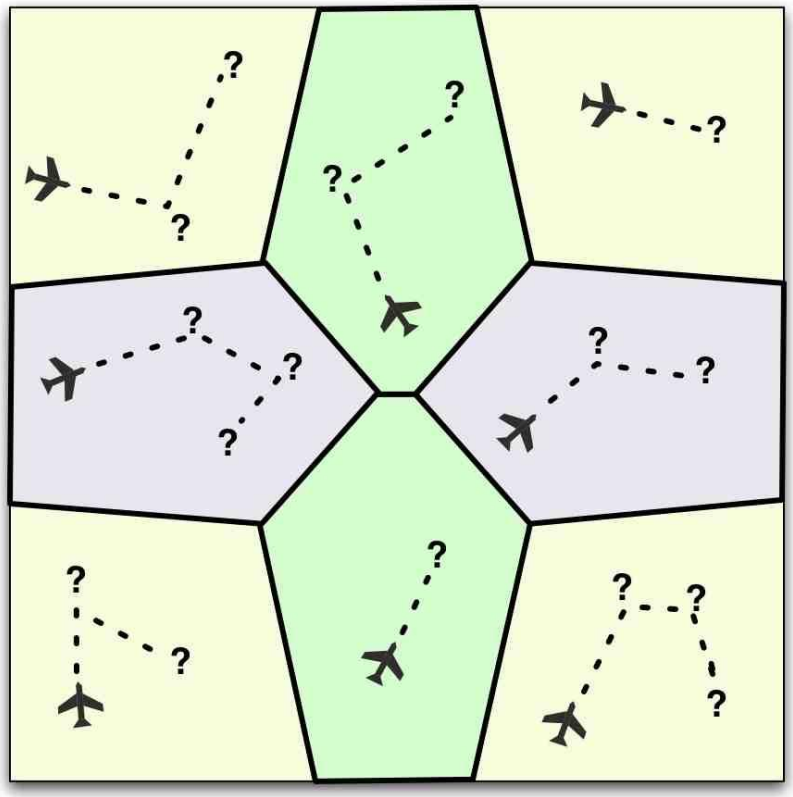
- Look at more general strategies
- Perhaps try to characterize algorithms for families of graphs without worrying about tradeoffs
  - Cycle graphs, path graphs
- Ultimately: Look for generalizations and adaptations to incorporate minimizing the tradeoffs for families of network topologies

First steps

- Fundamental tradeoffs for classes of algorithms
- Listing desirable properties and formalize them
  - How can we tackle these properties in isolation
- Create a network modeling to test them
- Can we create a code a better algorithm?

Different Directions

- Background in robotic networks
- Applying aspects of control theory and communication complexity
- Can distributed networks and robotic controls apply to this problem?



Theoretical Applications

- Classes or families of algorithms
- Looking at networks as metrics
  - Coverage vs. time
  - Set cover approaches
  - NP Hard problems
- Modeling and average case complexity

Thank you for listening!

References

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3. Y. Bejerano and R. Rastogi, “Robust Monitoring of Link Delays and Faults in IP Networks,” in *Proceedings of IEEE INFOCOM’03*, April 2003.