Distributed Algorithms

Distributed algorithms

- System of N processes modeled as a graph with N nodes
  - Links usually represent the logical topology

- Centralized algorithms:
  - Most of the work is done by one or more of the nodes
  - Other nodes play a smaller role

- Distributed algorithms:
  - Each node plays an equal role
### Basic concepts

- Symmetric algorithms
  - Vs asymmetric
- Anonymous algorithms
- Uniform algorithms
- Deterministic algorithms
  - Vs non-deterministic
- Synchronous algorithms
  - Vs asynchronous
- Online algorithms
  - Vs offline algorithms

### Spanning tree

- A **spanning tree** is a subgraph that contains all the vertices of the graph, but is a tree.
- A graph may have many spanning trees.

[Image of a graph with labeled vertices and edges, showing a spanning tree highlighted.](https://commons.wikimedia.org/wiki/index.php?curid=408540)
Synchronous single-initiator ST algorithm

Termination:
- Algorithm terminates after specified number of rounds

Complexity:
- Local space = $O(\text{degree})$
- Local time = $O(\text{diameter} + \text{degree})$
- Global space = sum of local space
- Total number of messages sent = between $e$ and $2e$
- Message time complexity = $d$ rounds

Analysis
Asynchronous single-initiator ST algorithm

Analysis

- Termination:
  - Algorithm terminates after each node receives either a reject or an accept from all of its neighbors

- Complexity:
  - Local space = O(degree)
  - Local time = O(degree)
  - Global space = sum of local space
  - Total number of messages sent = between 2e and 4e
  - Message time complexity = unknown, but bounded by n-1
Leader Election – Ring algorithm

Goal: Elect highest id process as leader
Initiates the election

Goal: Elect highest id process as leader

Election: 32

Election: 80
Initiates the election

Election: 80

Goal: Elect highest id process as leader
Initiates the election

Goal: Elect highest id process as leader

Elected: 80

Goal: Elect highest id process as leader
Initiates the election

Elected: 80

elected = 80

elected = 80

elected = 80

elected = 80

elected = 80

Goal: Elect highest id process as leader
**Final decision**

- **Goal:** Elect highest id process as leader

- **Diagram:**
  - N12: elected = 80
  - N6: elected = 80
  - N80: elected = 80
  - N32: elected = 80
  - N3: elected = 80
  - N5: elected = 80

- **Assume no failures occur during the election protocol itself**

**Analysis**

- **Assume no failures occur during the election protocol itself**

- **How many messages will be sent?**
  - **Single initiator**
    - Note: Worst case occurs when the initiator is the ring successor of the would-be leader
  - **Multiple initiators**
What about failures?