Self-Stabilizing Unidirectional Network Algorithms by Power Supply

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Model

- **Self-stabilization**

  Initially each node in a distributed system in an arbitrary state.

- **Arbitrary topology**

  Unidirectional (strongly connected) network

  - Synchronous

  - Asynchronous

- **Problems solved:**

  BFS,DFS,Leader Election and more.

In this paper

New simple, elegant and efficient technique: Power Supply

Provides:

- **O(n) Stabilization time in unidirectional network.**
- **O(logn) Space / node.**
- **No prior knowledge on network size.**

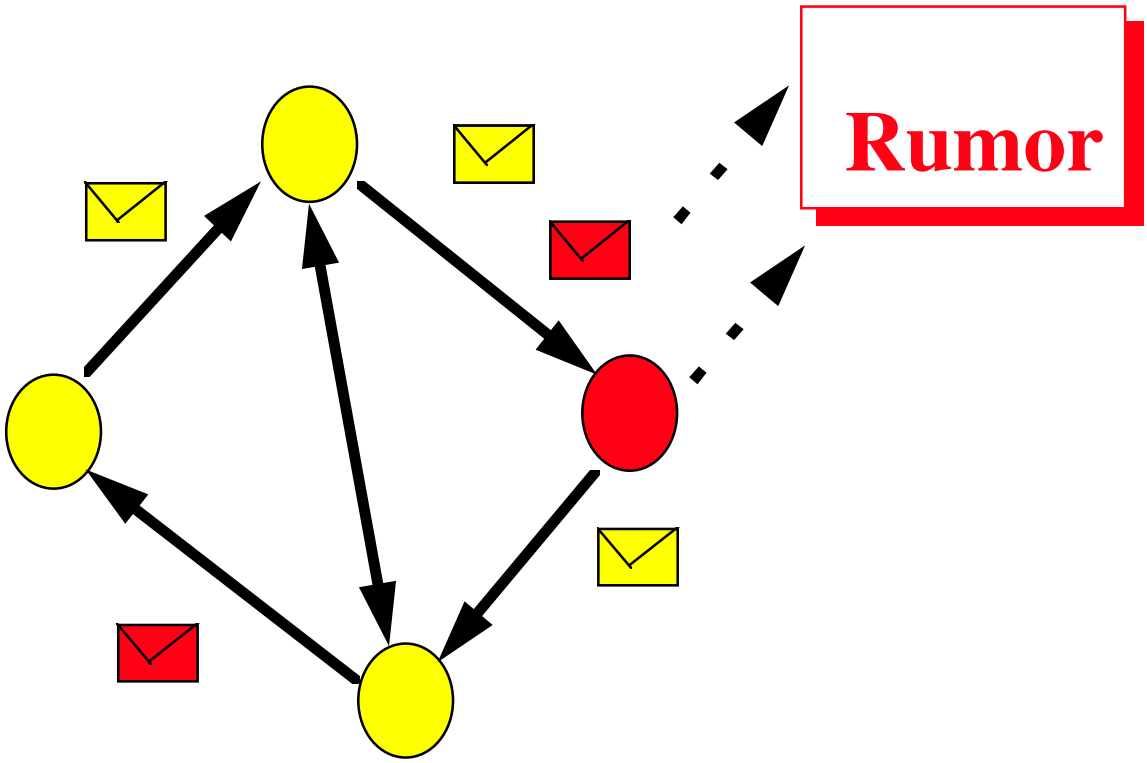
Out line

- **The rumor problem,**
  An abstraction of self-stabilization

- **Power Supply method**
  - **Synchronous**
  - **Asynchronous**

- **Generic Algorithms**

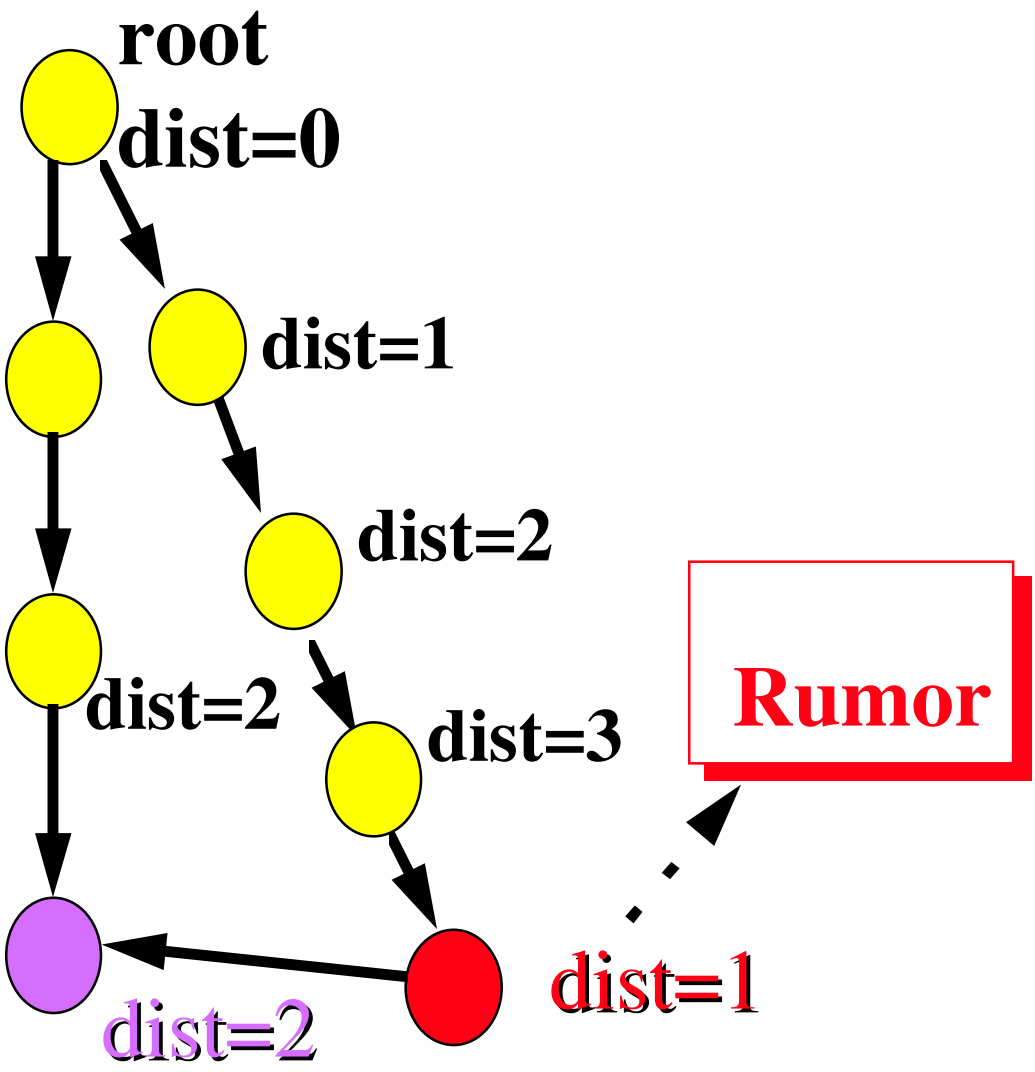
The Rumor Problem



Methodology: Self Stabilization

Example:

Single Source Shortest Path

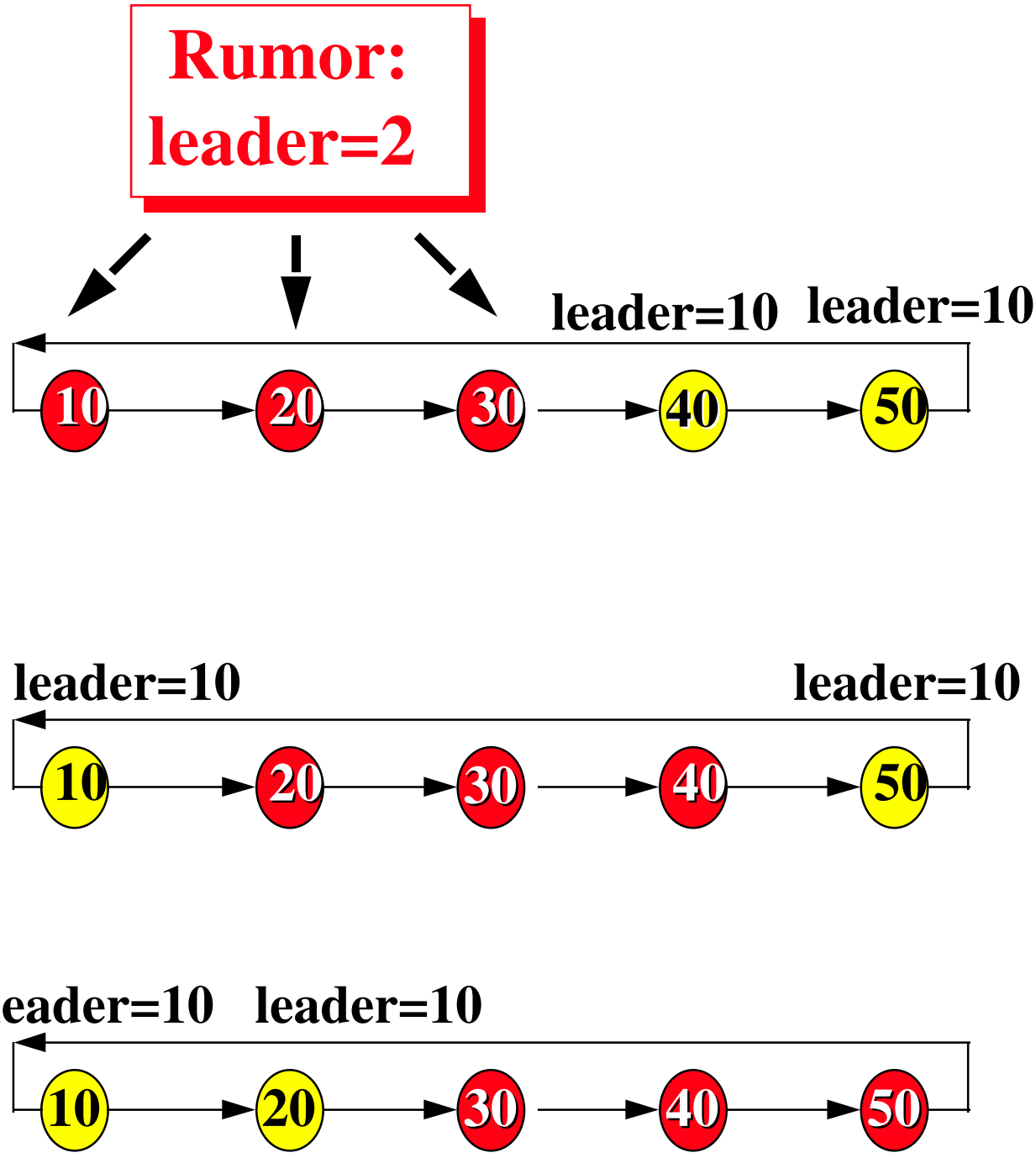


Solution:

- The root cannot be deceived.
- Periodically check consistency with Parent.

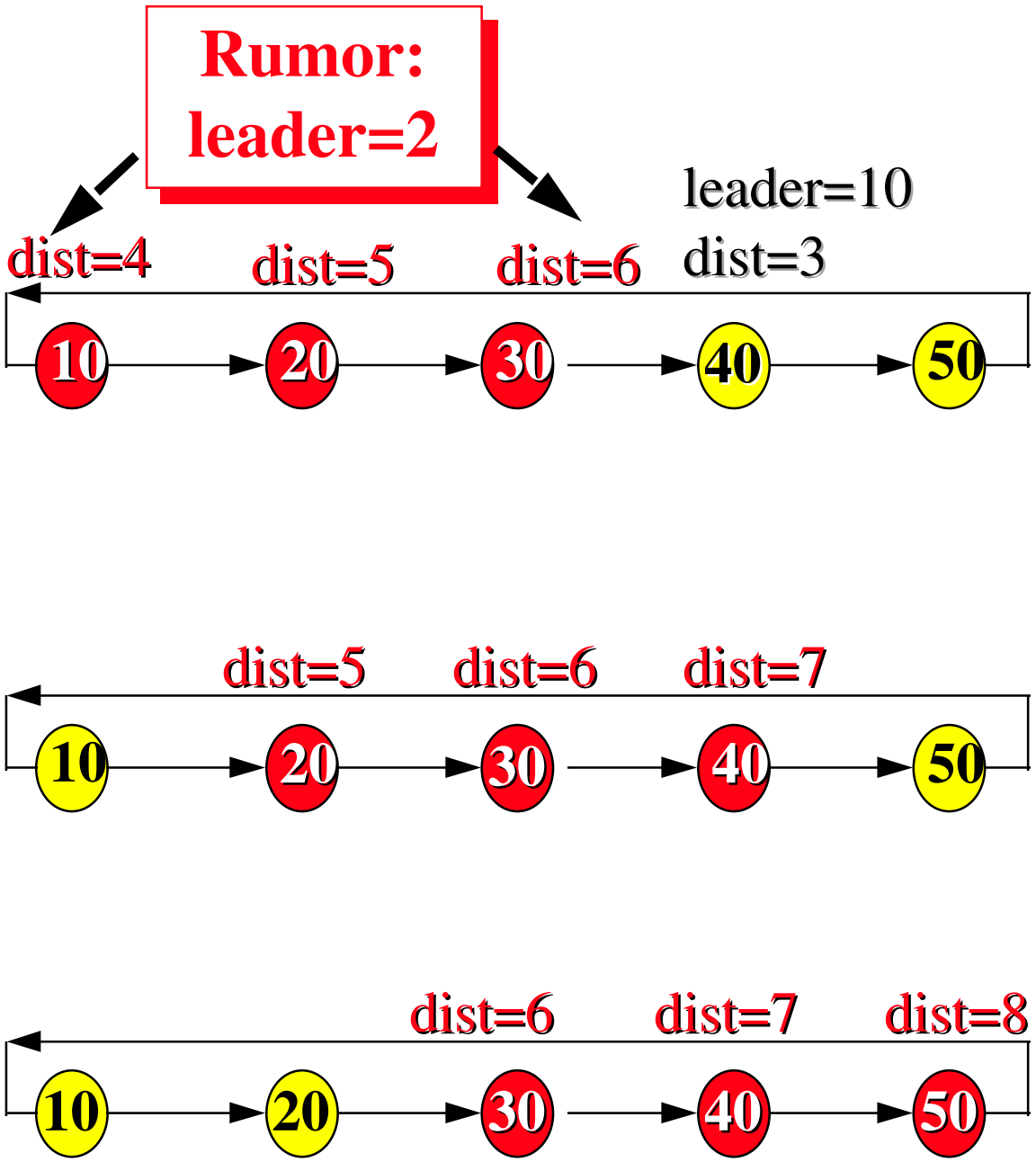
A different Example:

Elect smallest id node



Attempted solution:

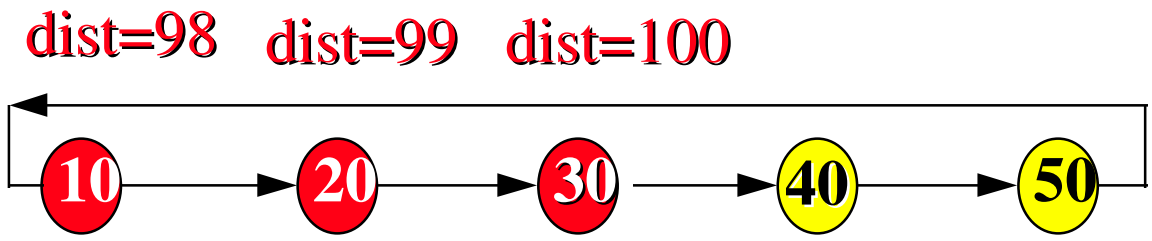
Build S.S.S.Path from leader

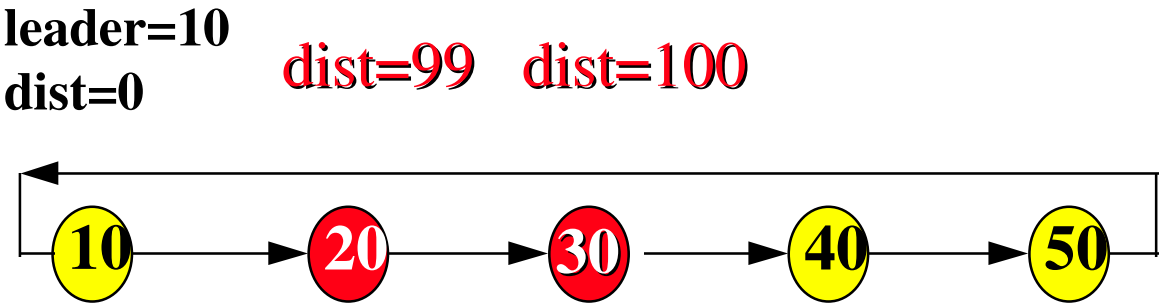


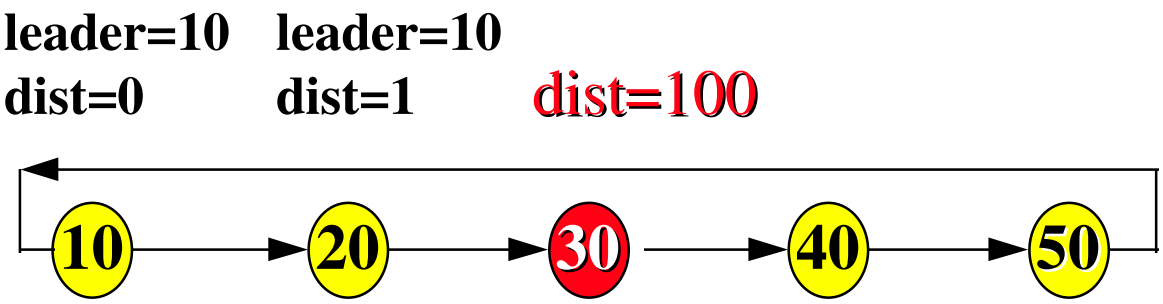
Bug: Rumor *id* cycles indefinitely

[Arora & Guoda 90] Use an upperbound

Example: Upperbound=100







Related Work

Self-stabilization

[Dijkstra 73],[KP89],[AG90], [AKY90],[DIM91],[APSV91], [AV91] ...

All Bi-directional

[MOY96]

Unidirectional Ring

Only [AG90] applies to

Arbitrary unidirectional

But ...

Extra Assumption & in-efficient

Power Supply
Synchronous implementation

A true data: Source

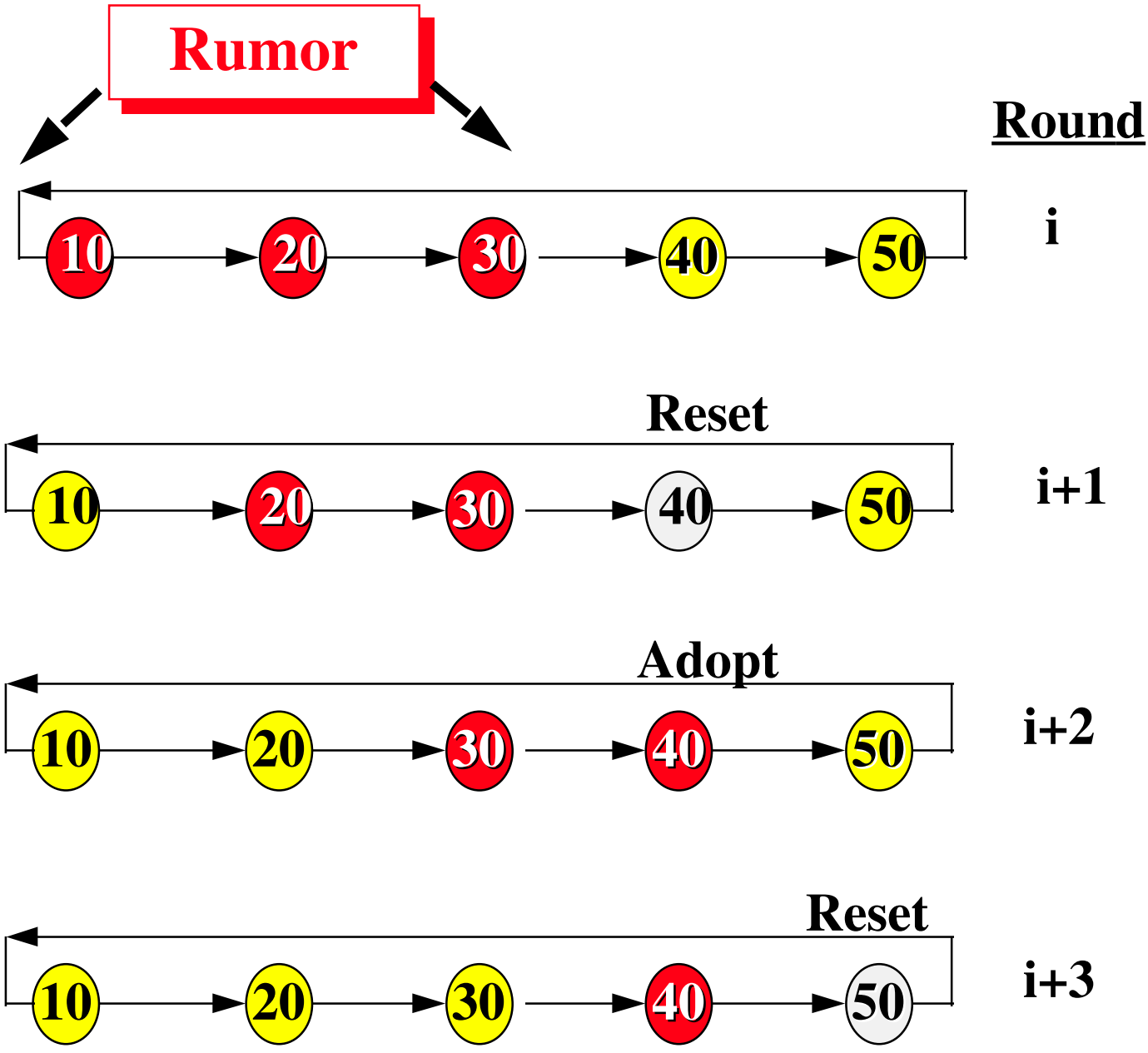
A rumor: No source

Skeptical Principle (synchronous):
Adopt new data only if received in two consecutive rounds (messages).

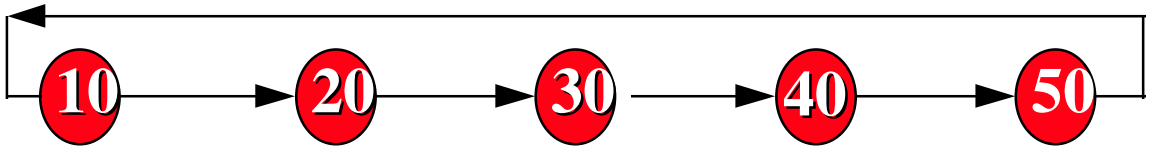
1-st round(message): Reset
2-nd round(message): Adopt new data

Power Principle: Only source of data repeatedly produces messages with the data.

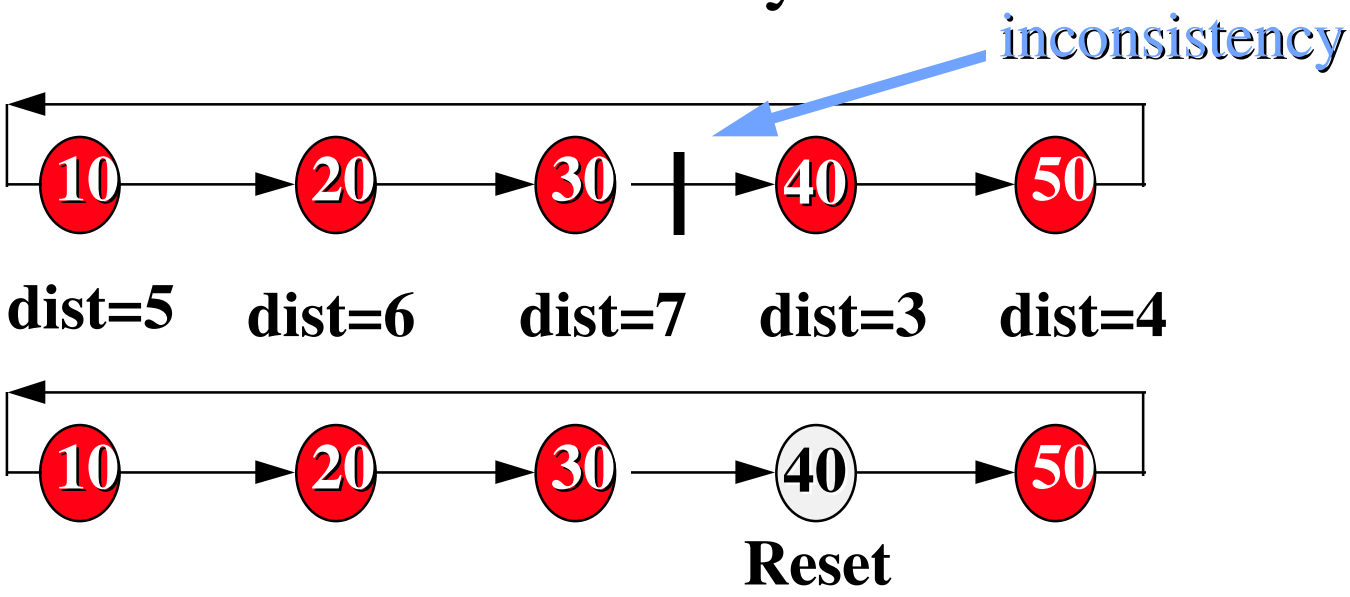
An Example:



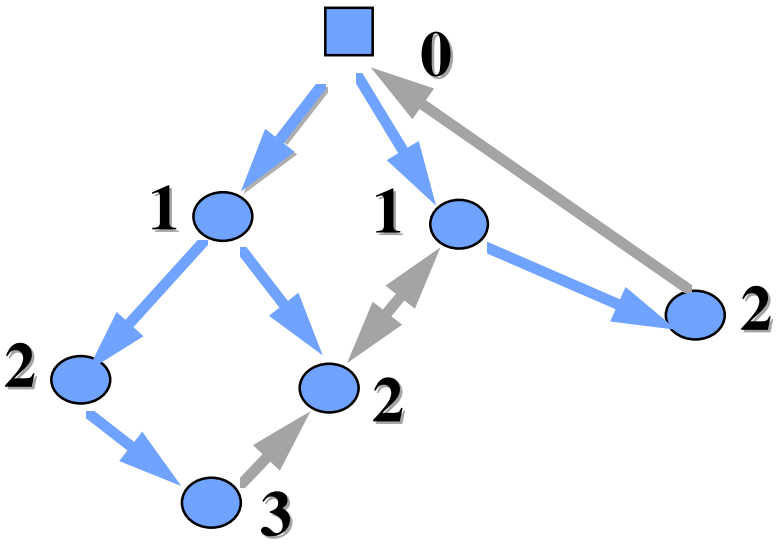
Problem: A cycle of rumor



Solution: Break the cycle



Result: Leader Election + Breadth First Search



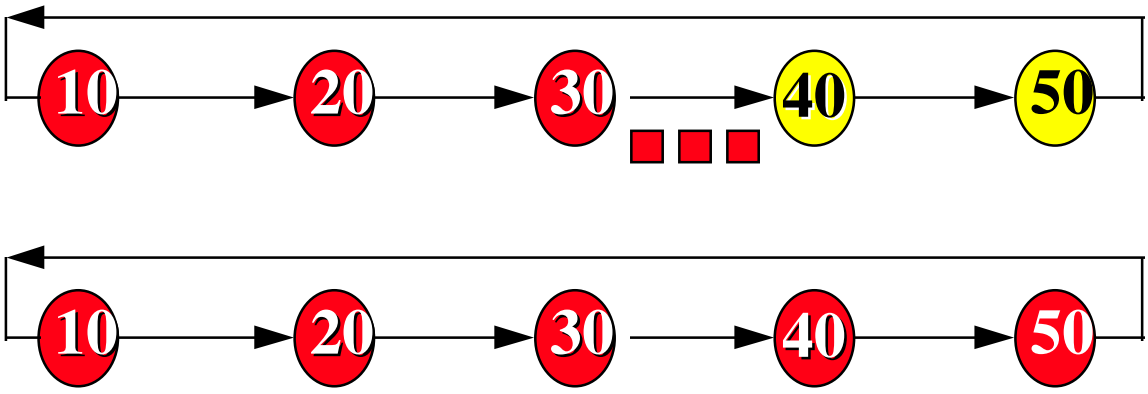
Asynchronous Implementation

Problem:

Nodes Periodically transmit messages to check local consistency.

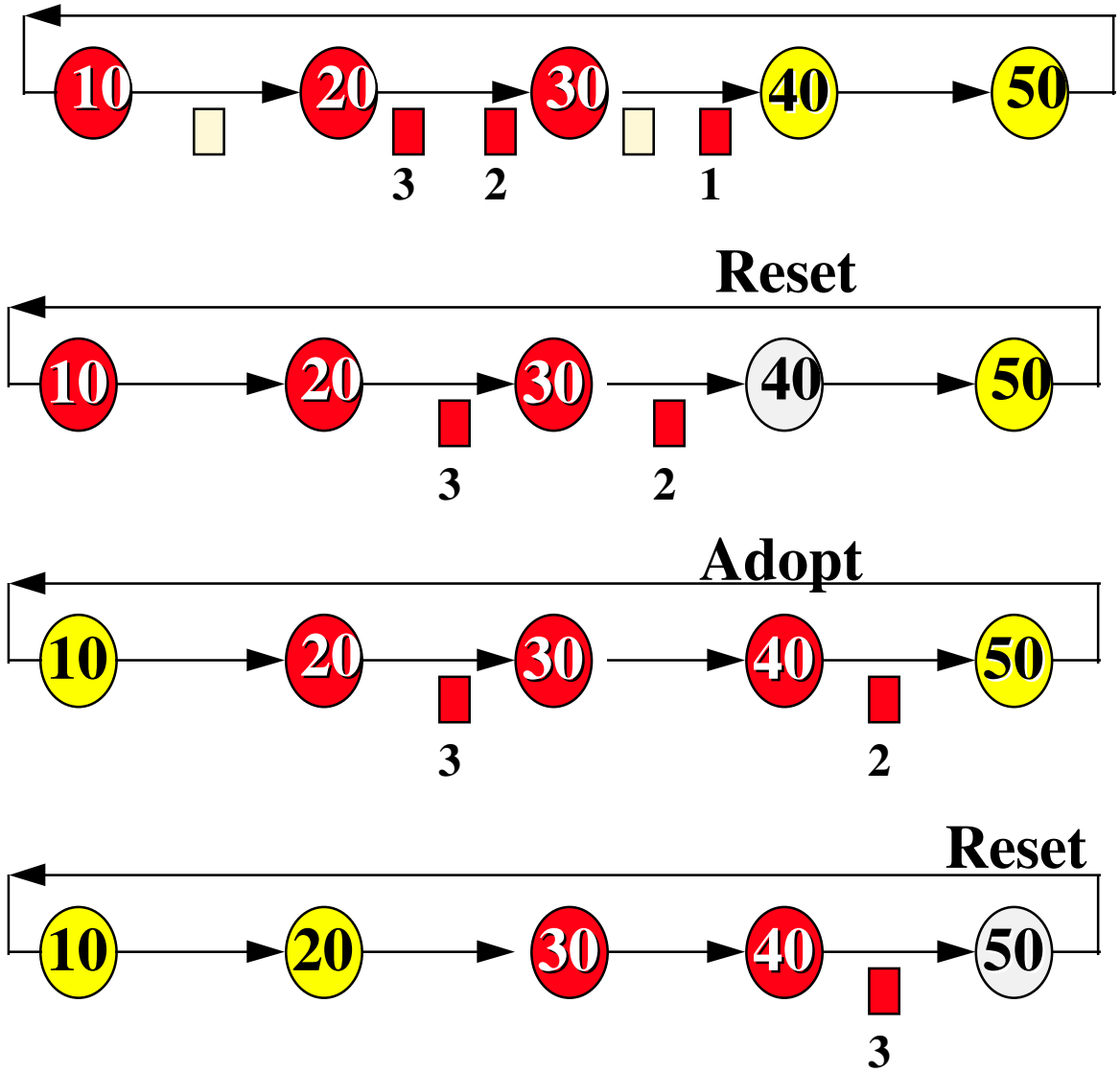
The problem: Repetitive messages give Power to the rumor.

Example of the problem:



Solution: Two kind of messages:

- Strong - with power to convince a node of new data.
- Weak - without power, only sends to check local consistency.



The principles of Power Supply Asynchronous implementation

A true data: Source ✓

A rumor: No source ✗

Skeptical Principle (Asynchronous): **Adopt new data only if received in two consecutive strong messages.**

1-st strong message: Reset
2-nd strong message: Adopt new data

Received inconsistent weak message: Reset

Power Principle: Only source of data repeatedly produces strong messages with the data.

Generic Algorithm

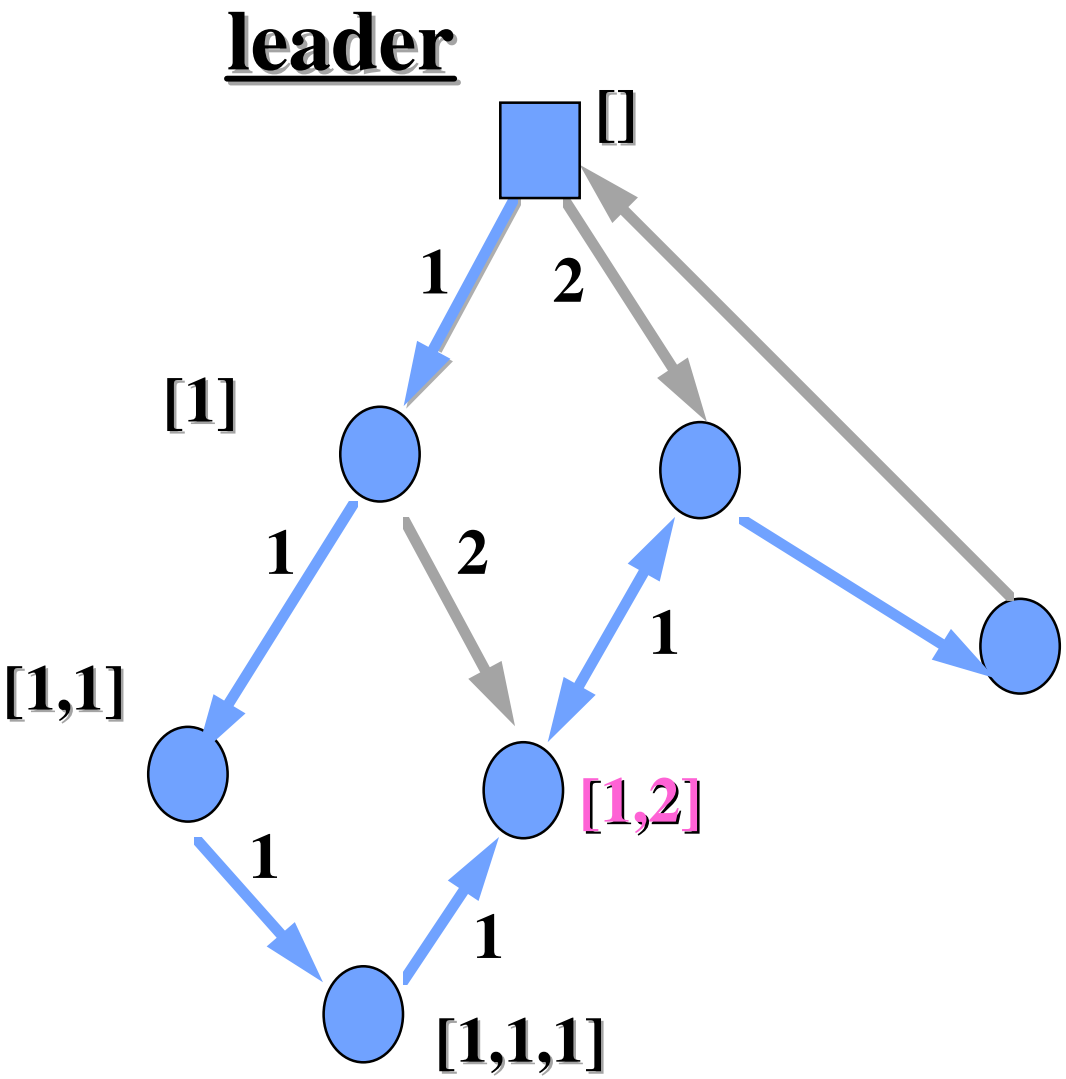
- Power Supply + S.S.S.Path (dist)
- Power Supply + DFS ((CD94))
- Power Supply + other metric

Self -Stabilizing Algorithms for Leader Election, DFS, BFS

Depth First Search

Label each node with lexicographically smallest path label (sequence of port *ids* from leader to the node)

[Collin & Dolev 94]



Main Results

Stabilization time

Synchronous	Asynchronous
O(n)	O(nB)

Memory space

O(logn)

- With no prior knowledge of any kind.
- Arbitrary Unidirectional strongly connected network.