Hierarchical Leader Election Algorithm With Remoteness Constraint

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Outline

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What's a Distributed System ?

A distributed system is a network that consists of autonomous computers that are connected using a distribution middleware. They help in sharing different resources and capabilities to provide users with a single and integrated coherent network.

The Bully Algorithm

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- *P* sends an *ELECTION* message to all processes with higher numbers.
- If no one responds, *P* wins the election and becomes coordinator.
- If one of the higher-ups answers, it takes over. *P*'s job is done.

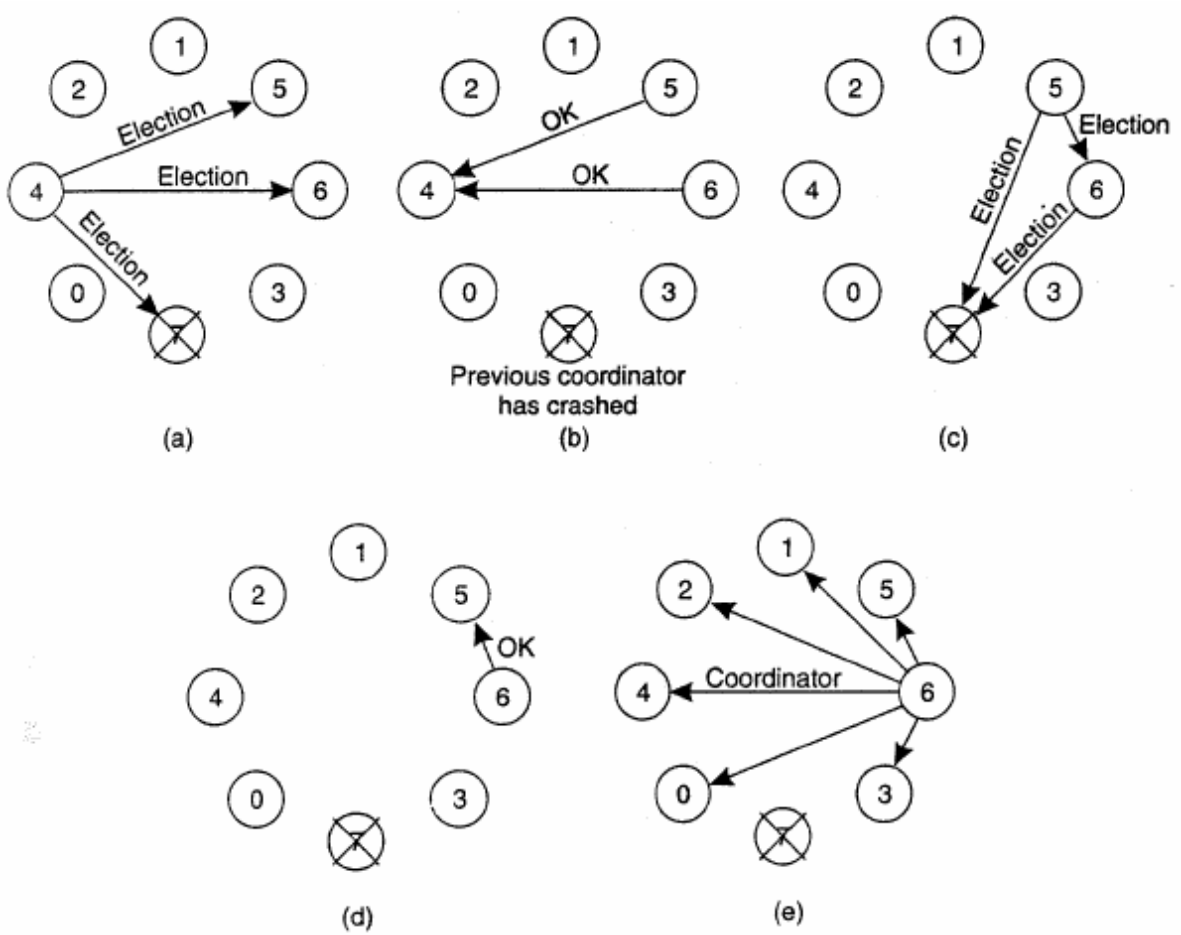

Figure: Bully Algorithm

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System Model

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- We model the whole system as a set of (infinite) state machines that interact through shared events (a specialization of the IOA model).

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- a $status_{uv}$ variable;
- and a queue $mqueue_{uv}$ of messages.

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- A configuration is a vector of node states, one for each node in P, and a vector of channel states, one for each channel in χ.

Problem Definition

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- a local variable lid_u to hold the id of the supreme leader;
- another local variable $slid_u$ to hold the identifier of the sub-leader whose remoteness towards u obeys the constraint.

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- First wave : initiated by one of the lost leader's neighbors looking for it;
- Second wave : initiated by the node located at the edge of the network if the search has hit a dead-end;
- Third wave : initiated by the same node which initiated the first wave updating the other nodes' heights.

Nodes, Neighbors and Heights

The height for each node is a 7-tuple of integers $((\tau, oid, r), \delta, (nlts, lid), id)$, where the first three components are referred to as the reference level (RL) and the fifth and sixth components are referred to as the leader pair (LP). In more detail, the components are defined as follows:

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- τ, a non-negative timestamp which is either 0 or the value of the causal clock time when the current search for an alternate path to the leader was initiated.
- oid, is a non-negative value that is either 0 or the id of the node that started the current search (we assume node ids are positive integers).

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- δ an integer that is set to ensure that links are directed appropriately to neighbors with the same first three components.

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- for each v in N_u, $height_u[v] = height_v[v]$ (i.e., u has accurate information about v's height), and
- $\mathcal{T}_u$ is initialized properly with respect to the definition of causal clocks.

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The height for each node is a 7-tuple of integers $((\tau, oid, r), \delta, (nlts, lid), id)$, where the first three components are referred to as the reference level (RL) and the fifth and sixth.

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- δ

The Code triggered by Update Message

When node u receives $Update(h)$ from node $v \in forming \cup N$:

```
      // if v is in neither forming nor N, message is ignored
 1.   height[v] := h
 2.   forming := forming \ {v}
 3.   N := N ∪ {v}
 4.   myOldHeight := height[u]
 5.   if ((nlts^u, lid^u) = (nlts^v, lid^v)) // leader pairs are the same
 6.       if (SINK)
 7.           if (∃ (τ,oid,r) | (τ^w, oid^w, r^w) = (τ,oid,r) ∀ w ∈ N)
 8.               if ((τ > 0) and (r = 0))
 9.                   REFLECTREFLEVEL
10.               else if ((τ > 0) and (r = 1) and (oid = u))
11.                   ELECTSELF
12.               else // (τ = 0) or (τ > 0 and r = 1 and oid ≠ u)
13.                   STARTNEWREFLEVEL
14.               end if
15.           else // neighbors have different ref levels
16.               PROPAGATELARGESTREFLEVEL
17.           end if
          // else not sink, do nothing
18.       end if
19.   else // leader pairs are different
20.       ADOPTLPIFPRIORITY(v)
21.   end if
22.   if (myOldHeight ≠ height[u])
23.       send Update(height[u]) to all w ∈ (N ∪ forming)
24.   end if
```

Subroutines

ELECTSELF
1. $height[u] := (0,0,0,0,-\mathscr{T}_u,u,u)$

REFLECTREFLEVEL
1. $height[u] := (\tau,oid,1,0,nlts^u,lid^u,u)$

PROPAGATELARGESTREFLEVEL
1. $(\tau^u,oid^u,r^u) := max\{(\tau^w,oid^w,r^w) \mid w \in N\}$
2. $\delta^u := min\{\ \delta^w \mid w \in N \text{ and } (\tau^u,oid^u,r^u) = (\tau^w,oid^w,r^w)\} - 1$

STARTNEWREFLEVEL
1. $height[u] := (\mathscr{T}_u,u,0,0,nlts^u,lid^u,u)$

ADOPTLPIFPRIORITY(v)
1. if $((nlts^v < nlts^u)$ or $((nlts^v = nlts^u)$ and $(lid^v < lid^u)))$
2. $\quad height[u] := (\tau^v,oid^v,r^v,\delta^v+1,nlts^v,lid^v,u)$
3. else send Update($height[u]$) to v
4. end if

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What's JBotSim ?

JBoTSim is a java library that offers basic primitives for proto-typing, running, and visualizing distributed algorithms in dynamic networks.


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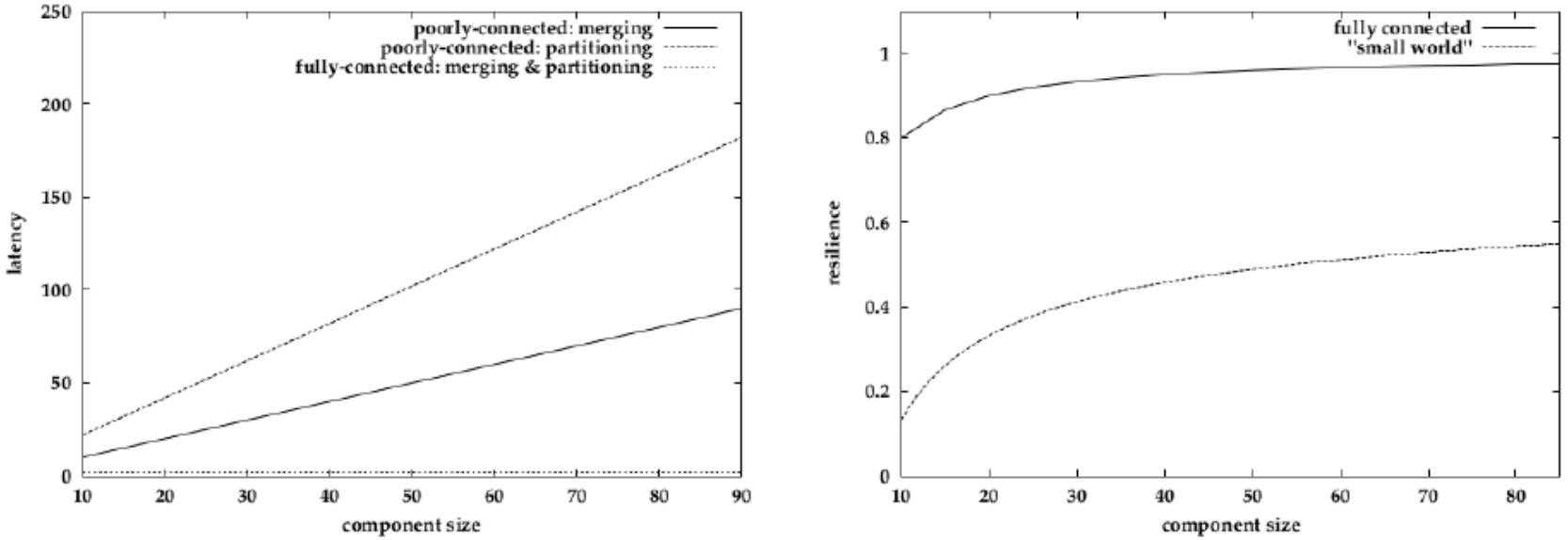
How is our algorithm's performance ?



(a) Latency (b) Resilience

Figure: Simulation Results

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Is The Algorithm Perfect ?

An open question is how to extend our algorithm and its analysis to handle a wider range of clocks, such as approximately synchronized clocks and vector clocks.

Question ?