Hierarchical Leader Election Algorithm With Remoteness Constraint

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Outline

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What is the problem of leader election ?

Leader election is an important primitive for distributed computing, useful as a sub-routine for any application that requires the selection of a unique processor among multiple candidate processors (video conferencing, multi-player games, ...).

What is distributed computing ?

Distributed computing is a model in which components of a software system are shared among multiple computers to improve efficiency and performance.

State of art

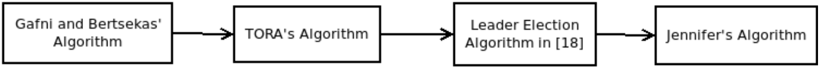

Figure:

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System 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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Each node u in the system has :

- 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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- δ

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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
height[v] := h
forming := forming \ {v}
N := N ∪ {v}
myOldHeight := height[u]
if ((nlts^u, lid^u) = (nlts^v, lid^v)) // leader pairs are the same
    if (SINK)
        if (∃ (τ,oid,r) | (τ^w, oid^w, r^w) = (τ,oid,r) ∀ w ∈ N)
            if ((τ > 0) and (r = 0))
                REFLECTREFLEVEL
            else if ((τ > 0) and (r = 1) and (oid = u))
                ELECTSELF
            else // (τ = 0) or (τ > 0 and r = 1 and oid ≠ u)
                STARTNEWREFLEVEL
            end if
        else // neighbors have different ref levels
            PROPAGATELARGESTREFLEVEL
        end if
    // else not sink, do nothing
    end if
else // leader pairs are different
    ADOPTLPIFPRIORITY(v)
end if
if (myOldHeight ≠ height[u])
    send Update(height[u]) to all w ∈ (N ∪ forming)
end if
```

Subroutines

ElectSelf

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

ReflectRefLevel

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

PropagateLargestRefLevel

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

StartNewRefLevel

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

AdoptLPIfPriority (v)

```
1.    if ((nlts^v < nlts^u) or ((nlts^v = nlts^u) and (lid^v < lid^u)))
2.          height[u] := (τ^v, oid^v, r^v, δ^v + 1, nlts^v, lid^v, u)
3.    else send Update(height[u]) to v
4.    end if
```

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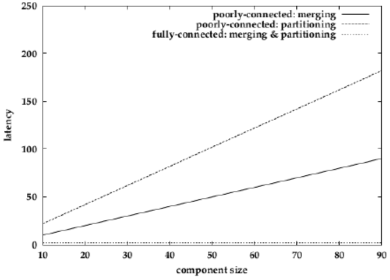
What's JBotSim ?

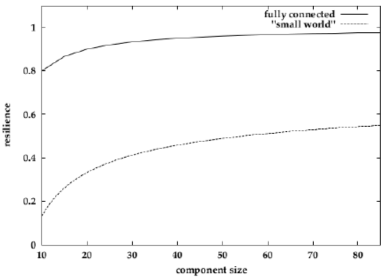
JBoTSim is a java library that offers basic primitives for proto-typing, running, and visualizing distributed algorithms in dynamic networks.

Simulation

How is our algorithm's performance ?



(a) Latency



(b) Resilience

Figure: Simulation Results

Outline

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 ?