Network Algorithms

Mutual Exclusion in Networks
Shared Objects

Common variable or datastructure:

Needs to be accessed, but not concurrently! How?
Shared Objects

Idea: store at central location, e.g., root of spanning tree

Access: send message to root, root processes request, result sent back down the tree.
Shared Objects

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Analysis?
Shared Objects

Idea: store at central location, e.g., root of spanning tree

Could improve many things:
- Don’t go via Spanning Tree, but route directly.
- If same node v needs object again and again, it would be better if v can have the object!

Access: send message to root, root processes request, result sent back down the tree.
Home-Based Solution

Idea that object has «home base»:
- processes get lock from there
- then retrieve object and process locally!
Similar to Mobile IP!

1. 
2. 
3.
Home-Based Solution

Idea that object has «home base»:
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1.  
2. request
3.  

Problem?
Home-Based Solution

Idea that object has «home base»:
- processes get lock from there
- then retrieve object and process locally!

Similar to Mobile IP!

1. ![Diagram 1](#)
2. ![Diagram 2](#)
3. ![Diagram 3](#)

Problem?

Triangle Routing if accessing nodes are close but root is far.
The Arrow Protocol

Idea: Make accessor responsible for object, i.e. the new «root».
How can this be achieved?
The Arrow Protocol

Idea: Make accessor responsible for object, i.e. the new «root».

(1) Make tree directed

I want access!

now
The Arrow Protocol

Idea: Make accessor responsible for object, i.e. the new «root».
(1) Make tree directed

I want access!

find()
The Arrow Protocol

Idea: Make accessor responsible for object, i.e. the new «root».
(1) Make tree directed
(2) Give object to accessor, new root!
The Arrow Protocol

Idea: Make accessor responsible for object, i.e. the new «root».
(1) Make tree directed
(2) Give object to accessor, new root!
(3) Invert pointers along the find path in spanning tree!

Stefan Schmid @ T-Labs Berlin, 2013/4
Arrow: What about concurrency?
Arrow: What about concurrency?

I want access!
Arrow: What about concurrency?

still in use!

wait()
Arrow: What about concurrency?

wait()  
I want access!  
still in use!

Stefan Schmid @ T-Labs Berlin, 2013/4
Perfect: tree automatically rooted at node v now! Distributed queue. Node u can just send it directly to v («out-of-band») when done.
Arrow

Start Find Request at Node $u$:
1: do atomically
2: $u$ sends “find by $u$” message to parent node
3: $u$.parent := $u$
4: $u$.wait := true
5: end do

Upon $w$ Receiving “Find by $u$” Message from Node $v$:
6: do atomically
7: if $w$.parent $\neq w$ then
8: $w$ sends “find by $u$” message to parent
9: $w$.parent := $v$
10: else
11: $w$.parent := $v$
12: if not $w$.wait then
13: send variable to $u$ // $w$ holds var. but does not need it any more
14: else
15: $w$.successor := $u$ // $w$ will send variable to $u$ a.s.a.p.
16: end if
17: end if
18: end do

Upon $w$ Receiving Shared Object:
19: perform operation on shared object
20: do atomically
21: $w$.wait := false
22: if $w$.successor $\neq$ null then
23: send variable to $w$.successor
24: $w$.successor := null
25: end if
26: end do

invert edge!
wait myself?
Arrow

Arrow is correct: find() terminates with message and time complexity $D$, where $D$ is the diameter of the spanning tree. Completely asynchronous and concurrent environments!

Proof.
- Each edge $\{u,v\}$ in the spanning tree is in one of four states:
  (A) $u$ points to $v$, no message on the edge, $v$ does not point to $u$
  (B) Message on the move from $u$ to $v$ (no pointer along edge)
  (C) $v$ points to $u$, no message on edge, $u$ does not point to $v$
  (D) Message on the move from $v$ to $u$ (no pointer along edge)
- So message will only travel on static tree!
- And can never traverse an edge twice (in opposite direction).

QED
End of Lecture