Concurrent Algorithms in Linear Logic Programming

Robert J. Simmons (Work with Frank Pfenning)

February 14, 2008

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Linear Logical Algorithms. Robert J. Simmons and Frank Pfenning. Submitted, February 2008.
(available from http://www.cs.cmu.edu/~fp)

Inference Rules

$$\frac{a \quad b}{c}$$

In Meld, Datalog, XSB:

“c :- a,b.”

Inference Rules

$$\frac{a \ \textit{true} \qquad b \ \textit{true}}{c \ \textit{true}}$$

Inference Rules

$$\frac{\text{path}(X,Y)\ \textit{true} \qquad \text{path}(Y,Z)\ \textit{true}}{\text{path}(X,Z)\ \textit{true}}$$

Inference Rules

$$\frac{\begin{array}{l}\text{path}(X,Y)\\ \text{car\_is\_at}(C,X)\end{array}}{\text{car\_is\_at}(C,Y)}$$

Inference Rules

$$\frac{\text{path}(X,Y)\ \textit{true} \qquad \text{car\_is\_at}(C,X)}{\text{car\_is\_at}(C,Y)}$$

Inference Rules

$$\frac{\text{path}(X,Y)\ \textit{true} \qquad \text{car\_is\_at}(C,X)\ ?}{\text{car\_is\_at}(C,Y)}$$

Inference Rules

$$\frac{\text{path}(X,Y)\ \textit{true} \qquad \text{car\_is\_at}(C,X)\ \textit{?}}{\text{car\_is\_at}(C,Y)\ \textit{?}}$$

Inference Rules

$$\frac{\text{path}(X,Y)\ \textit{persistent} \qquad \text{car\_is\_at}(C,X)\ \textit{?}}{\text{car\_is\_at}(C,Y)\ \textit{?}}$$

Inference Rules

$$\frac{\text{path}(X,Y)\ \textit{persistent} \qquad \text{car\_is\_at}(C,X)\ \textit{ephemeral}}{\text{car\_is\_at}(C,Y)\ \textit{?}}$$

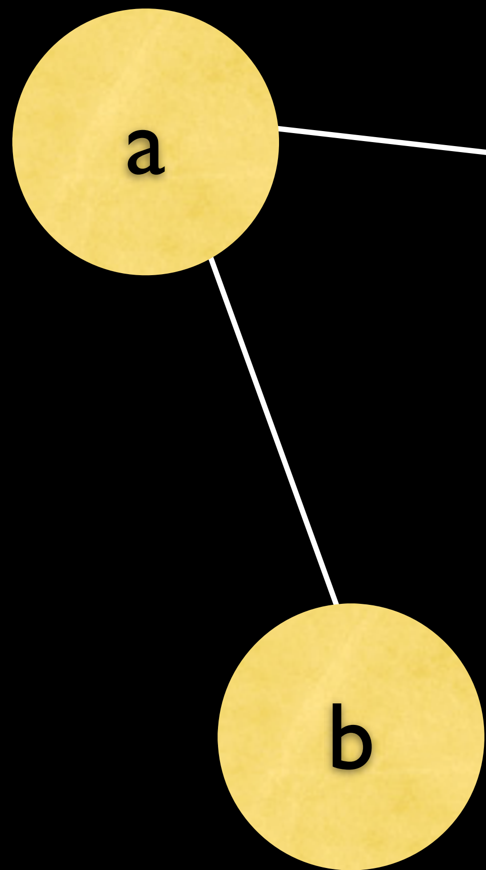
Inference Rules

$$\frac{\mathrm{path}(X,Y)\ \textit{persistent} \qquad \mathrm{car\_is\_at}(C,X)\ \textit{ephemeral}}{\mathrm{car\_is\_at}(C,Y)\ \textit{ephemeral}}$$

Inference Rules

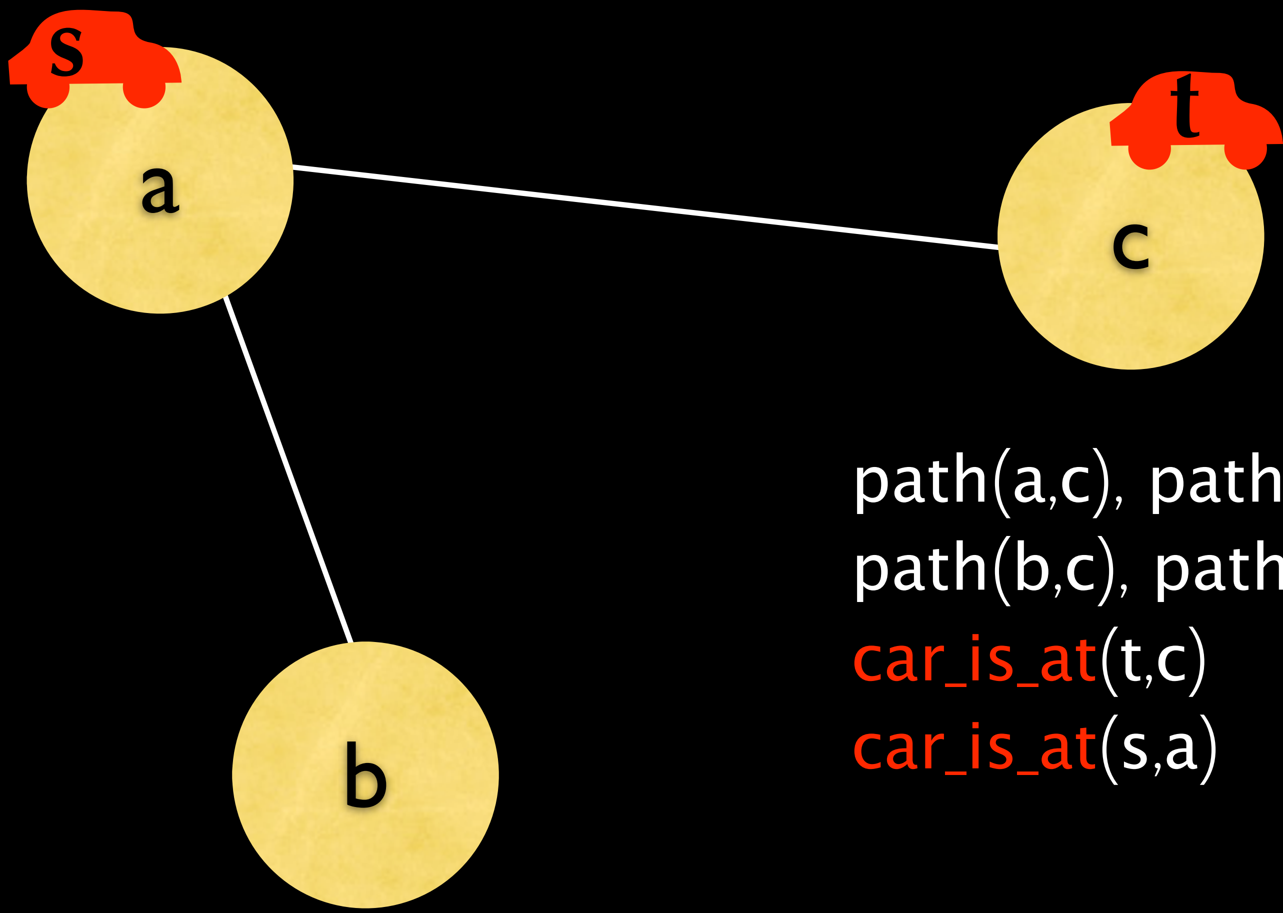
$$\frac{\begin{array}{l}\text{path}(X,Y)\ \textit{persistent} \\ \text{car\_is\_at}(C,X)\ \textit{ephemeral}\end{array}}{\text{car\_is\_at}(C,Y)\ \textit{ephemeral}}$$

(Linear Logic!)



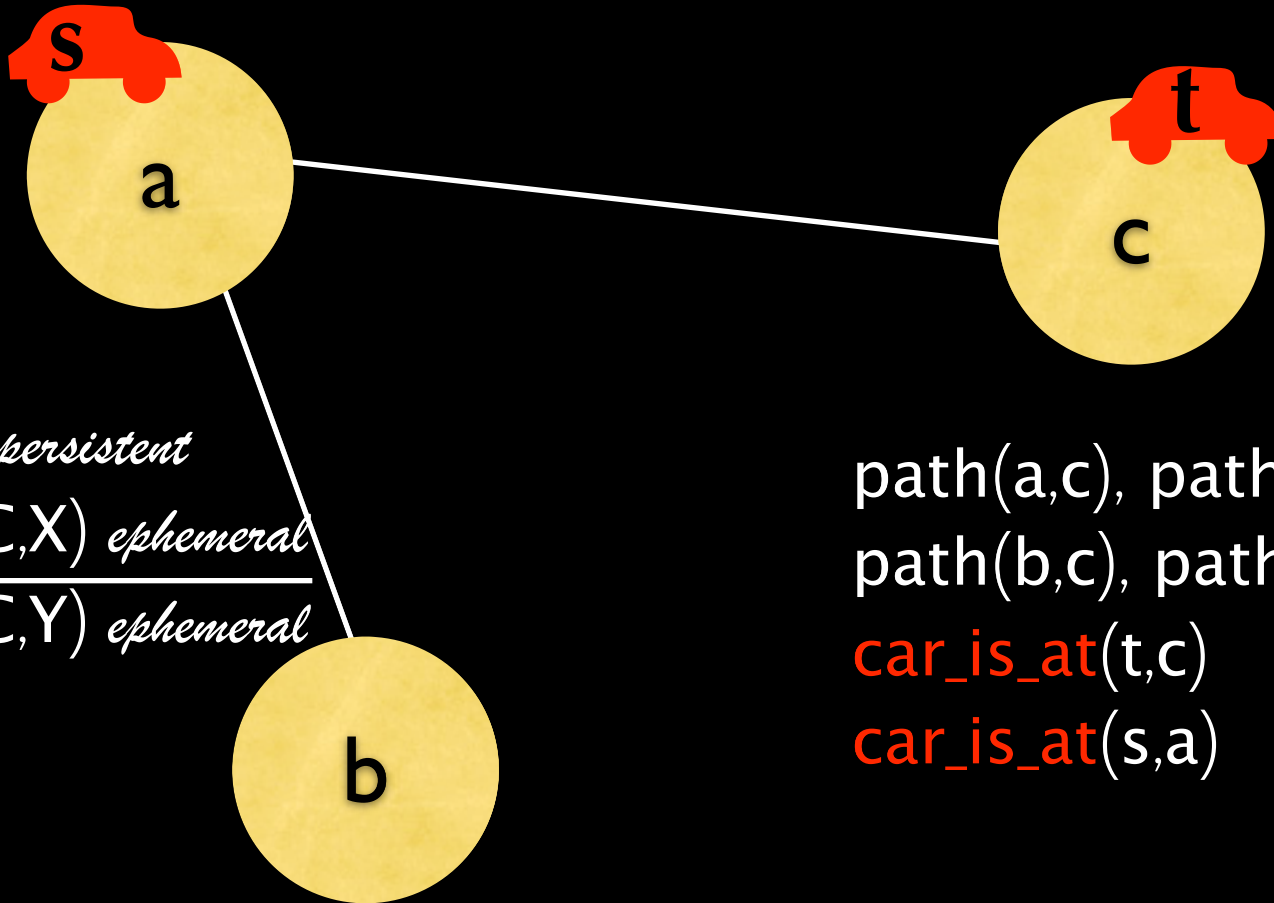
path(a,c), path(c,a), path(a,b),
path(b,c), path(c,b), path(b,a)

Persistent propositions
describe permanent truth the system



path(a,c), path(c,a), path(a,b),
path(b,c), path(c,b), path(b,a)
car_is_at(t,c)
car_is_at(s,a)

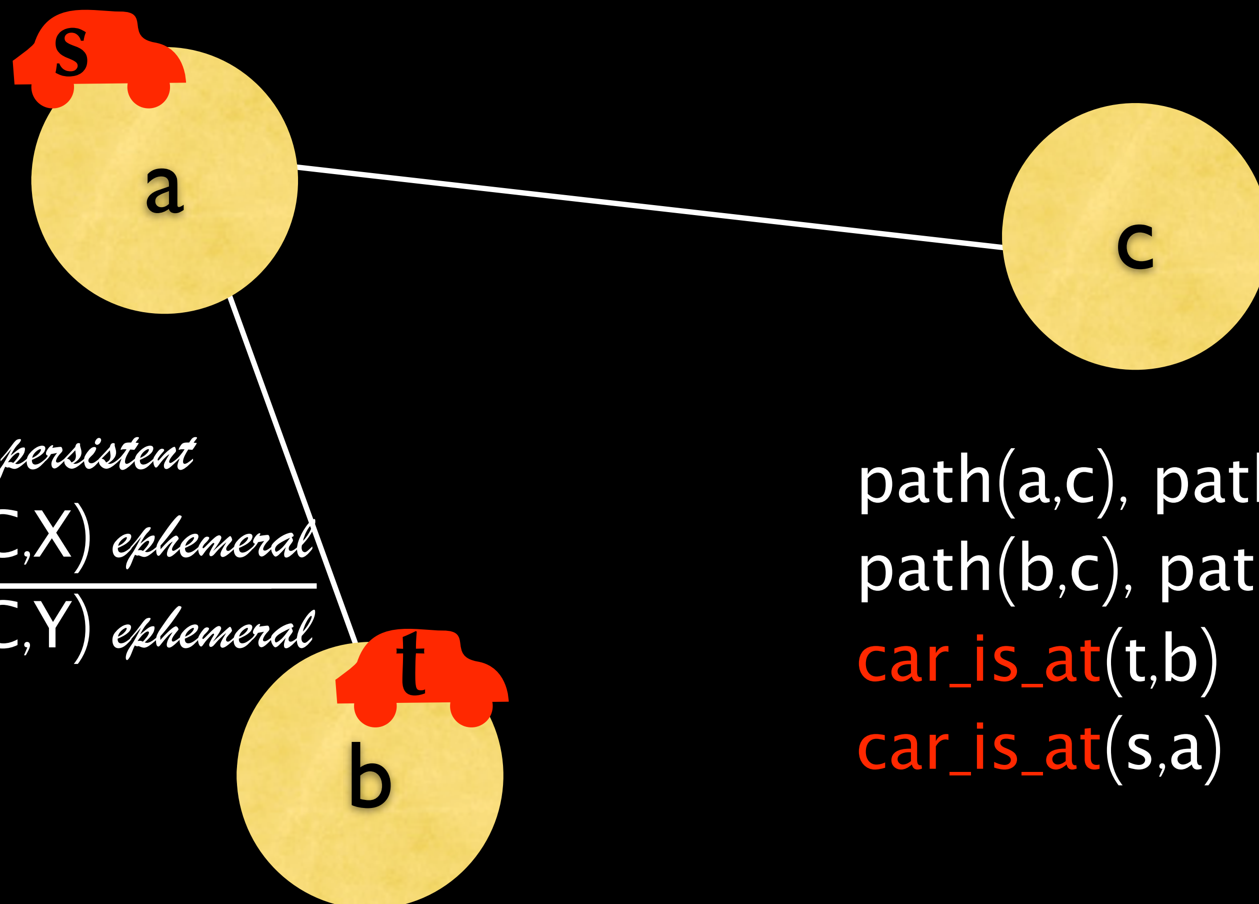
Ephemeral propositions
describe current state of system



$$\frac{\text{path}(X,Y)\ \textit{persistent} \qquad \text{car\_is\_at}(C,X)\ \textit{ephemeral}}{\text{car\_is\_at}(C,Y)\ \textit{ephemeral}}$$

path(a,c), path(c,a), path(a,b),
path(b,c), path(c,b), path(b,a)
car_is_at(t,c)
car_is_at(s,a)

Ephemeral rules describe potential changes to system



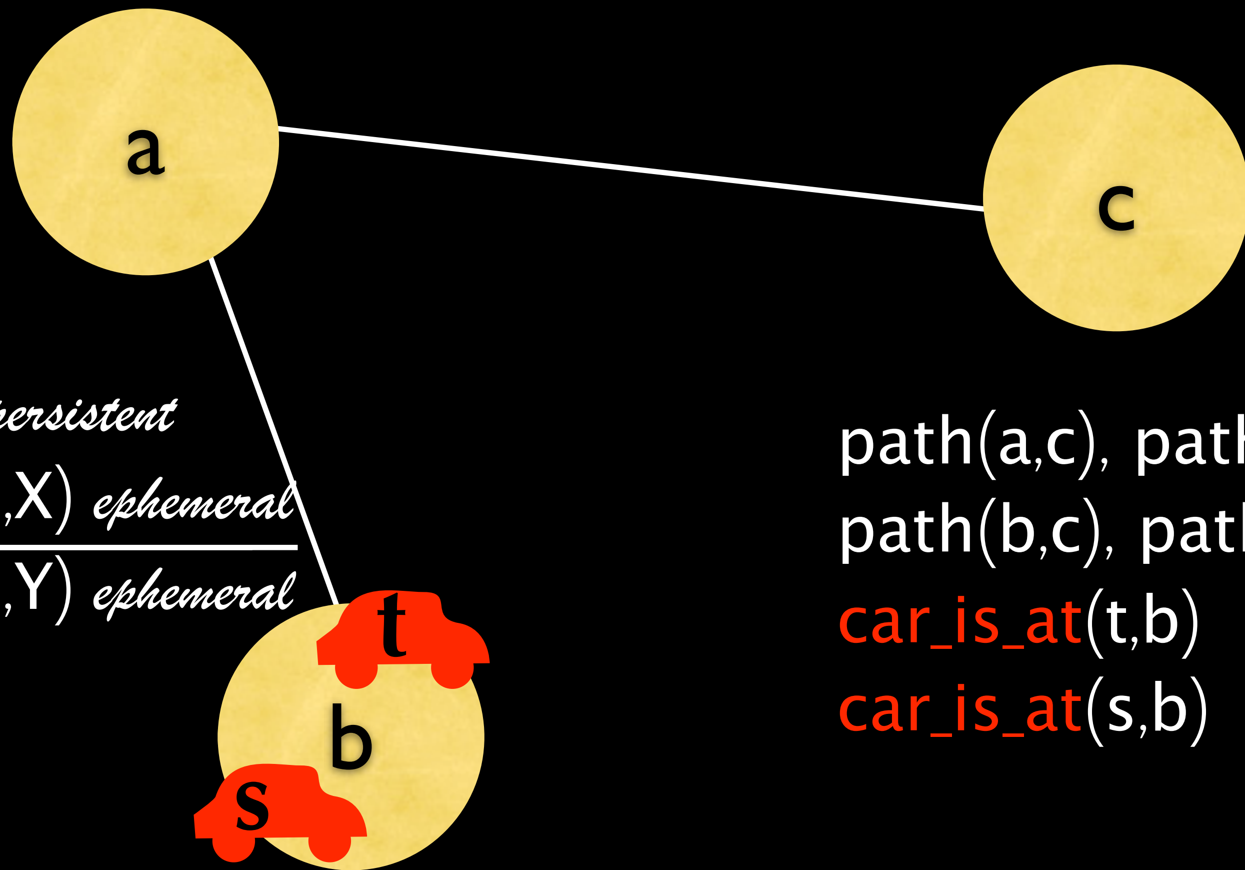
path(X,Y) *persistent*
car_is_at(C,X) *ephemeral*

---

car_is_at(C,Y) *ephemeral*

path(a,c), path(c,a), path(a,b),
path(b,c), path(c,b), path(b,a)
car_is_at(t,b)
car_is_at(s,a)

Ephemeral rules describe potential changes to system



$$\frac{\begin{array}{l}\text{path}(X,Y)\ \textit{persistent}\\ \text{car\_is\_at}(C,X)\ \textit{ephemeral}\end{array}}{\text{car\_is\_at}(C,Y)\ \textit{ephemeral}}$$

path(a,c), path(c,a), path(a,b),
path(b,c), path(c,b), path(b,a)
car_is_at(t,b)
car_is_at(s,b)

Ephemeral rules
describe potential changes to system

$$\frac{\text{unvisited}(\text{root})}{\text{visited}(\text{root})}$$

$$\frac{\begin{array}{c}\text{edge}(X,Y)\\ \text{visited}(X)\\ \text{unvisited}(Y)\end{array}}{\begin{array}{c}\text{visited}(Y)\\ \text{tree}(X,Y)\end{array}}$$

Ephemeral propositions are "mutual exclusion locks"

$$\frac{\text{unvisited(root)}}{\text{visited(root)}}$$

$$\frac{\text{edge(X,Y)} \quad \text{visited(X)} \quad \text{unvisited(Y)}}{\text{visited(Y)} \quad \text{tree(X,Y)}}$$

$$\frac{\mathrm{item}(X) \qquad \mathrm{list}(L)}{\mathrm{list}(\mathrm{cons}(X,L))}$$

Ephemeral propositions are "state objects"

$$\frac{\text{item}(X) \quad \text{list}(L)}{\text{list}(\text{cons}(X,L))}$$

Logical account of concurrency

Ephemeral propositions are
“mutual exclusion locks”
“state objects”
...what else?

Represent locality? (@modal logic)
Global synchronization? (temporal logic)

Declarative model of programming can allow more optimizations

Executable specifications!

Huge success with purely-persistent Datalog programming (Whaley et. al)

Spiral too, it seems!

Both are domain-specific (whether de facto or de jure)