

Model Based Analysis of Time-aware Web Services Interactions



Julien Ponge
PhD thesis defense



Outline

1

Introduction

2

Timed protocols modeling

3

Theoretical study of time impacts

4

Prototyping, applications

5

Conclusion

Introduction





databases, new & legacy applications

applications and clients



RPC, MOM, ESB, ...



databases, new & legacy applications

partner 1

partner 2

my company

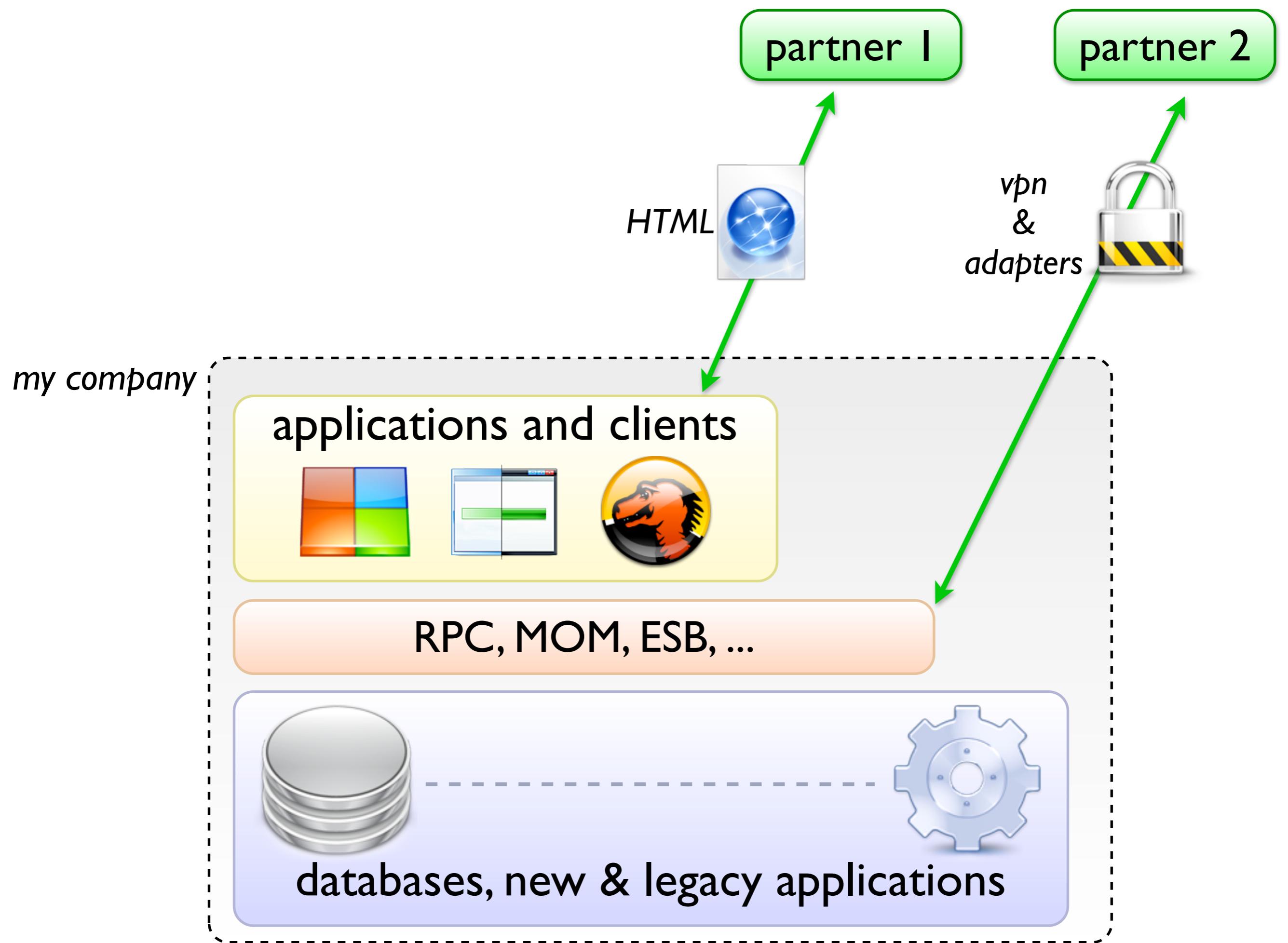
applications and clients

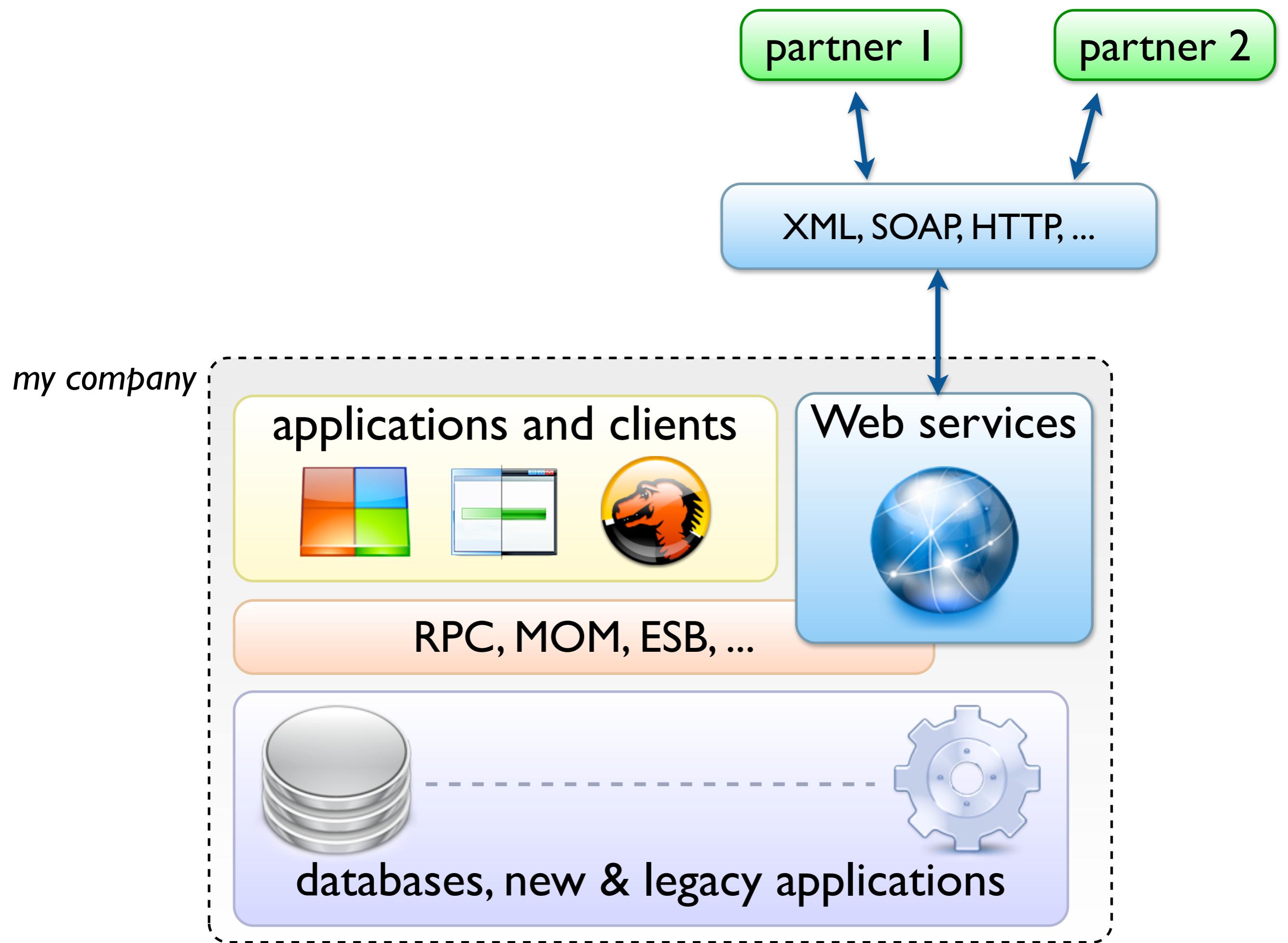


RPC, MOM, ESB, ...

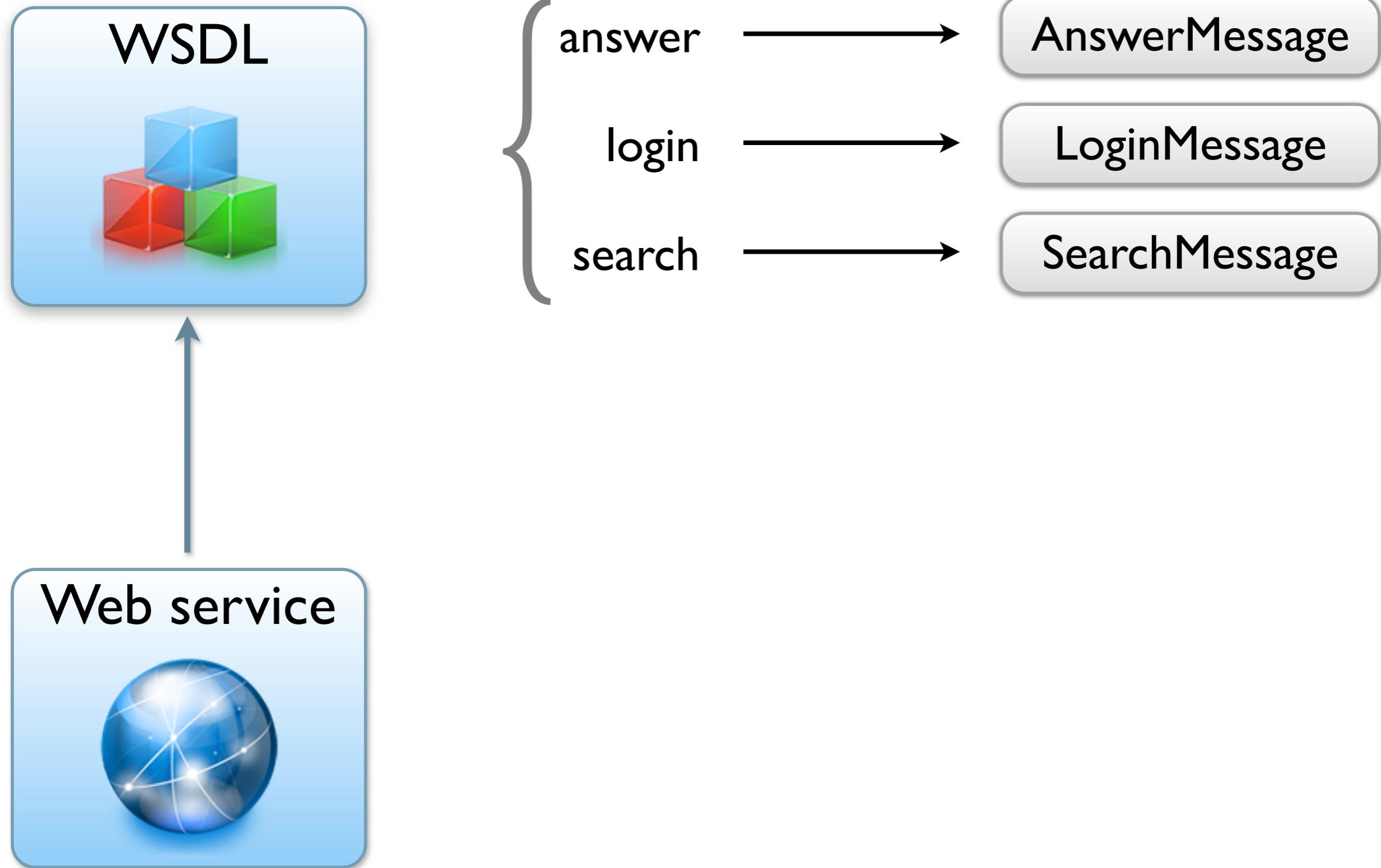


databases, new & legacy applications

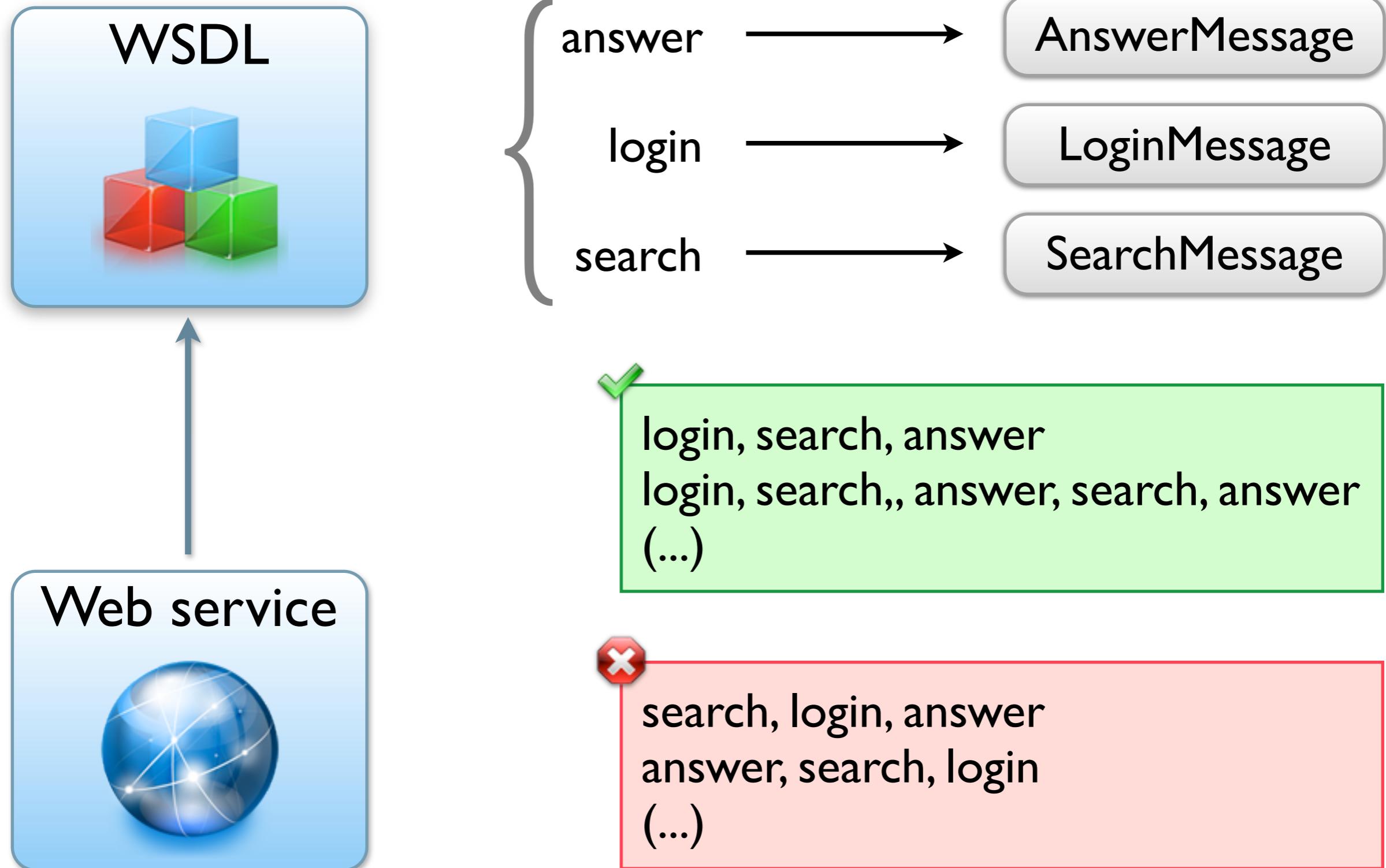




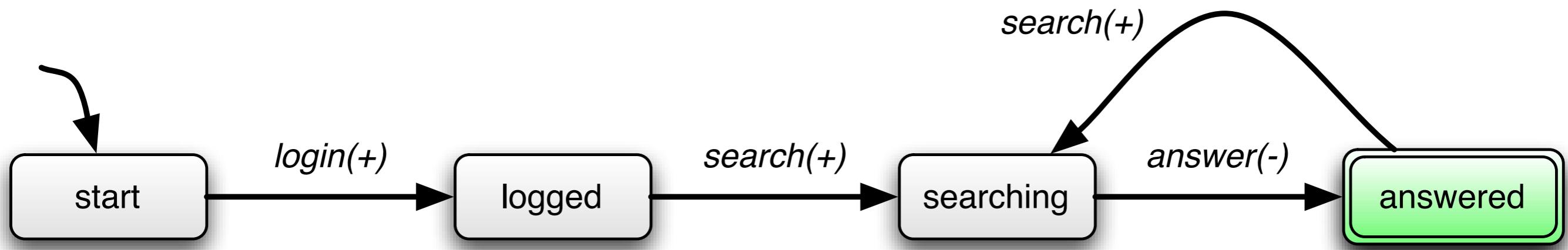
Static vs dynamic interface



Static vs dynamic interface



Business protocols



- ✓ Finite deterministic automata
- ✓ Conversations = language
- ✓ Extensions: transactions, timing constraints, policies, ...

Compatibility

Service



Requester



Compatibility



Replaceability

Service



Requester

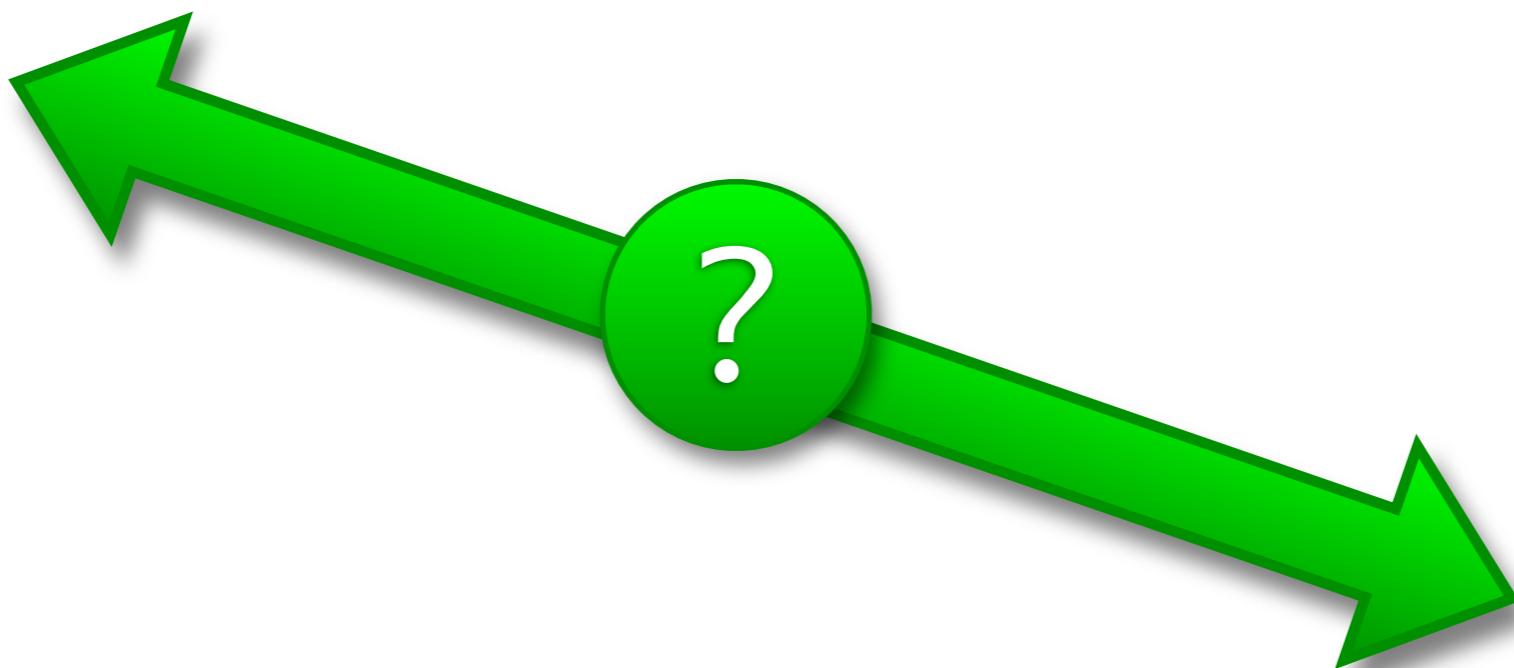


Replaceability



Replaceability

Service



Service



Requester



(flexible) classes

Compatibility

Replaceability

Full

Full

Partial

Partial

Subsumption, equivalence

w.r.t. client protocol

w.r.t. interaction role

It facilitates...

Binding



Discovery

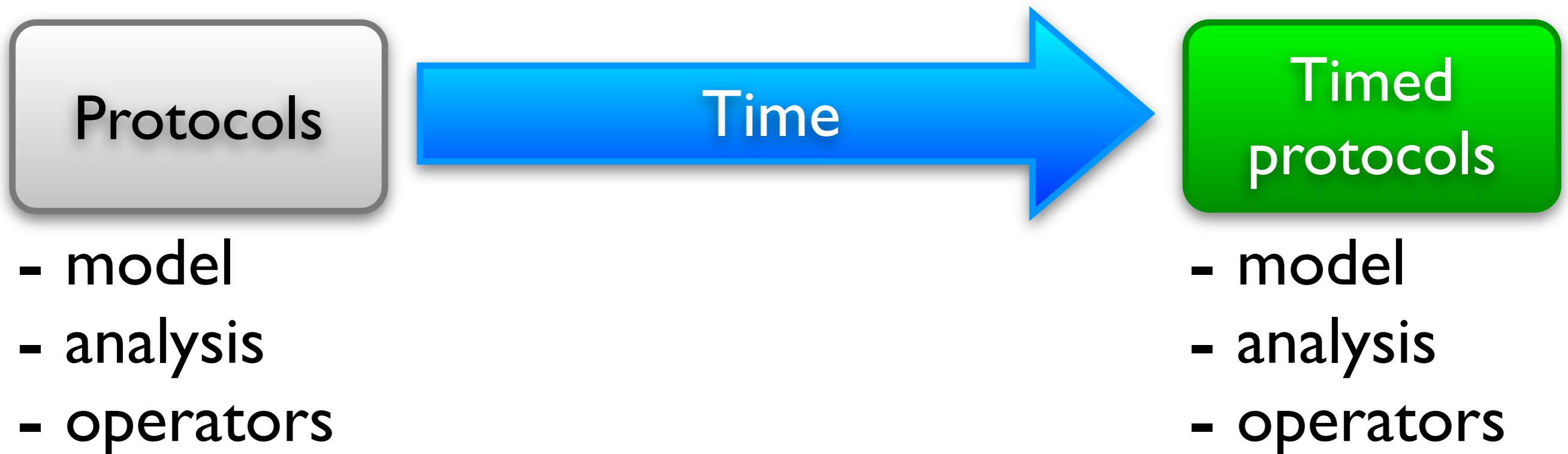


Problem overview

Protocols

- model
- analysis
- operators

Problem overview





Time is everywhere!

TCP/IP

Watchdogs

Transaction locks

Business agreements

BPEL (wait / onAlarm)

RosettaNet

(...)



Contributions



Contributions

Model

Timed protocols

Impact

Timed automata + a new class

Prototype

ServiceMosaic + applications



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Timed protocols

Timing constraints

C-Invoke



M-Invoke



Timing constraints

C-Invoke

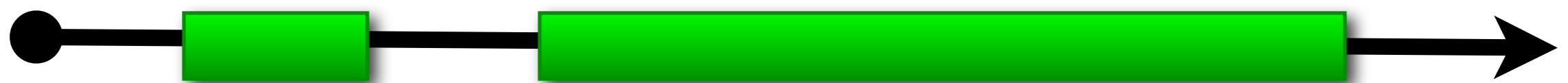


M-Invoke

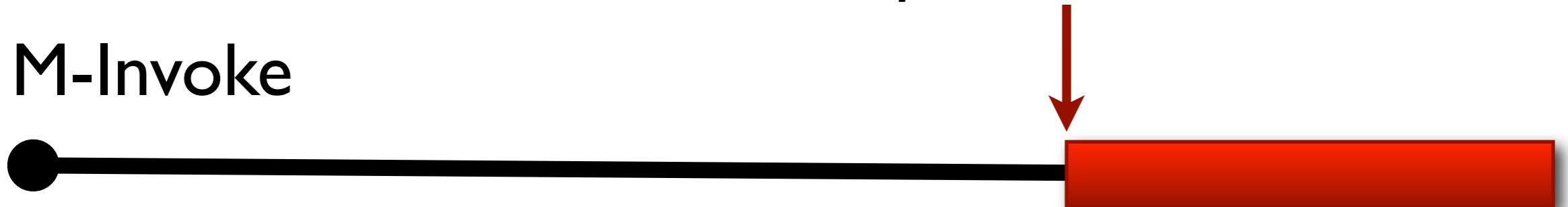


Timing constraints

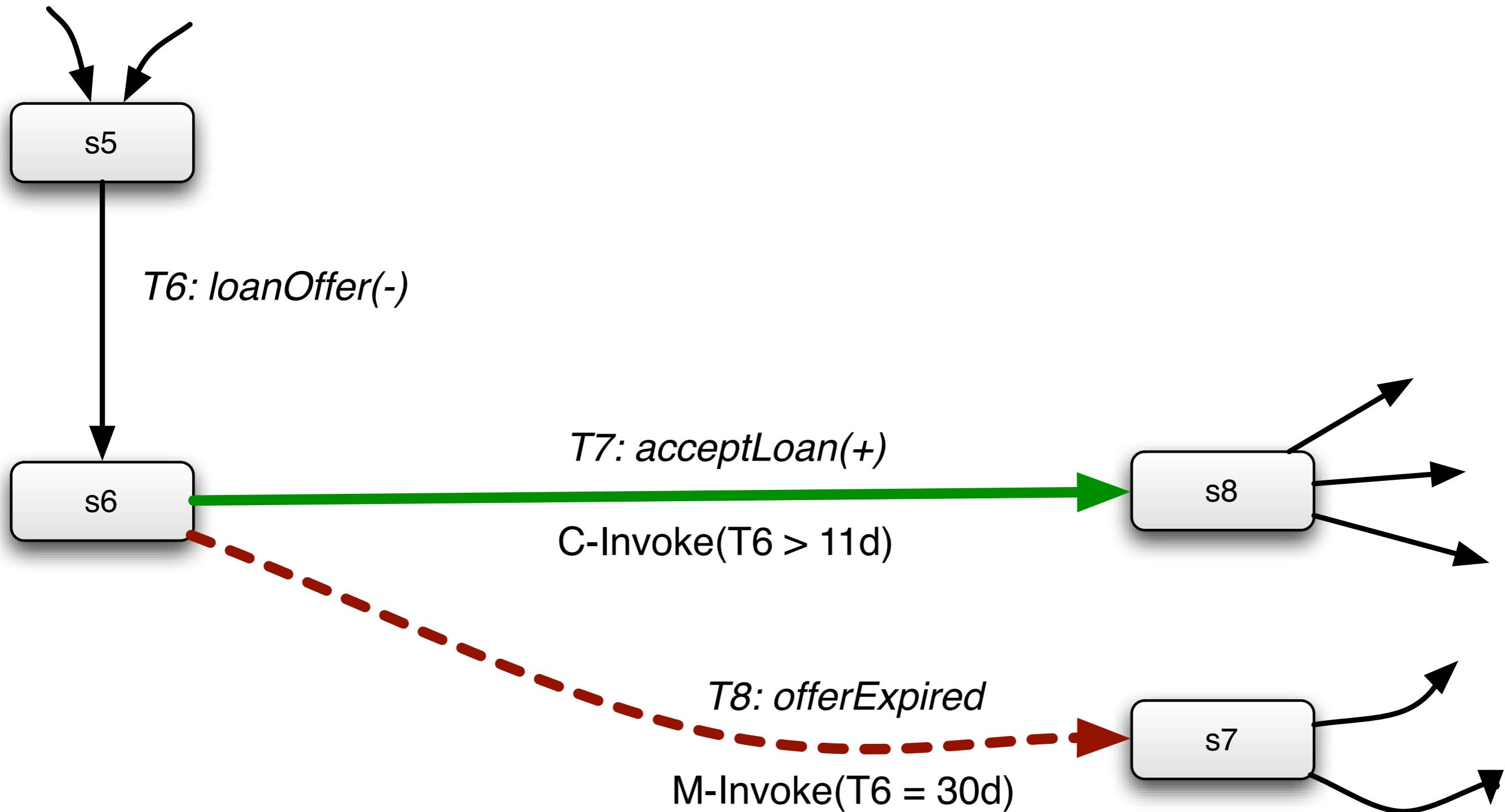
C-Invoke



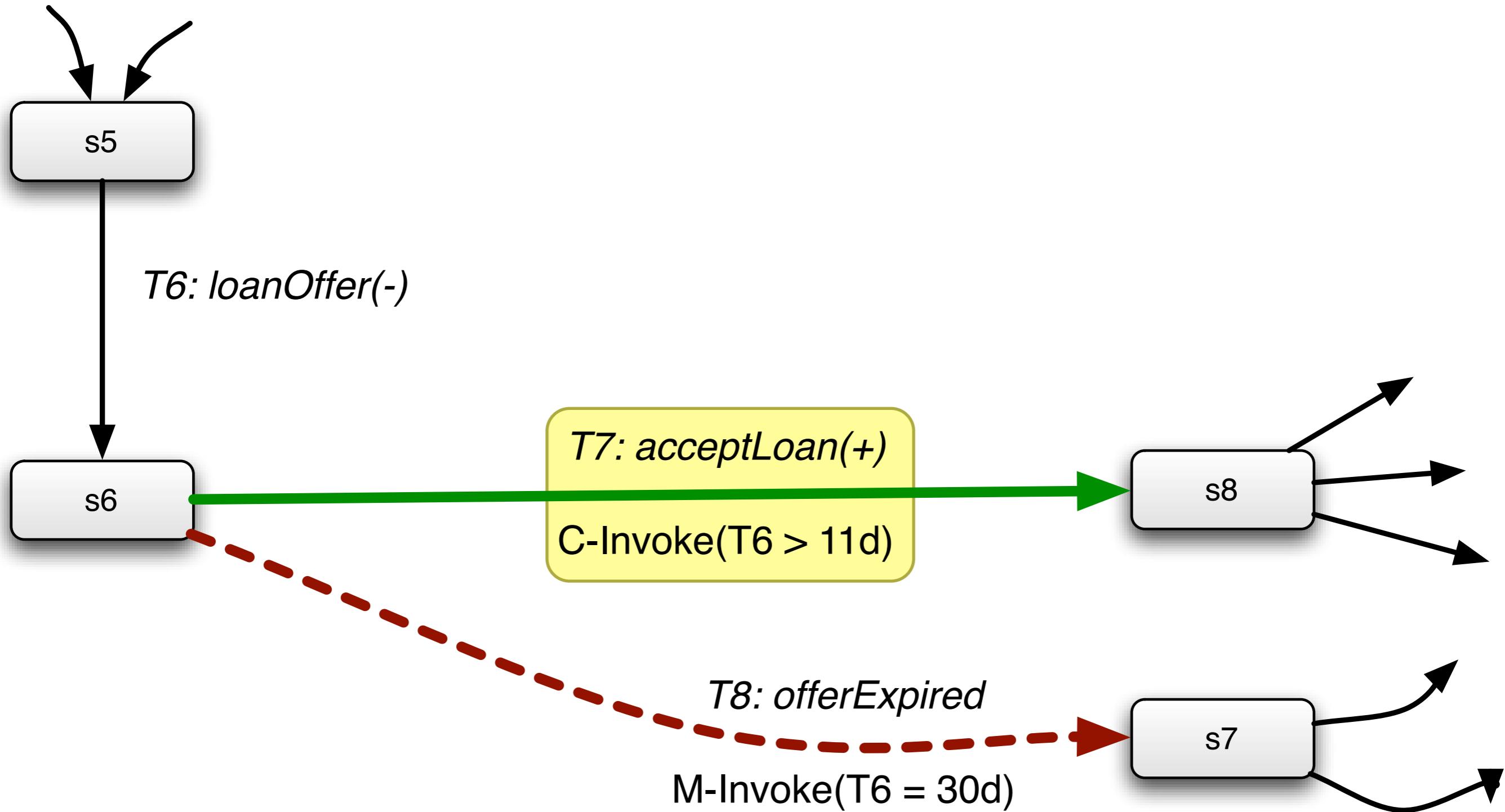
M-Invoke



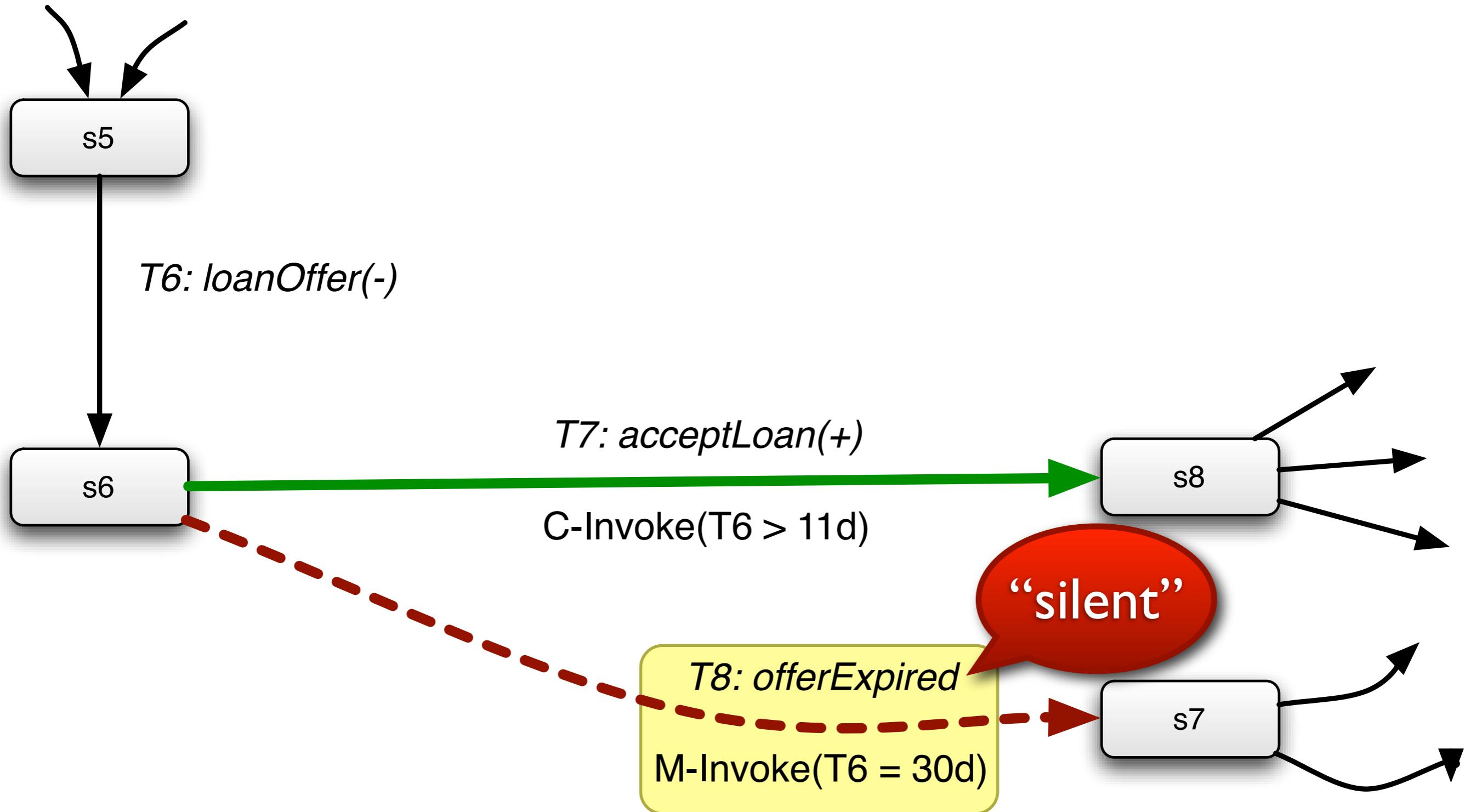
Extensions



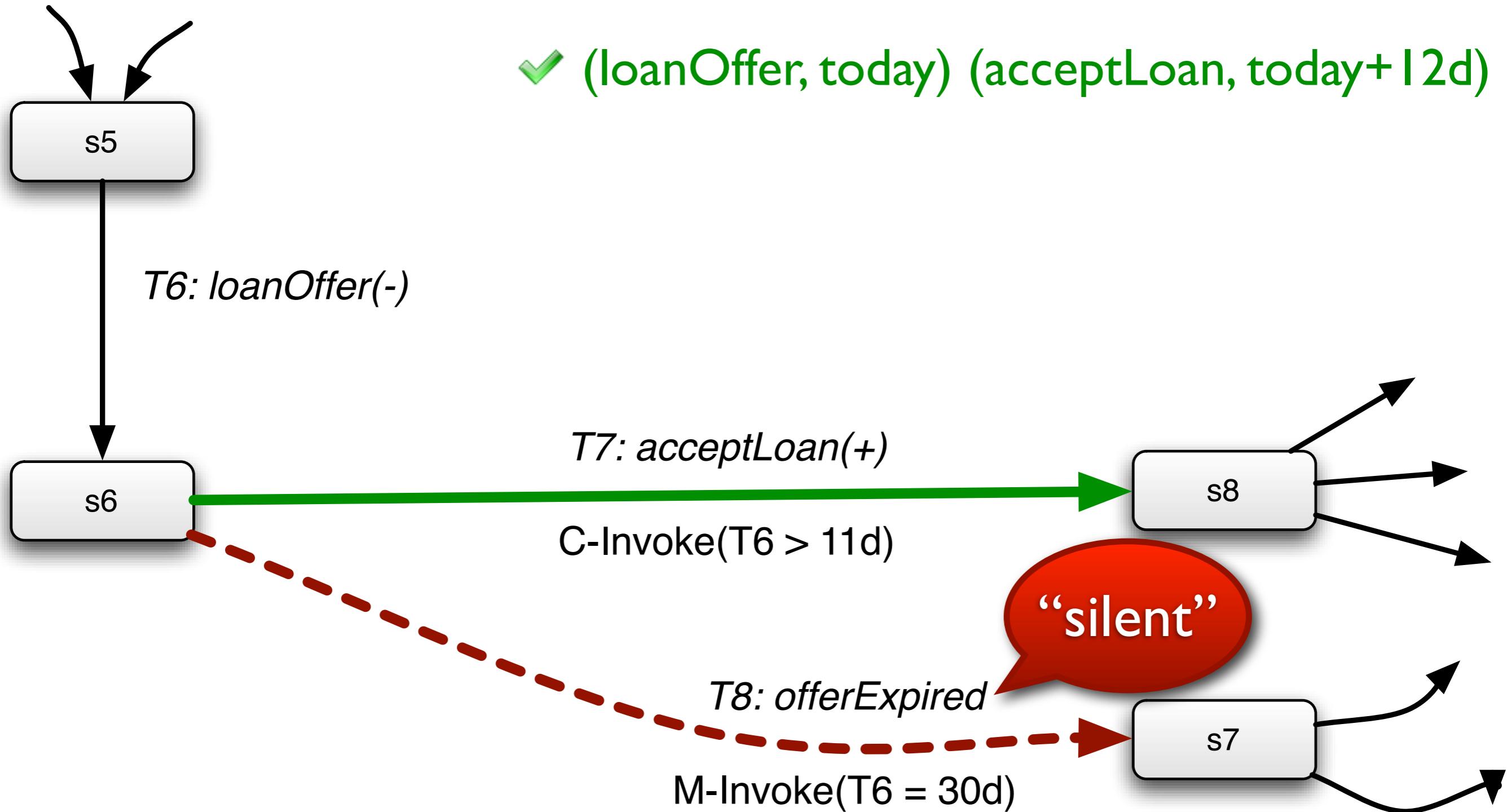
Extensions



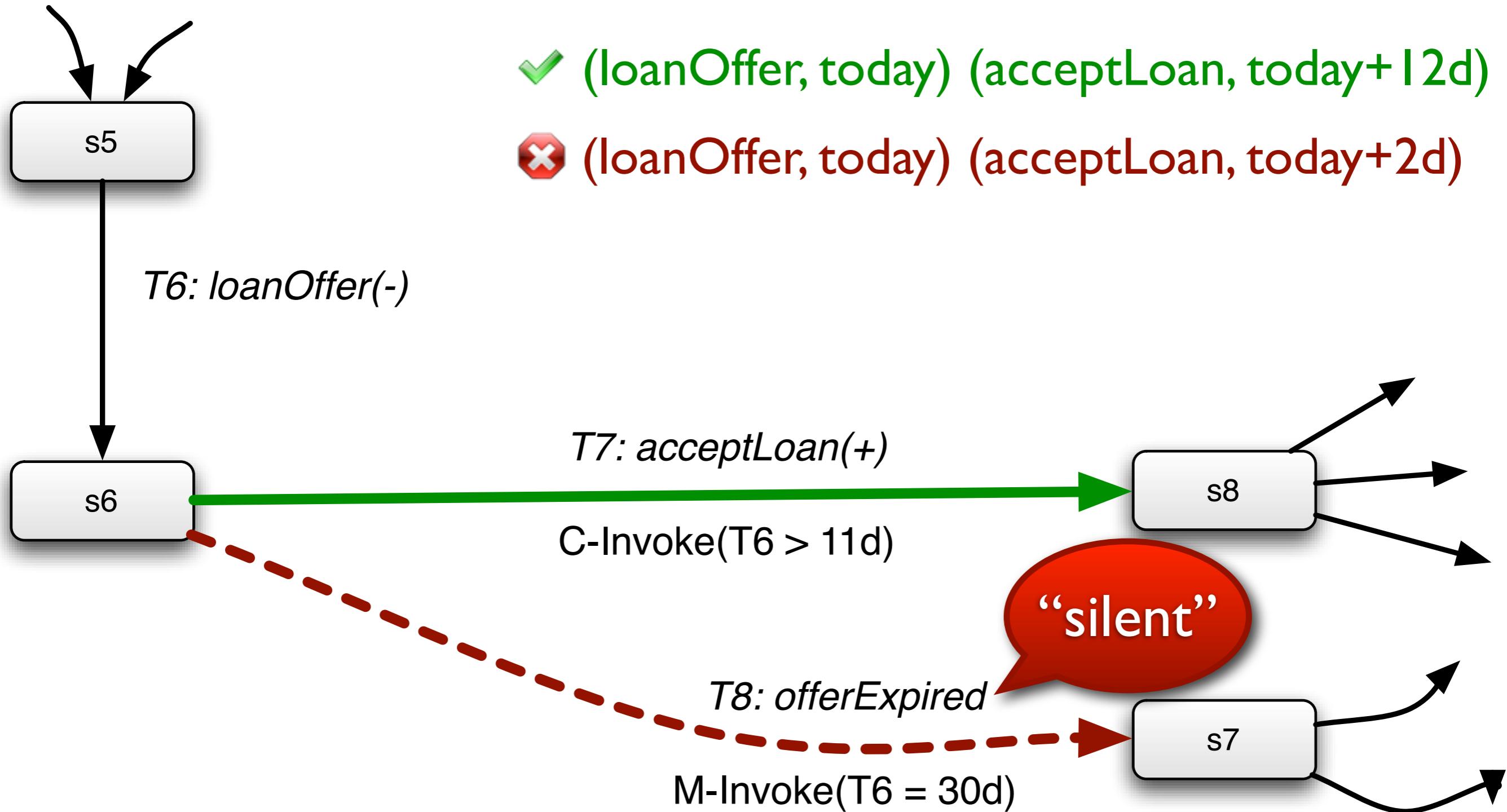
Extensions



Extensions



Extensions



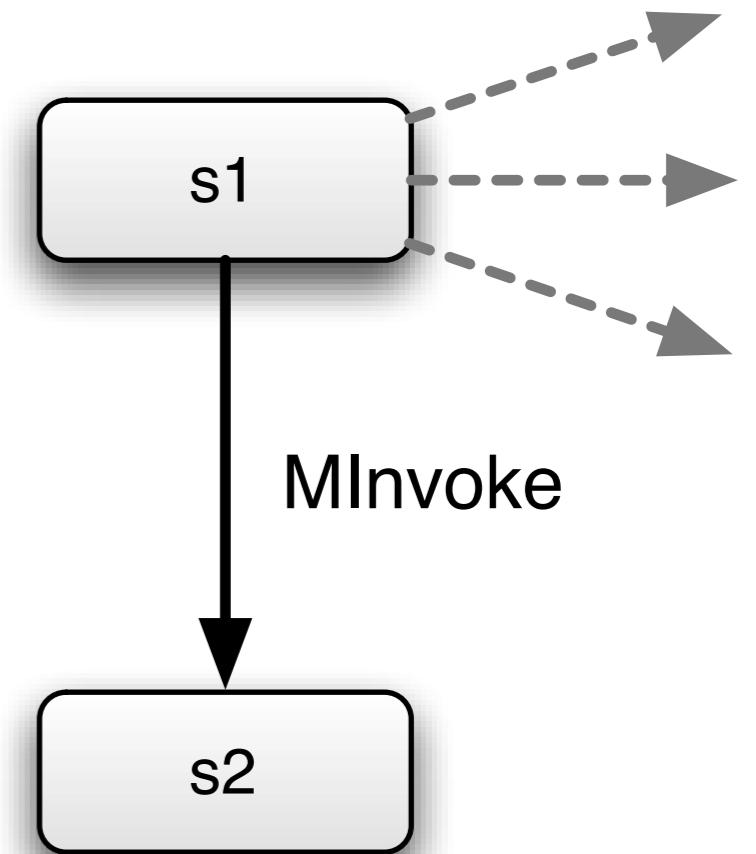


MInvoke semantics

MInvoke($T1 = 1h$)

MInvoke($T1 = 1h \&& T2 > 5m$)

MInvoke($T1 = 1h || (T2 = 30m \&& T3 < 15m)$)





MInvoke semantics

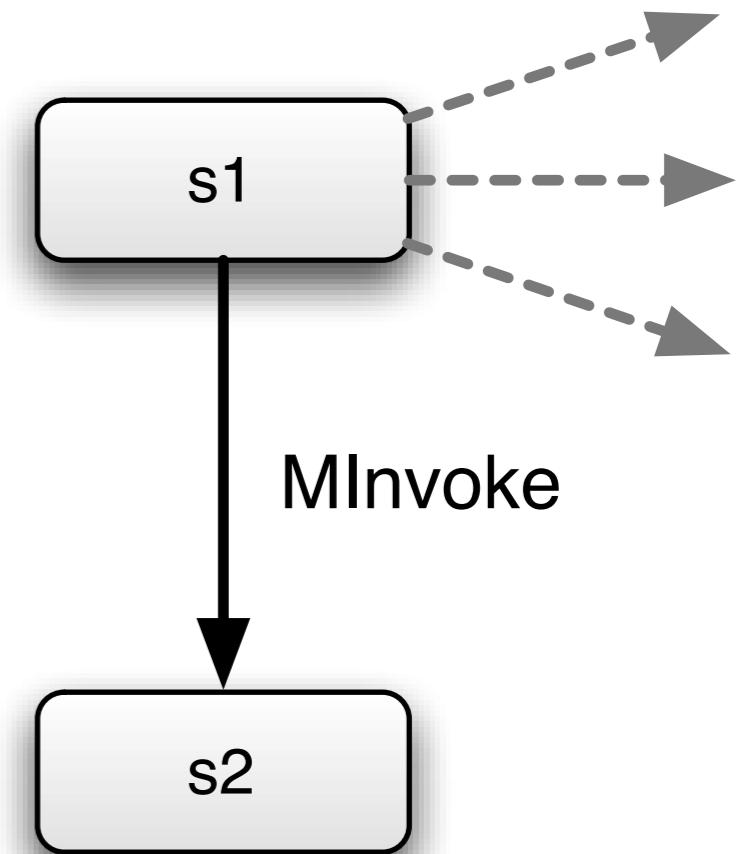
MInvoke($T1 = 1h$)

MInvoke($T1 = 1h \&& T2 > 5m$)

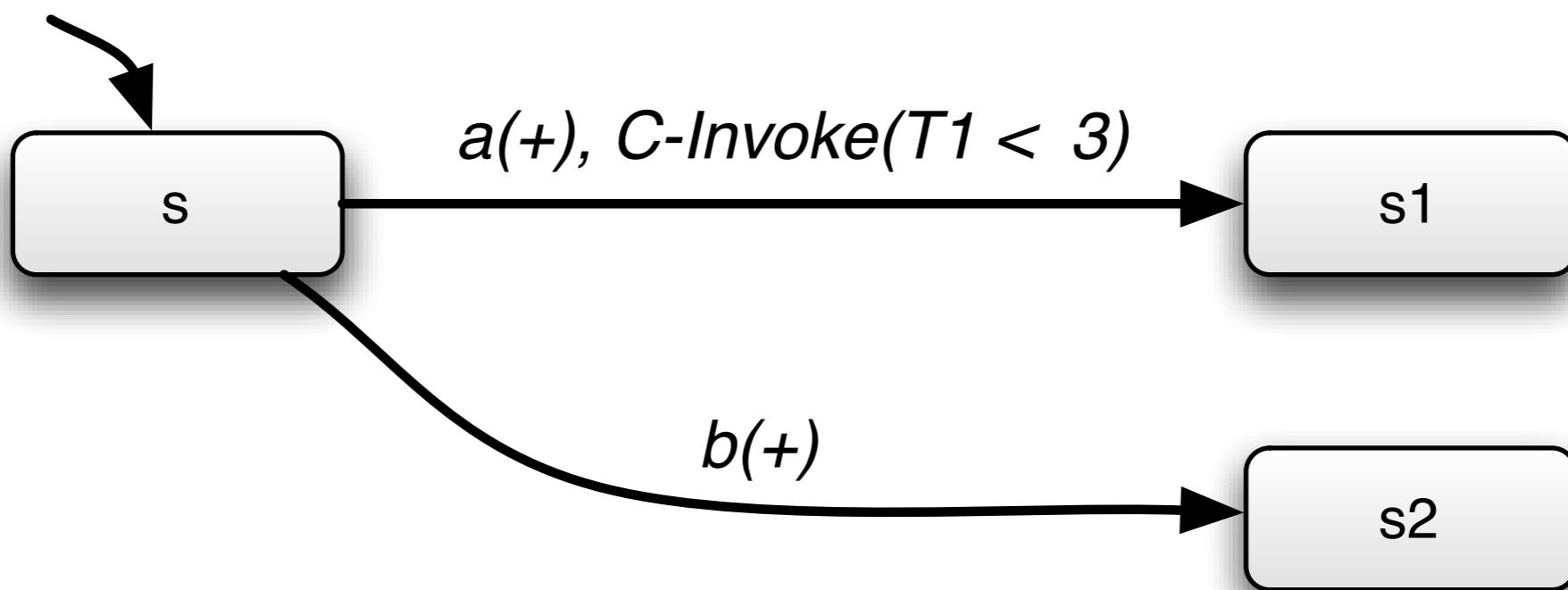
MInvoke($T1 = 1h || (T2 = 30m \&& T3 < 15m)$)



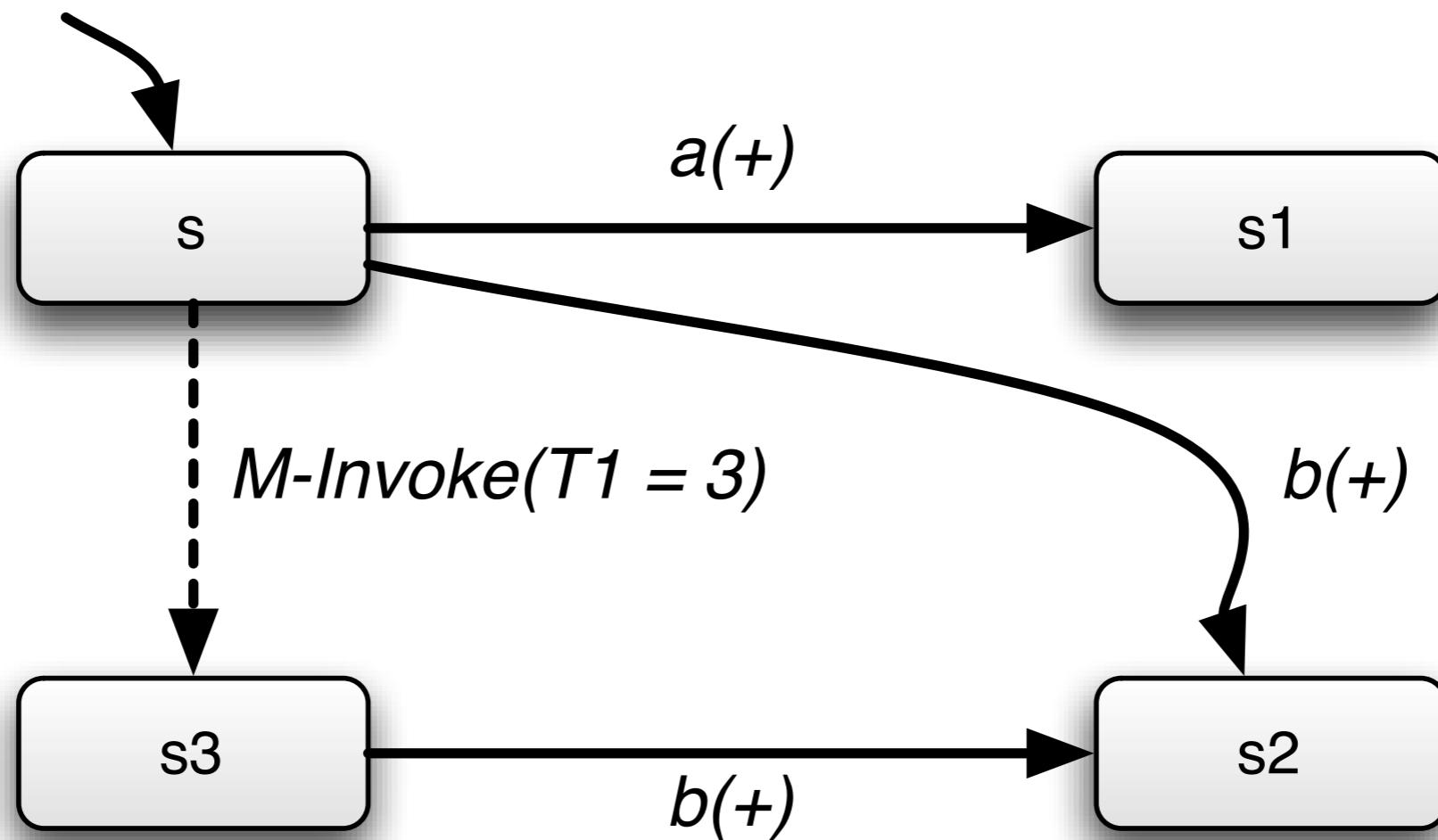
MInvoke($T1 > 1h$)



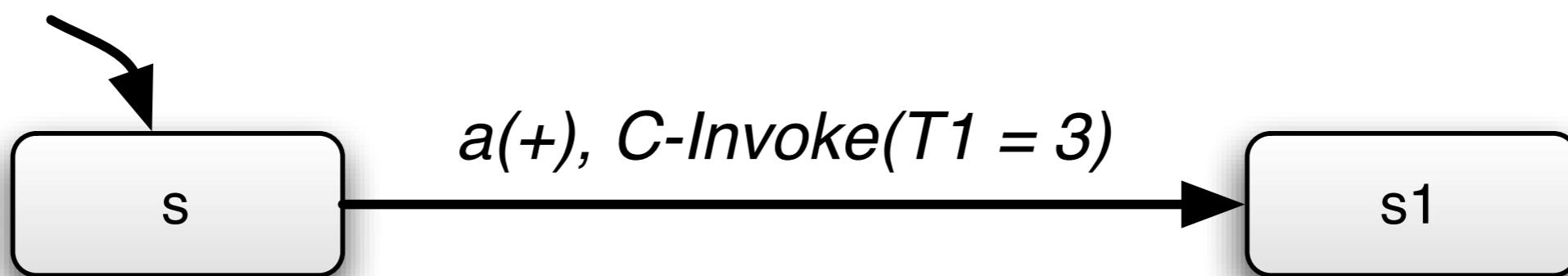
CInvoke vs MInvoke



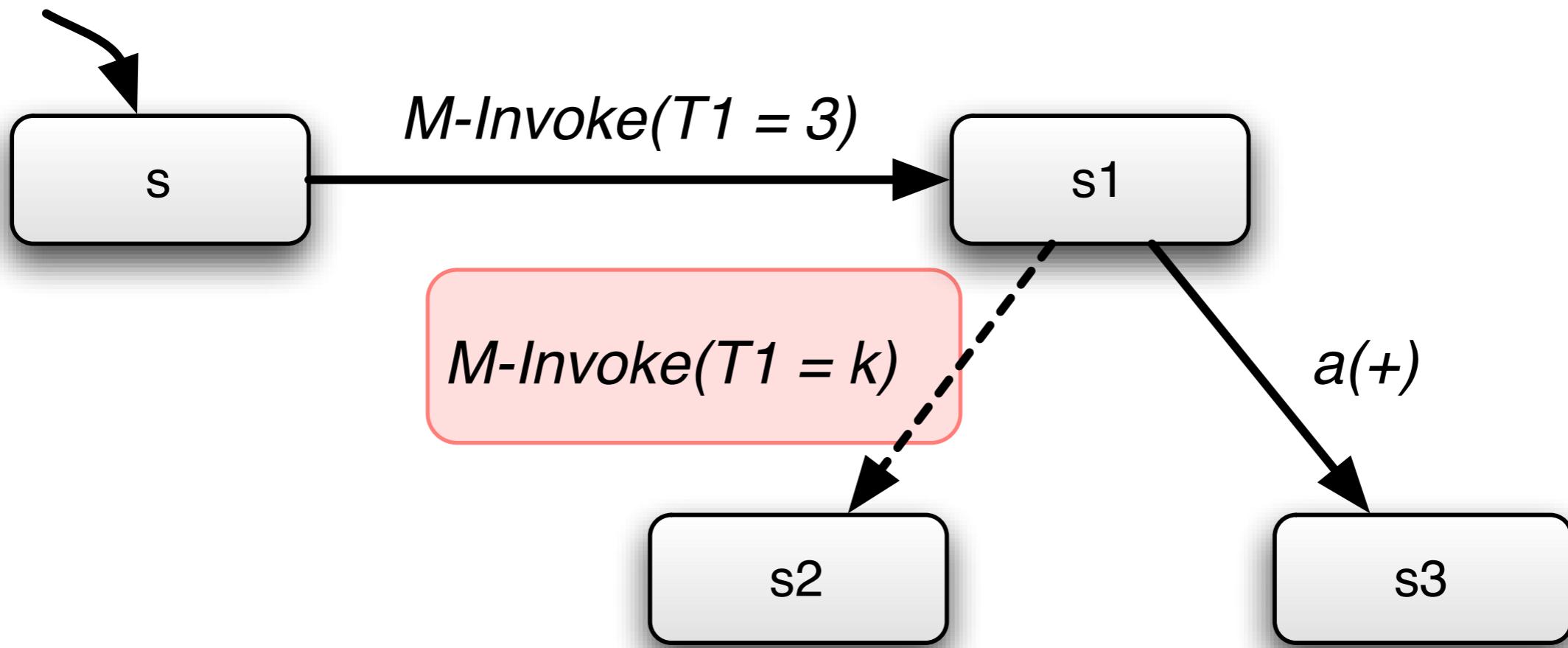
CInvoke vs MInvoke



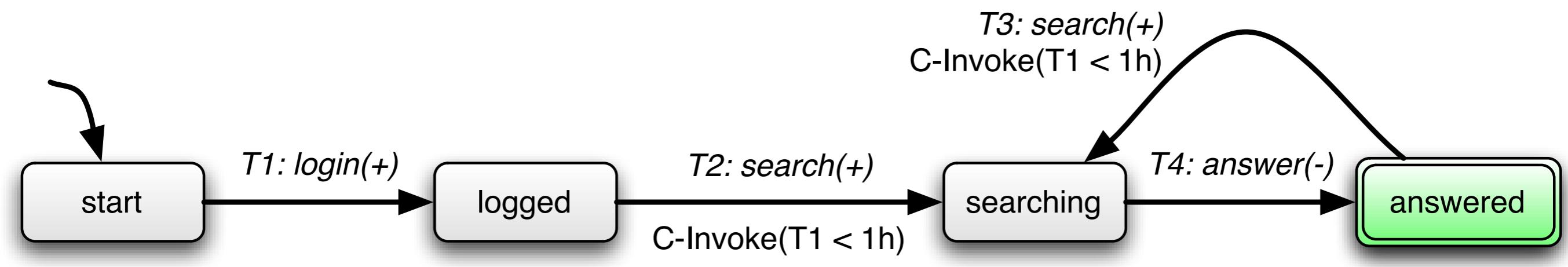
CInvoke vs MInvoke



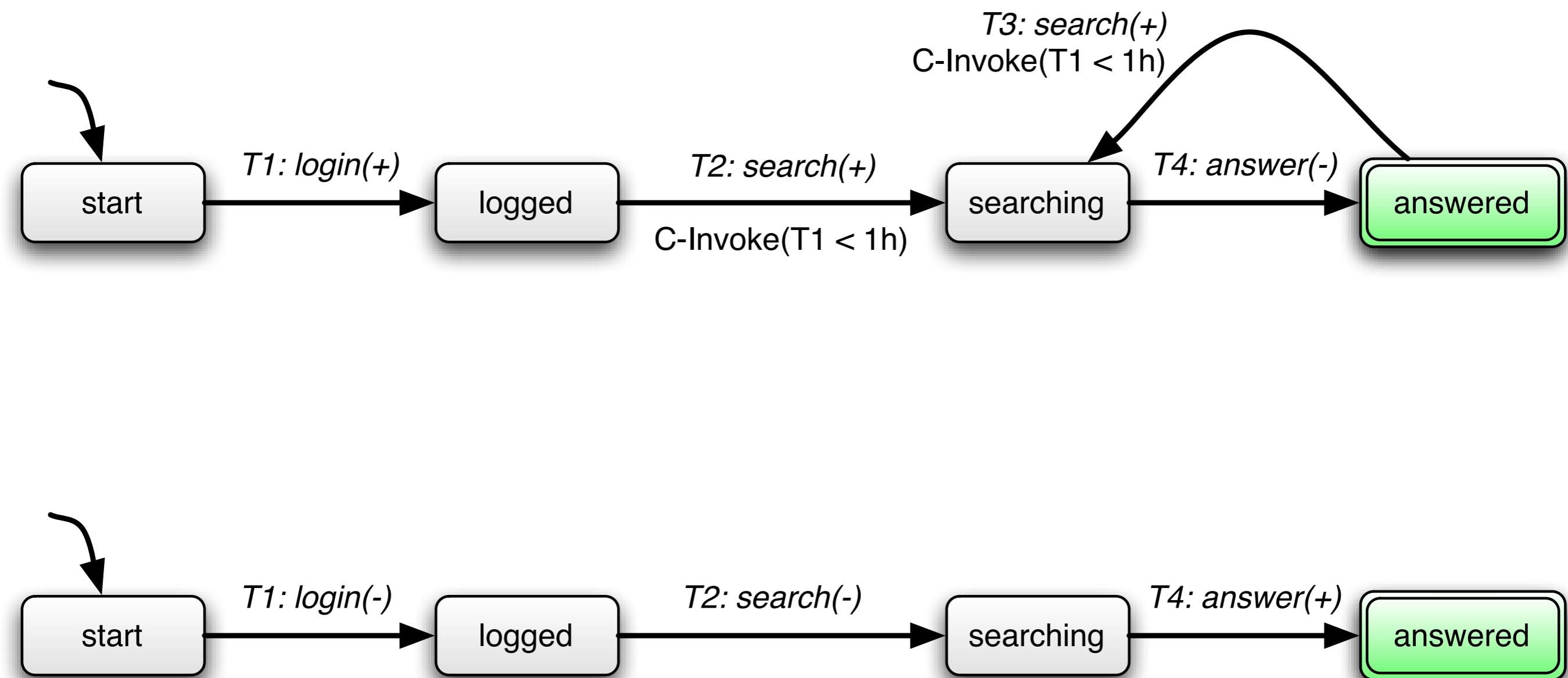
CInvoke vs MInvoke



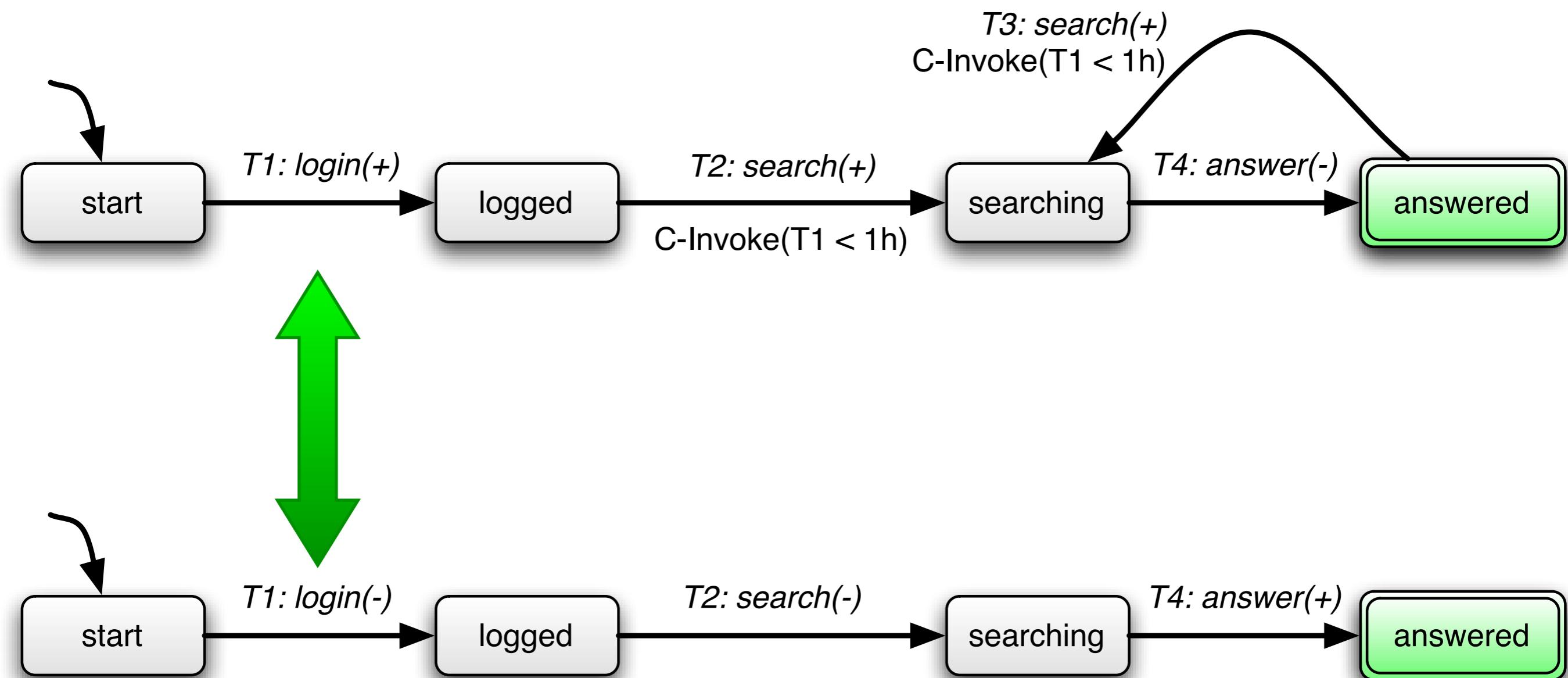
Time-sensitive compatibility



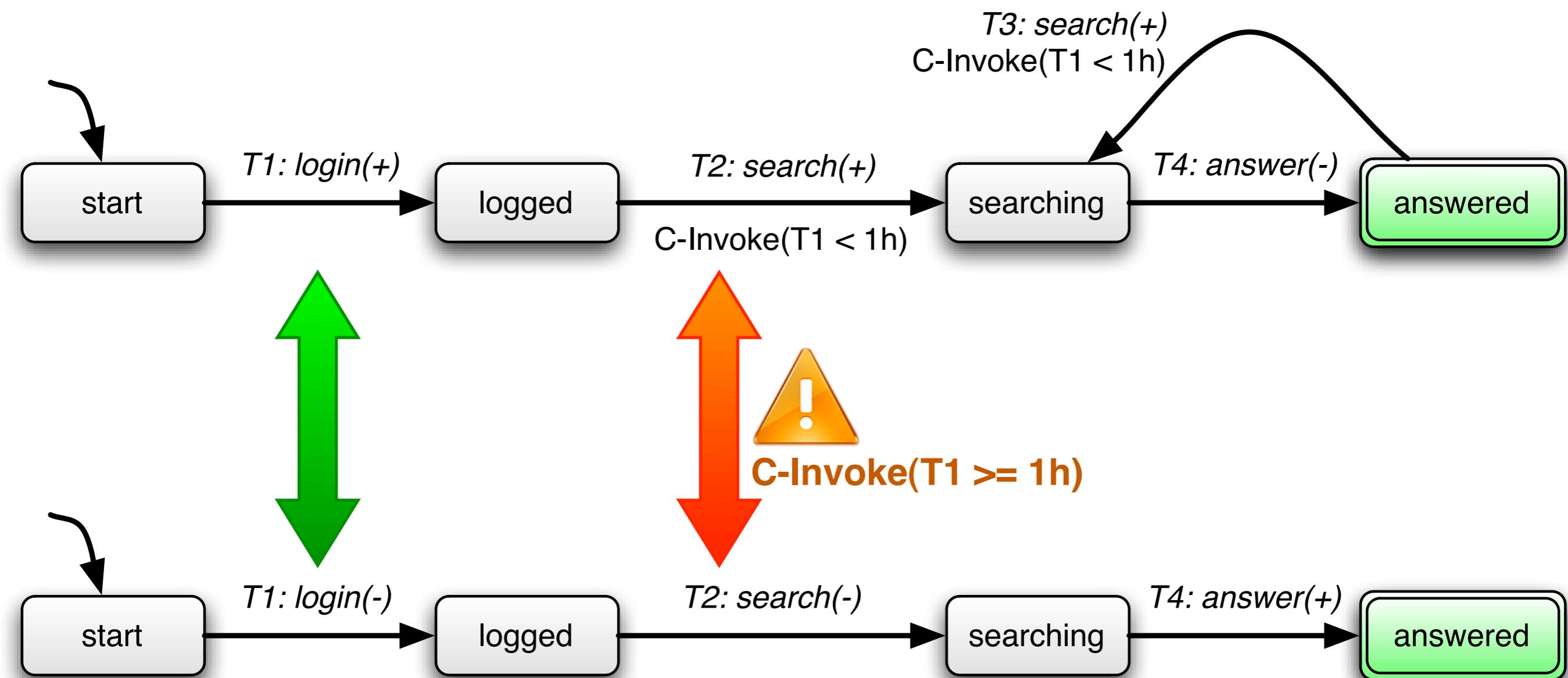
Time-sensitive compatibility



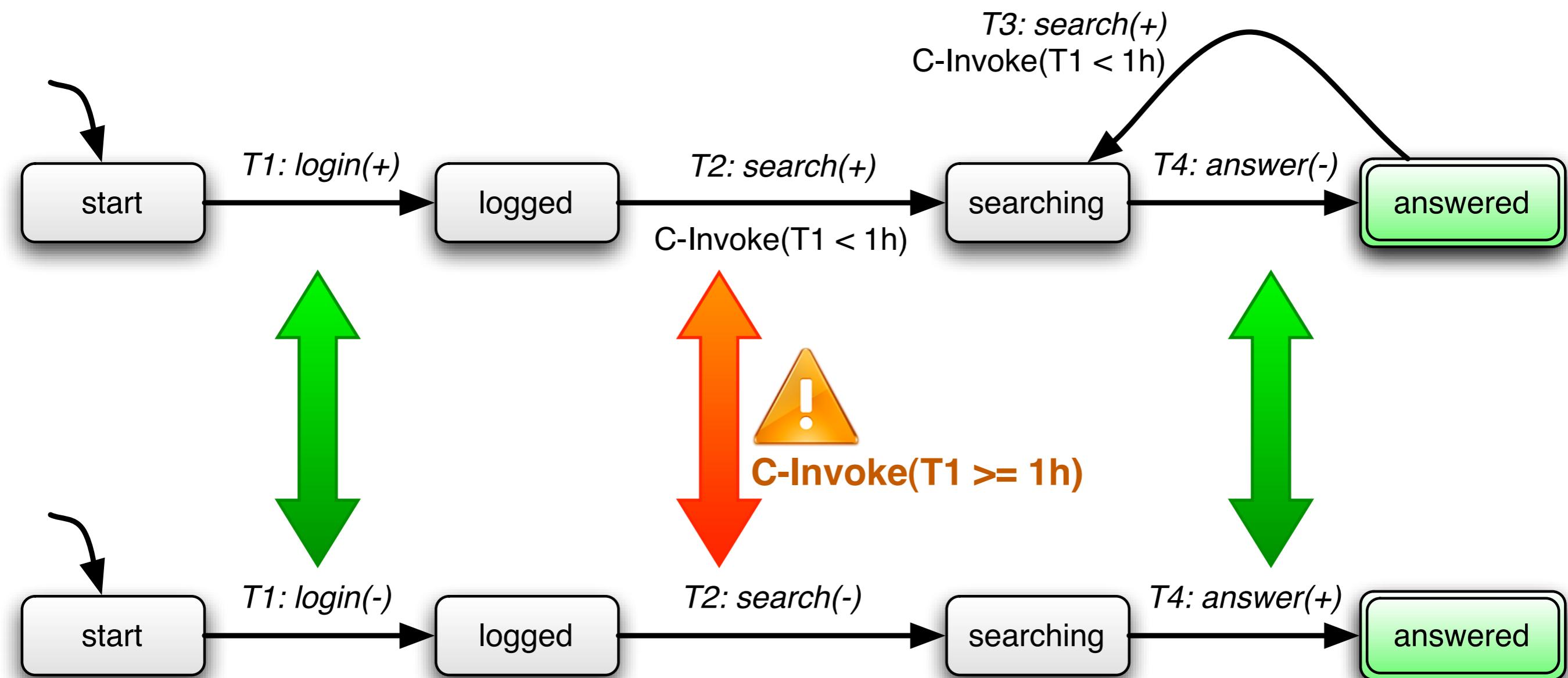
Time-sensitive compatibility



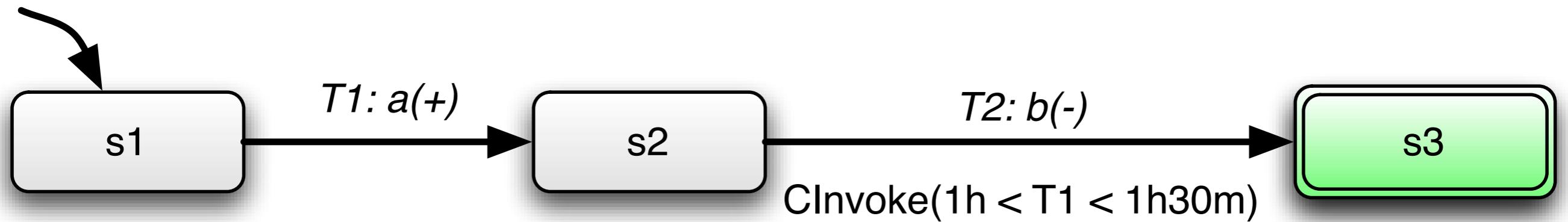
Time-sensitive compatibility



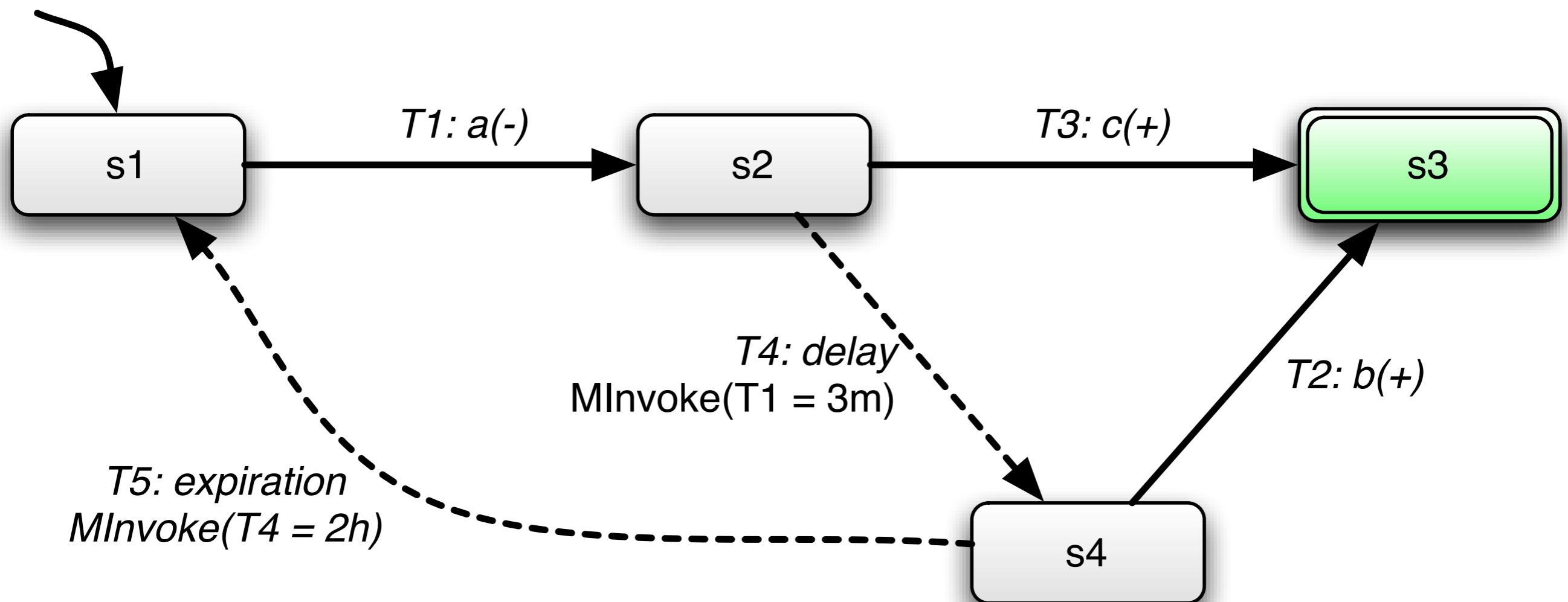
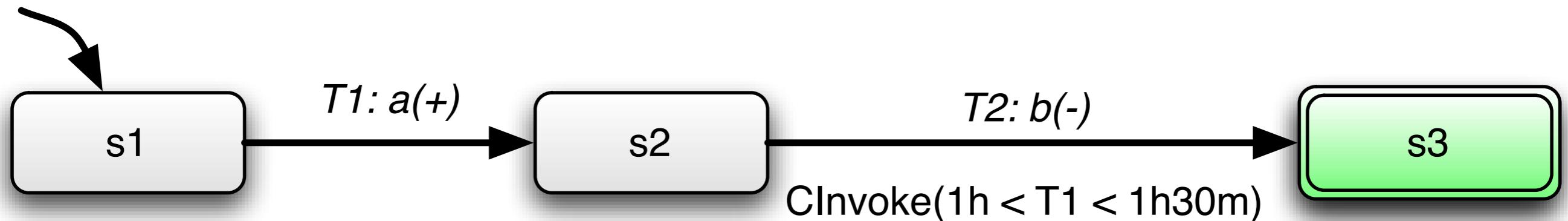
Time-sensitive compatibility



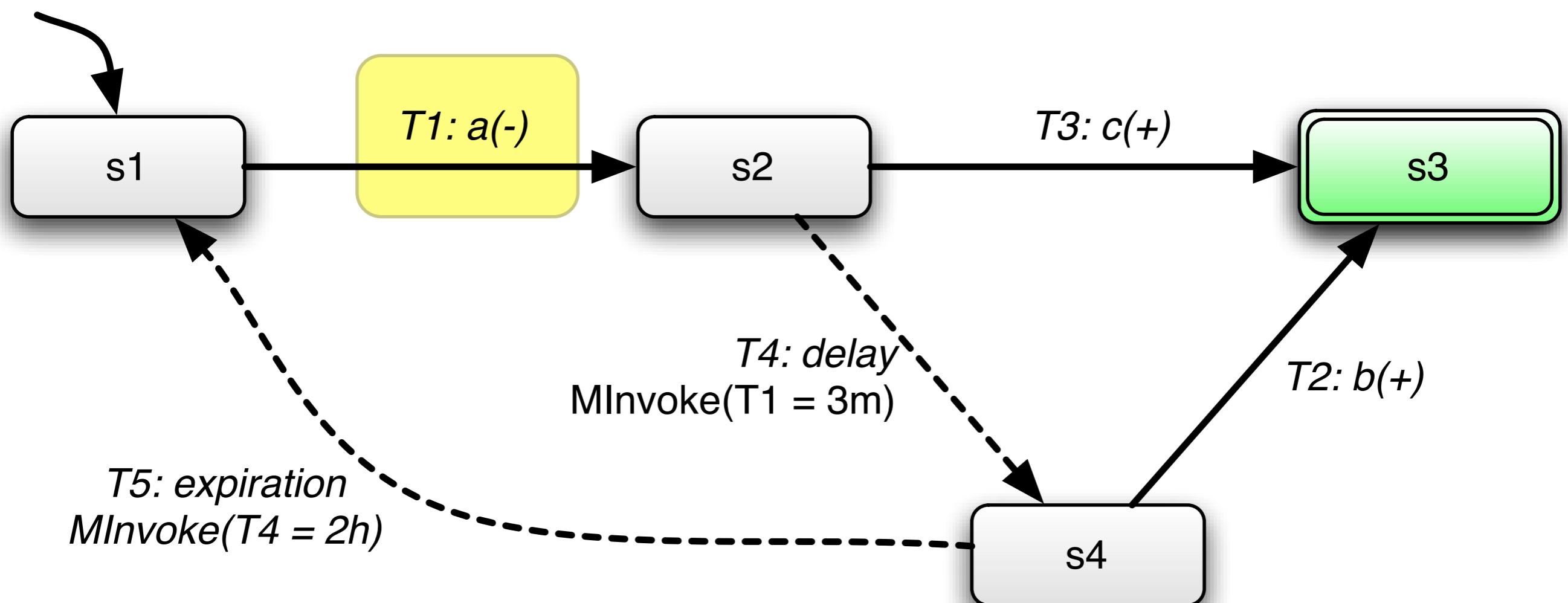
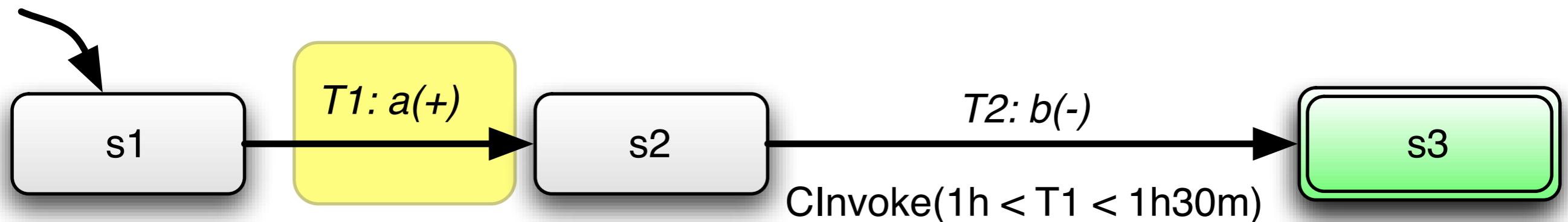
Full compatibility



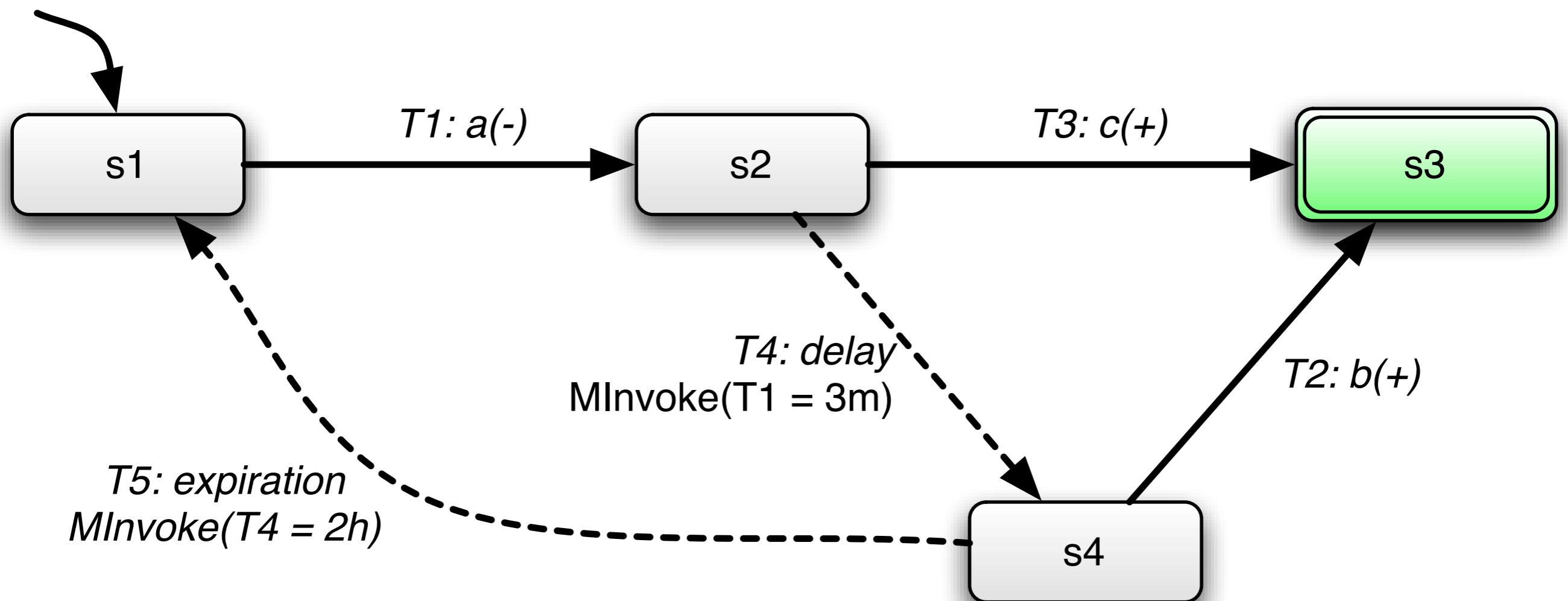
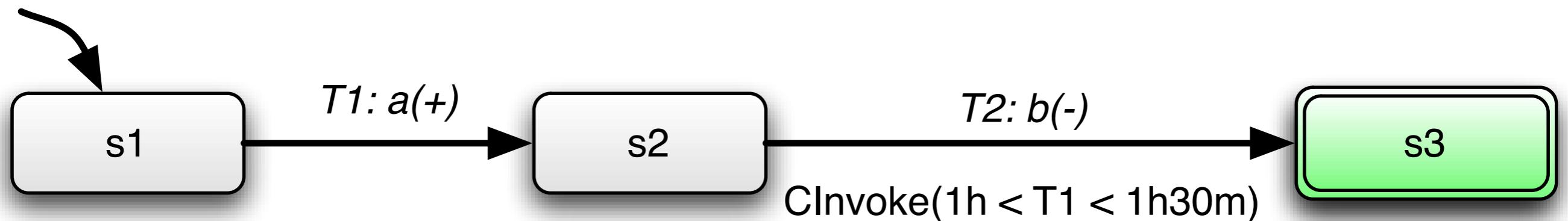
Full compatibility



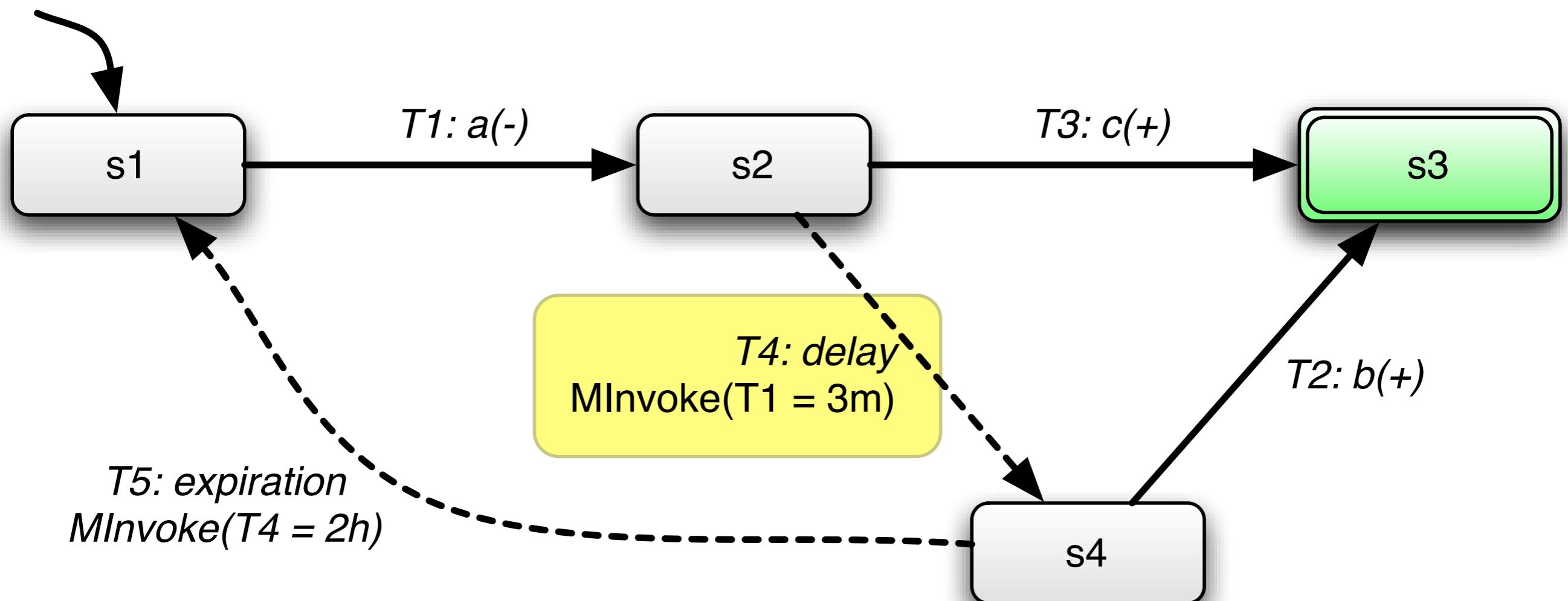
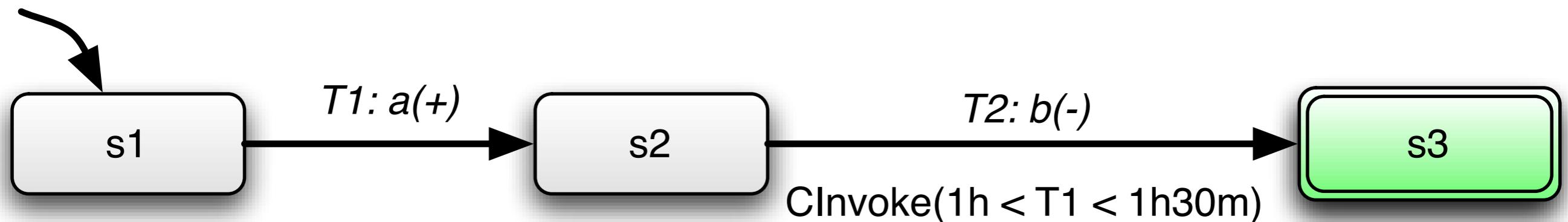
Full compatibility



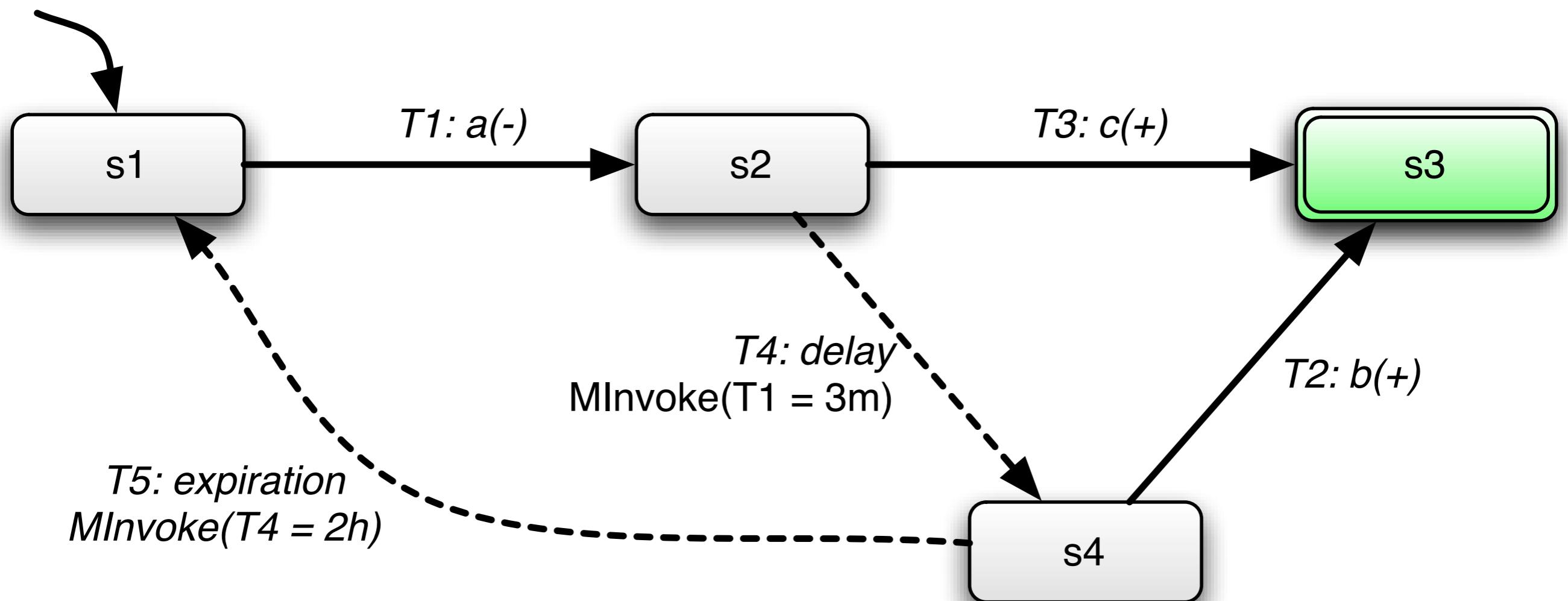
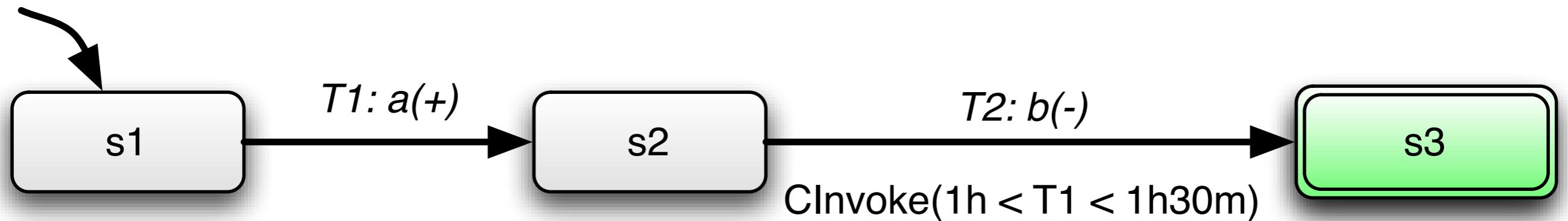
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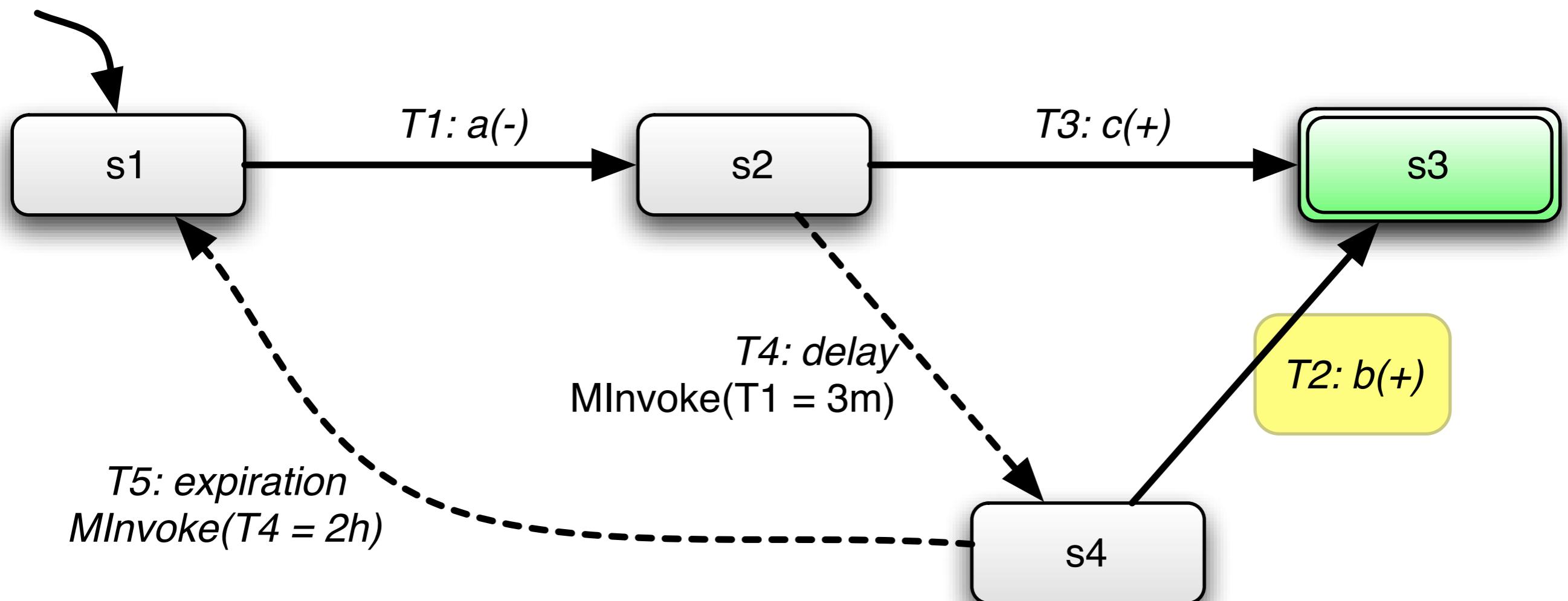
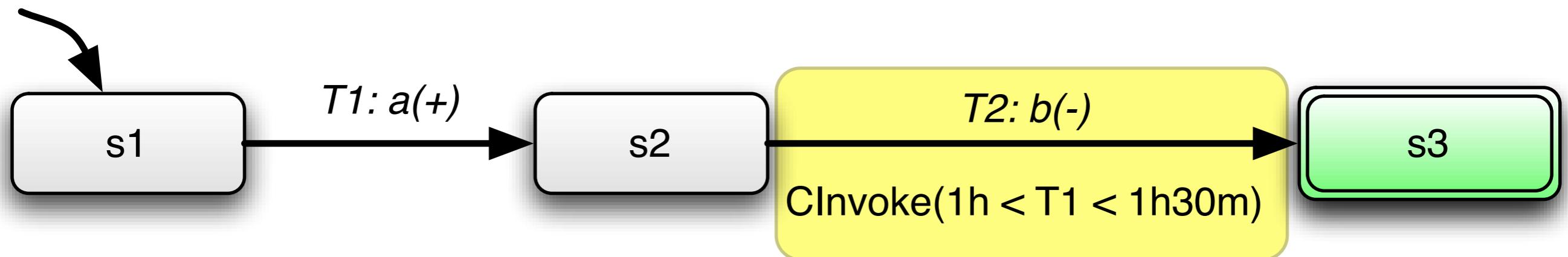
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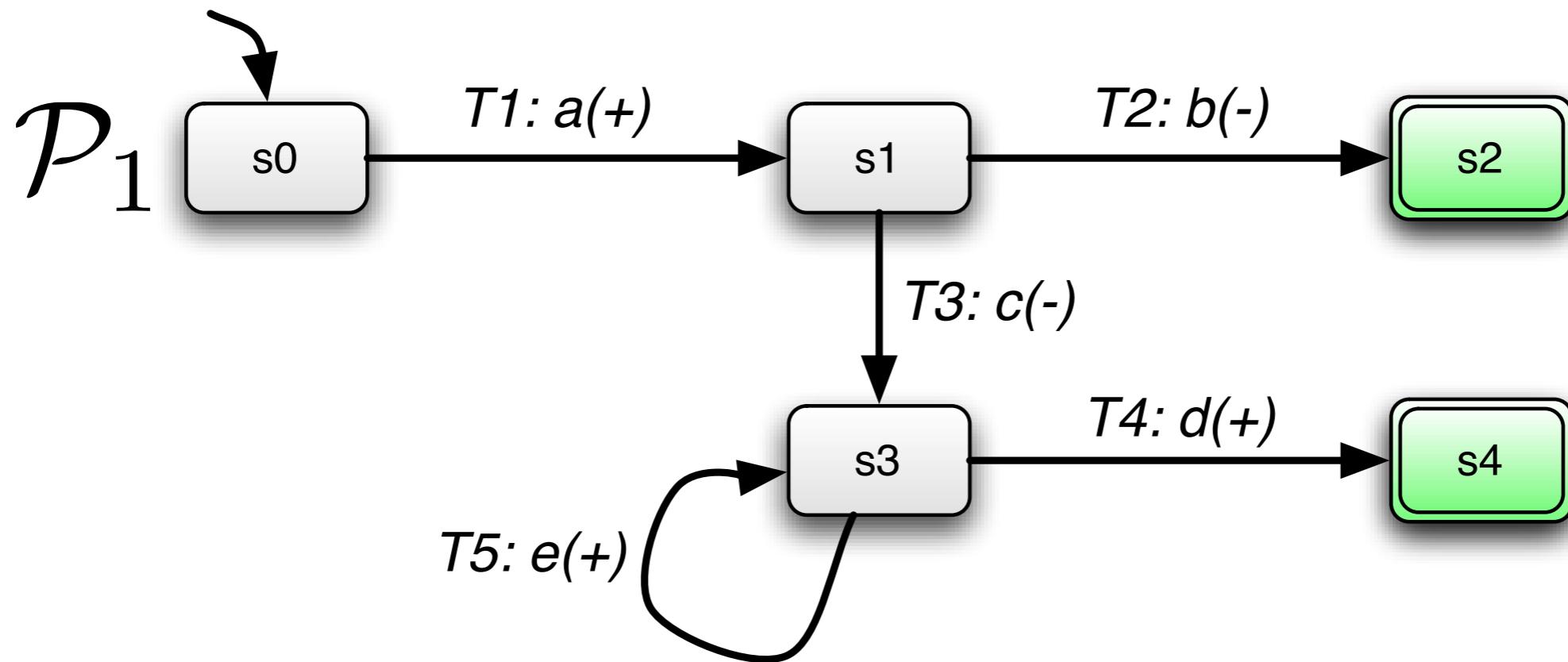
Full compatibility



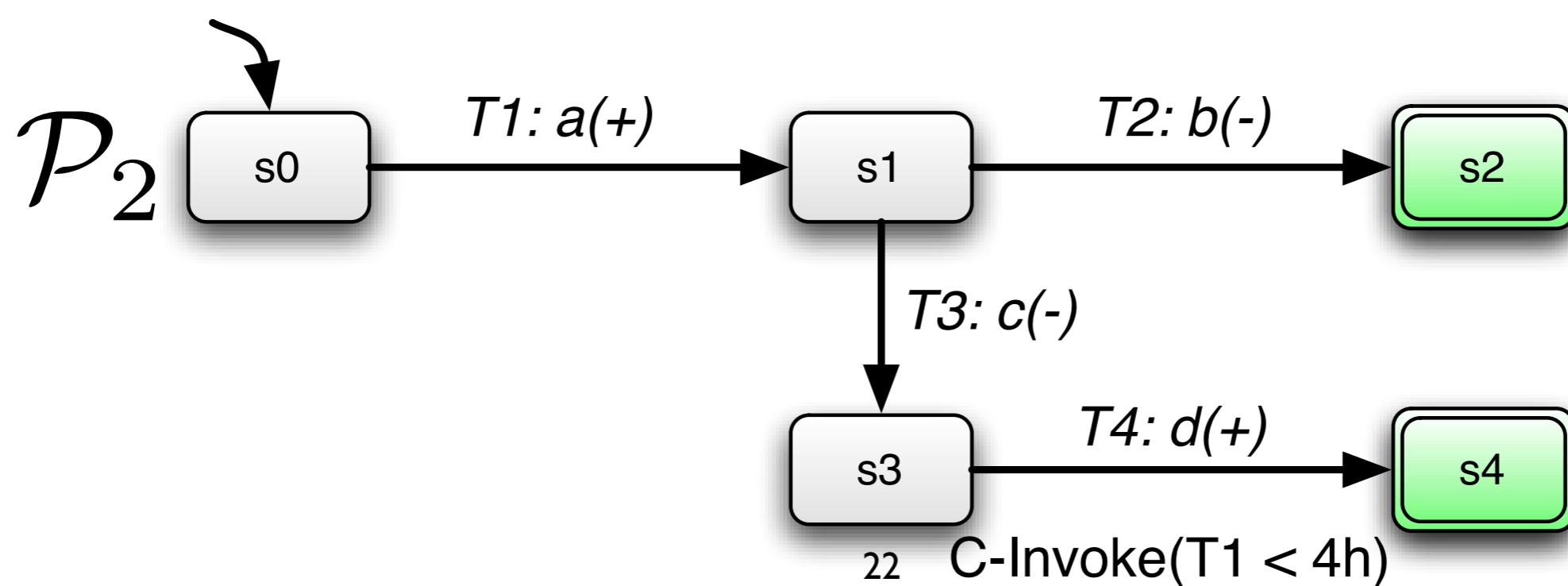
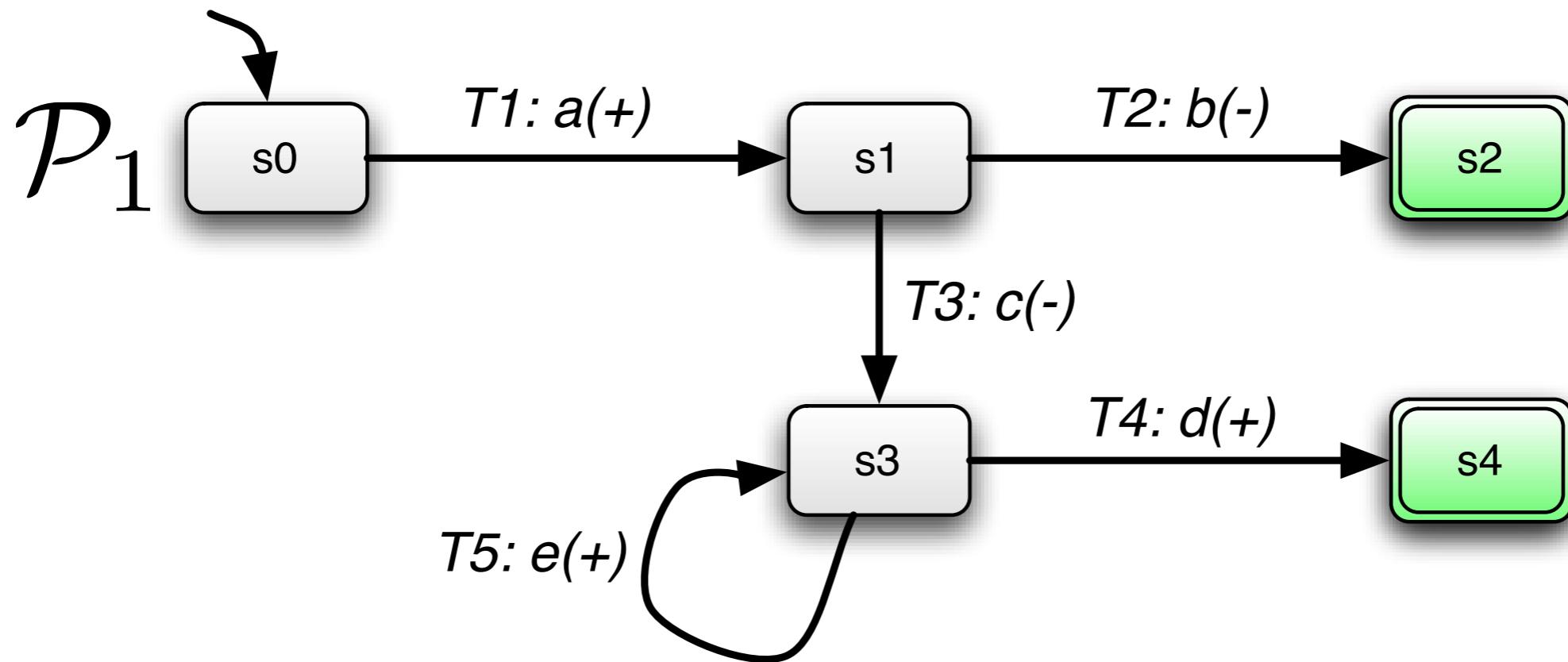
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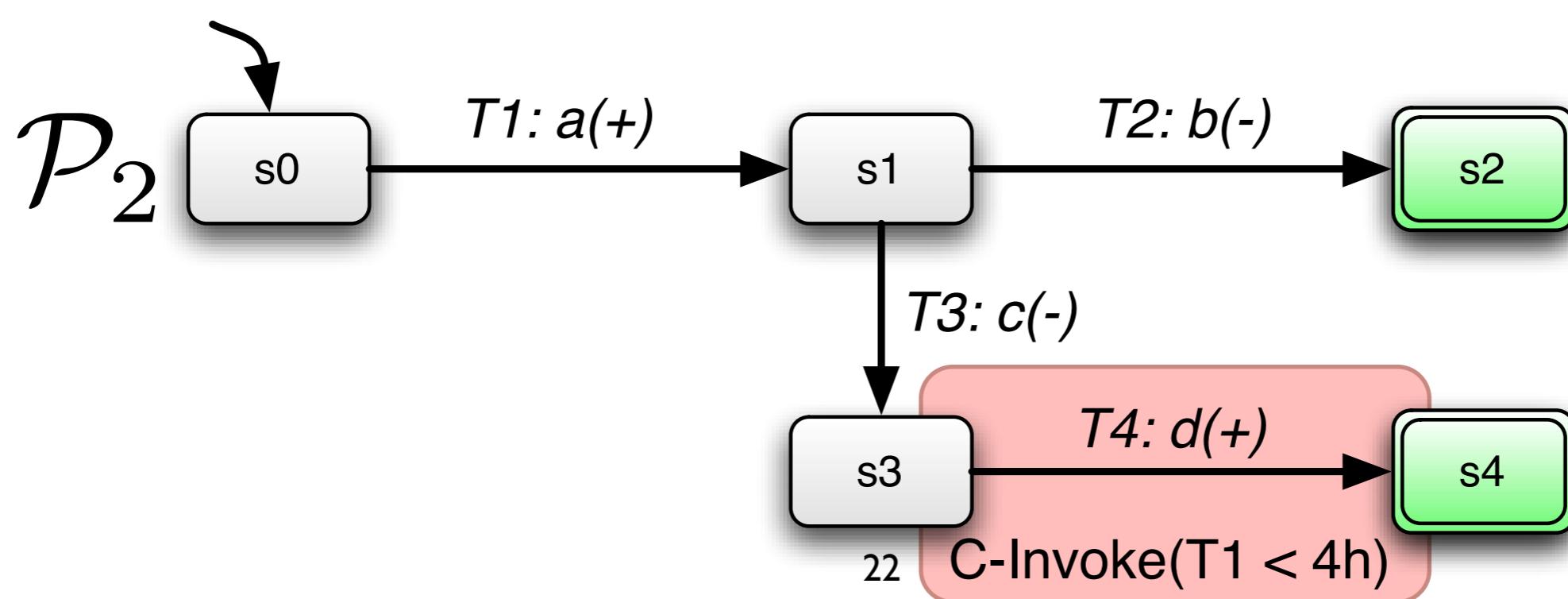
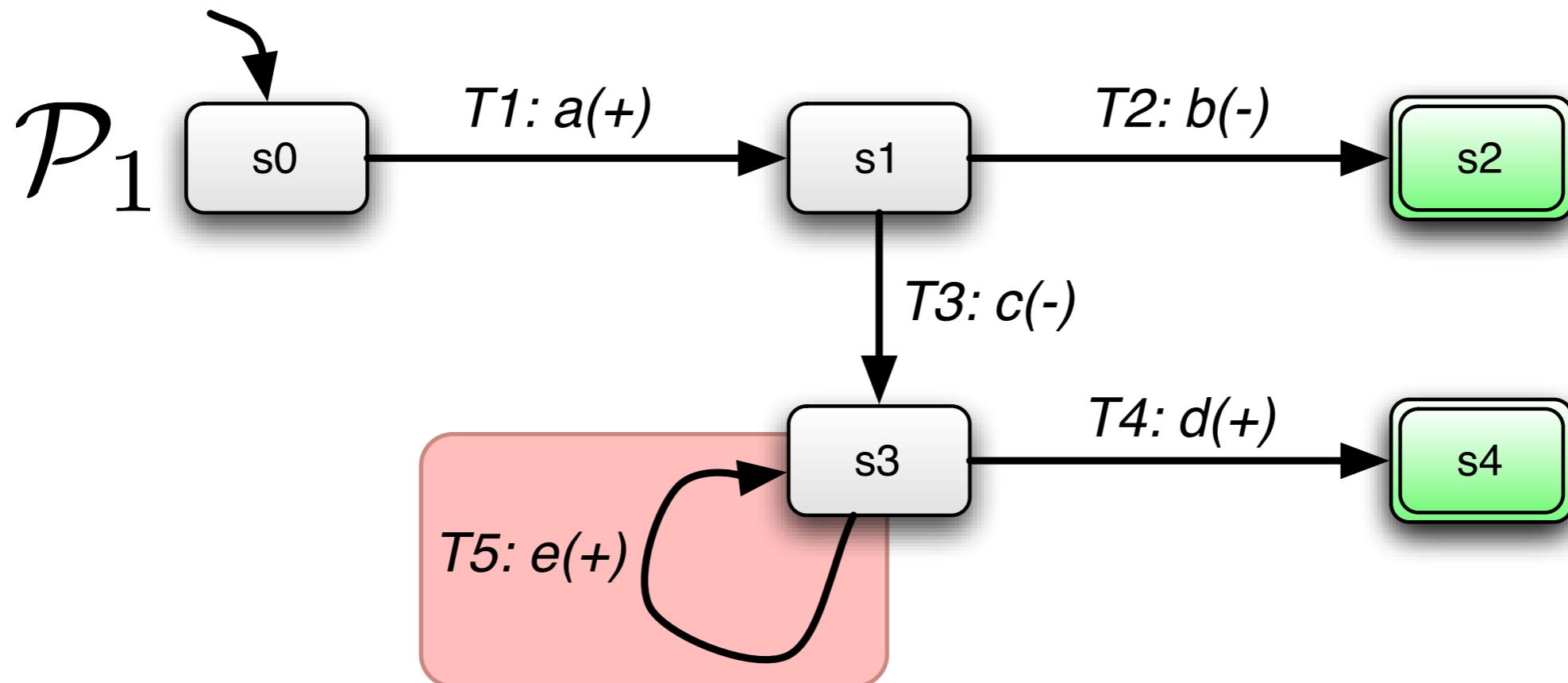
Repl. w.r.t. client protocol



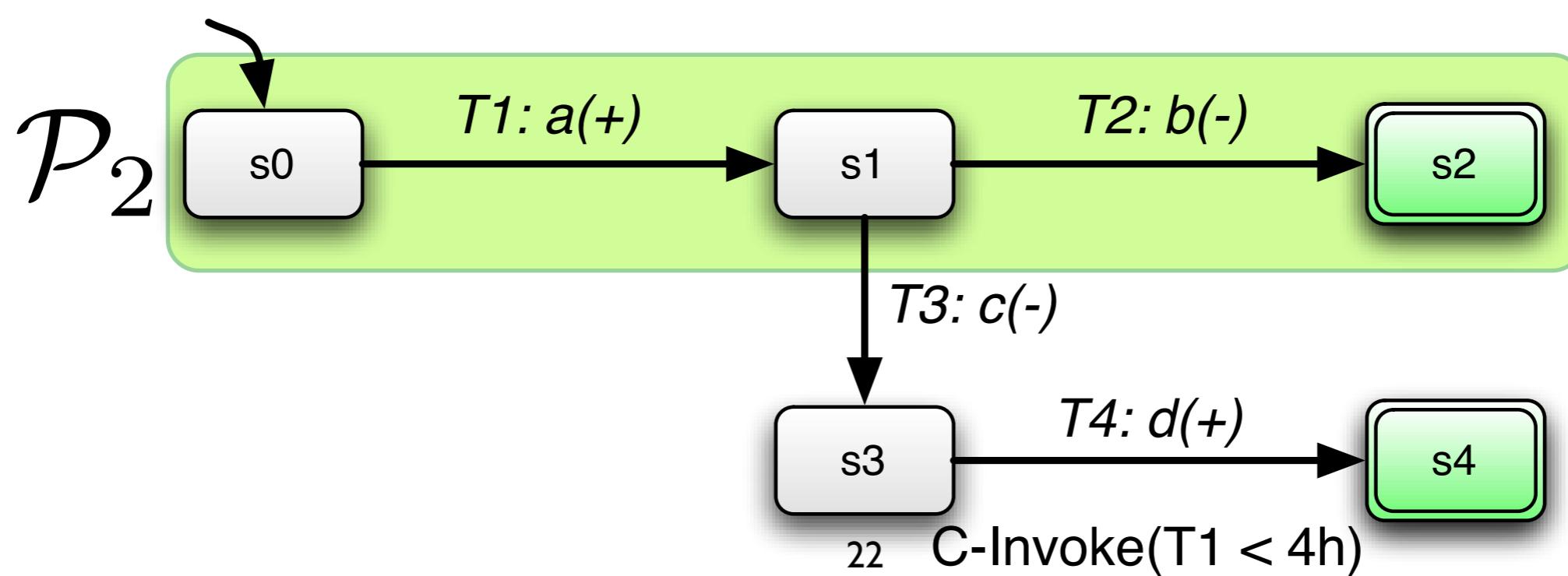
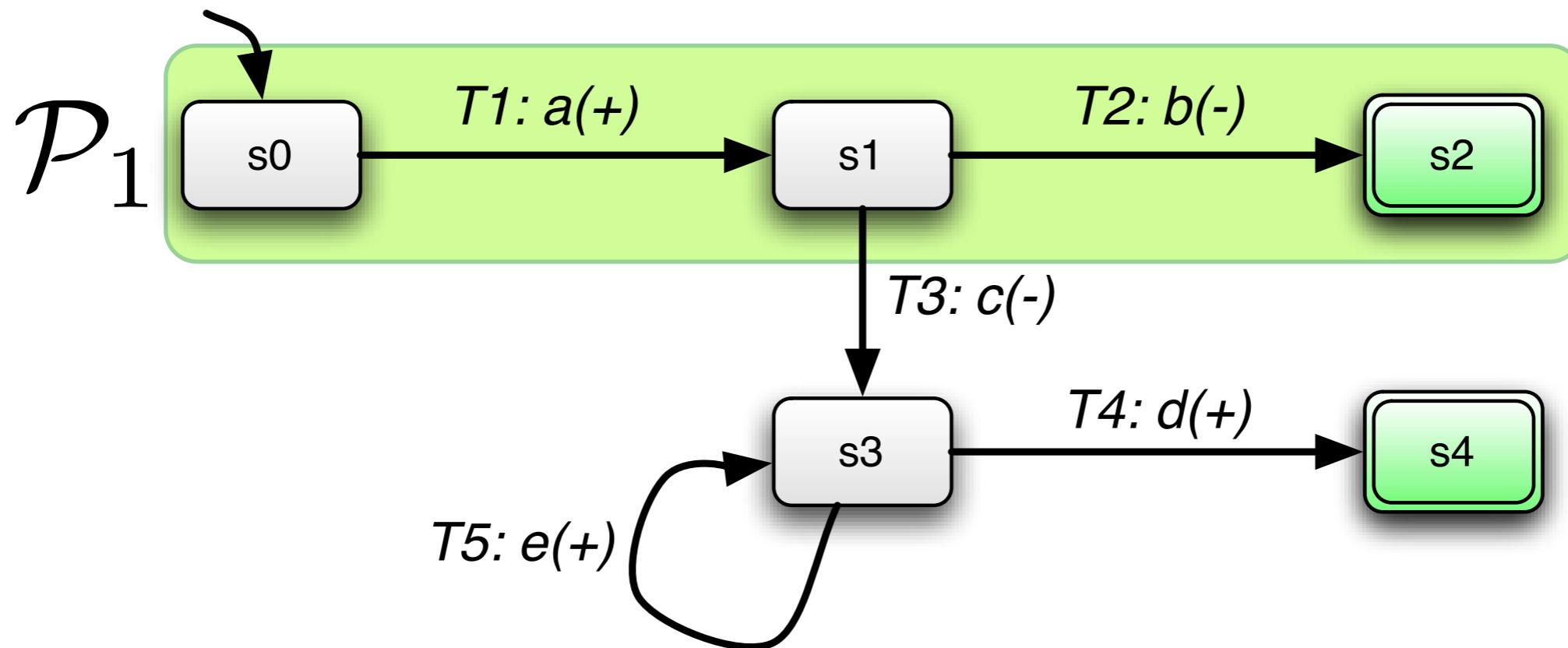
Repl. w.r.t. client protocol



Repl. w.r.t. client protocol



Repl. w.r.t. client protocol



Protocol operators

Subsumption

 \sqsubseteq

Equivalence

 \equiv

Parallel composition

 \parallel^{tc}

Intersection

 \parallel^{ti}

Difference

 \parallel^{td}

Protocol operators

Subsumption \sqsubseteq

Equivalence \equiv

Parallel composition \parallel^{tc}

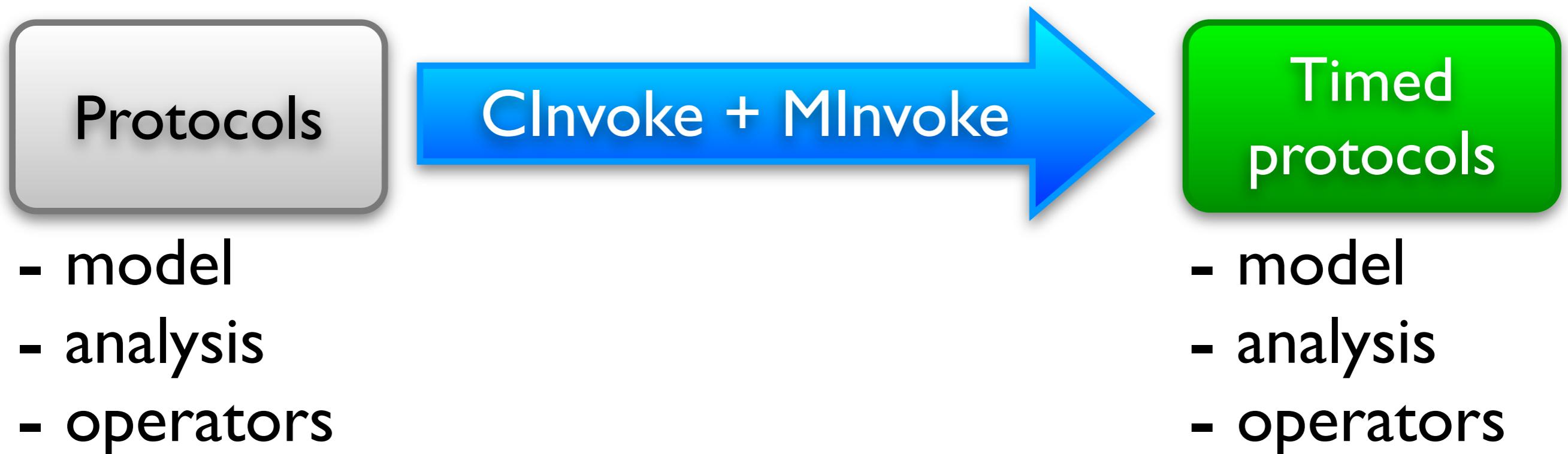
Intersection \parallel^{ti}

Difference \parallel^{td}

Full compatibility

$$[\mathcal{P}_1 \parallel^{tc} \mathcal{P}_2]_{\mathcal{P}_1} \equiv \mathcal{P}_1$$

Approach



Approach



Approach





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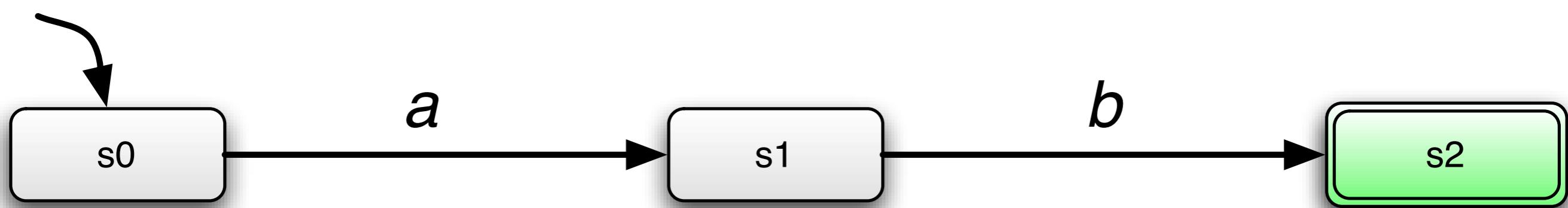
Protocol timed automata

Timed automata (Alur, Dill 94)

Clocks over dense time

Guards and resets

Extensive research in model checking

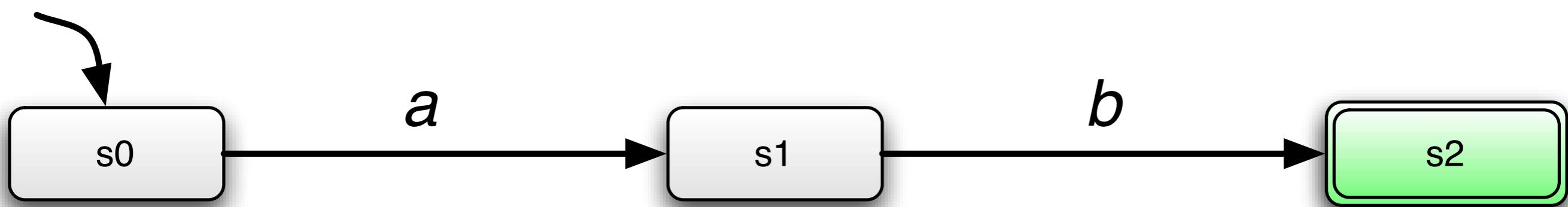


Timed automata (Alur, Dill 94)

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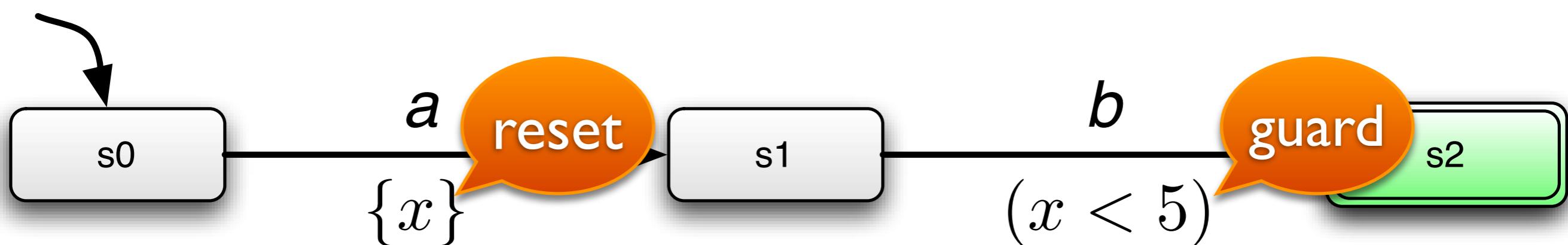
$$L = \{(a, t_1) \cdot (b, t_2) \mid t_2 - t_1 < 5\}$$

Timed automata (Alur, Dill 94)

Clocks over dense time

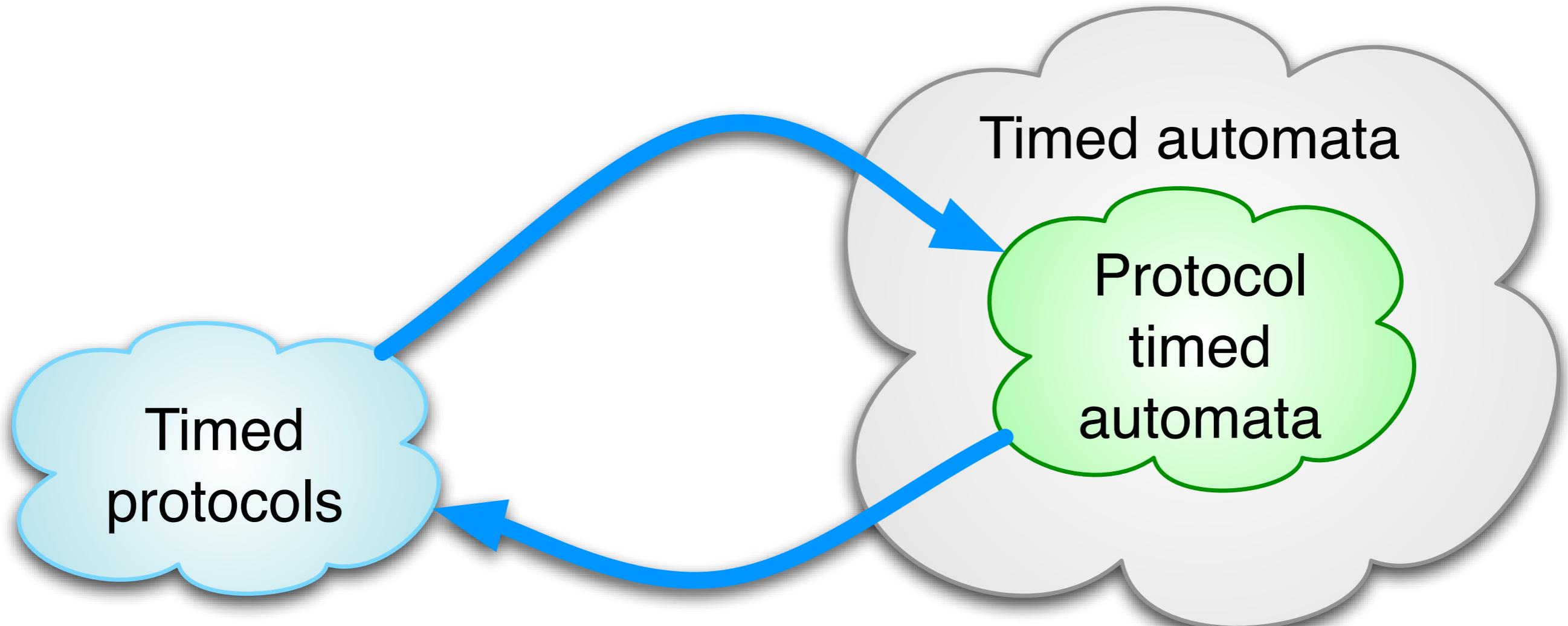
Guards and resets

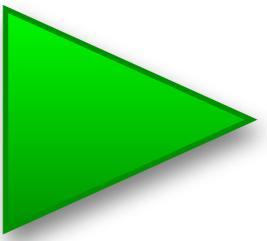
Extensive research in model checking



$$L = \{(a, t_1) \cdot (b, t_2) \mid t_2 - t_1 < 5\}$$

Approach



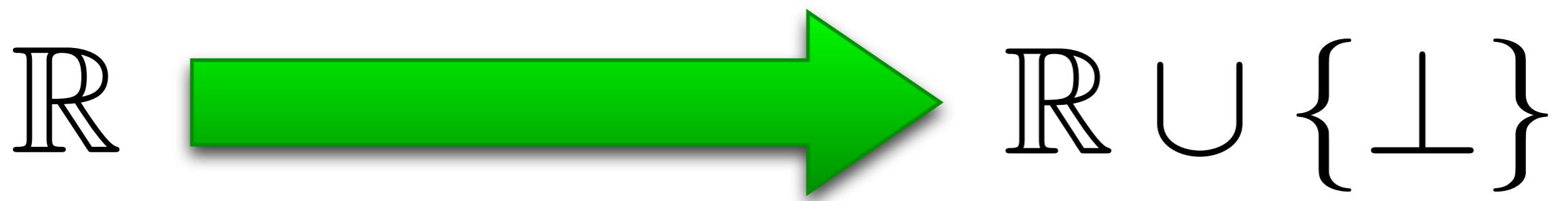


Mapping

Class characterization

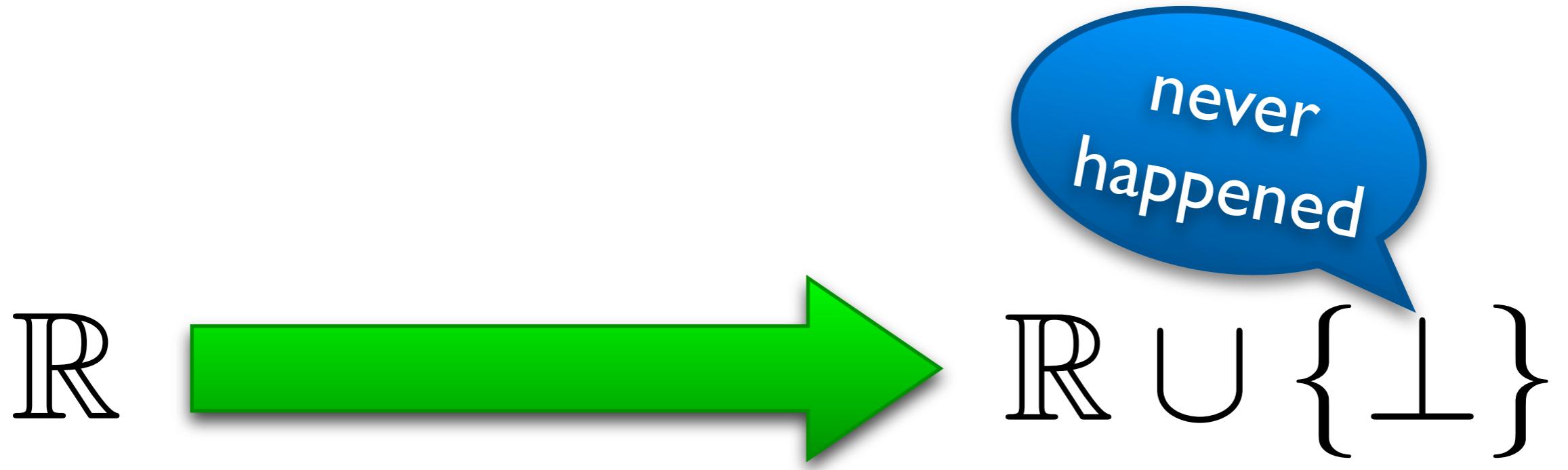
New results

Time domain



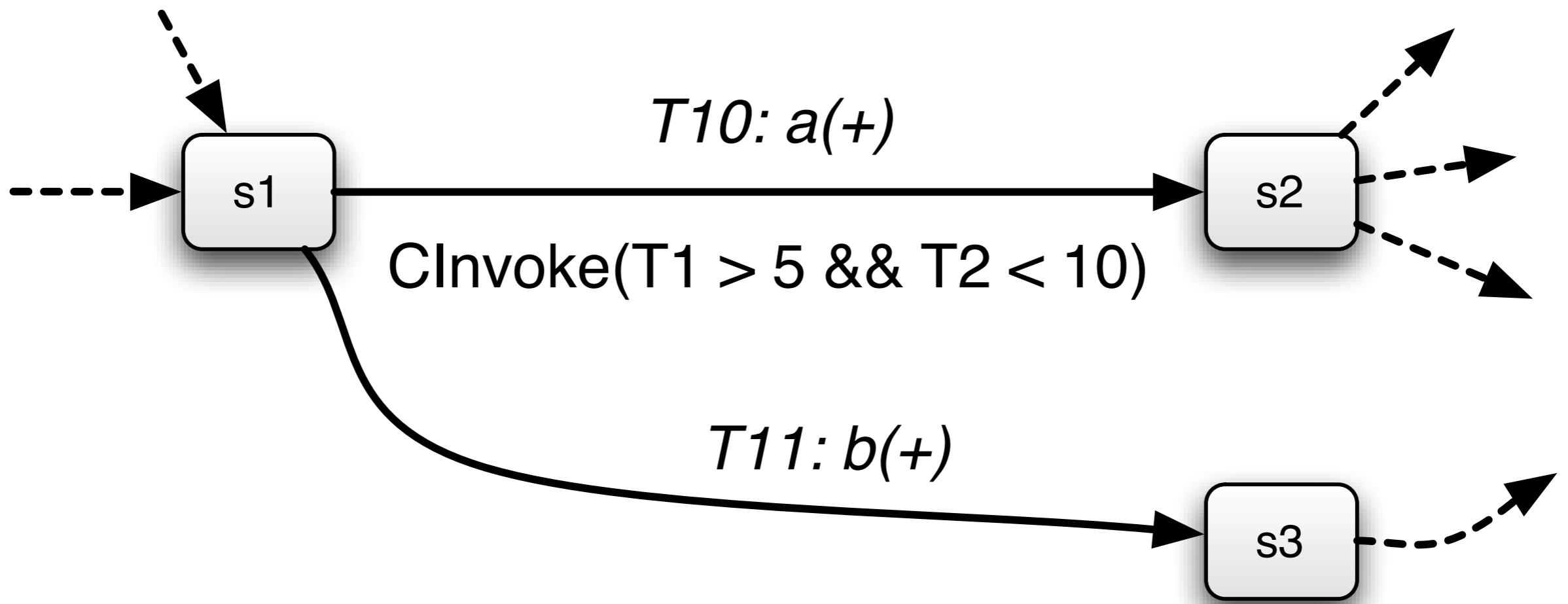
(like event-recording automata)

Time domain

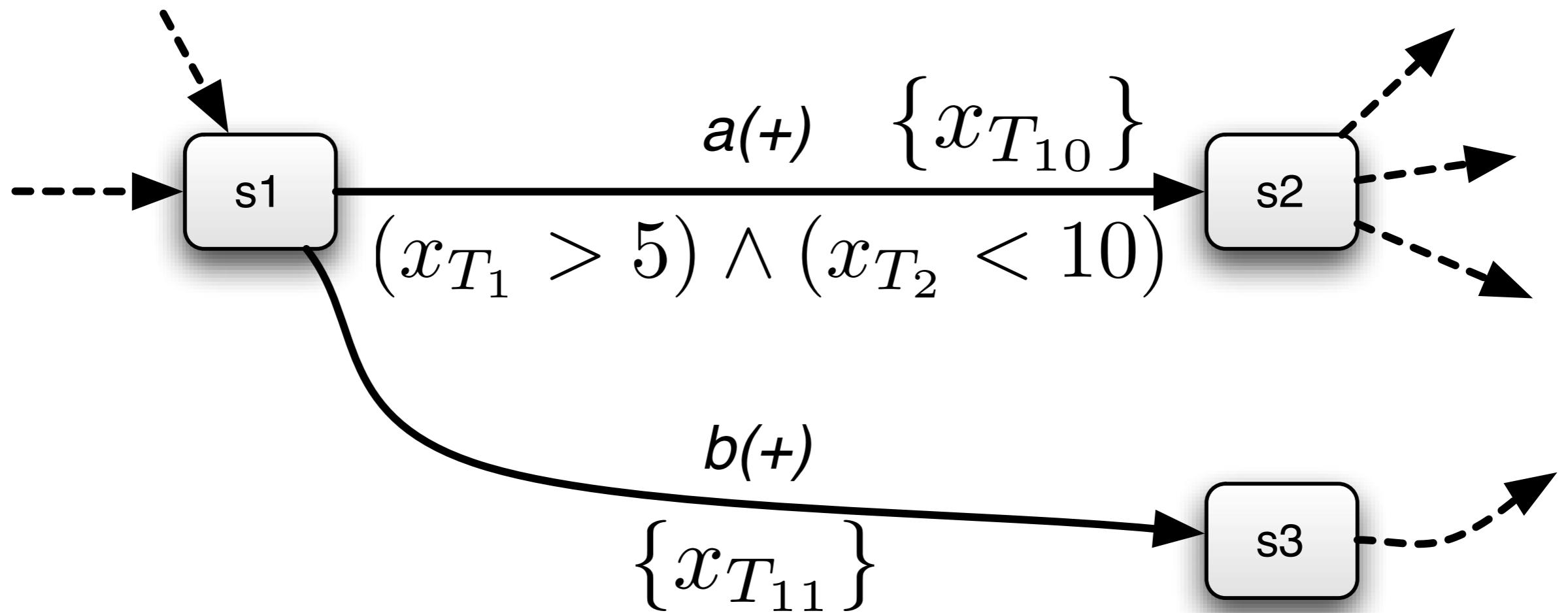


(like event-recording automata)

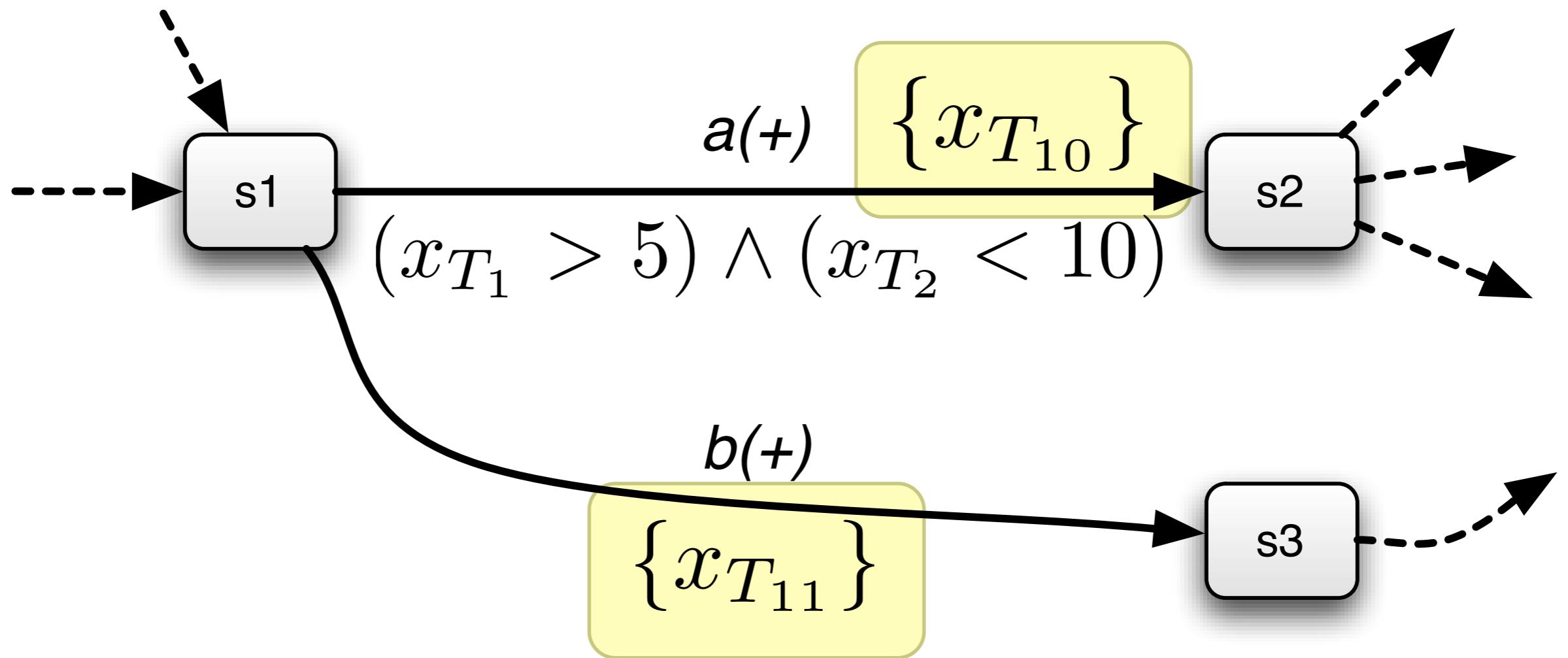
CInvoke mapping



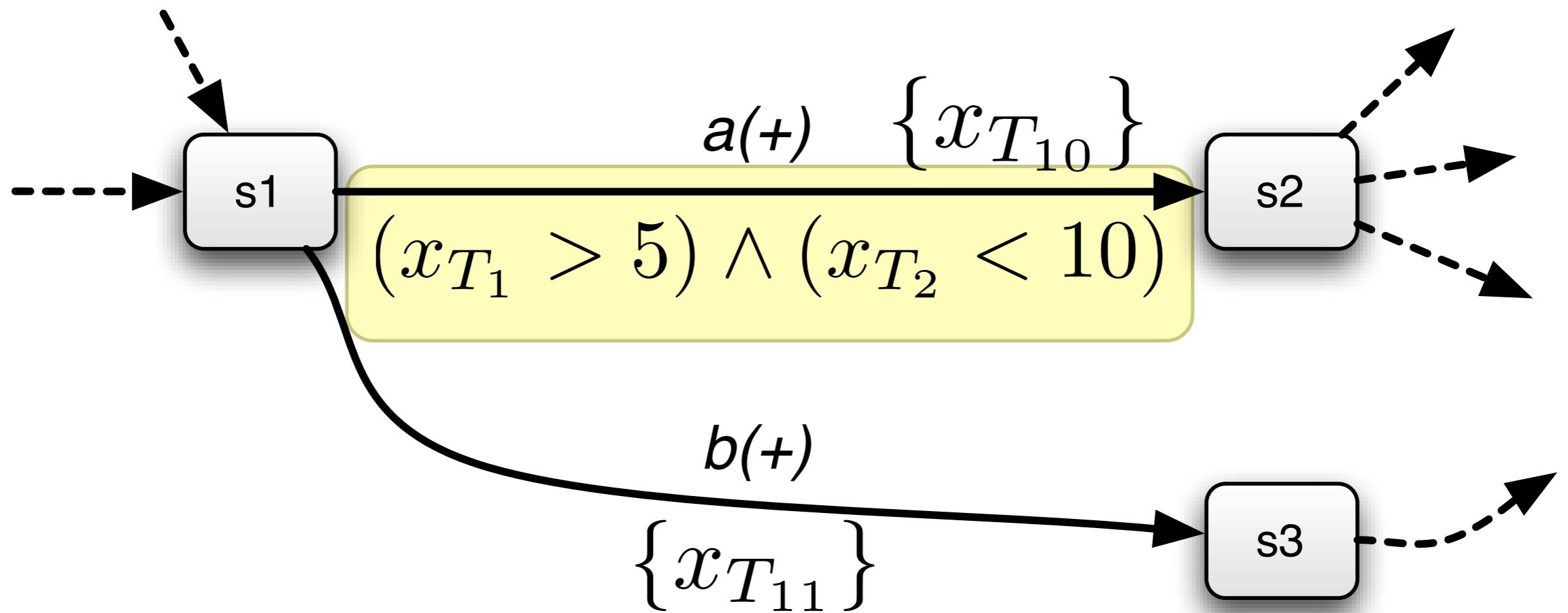
CInvoke mapping



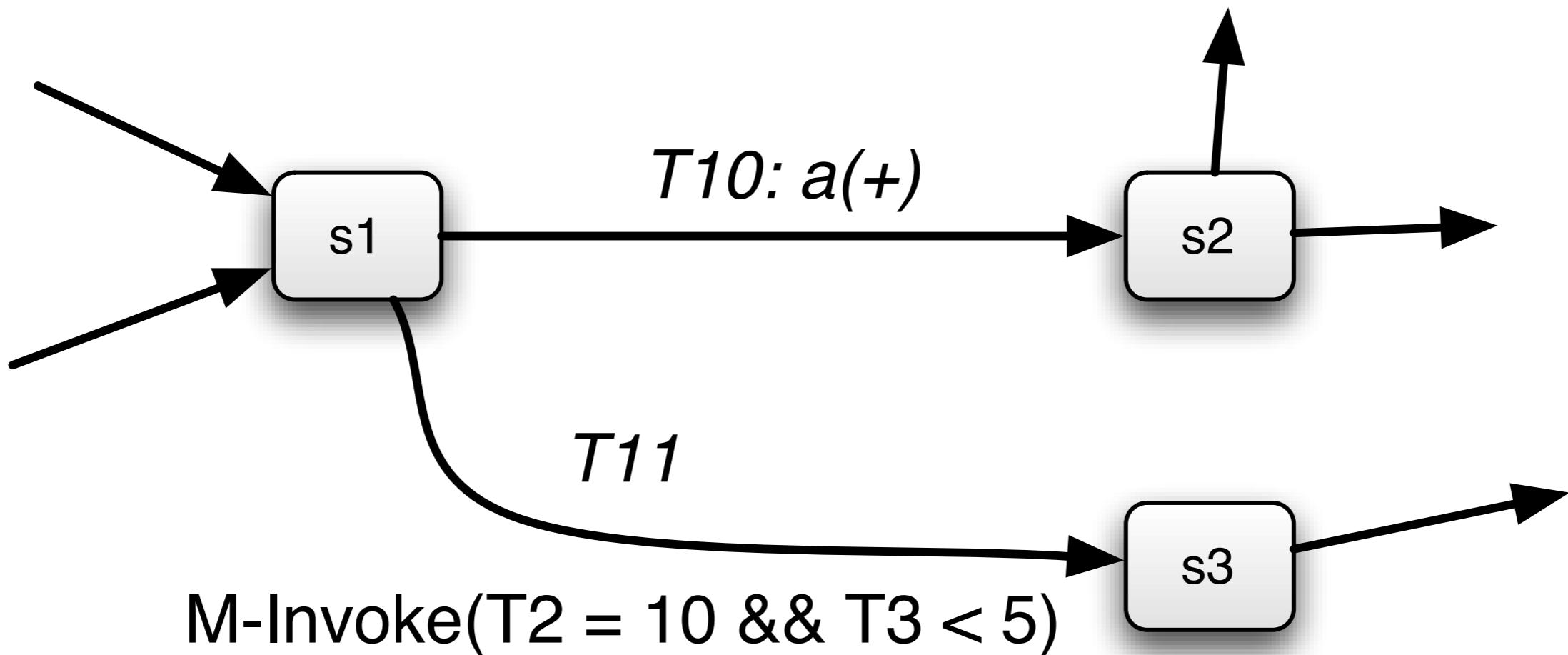
CInvoke mapping



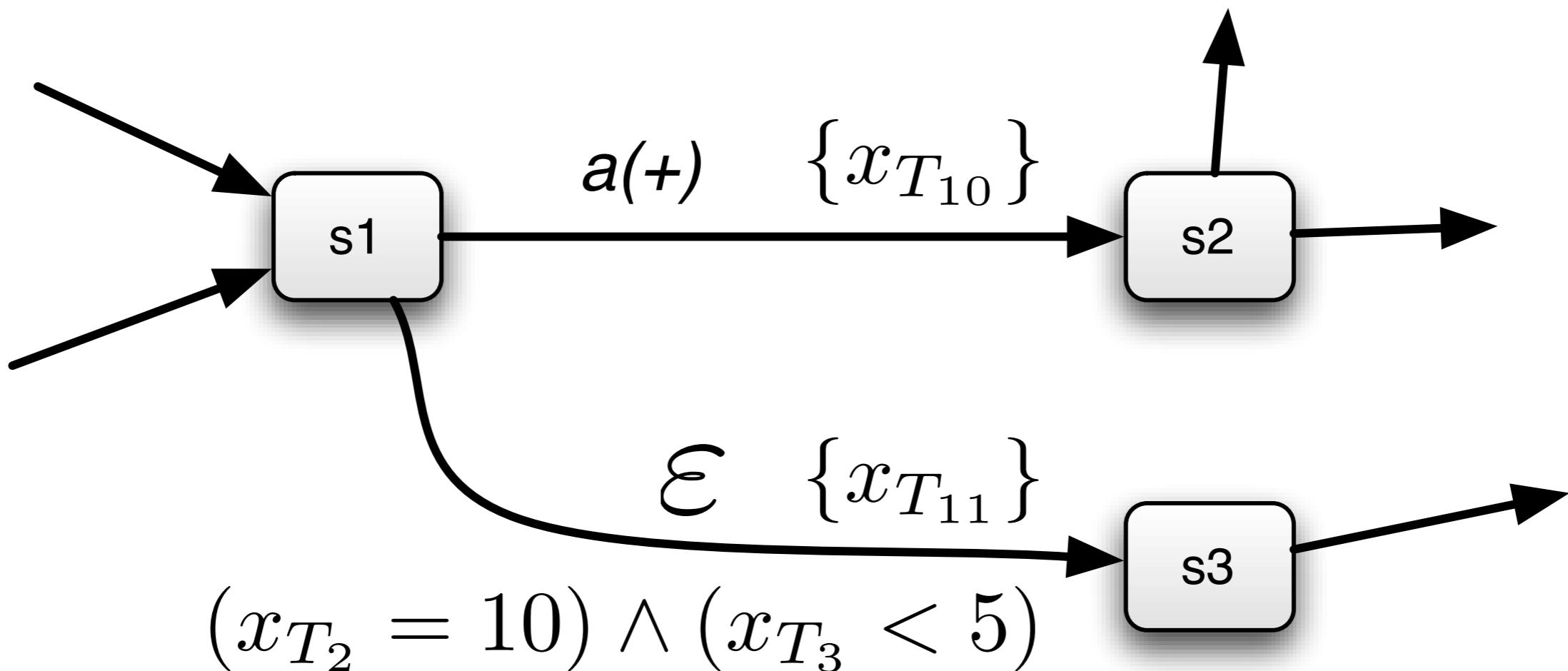
CInvoke mapping



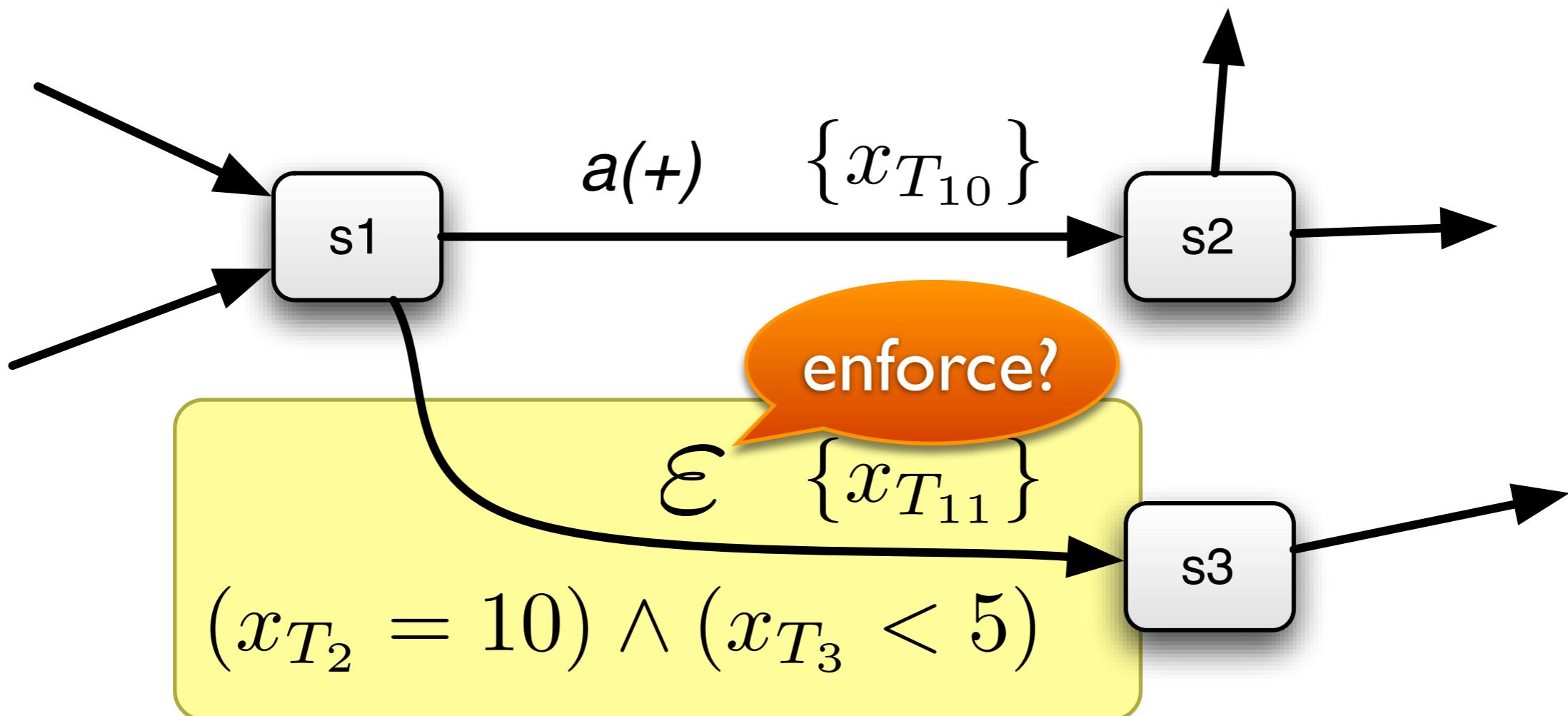
MInvoke mapping



MInvoke mapping



MInvoke mapping

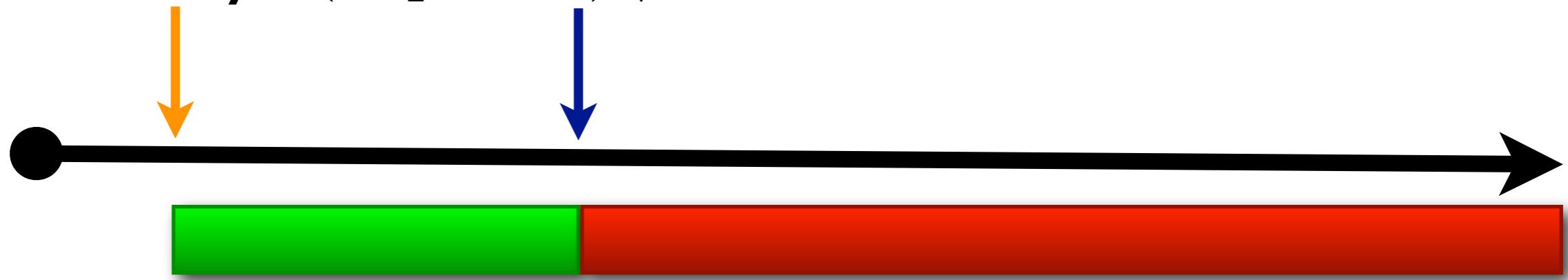


MInvoke behavior

$$(x_{T_2} = 10) \wedge (x_{T_3} < 5)$$

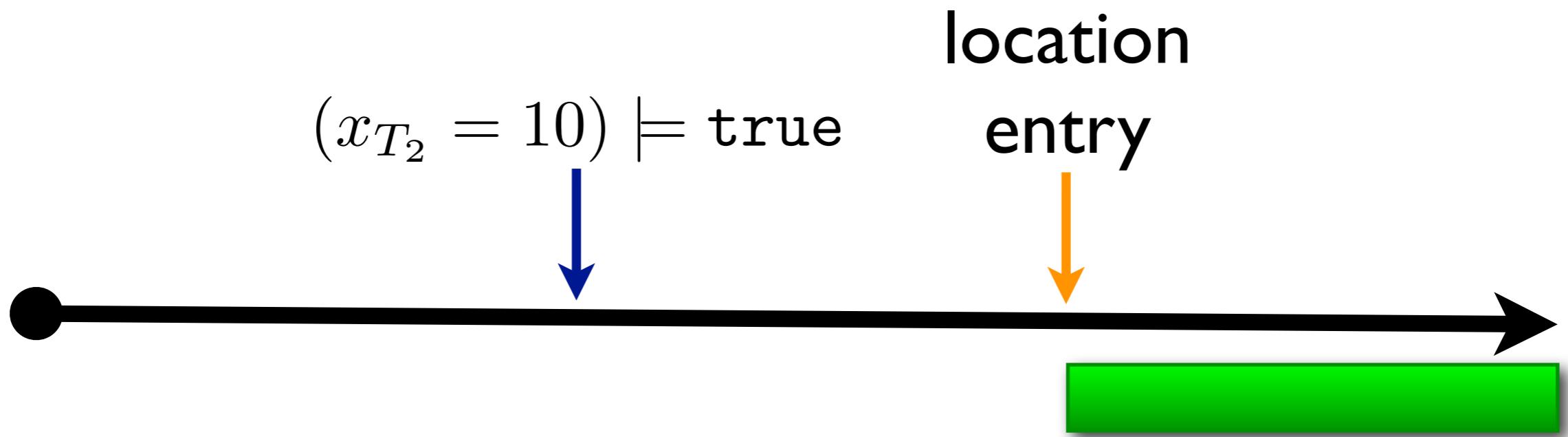
location

entry $(x_{T_2} = 10) \models \text{true}$



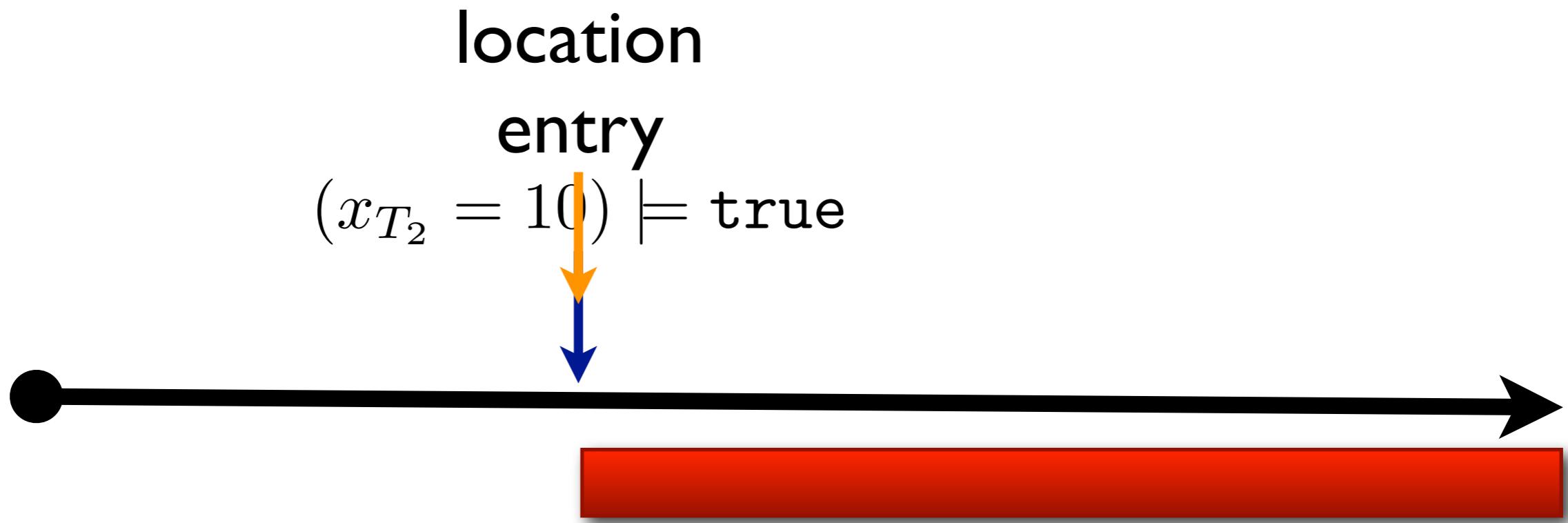
MInvoke behavior

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MInvoke behavior

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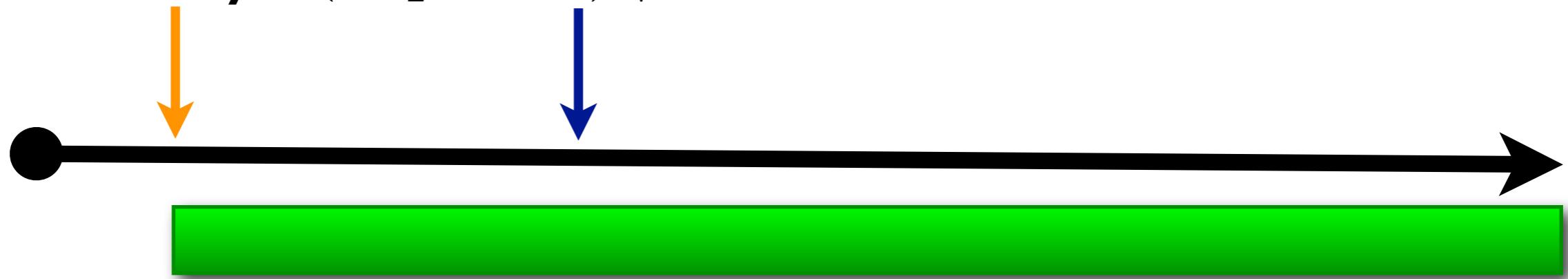


MInvoke behavior

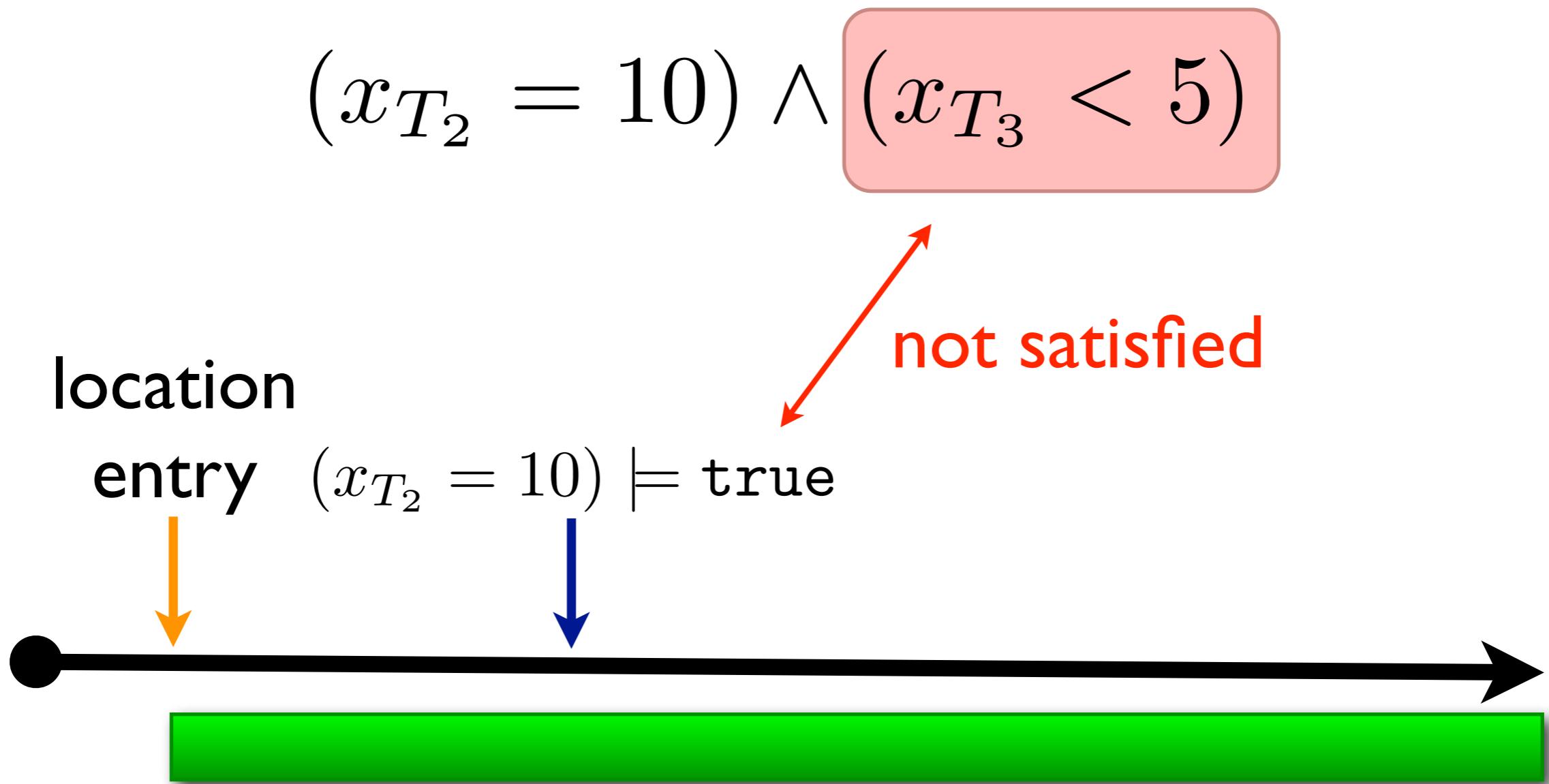
$$(x_{T_2} = 10) \wedge (x_{T_3} < 5)$$

location

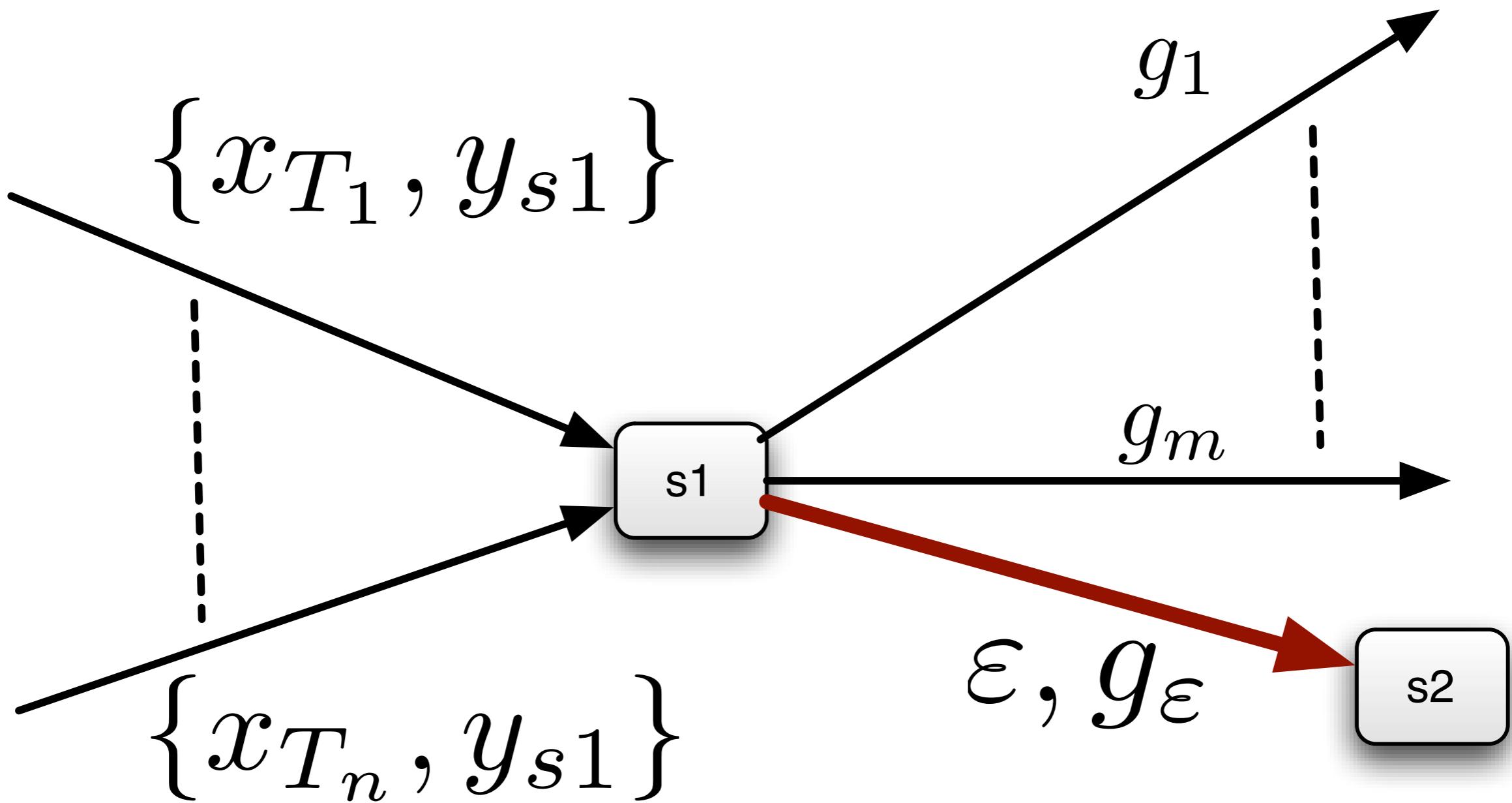
entry $(x_{T_2} = 10) \models \text{true}$



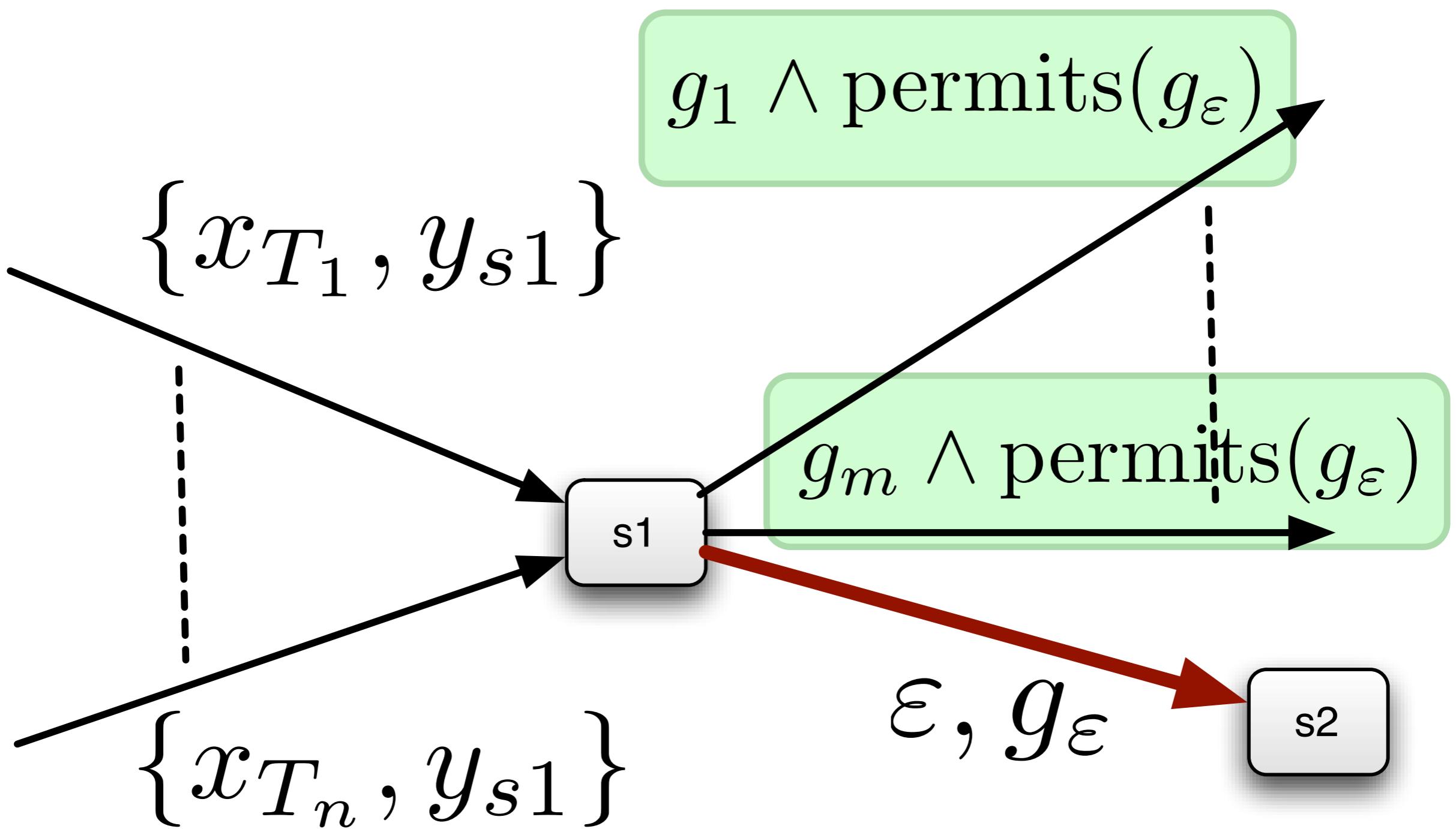
MInvoke behavior



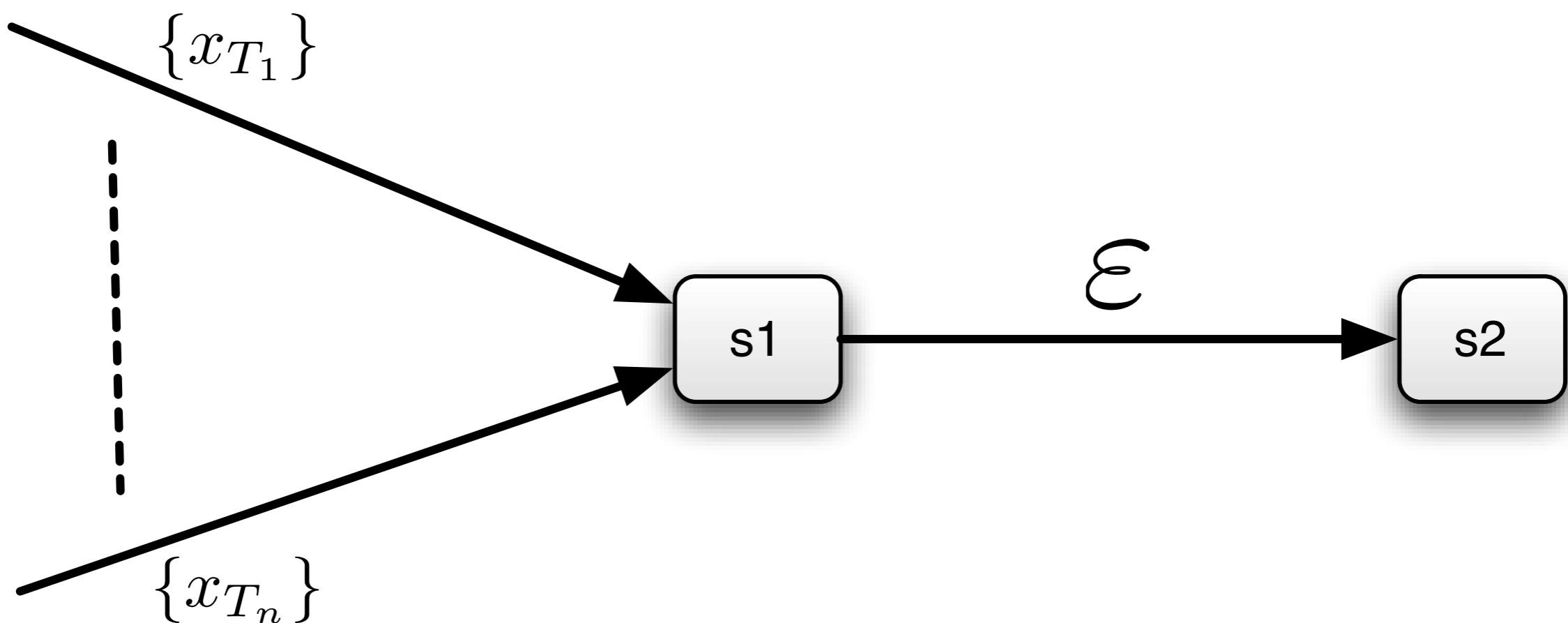
Rewriting



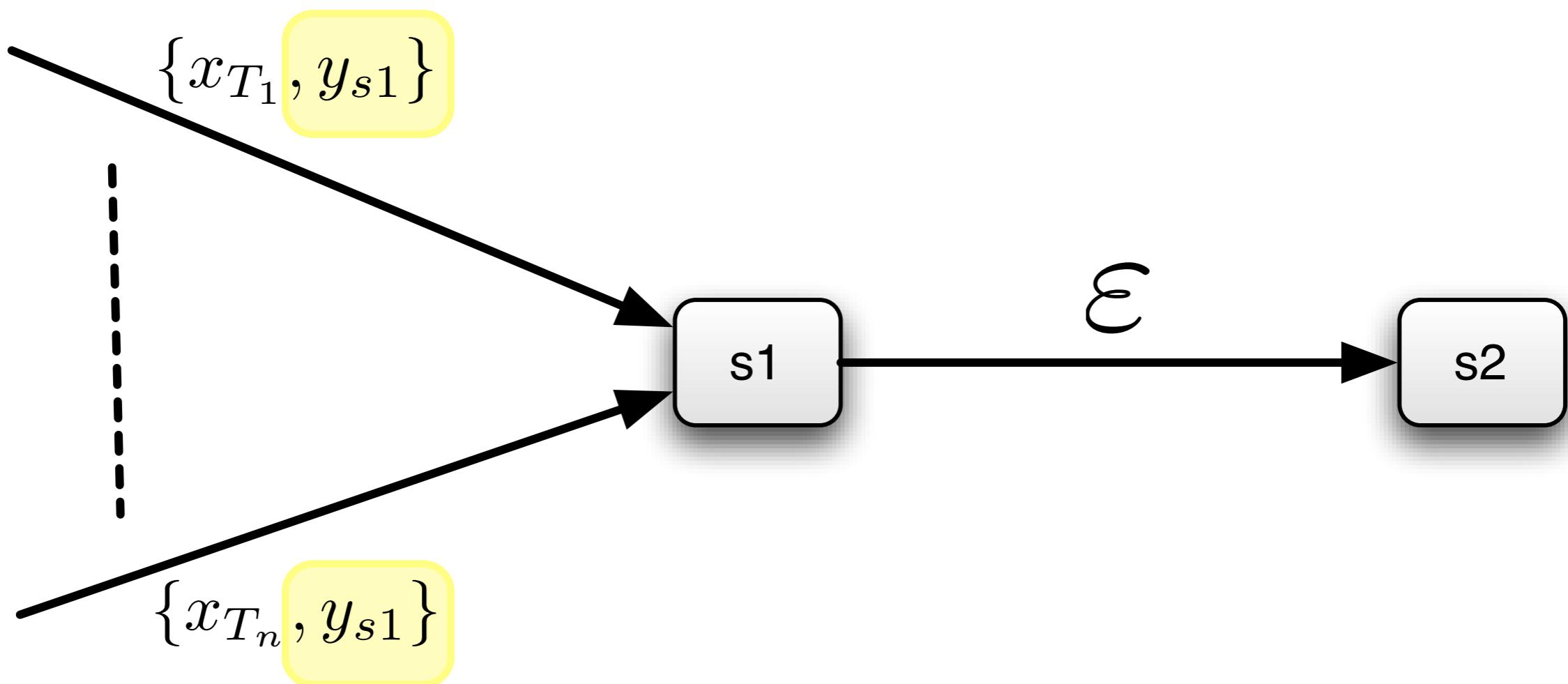
Rewriting



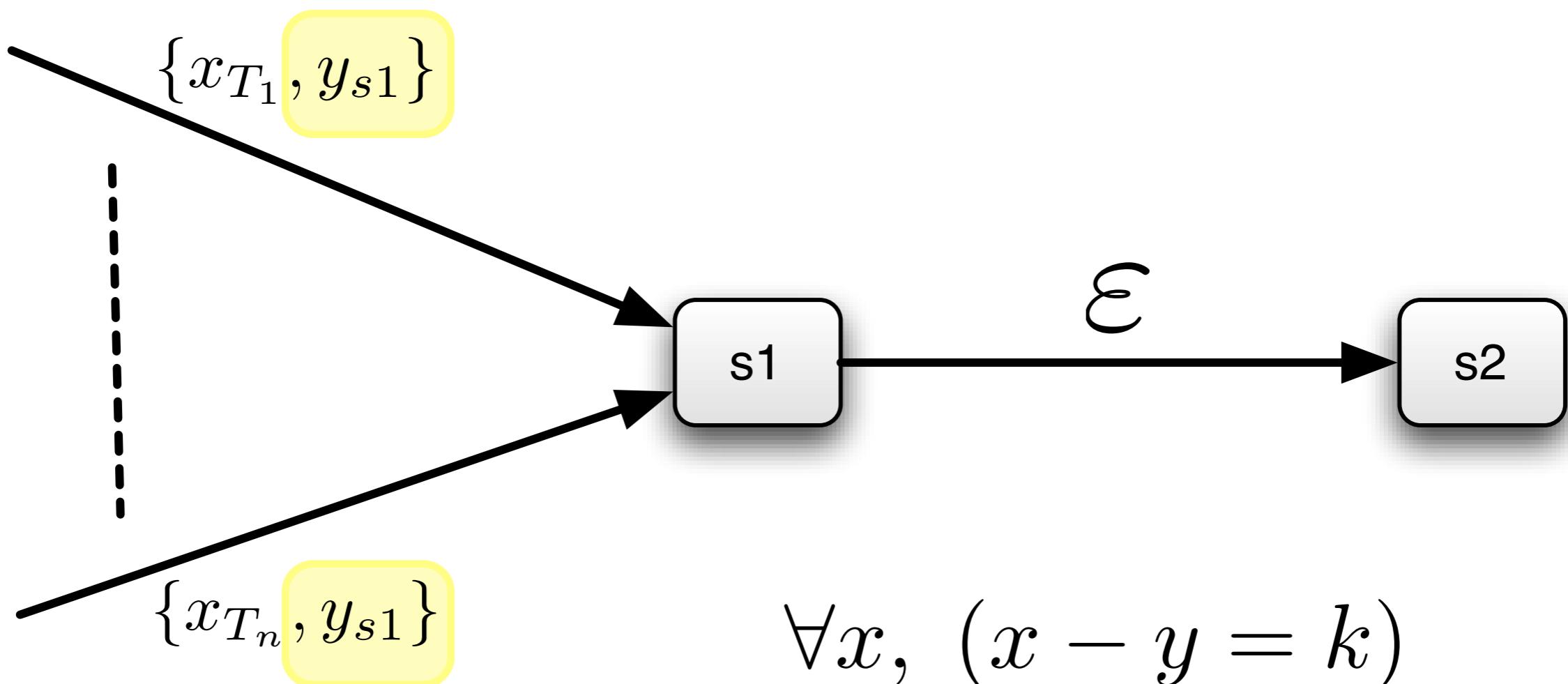
Capturing valuations



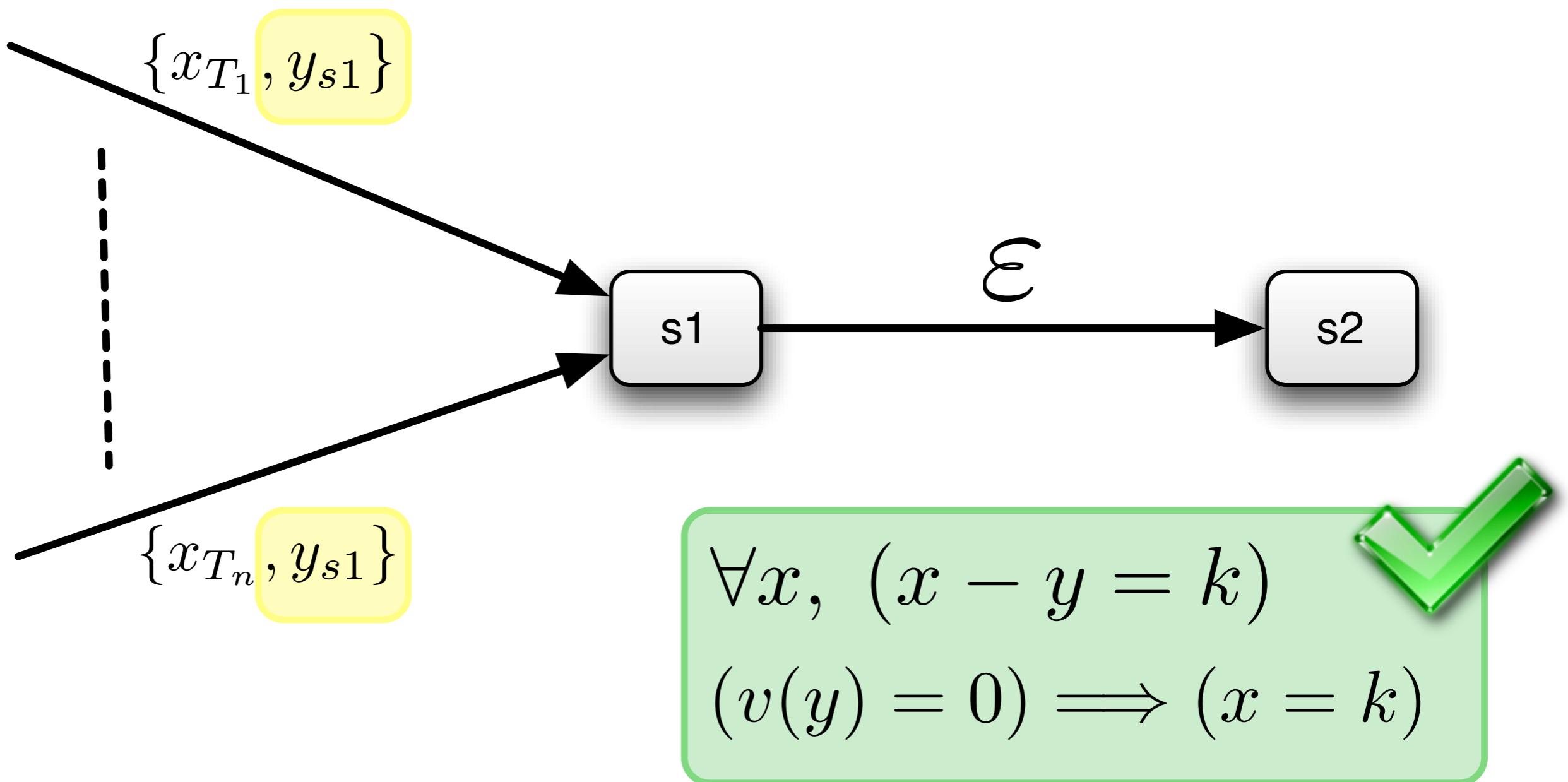
Capturing valuations



Capturing valuations



Capturing valuations

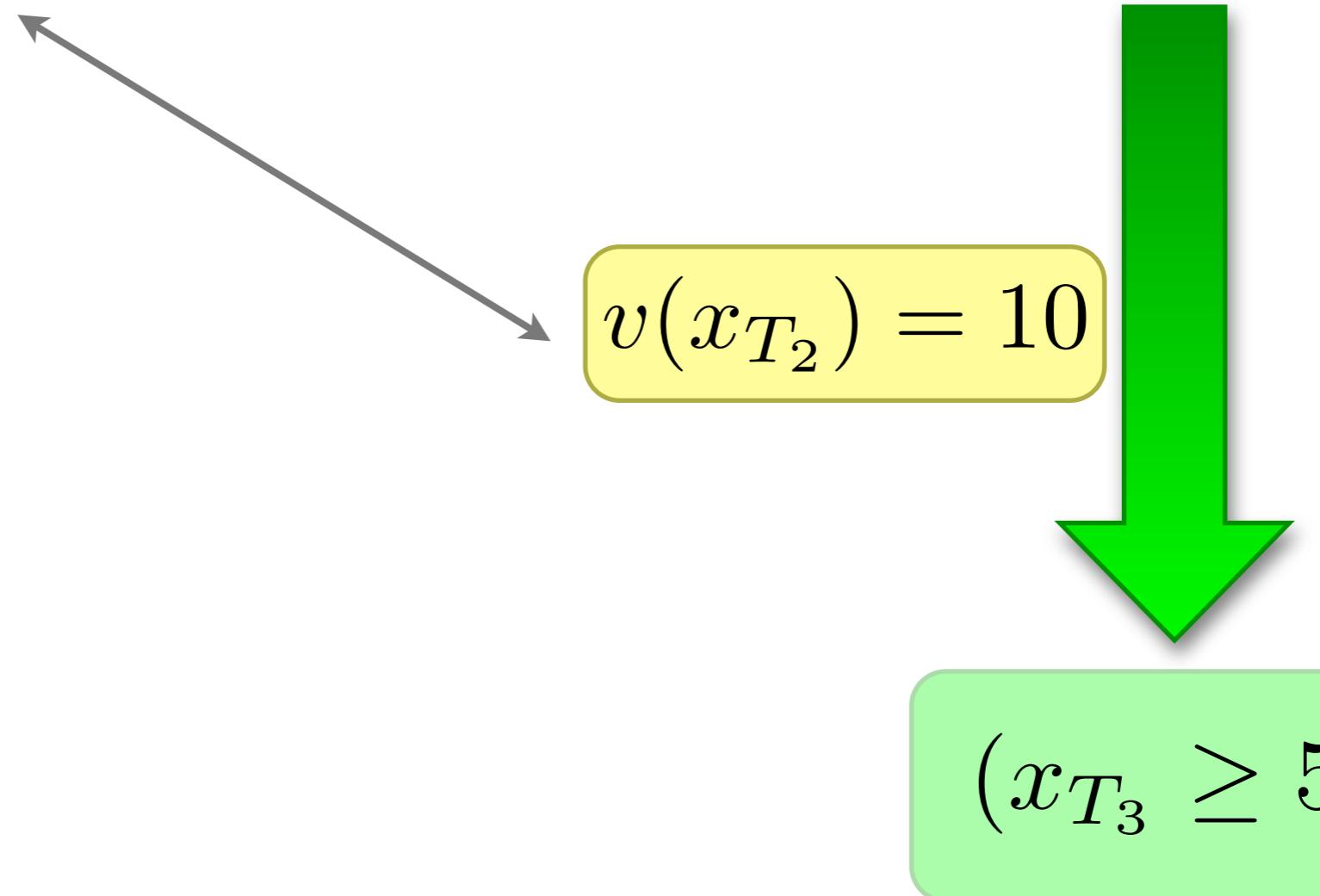


MInvoke inhibitor

$$\text{inhib}((x_{T_2} = 10) \wedge (x_{T_3} < 5)) = (x_{T_3} - x_{T_2} \geq 5 - 10)$$

MInvoke inhibitor

$$\text{inhib}((x_{T_2} = 10) \wedge (x_{T_3} < 5)) = (x_{T_3} - x_{T_2} \geq 5 - 10)$$





Please note that...

inhib ($x_{T_2} = 10$) = false

Permitting / disabling

$$\frac{\mathcal{E}}{g := (x = k) \wedge g'}$$

Permitting / disabling



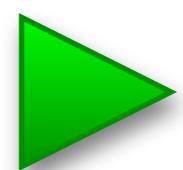
$$S_1 = (x < k)$$

$$S_2 = (x > k) \wedge (x - y > k)$$

$$S_3 = (x > k) \wedge (x - y \leq k) \wedge \text{inhib}(g)$$

$$S_4 = (x = k) \wedge \text{inhib}(g)$$

Permitting / disabling



$$S_1 = (x < k)$$

$$S_2 = (x > k) \wedge (x - y > k)$$

$$S_3 = (x > k) \wedge (x - y \leq k) \wedge \text{inhib}(g)$$

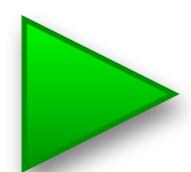
$$S_4 = (x = k) \wedge \text{inhib}(g)$$

Permitting / disabling

$$\frac{\mathcal{E}}{g := (x = k) \wedge g'} \quad \text{permits}(g)$$

$$S_1 = (x < k)$$

$$S_2 = (x > k) \wedge (x - y > k)$$



$$S_3 = (x > k) \wedge (x - y \leq k) \wedge \text{inhib}(g)$$

$$S_4 = (x = k) \wedge \text{inhib}(g)$$

Permitting / disabling

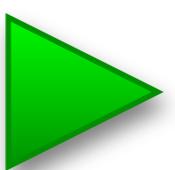
$$\frac{\mathcal{E}}{g := (x = k) \wedge g'} \quad \text{permits}(g)$$

$$S_1 = (x < k)$$

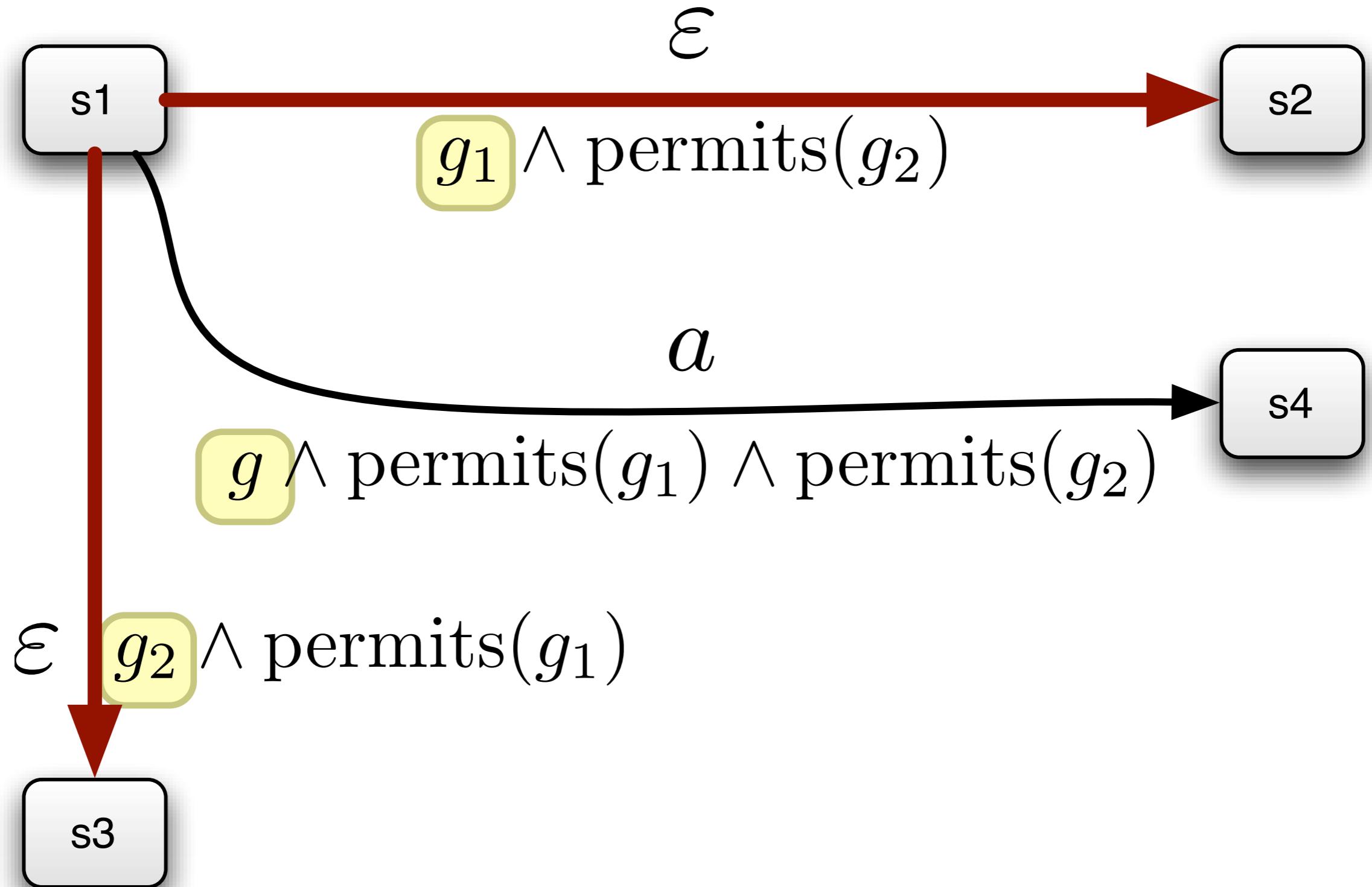
$$S_2 = (x > k) \wedge (x - y > k)$$

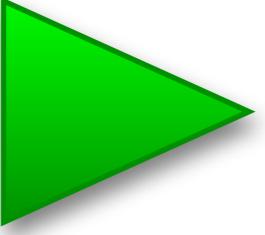
$$S_3 = (x > k) \wedge (x - y \leq k) \wedge \text{inhib}(g)$$

$$S_4 = (x = k) \wedge \text{inhib}(g)$$



Generalization



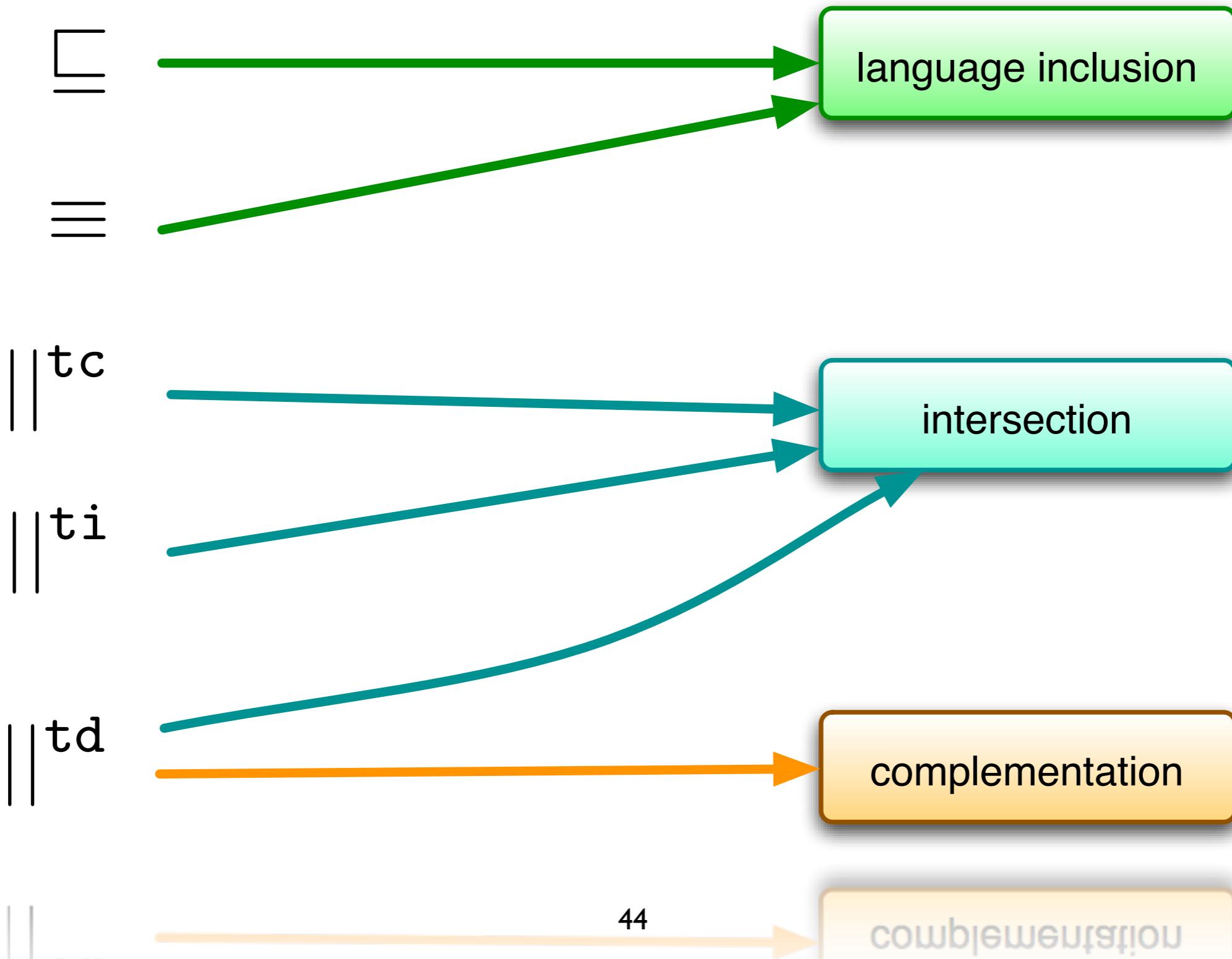


Mapping

Class characterization

New results

What do we need?



Timed automata

Problem	Result
Union	Closed
Intersection	Closed
Projection	Closed
Complementation	Not closed
Language inclusion	Not decidable
Language equivalence	Not decidable
Universality	Not decidable
Emptiness / reachability	PSPACE-Complete

Timed automata

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Better classes?

Class	Complementation
Deterministic TA	Closed
Event-clock TA	Closed
(others)	Not closed

Better classes?

Class	Complementation
 Deterministic TA	Closed
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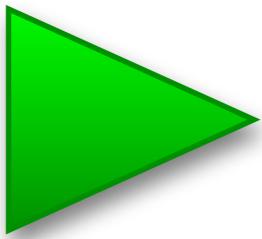
Better classes?

Class	Complementation
-------	-----------------

	Deterministic TA	Closed
	Event-clock TA	Closed
	(others)	Not closed



Silent transitions!



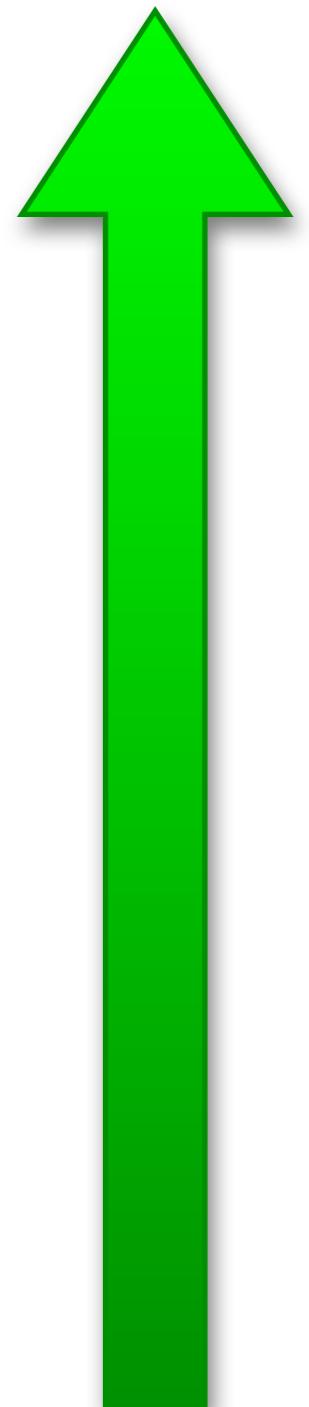
Mapping

Class characterization

New results

Expressiveness

Silent transitions cannot be removed!

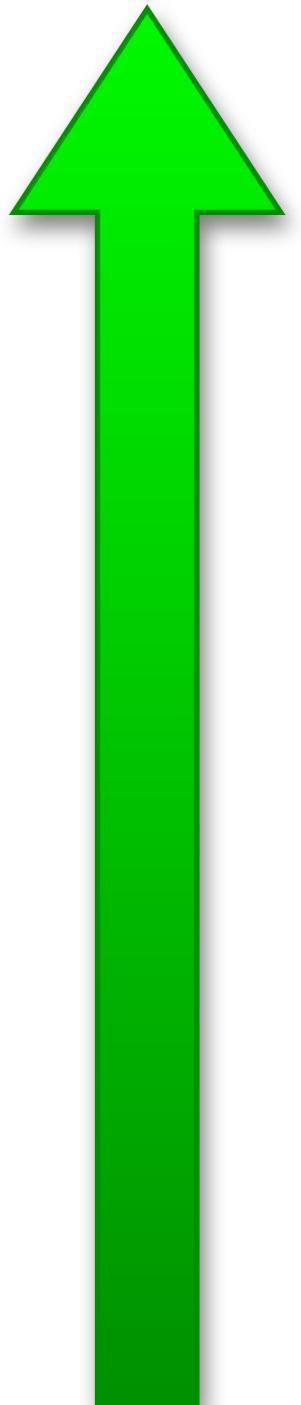


Expressiveness

Silent transitions cannot be removed!



Clocks resets



Expressiveness

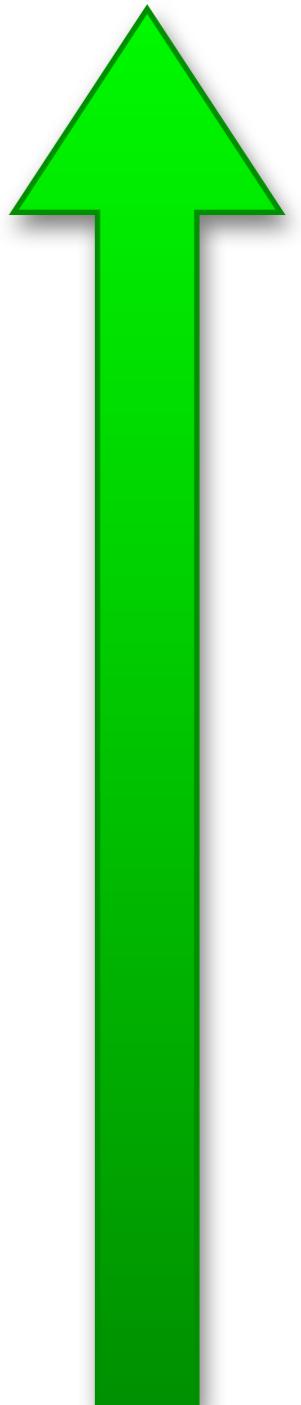
Silent transitions cannot be removed!



Clocks resets

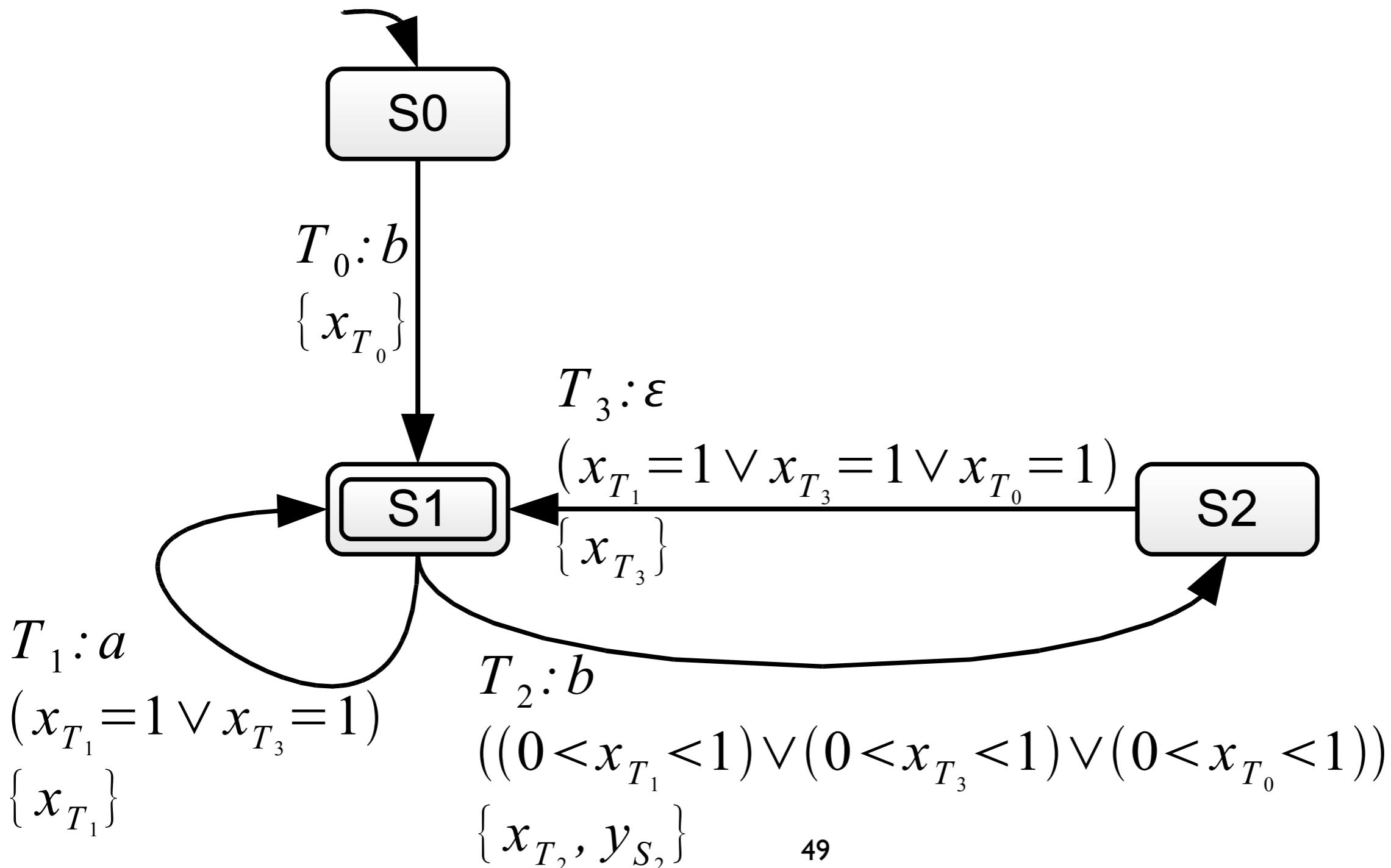
Precise actions

Corollary 29 of “**Characterization of the expressive power of silent transitions in timed automata**”, B.Bérard, V.Diekert, P. Gastin and A. Petit



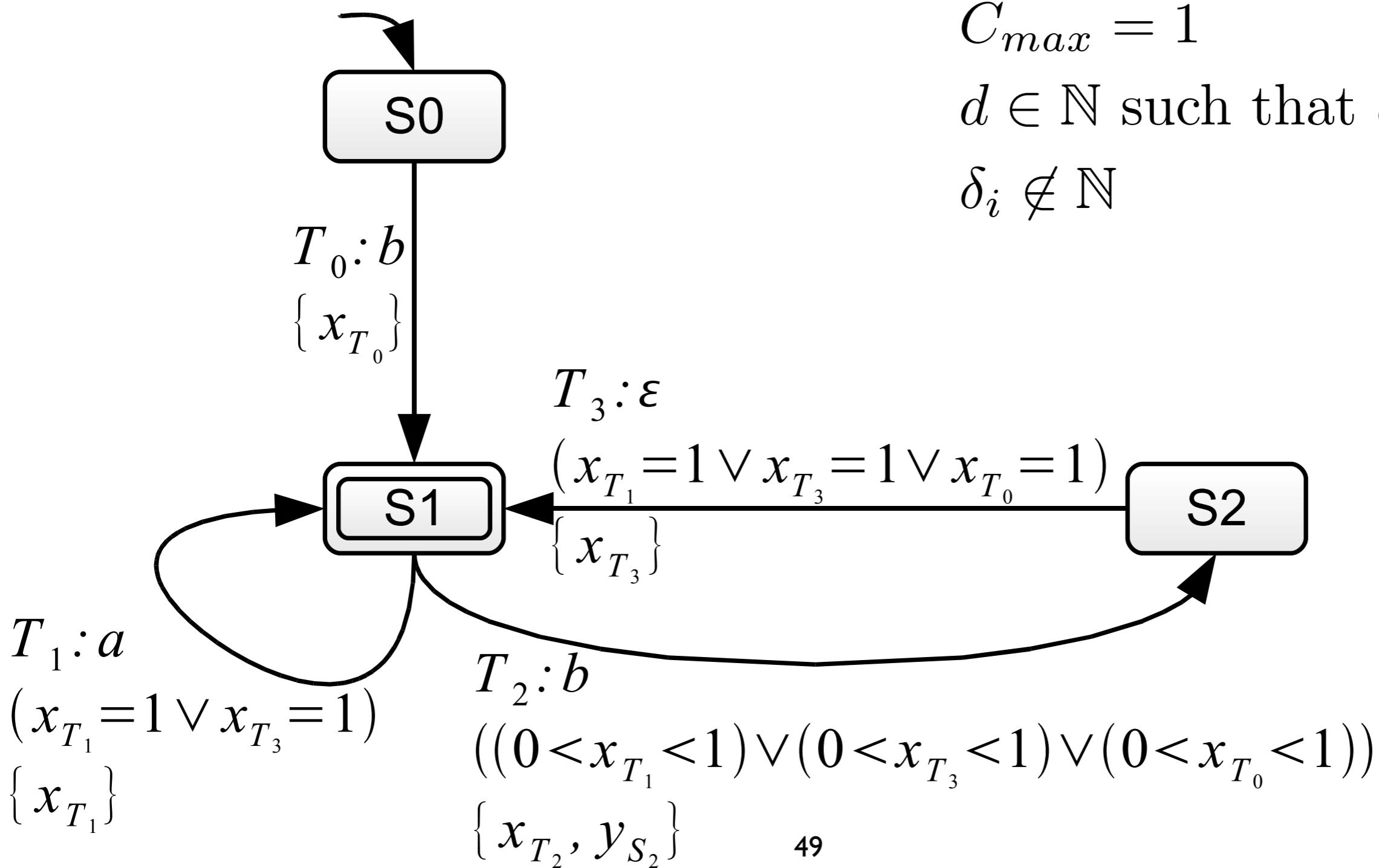
Proof sketch

$$(b, \delta_1) \cdot (b, \delta_2) \cdots (b, \delta_{d-1}) \cdot (a, d) \cdot (a, d+1) \cdots$$



Proof sketch

$$(b, \delta_1) \cdot (b, \delta_2) \cdots (b, \delta_{d-1}) \cdot (a, d) \cdot (a, d+1) \cdots$$



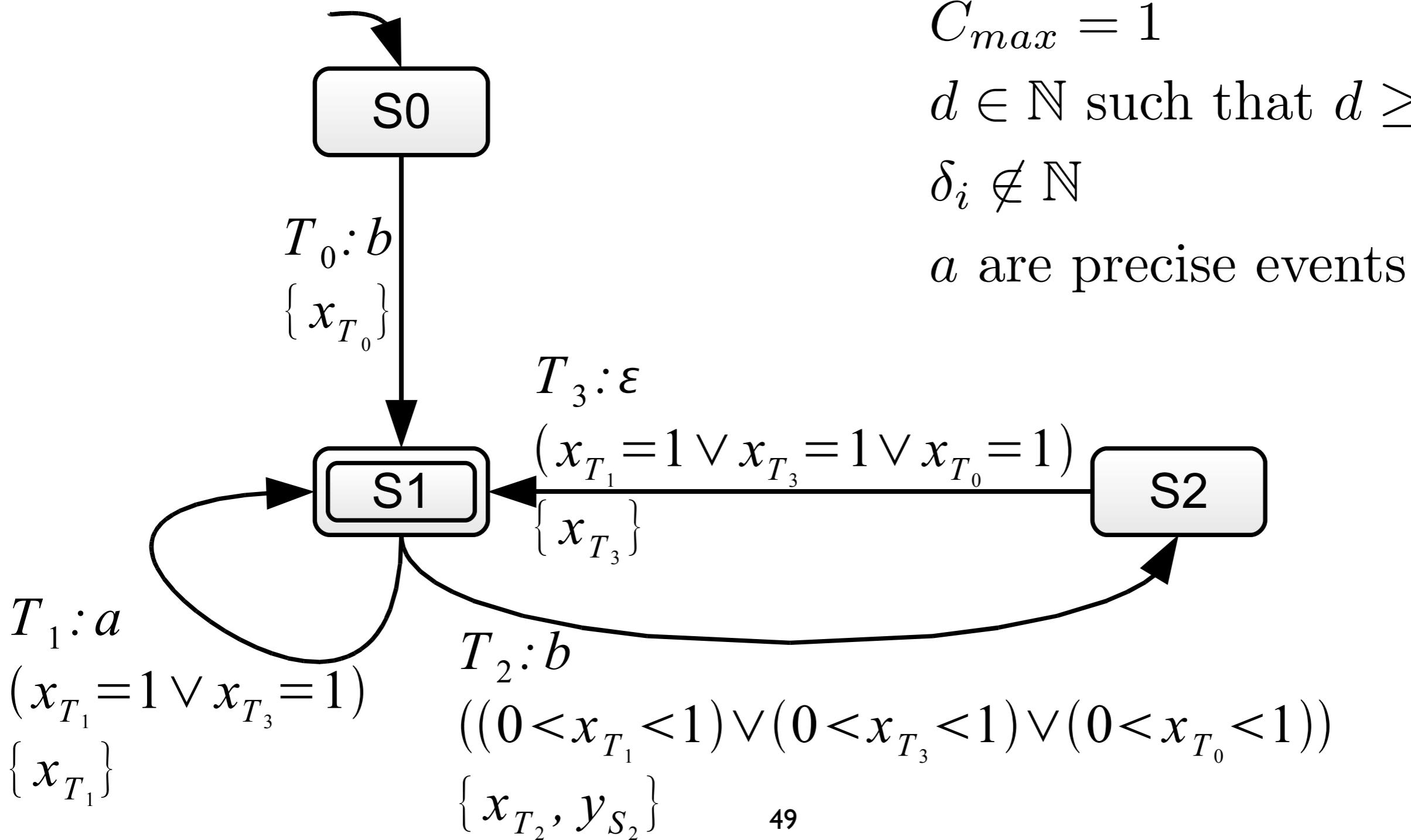
$$C_{max} = 1$$

$$d \in \mathbb{N} \text{ such that } d \geq c_{max}$$

$$\delta_i \notin \mathbb{N}$$

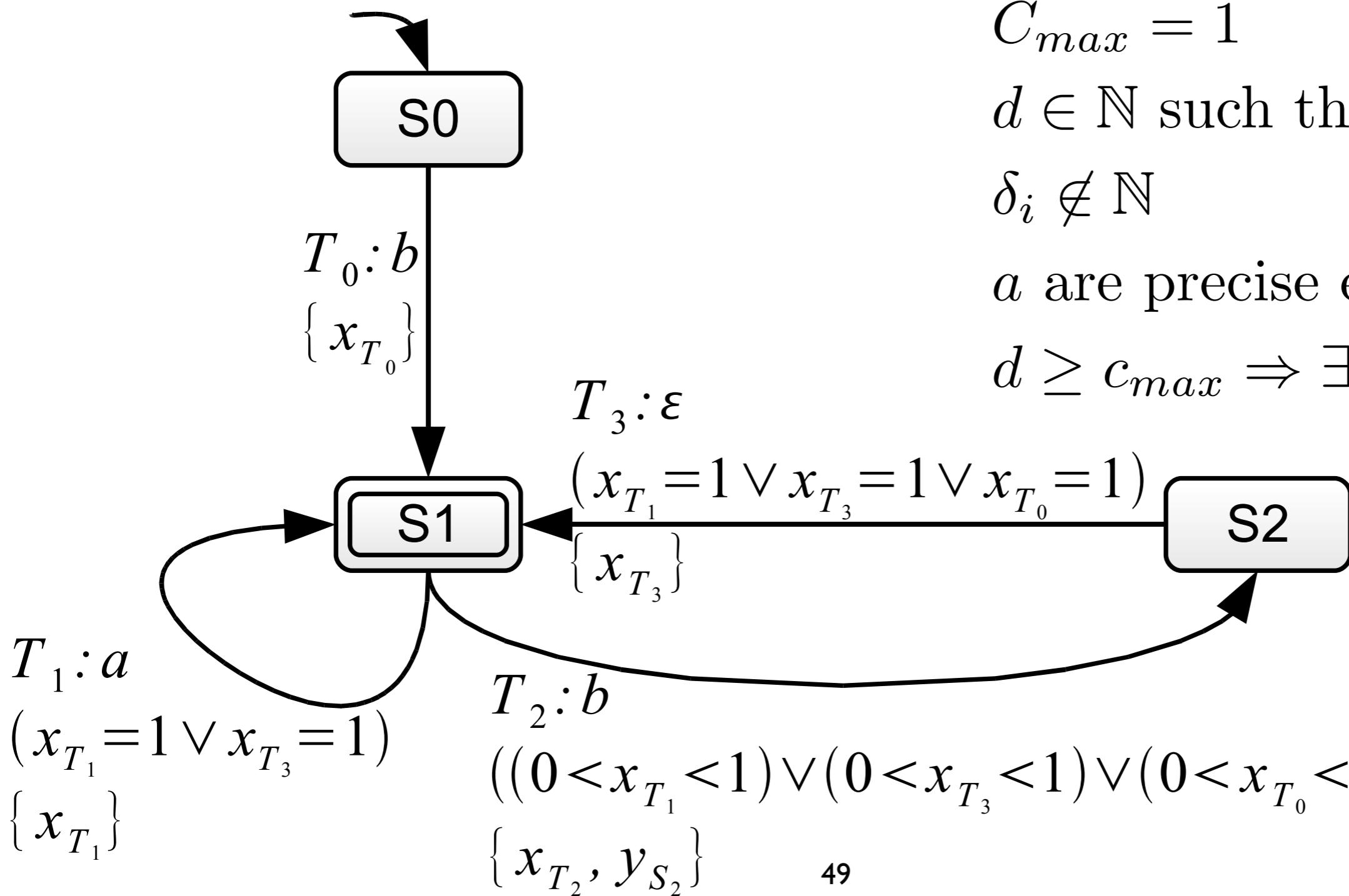
Proof sketch

$$(b, \delta_1) \cdot (b, \delta_2) \cdots (b, \delta_{d-1}) \cdot (a, d) \cdot (a, d+1) \cdots$$



Proof sketch

$$(b, \delta_1) \cdot (b, \delta_2) \cdots (b, \delta_{d-1}) \cdot (a, d) \cdot (a, d+1) \cdots$$



$$C_{max} = 1$$

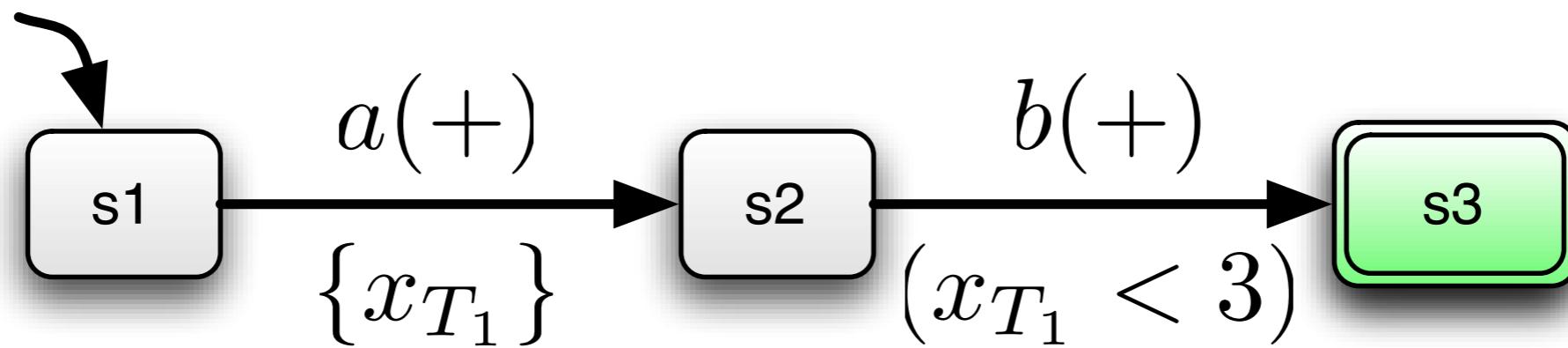
$$d \in \mathbb{N} \text{ such that } d \geq c_{max}$$

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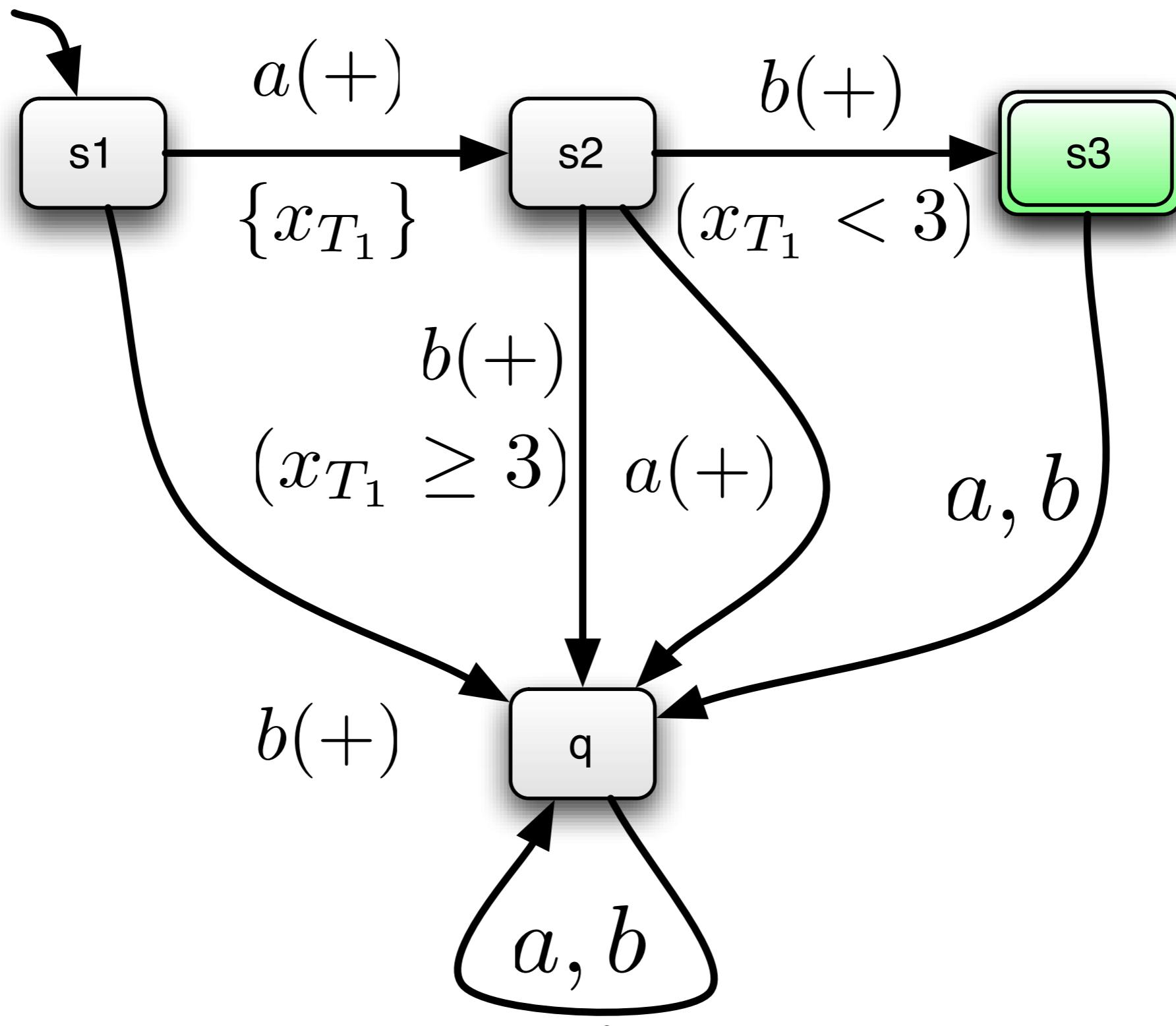
a are precise events

$$d \geq c_{max} \Rightarrow \exists \text{ precise } b$$

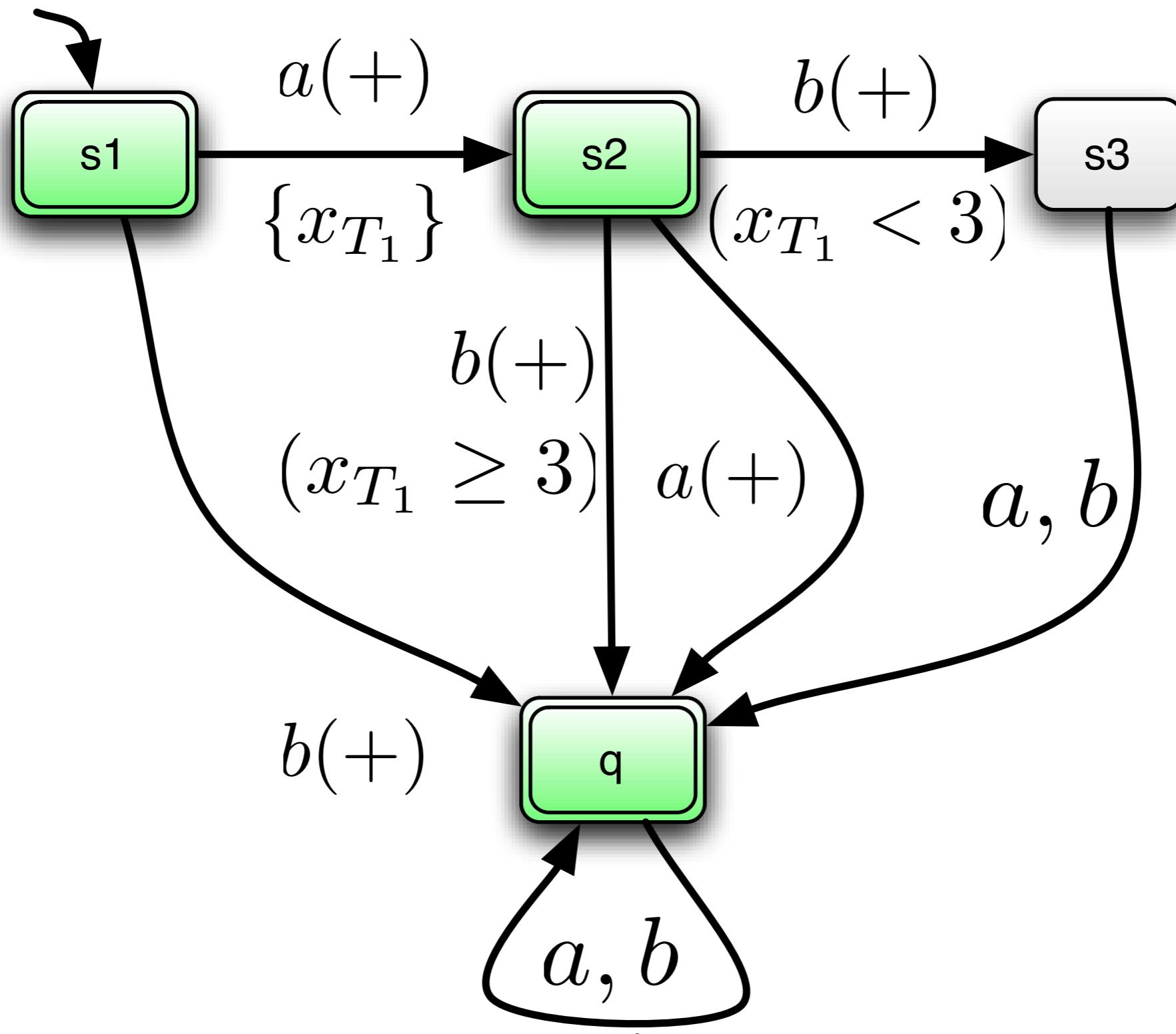
Complementation



Complementation



Complementation



Closure: complementation

“one run per
timed word”



Closure: complementation

“one run per
timed word”



MInvoke make
precise!



MInvoke($T_1 = 3h$ and $T_2 < 25m$)

Protocol timed automata



1 clock per switch

“1 clock per location”

Restricted form of unremovable silent transitions

Deterministic behavior

Closed under complementation!

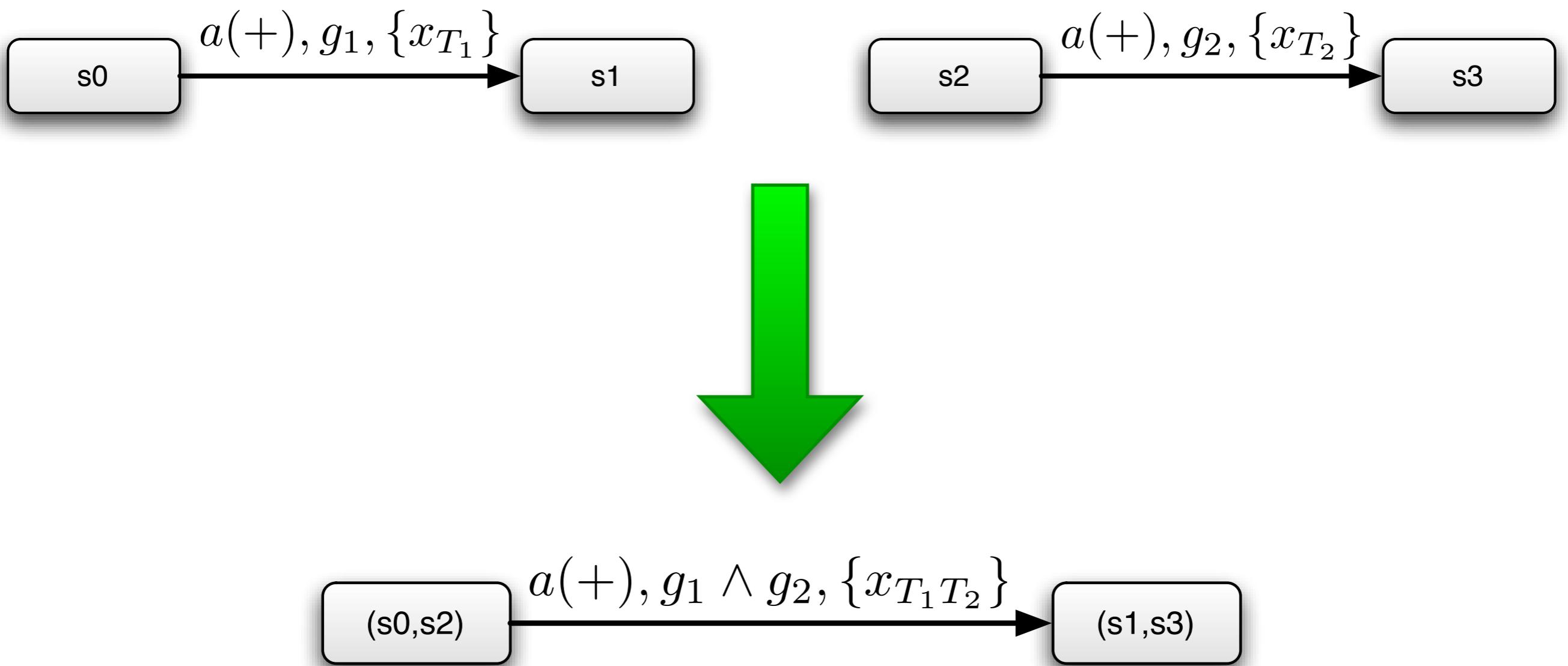
Protocol operators



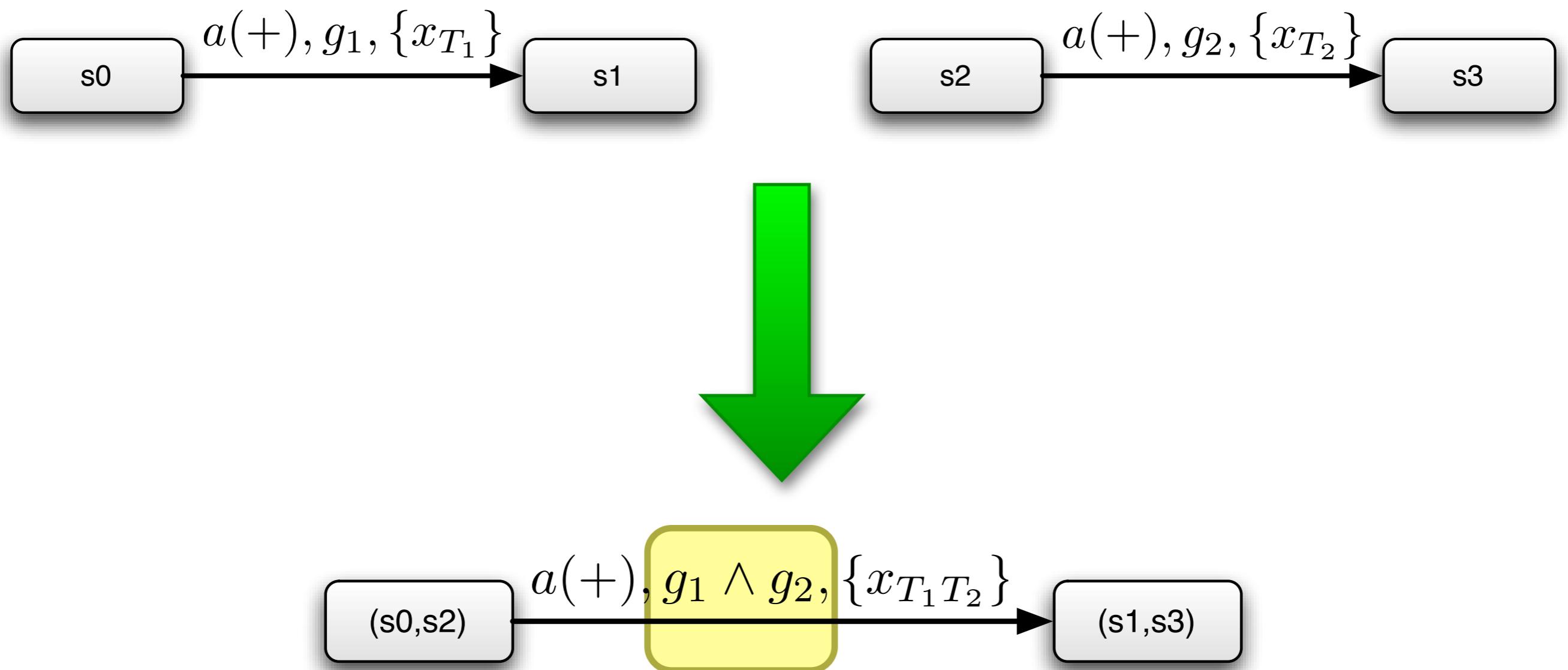
Intersection



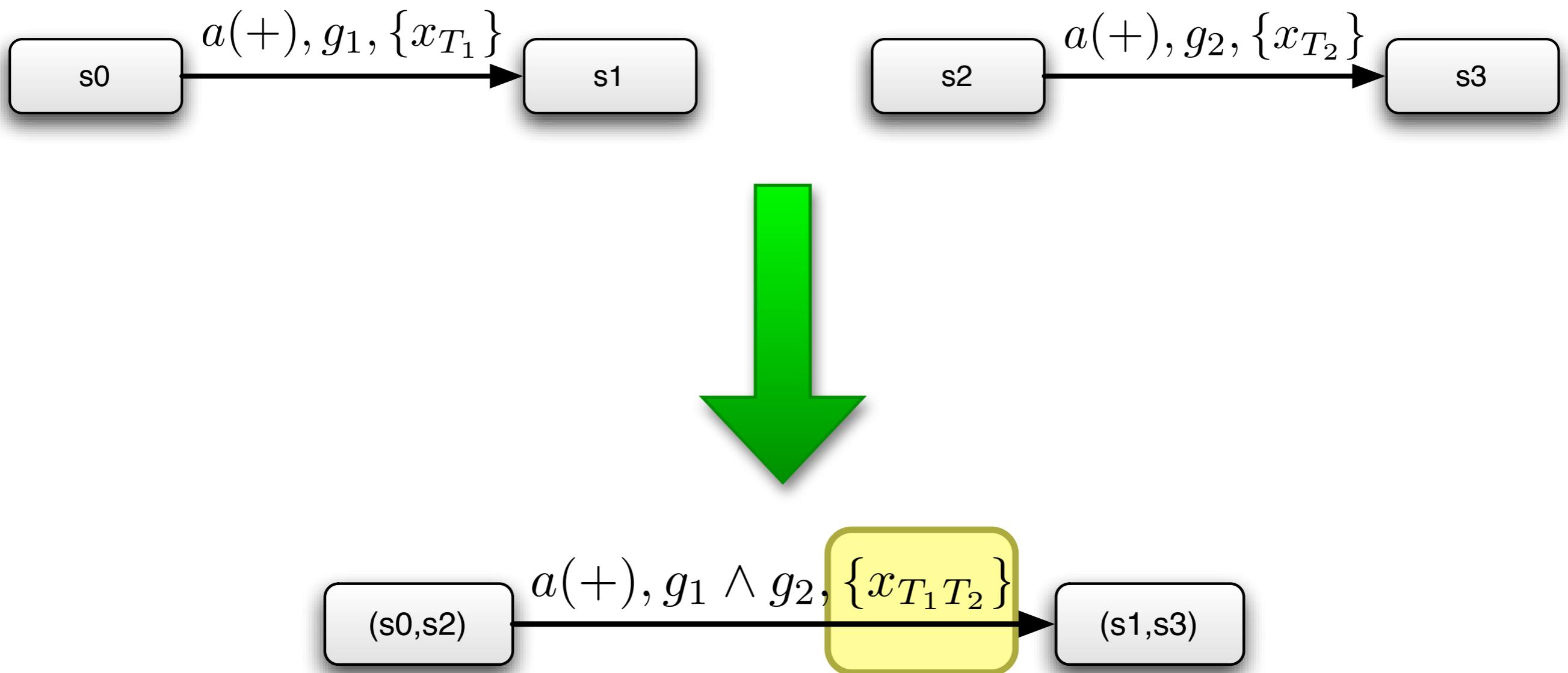
Intersection



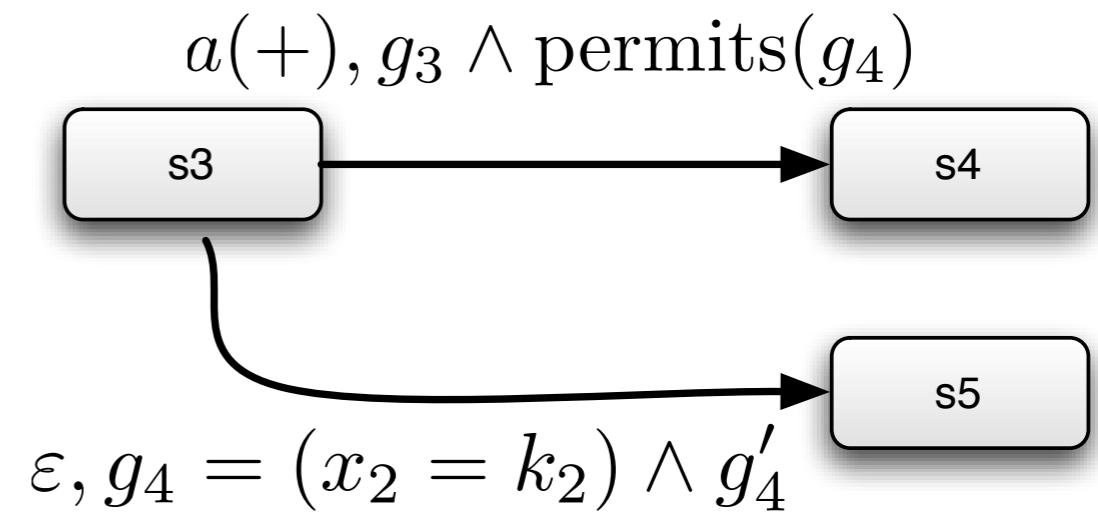
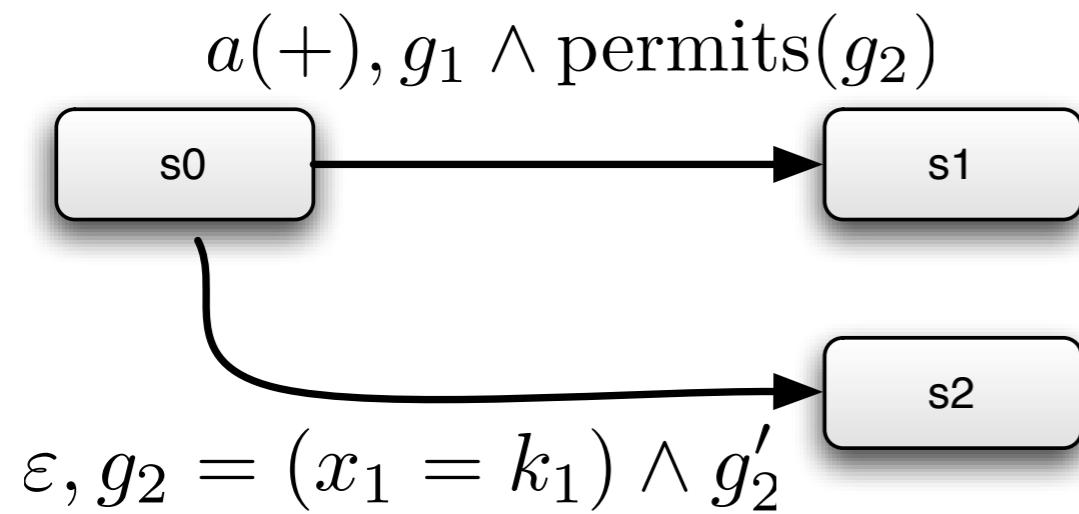
Intersection



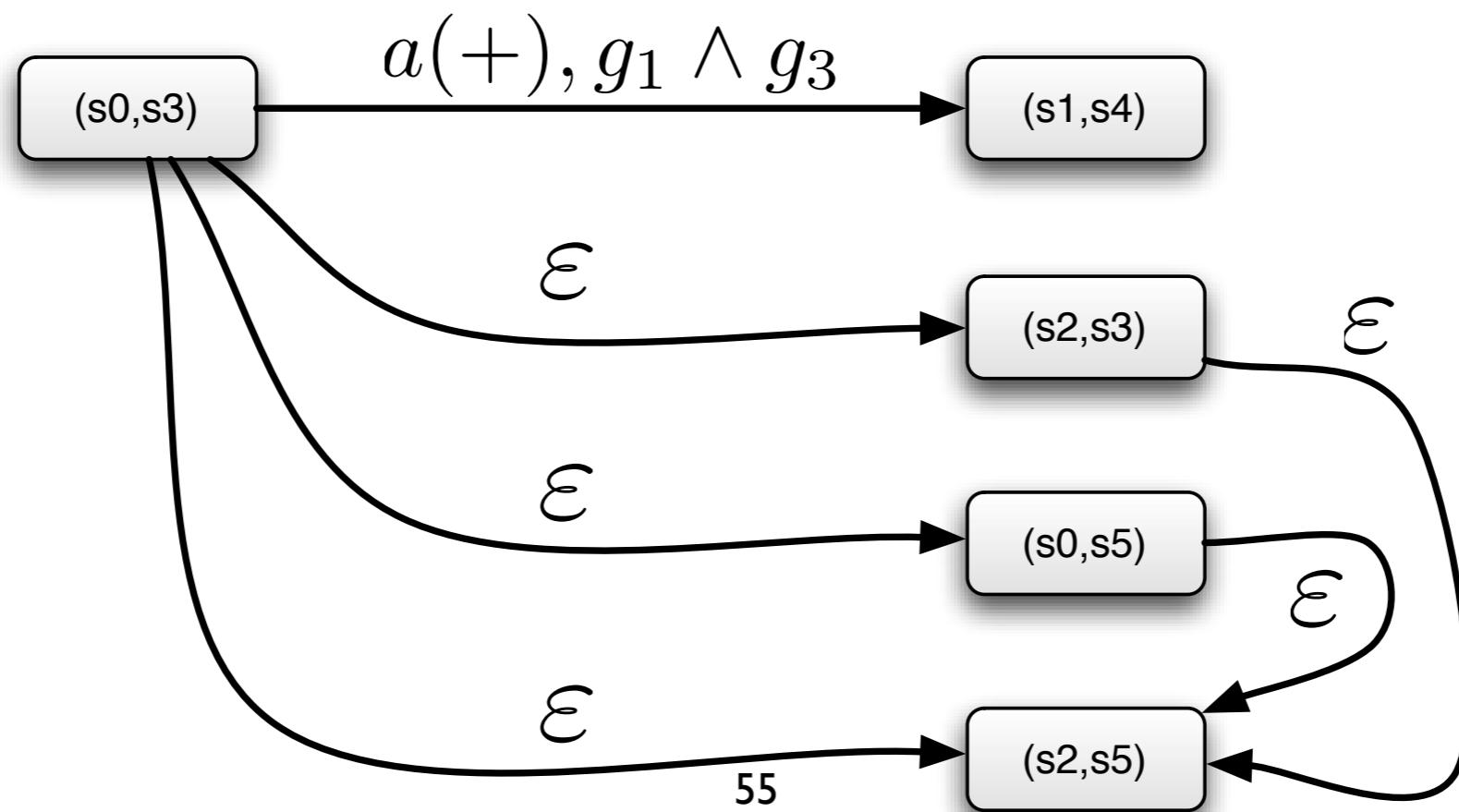
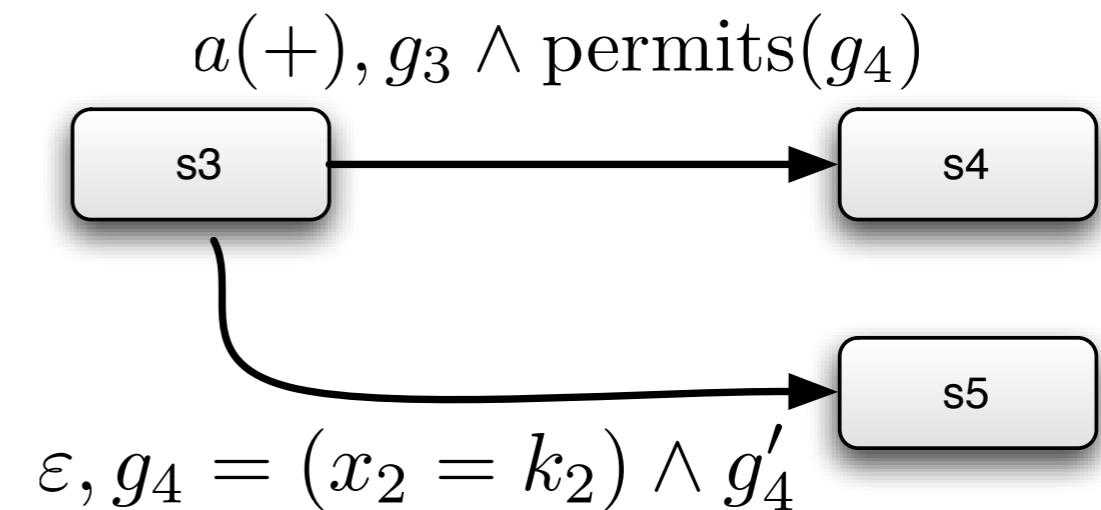
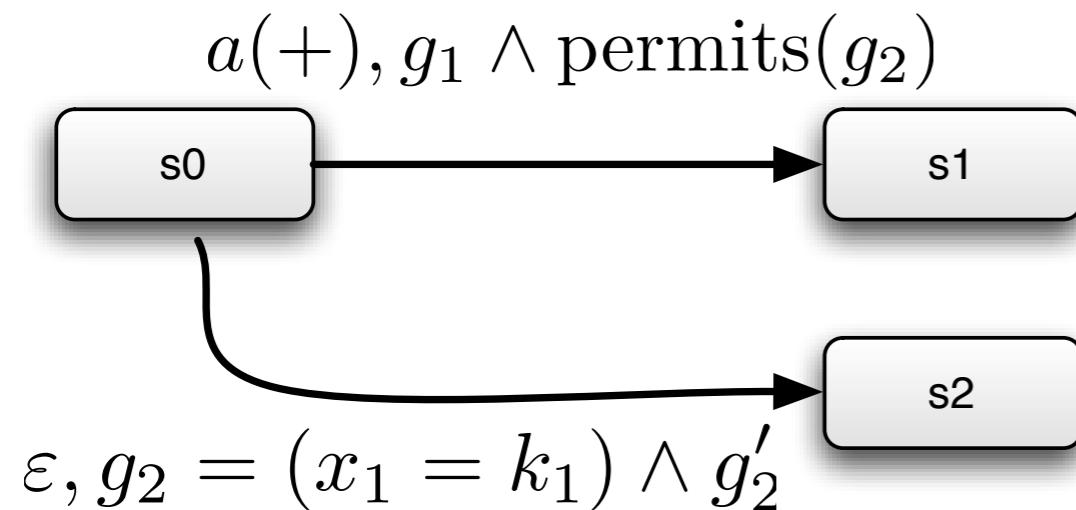
Intersection



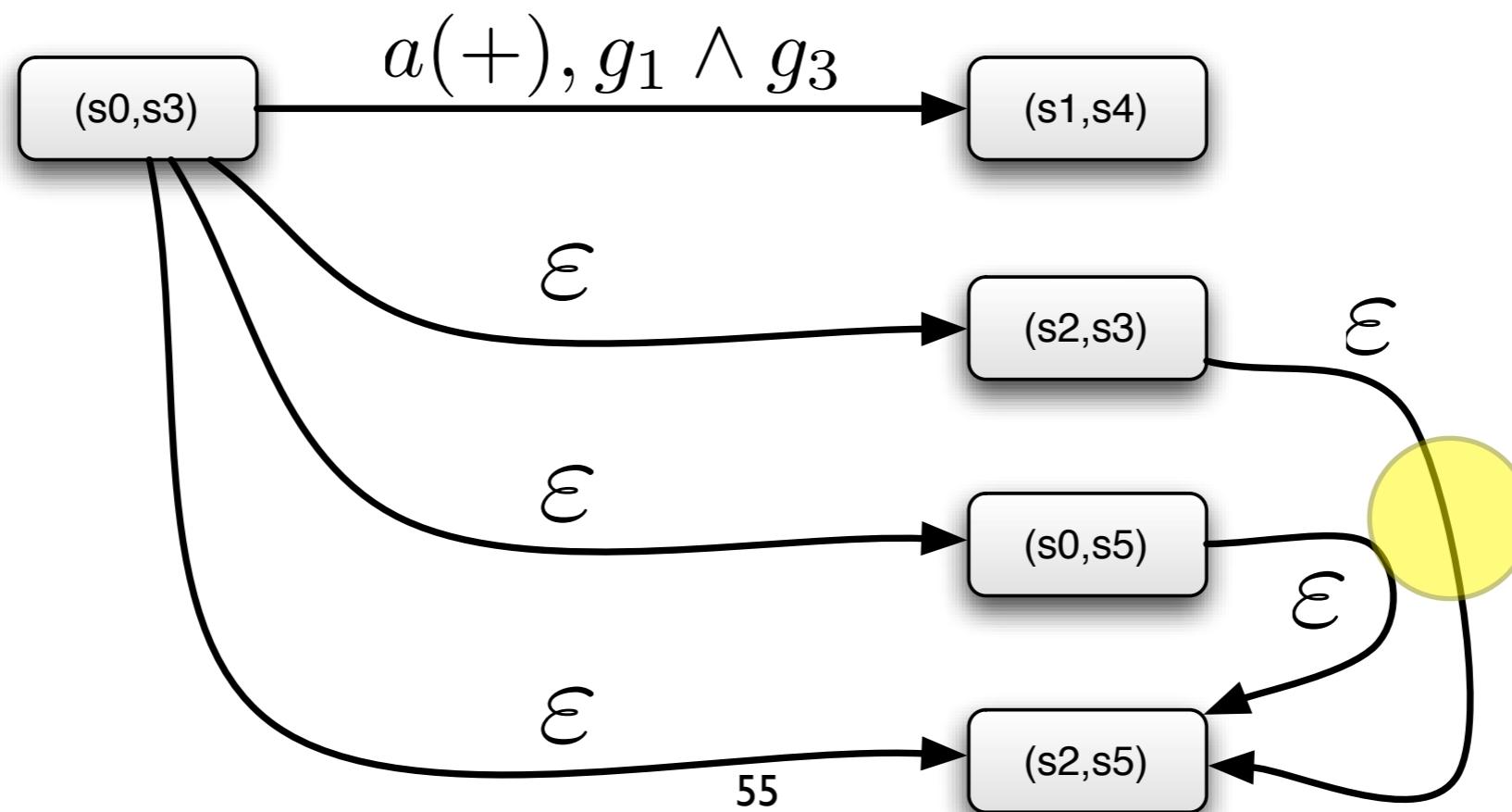
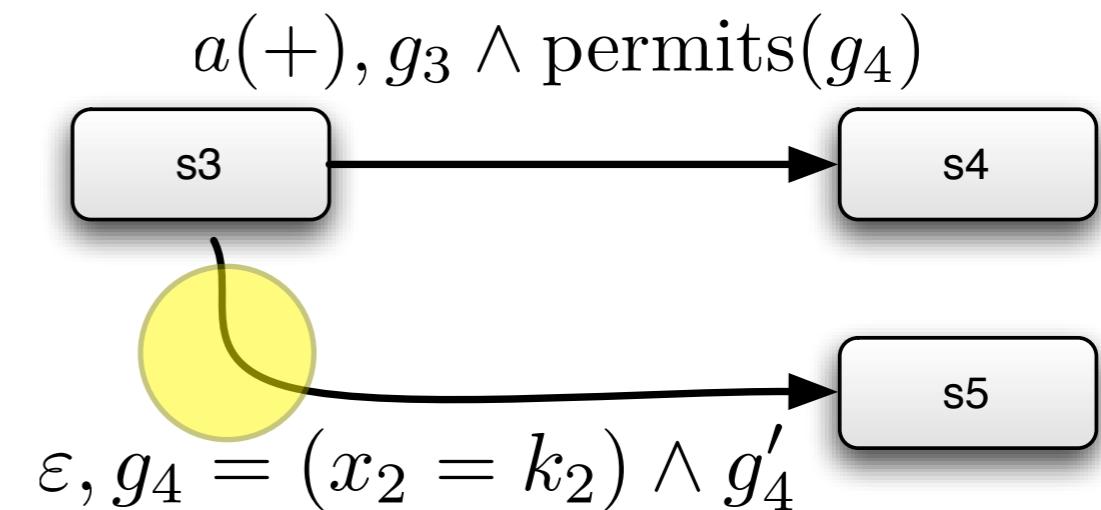
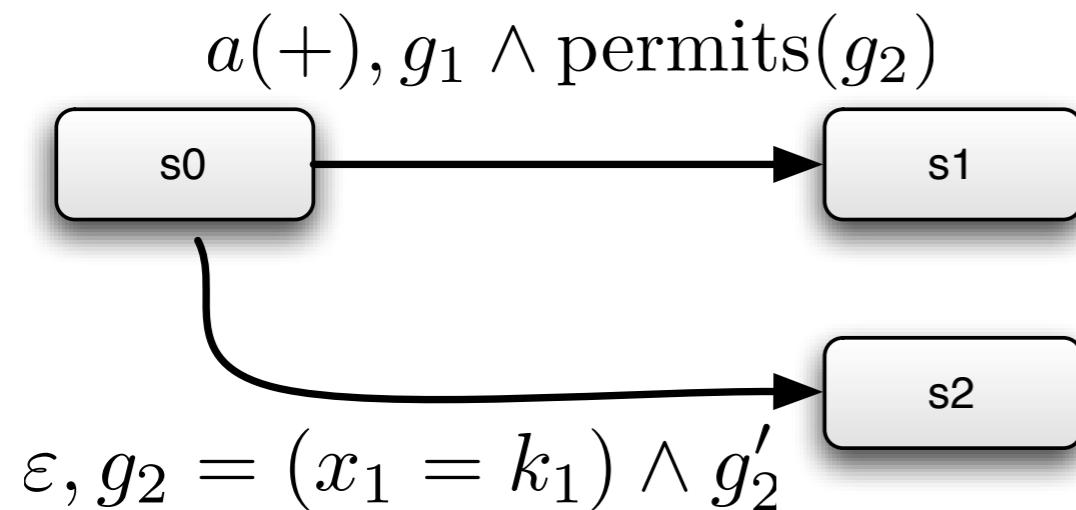
Intersection



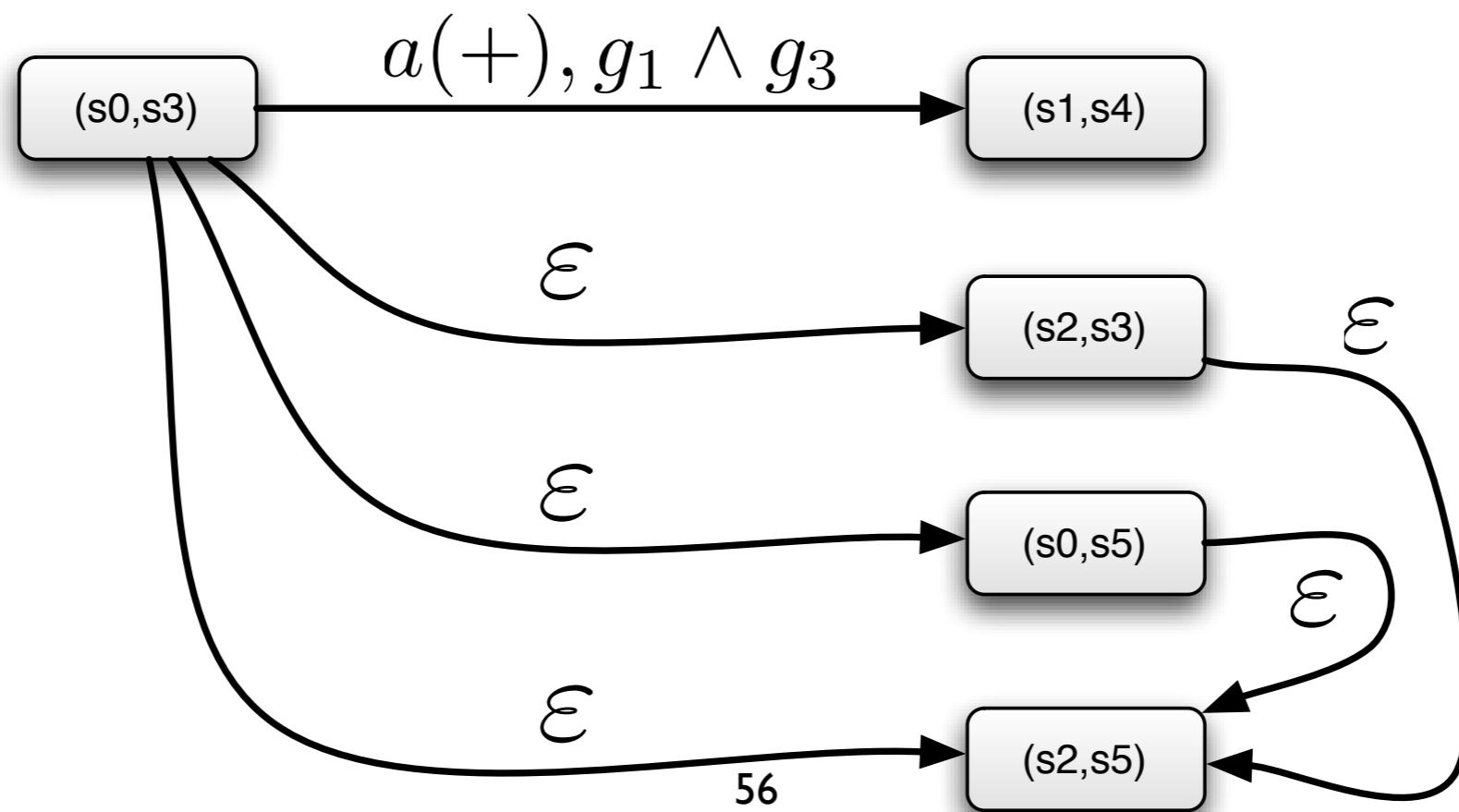
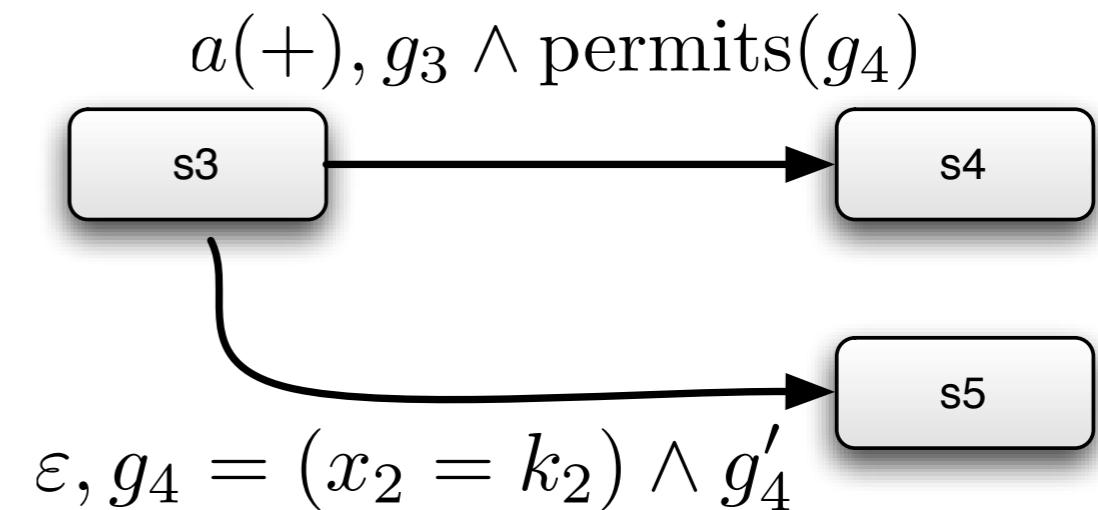
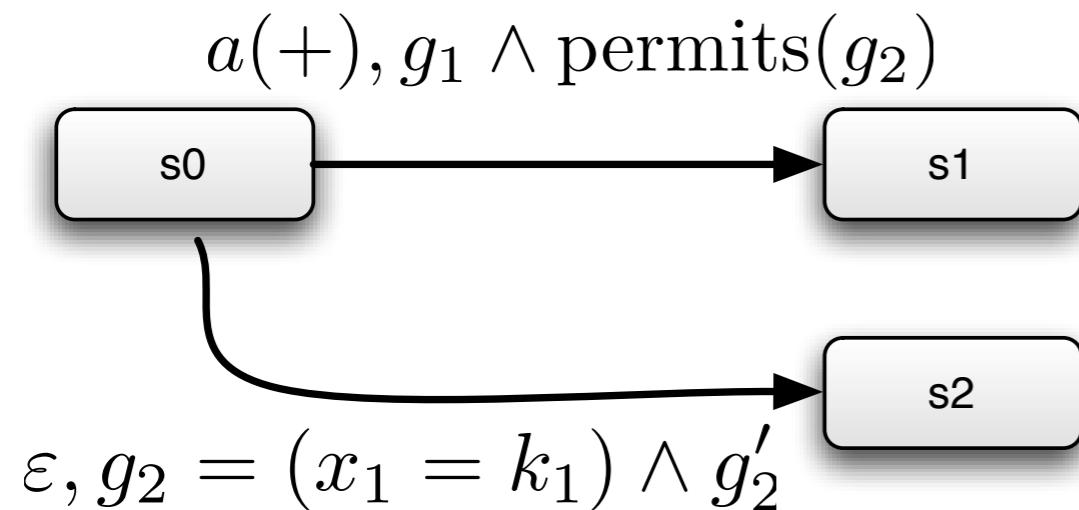
Intersection



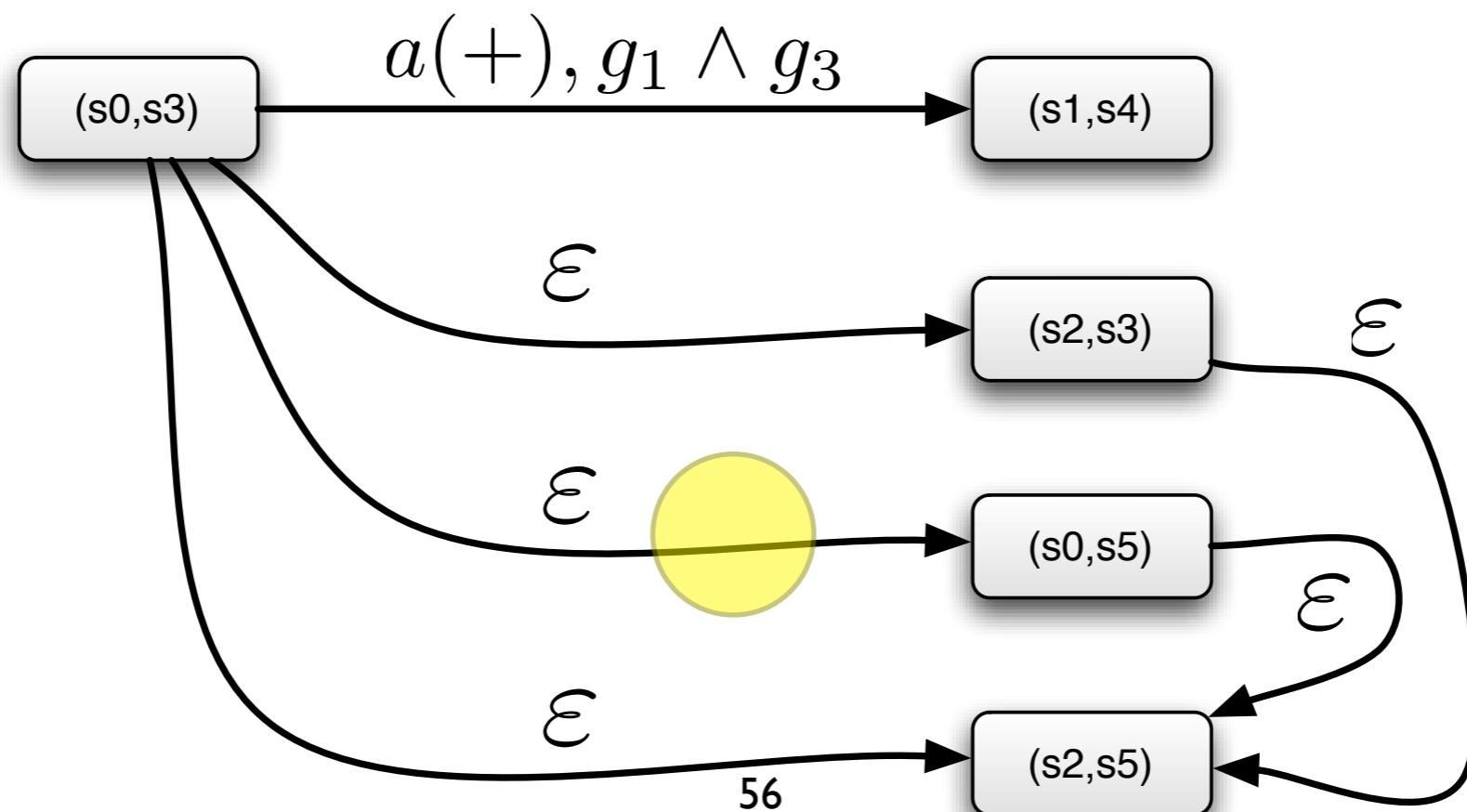
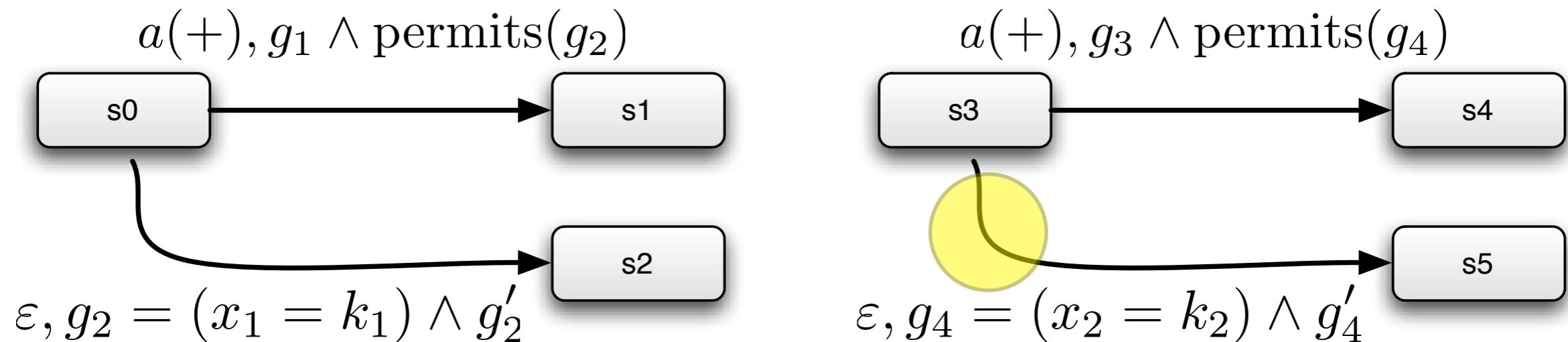
Intersection



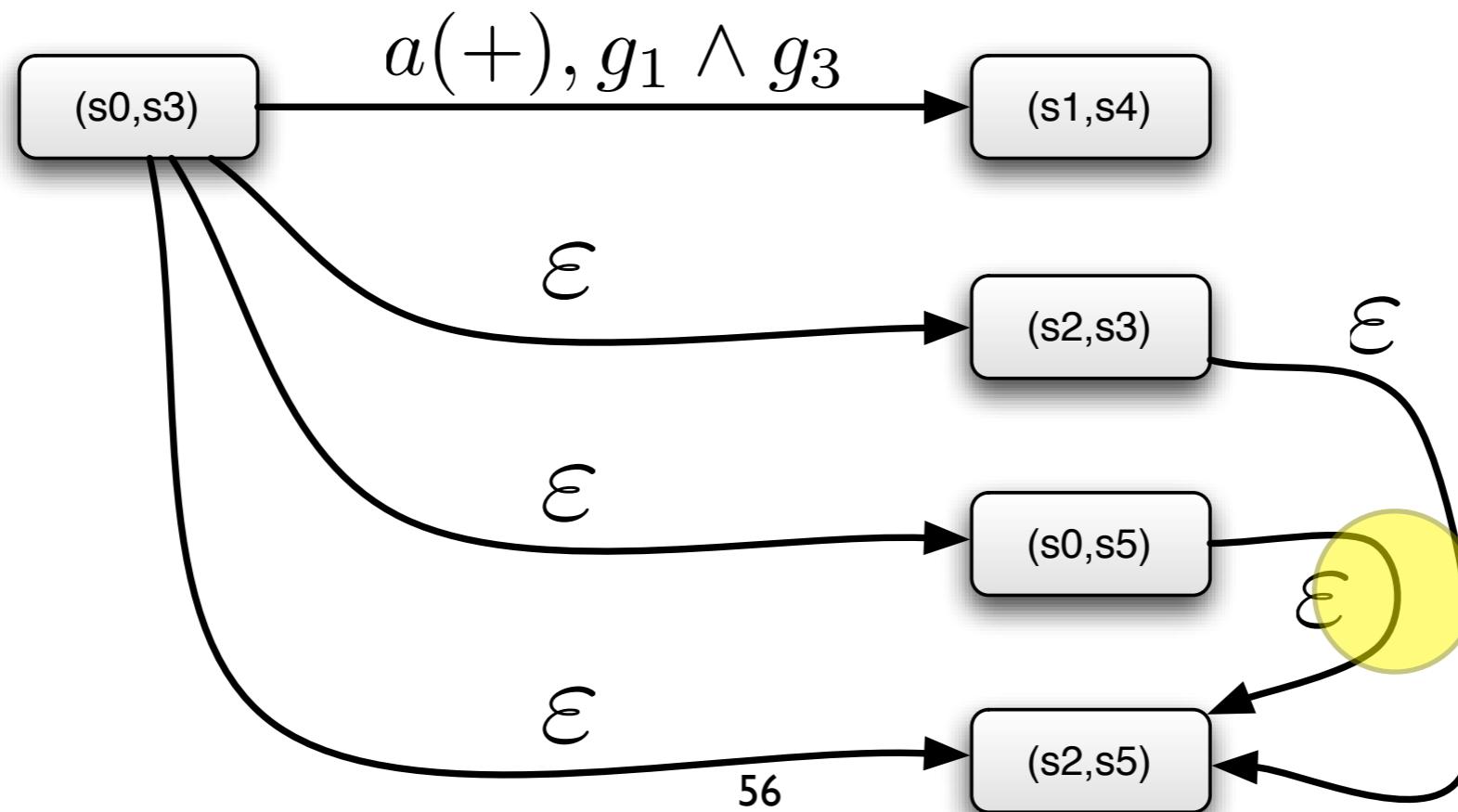
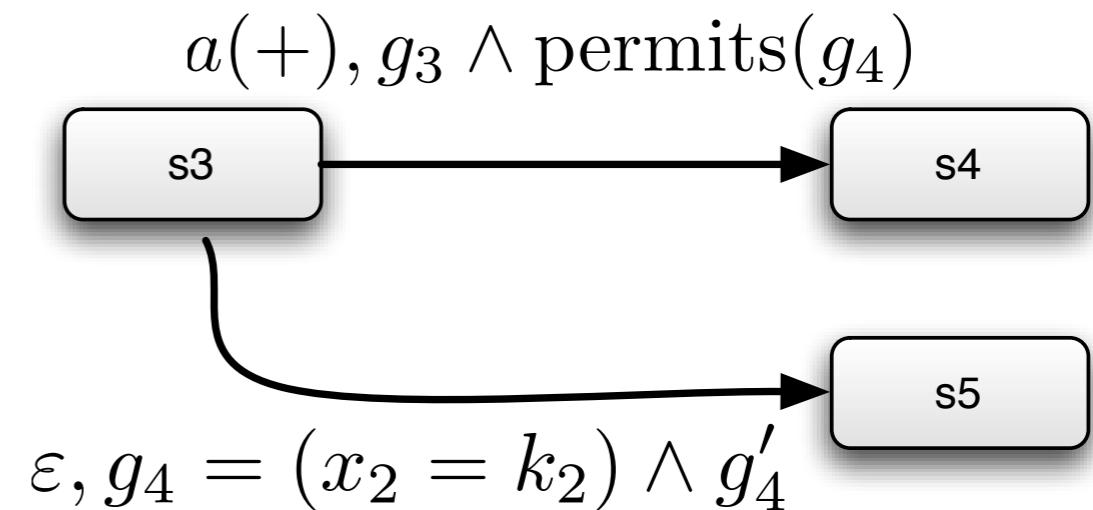
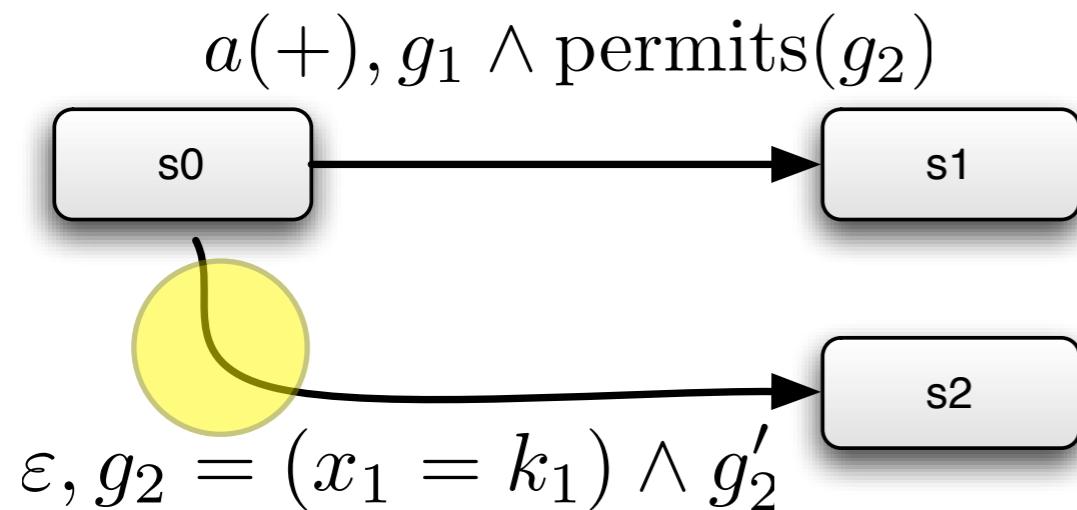
Intersection



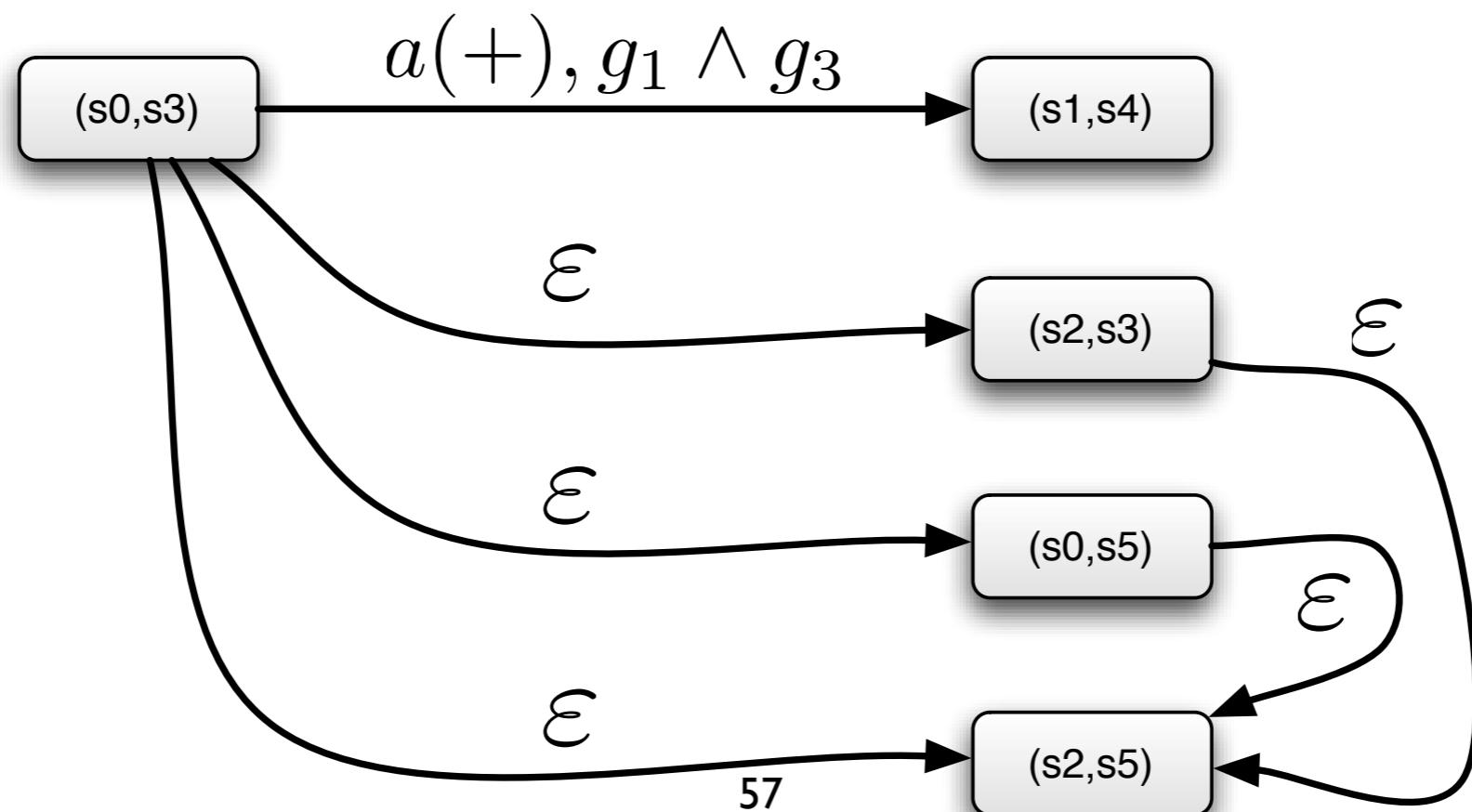
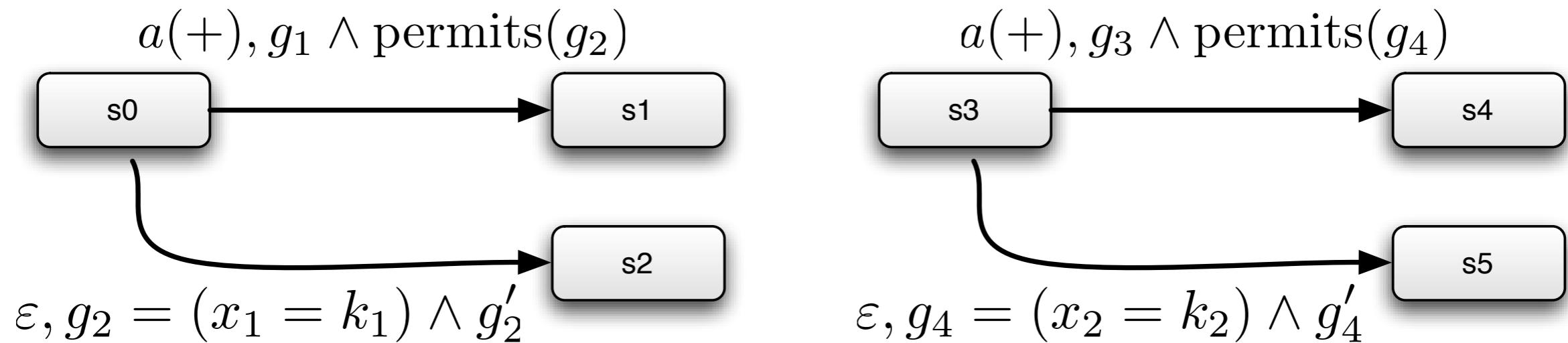
Intersection



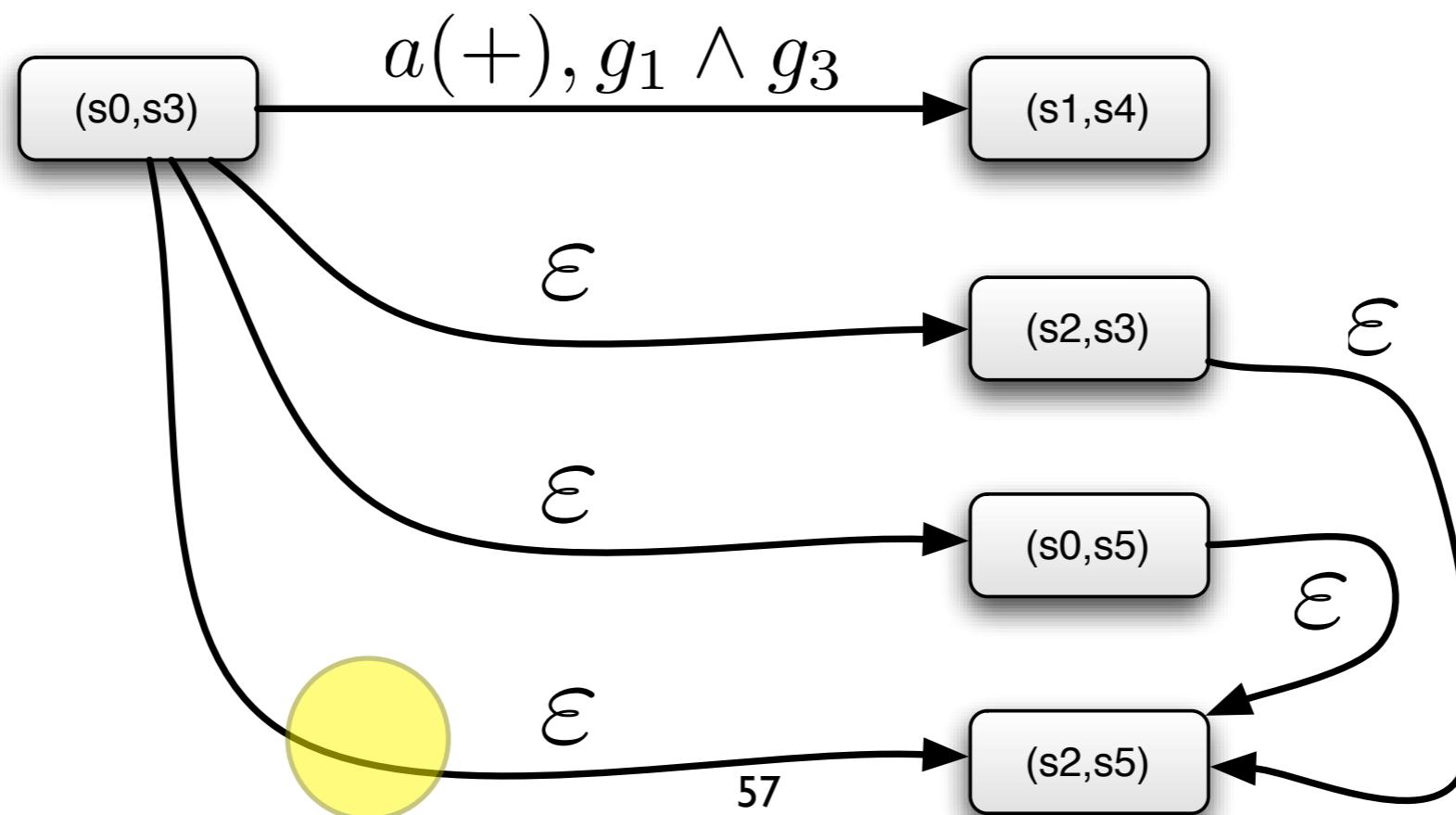
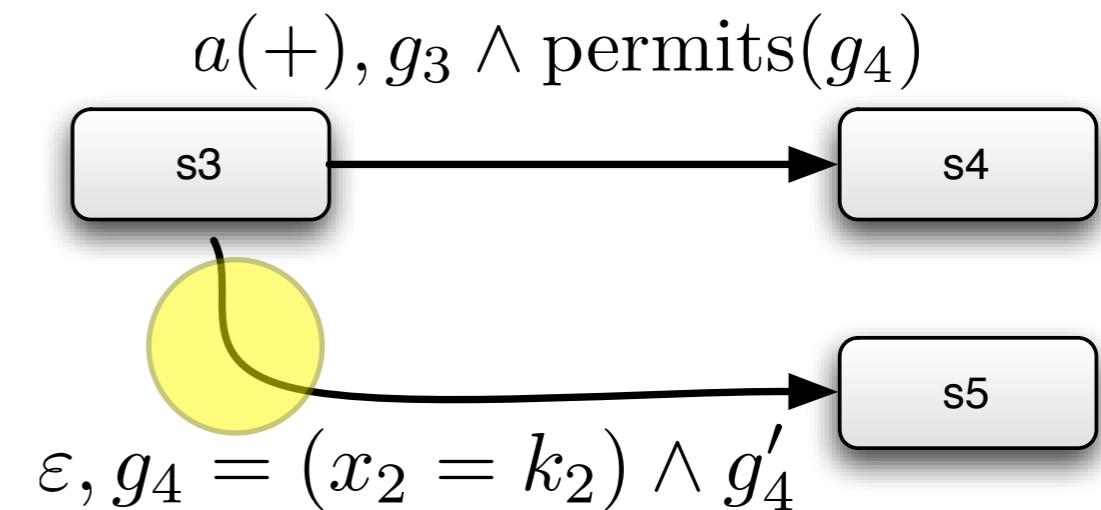
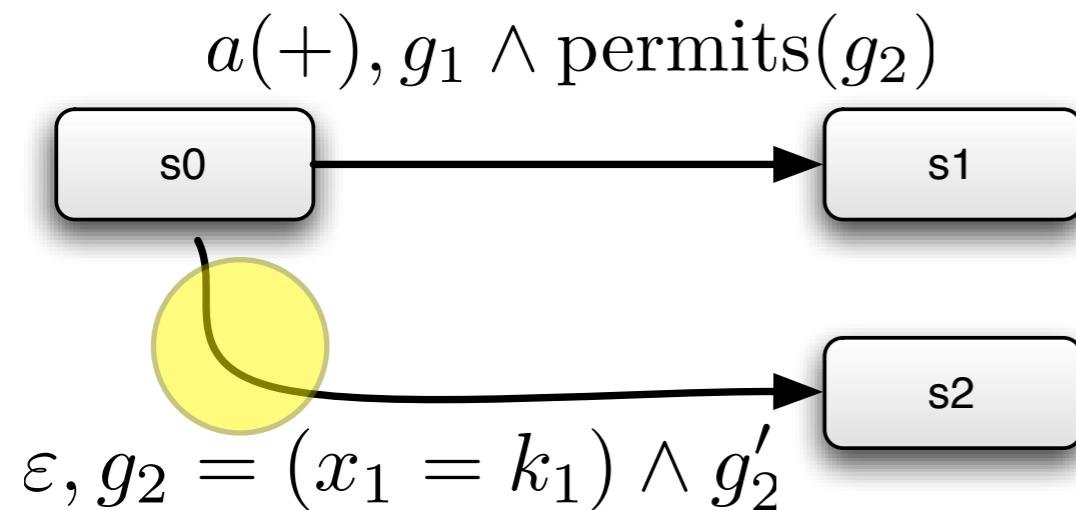
Intersection



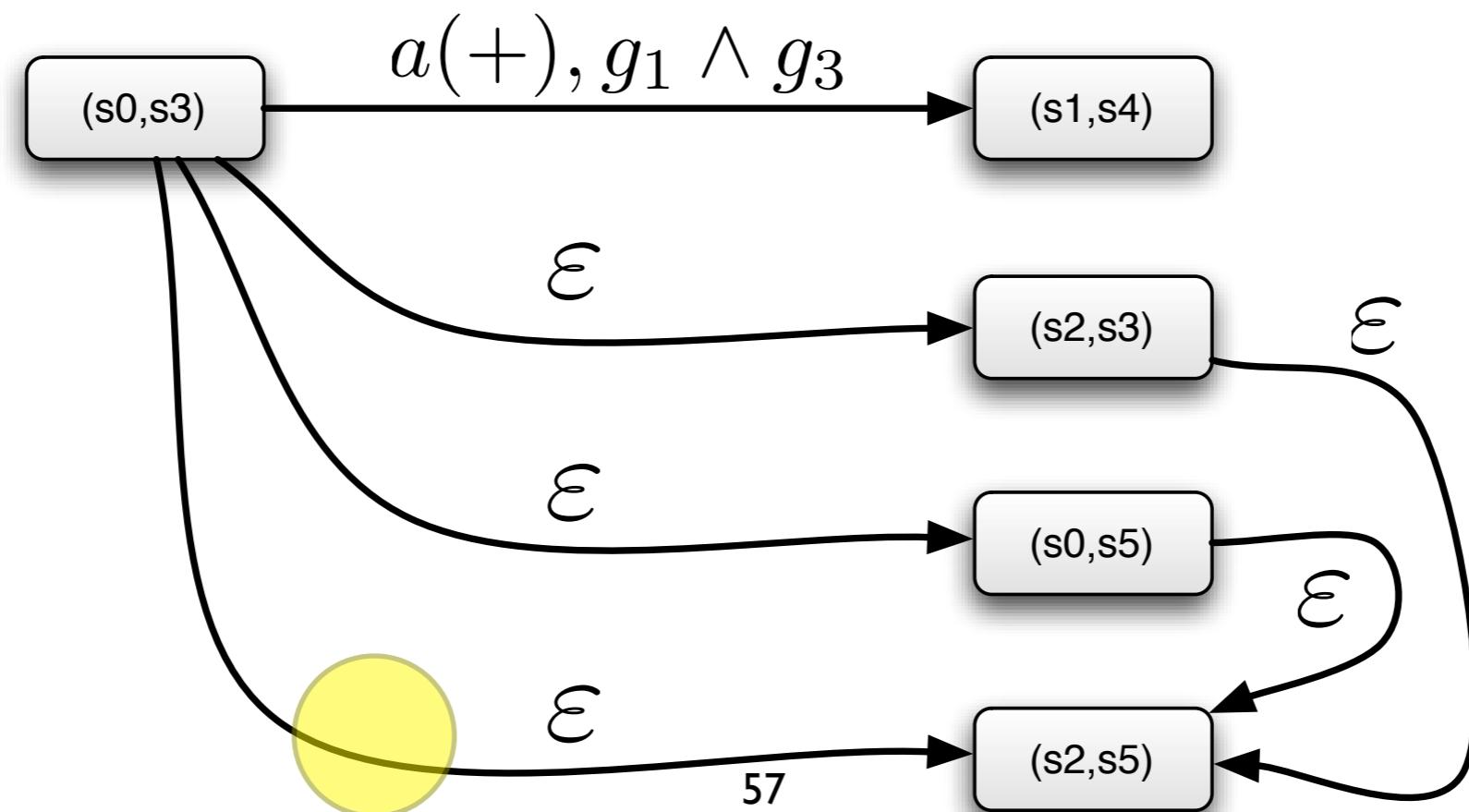
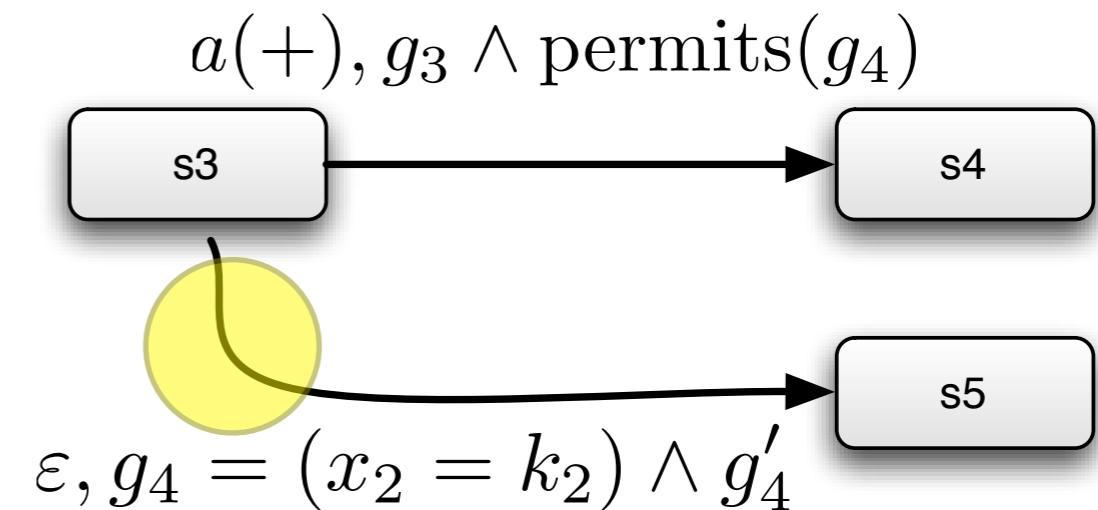
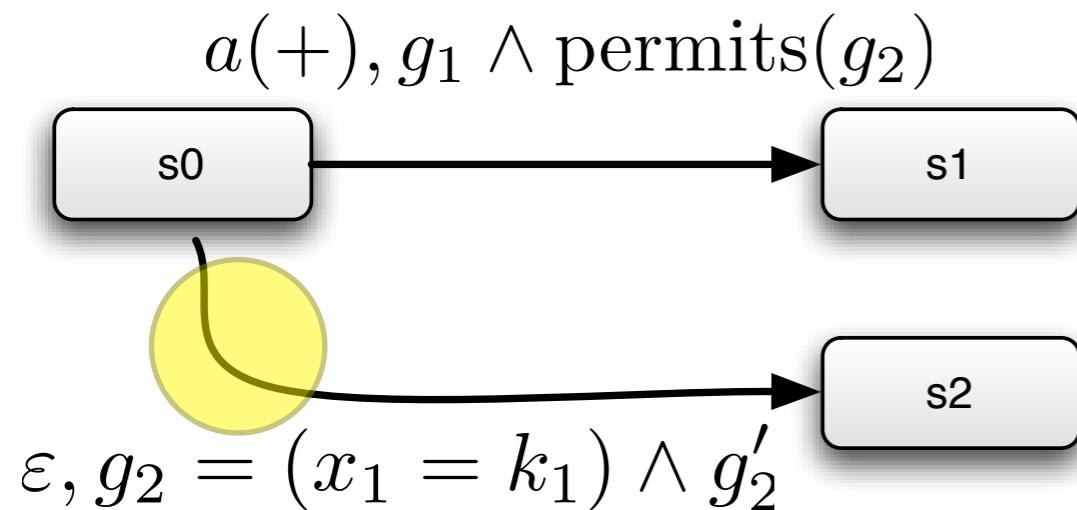
Intersection



Intersection



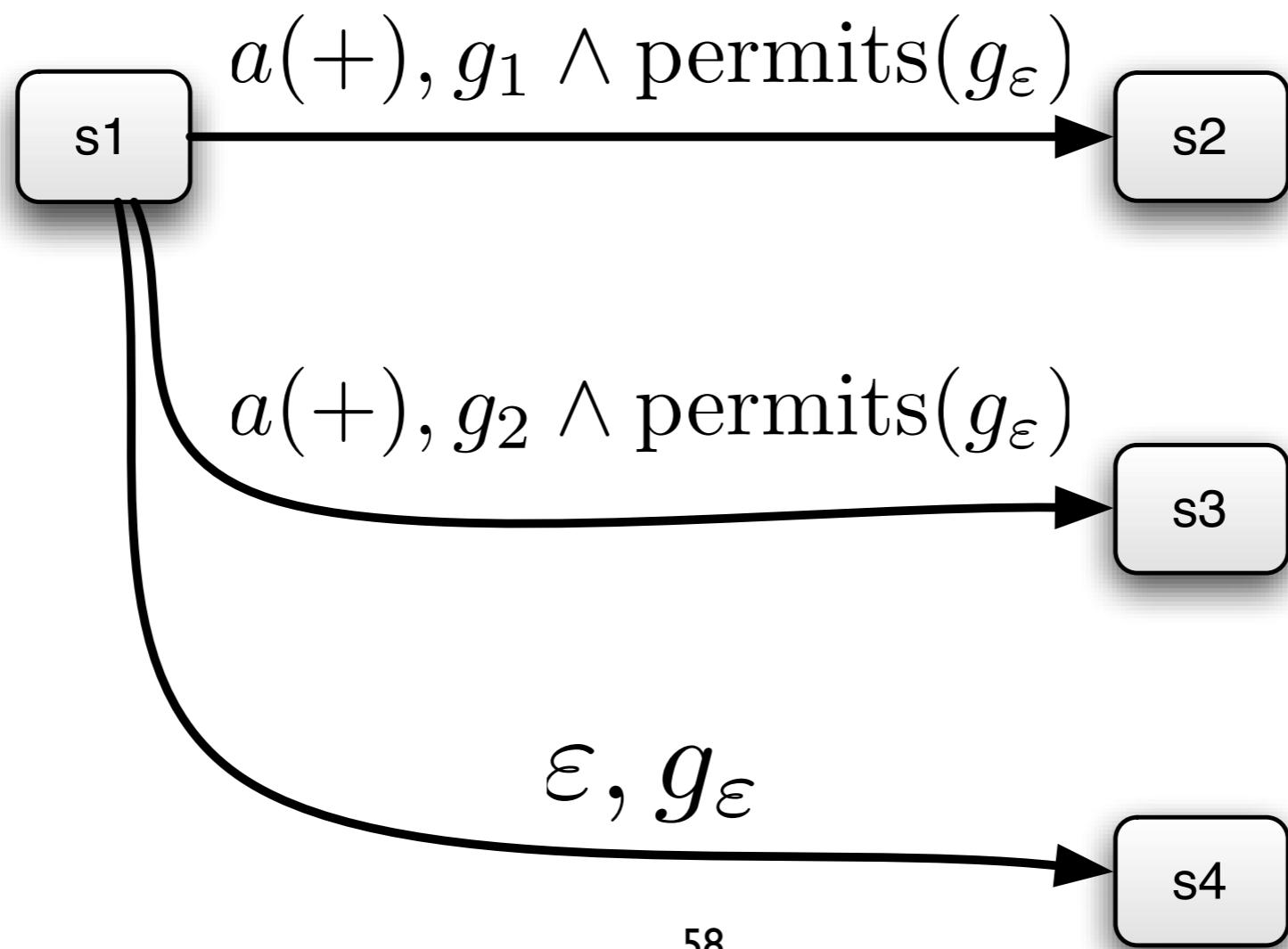
Intersection



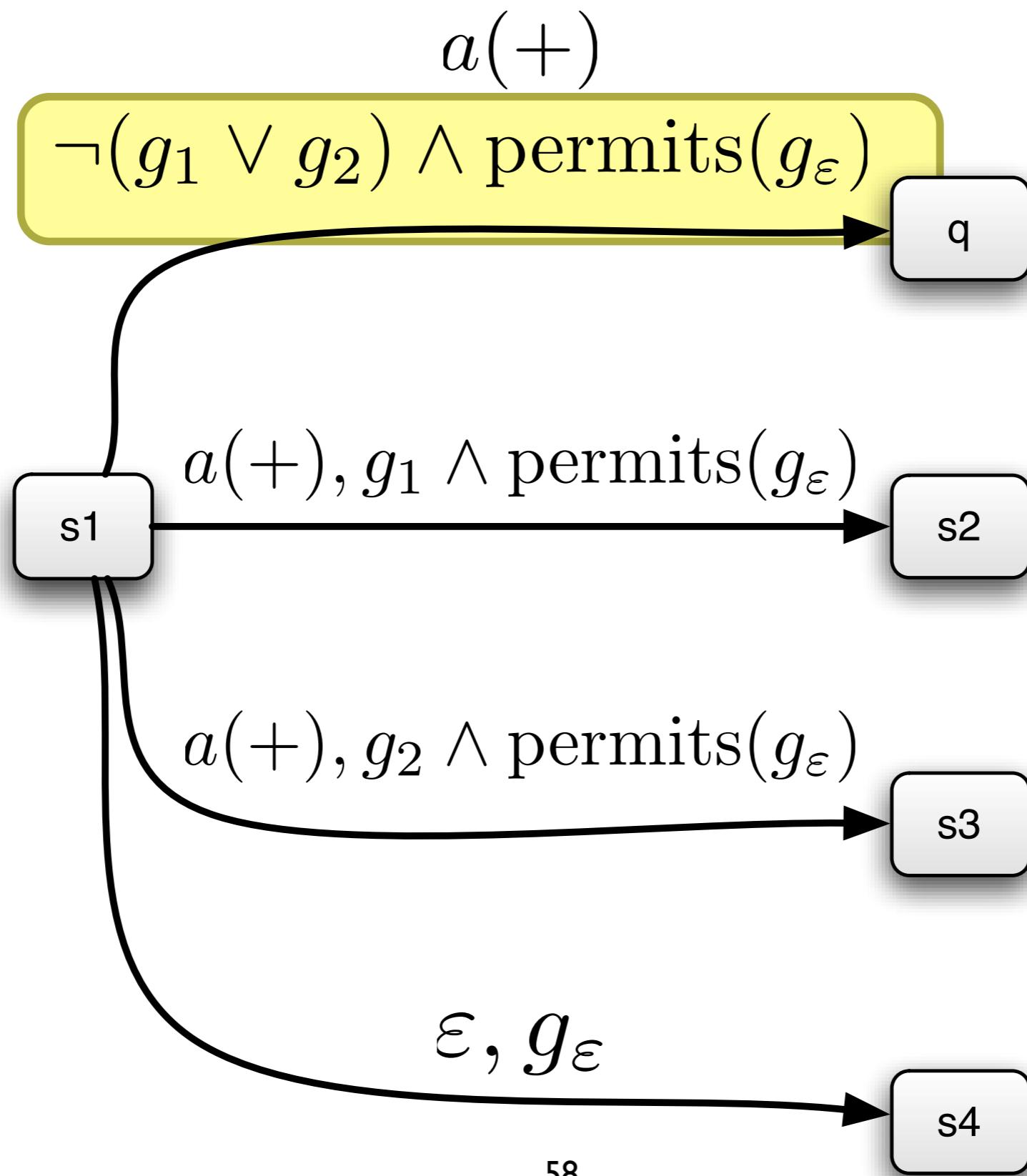
+ permits

+ y clocks

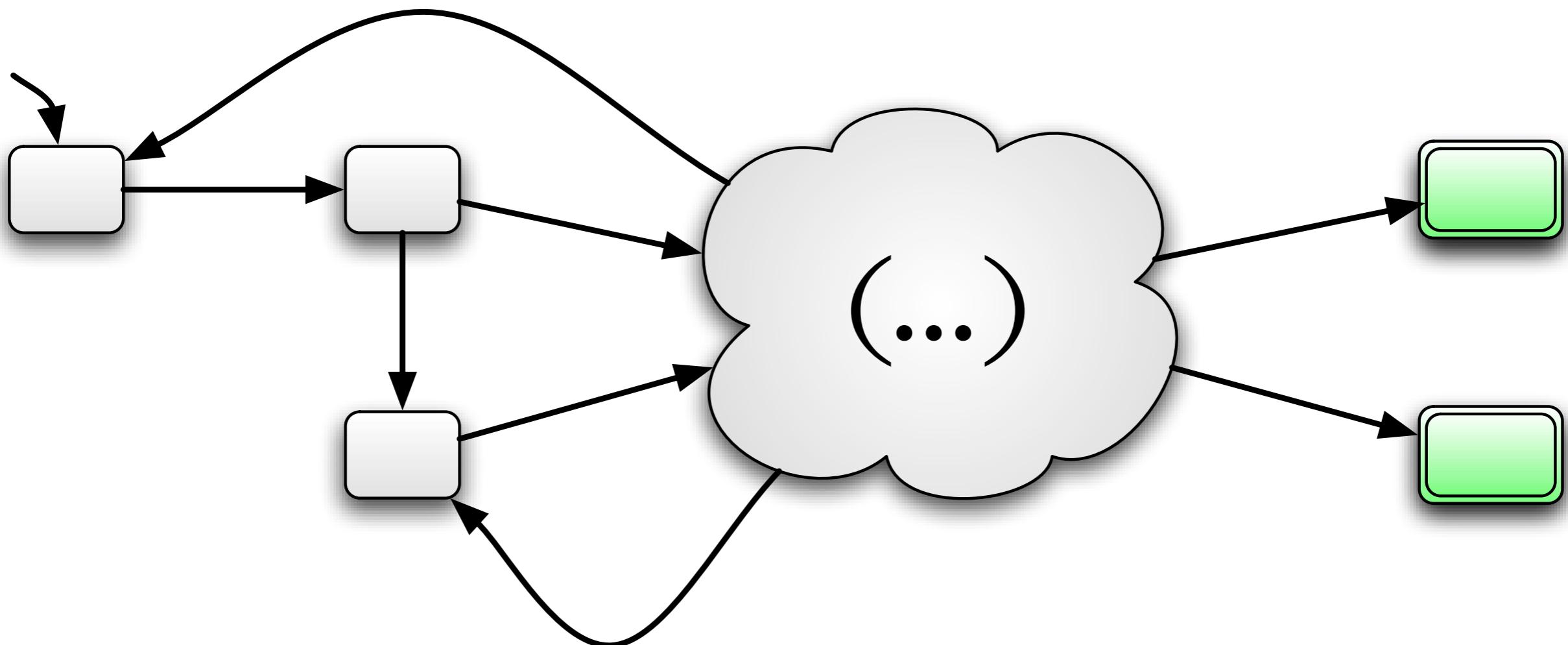
Complementation



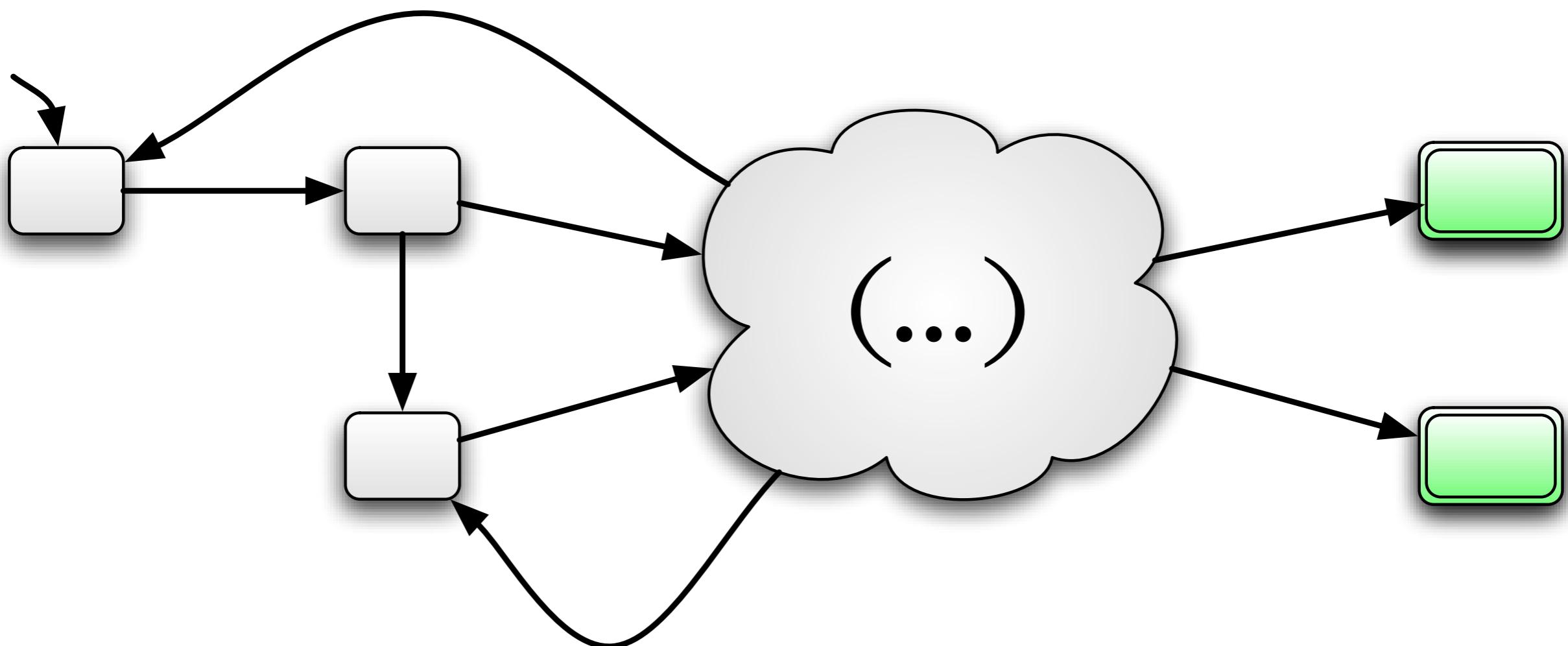
Complementation



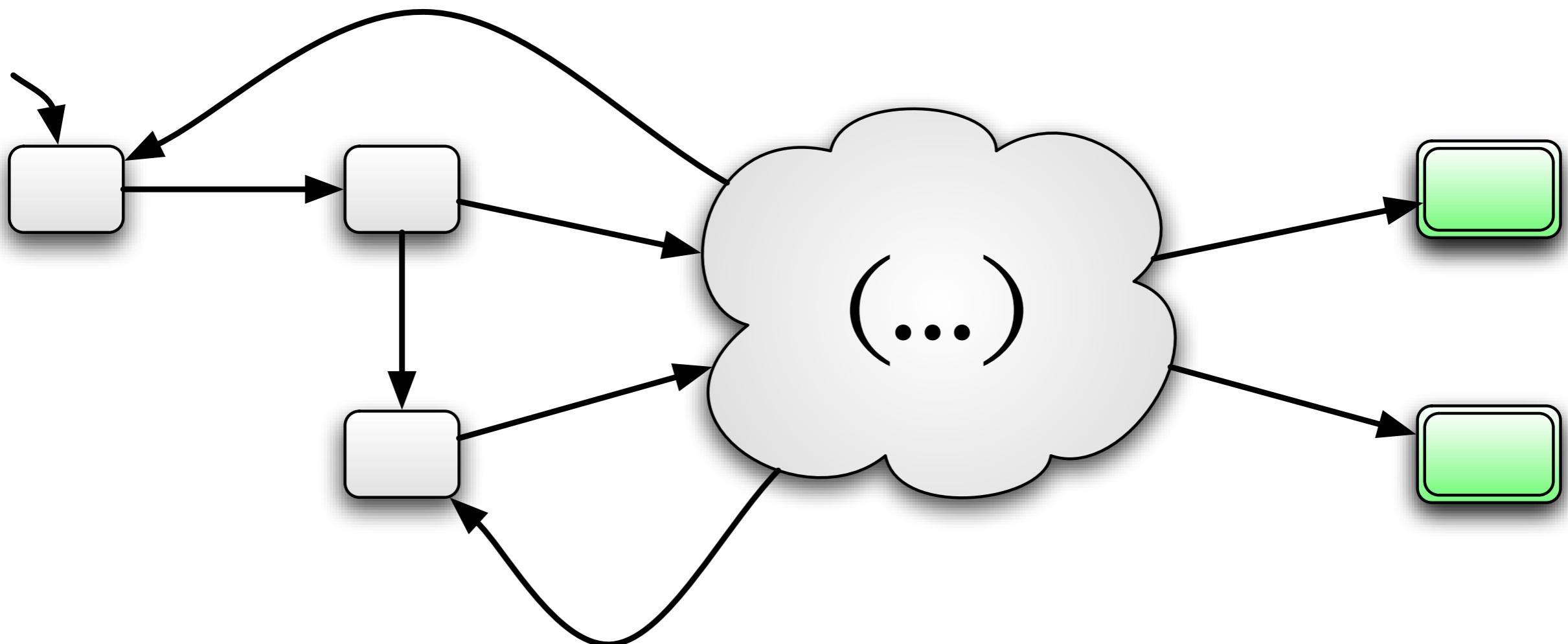
Emptiness checking



Emptiness checking



Emptiness checking



remains PSPACE-Complete

Closure / decidability

Problem	Result
Intersection	Closed
Complementation	Closed
Emptiness	PSPACE-Complete

Closure / decidability

Problem	Result
Intersection	Closed
Complementation	Closed
Emptiness	PSPACE-Complete



Protocol operators

Closure under:

- intersection
- parallel composition
- difference

Subsumption and equivalence are **decidable**



Outline

1

Introduction

2

Timed protocols modeling

3

Theoretical study of time impacts

4

Prototyping, applications

5

Conclusion

Applications





ServiceMosaic

ServiceMosaic

UNSW (Australia)

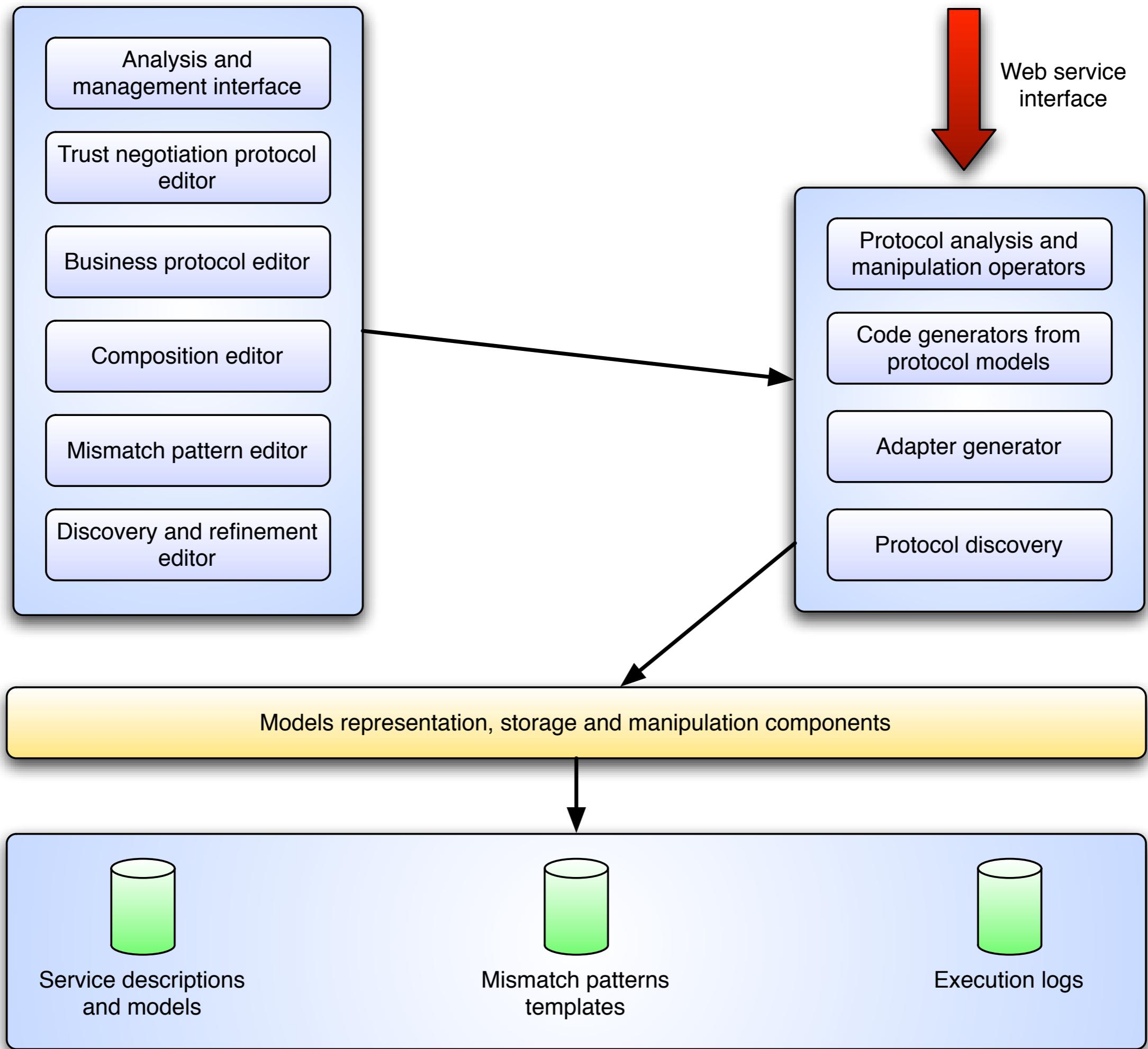
LIMOS (France)

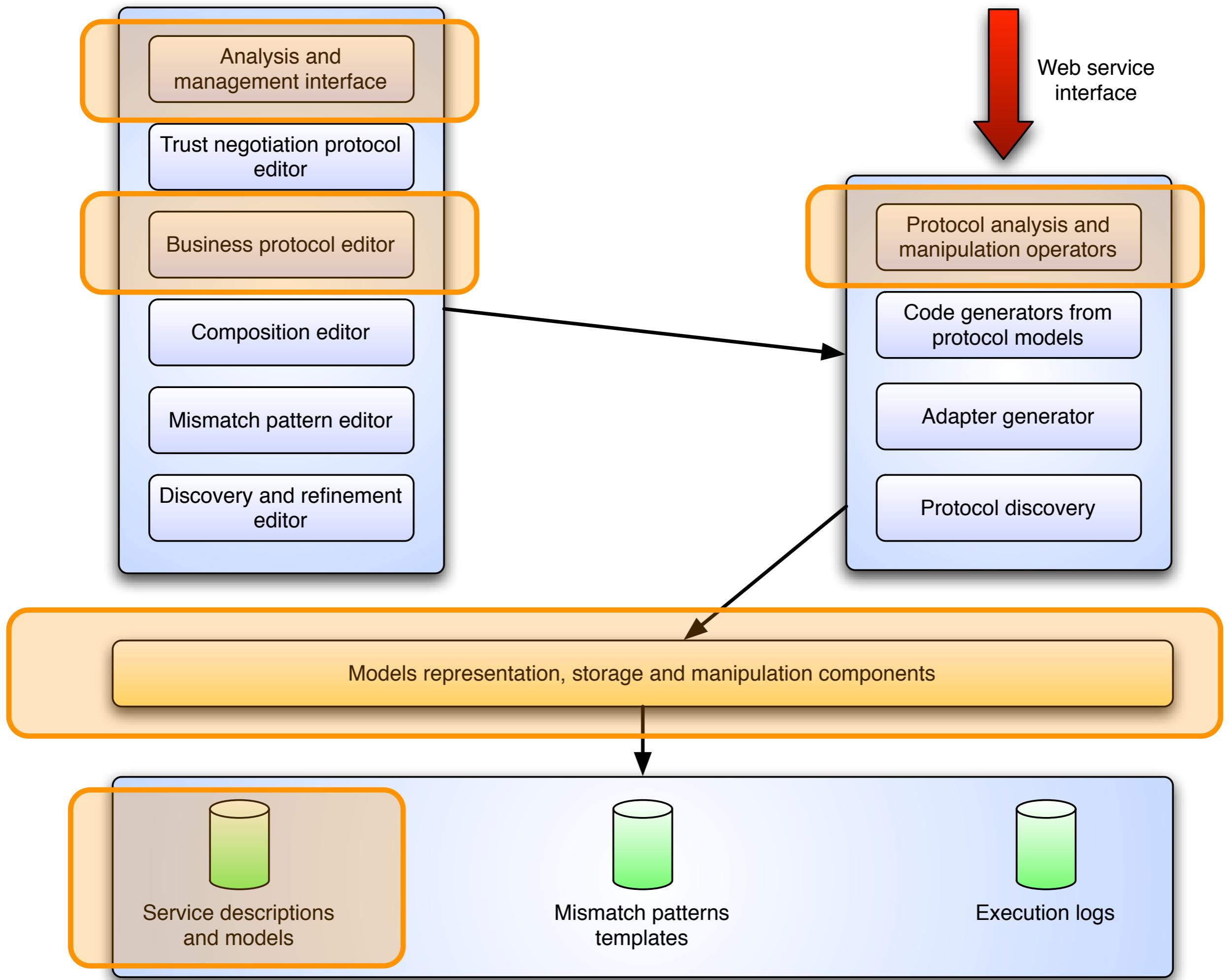
U.Trento (Italy)

LIRIS (France)



<http://servicemosaic.isima.fr/>





Protocols project

Eclipse plug-ins: editor, analysis, operators, extractor, help

Operators library

Protocols extraction library

Graphical editing framework

UPPAAL

Groovy

Protocols model library

AntLR

Eclipse
platform

Protocols project



Eclipse plug-ins: editor, analysis, operators, extractor, help

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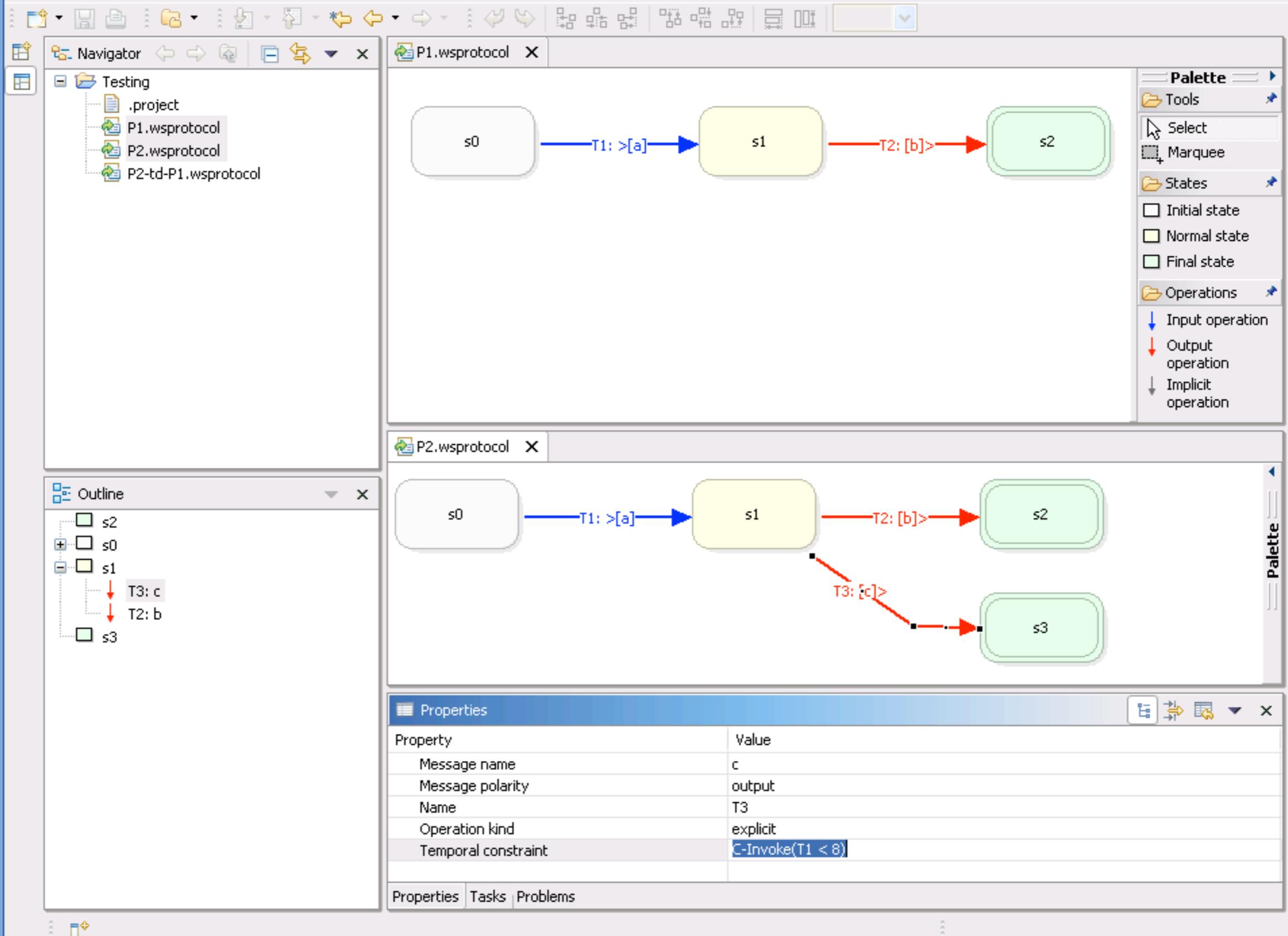
UPPAAL

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Protocols model library

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{3} All Tickets by Milestone - Protocols - Trac - Mozilla Firefox 3 Beta 5

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Available Reports Custom Query

{3} All Tickets by Milestone (9 matches)

This report shows how to color results by priority, while grouping results by milestone.

Last modification time, description and reporter are included as hidden fields for useful RSS export.

Edit report Copy report Delete report

v0.5 release Release

Ticket	Summary	Component	Version	Type	Owner	Created
#30	Licensing before the public release	OperationsLibrary	0.5	task	julien	01/04/08
#2	Add the protocols operators plug-in documentation	ProtocolsHelpPlugin	0.5	task	julien	12/19/05
#28	Eclipse update site	all	0.5	task	julien	01/04/08
#29	Trimmed-down Eclipse IDE for showcase	all	0.5	task	julien	01/04/08
#34	Add package-info.java files	all	0.5	enhancement	julien	03/09/08

v0.5 release candidate Release

Ticket	Summary	Component	Version	Type	Owner	Created
#25	Update the temporal-aware protocol operators	TemporalOperatorsLibrary	0.5	task	julien	01/04/08
#27	Update the Eclipse plug-ins	all	0.5	task	julien	01/04/08
#33	Randomize position of message Label in the operation arrow	ProtocolsLibraryPlugin	0.5	enhancement	kevinh	02/07/08
#26	Compatibility and replaceability analysis library	TemporalOperatorsLibrary	0.5	task	julien	01/04/08

Note: See [TracReports](#) for help on using and creating reports.

Download in other formats:

Terminé

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Roadmap - Protocols - Trac - Mozilla Firefox 3 Beta 5

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Google

trac Integrated SCM & Project Management

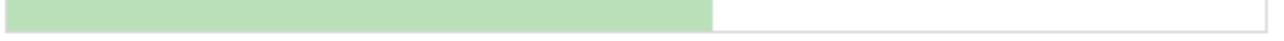
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Wiki Timeline Roadmap Browse Source View Tickets New Ticket Search Admin

Roadmap

Milestone: v0.5 release candidate
Due in 1 month (05/16/08)

Show already completed milestones

 56%

Closed tickets: 5 Active tickets: 4

The release candidate must be feature complete. A gap of 2 weeks is given for the stabilization before the public release.

Milestone: v0.5 release
Due in 2 months (06/01/08)

 0%

Closed tickets: 0 Active tickets: 5

Official public release of the protocols project.

Add new milestone

Note: See [TracRoadmap](#) for help on using the roadmap.

Terminé

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/ProtocolsLibrary/trunk - Protocols - Trac - Mozilla Firefox 3 Beta 5

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Wiki Timeline Roadmap Browse Source View Tickets New Ticket Search Admin

Last Change Revision Log

root / ProtocolsLibrary / trunk

View revision:

Name	Size	Rev	Age	Last Change
..				
.settings		163	3 months	julien: Upgrade the compiler settings to 1.5 / 1.5
doc		159	3 months	julien: 2007.12.30 (Julien Ponge): - Java 5 migration (generics). Addresses ...
lib		155	4 months	julien: * Embed the JUnit 3 jar in the project * IntelliJ IDEA project files
src		173	3 months	julien: Fixes after inspection through IntelliJ IDEA.
tests		172	3 months	julien: TemporalConstraintTreeWalker? checks that M-Invoke constraints are valid.
.antlr-eclipse	158 bytes	104	2 years	julien: Merged r71:85 from branches/TemporalConstraints.
.classpath	0.8 kB	160	3 months	julien: Updated Eclipse project classpath.
.project	1.0 kB	159	3 months	julien: 2007.12.30 (Julien Ponge): - Java 5 migration (generics). Addresses ...
ant.properties	1.1 kB	159	3 months	julien: 2007.12.30 (Julien Ponge): - Java 5 migration (generics). Addresses ...
build.xml	5.7 kB	164	3 months	julien: Include misc dotfiles in the source archive.
Changes.txt	4.5 kB	172	3 months	julien: TemporalConstraintTreeWalker? checks that M-Invoke constraints are valid.
LICENSE.antlr	1.0 kB	104	2 years	julien: Merged r71:85 from branches/TemporalConstraints.
LICENSE.apache-libraries.txt	11.1 kB	1	2 years	julien: Initial codebase import, closes #1.

Terminé

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Roadmap - Protocols - Trac - Mozilla Firefox 3 Beta 5

Édition Affichage Historique

Accueil Smart Bookmarks Démarrage

Roadmap

Milestone: v0.5 release candidate Due in 1 month (05/16/08)

Closed tickets: 5 Active tickets: 0

The release candidate must be...

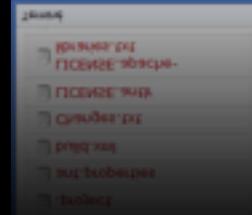
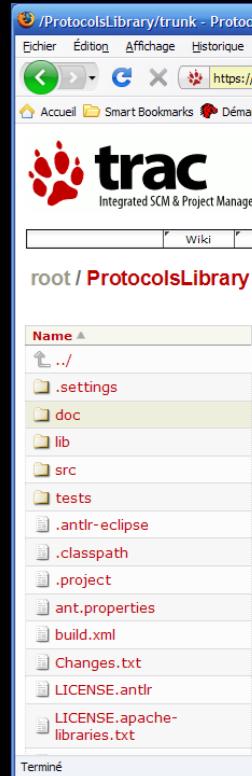
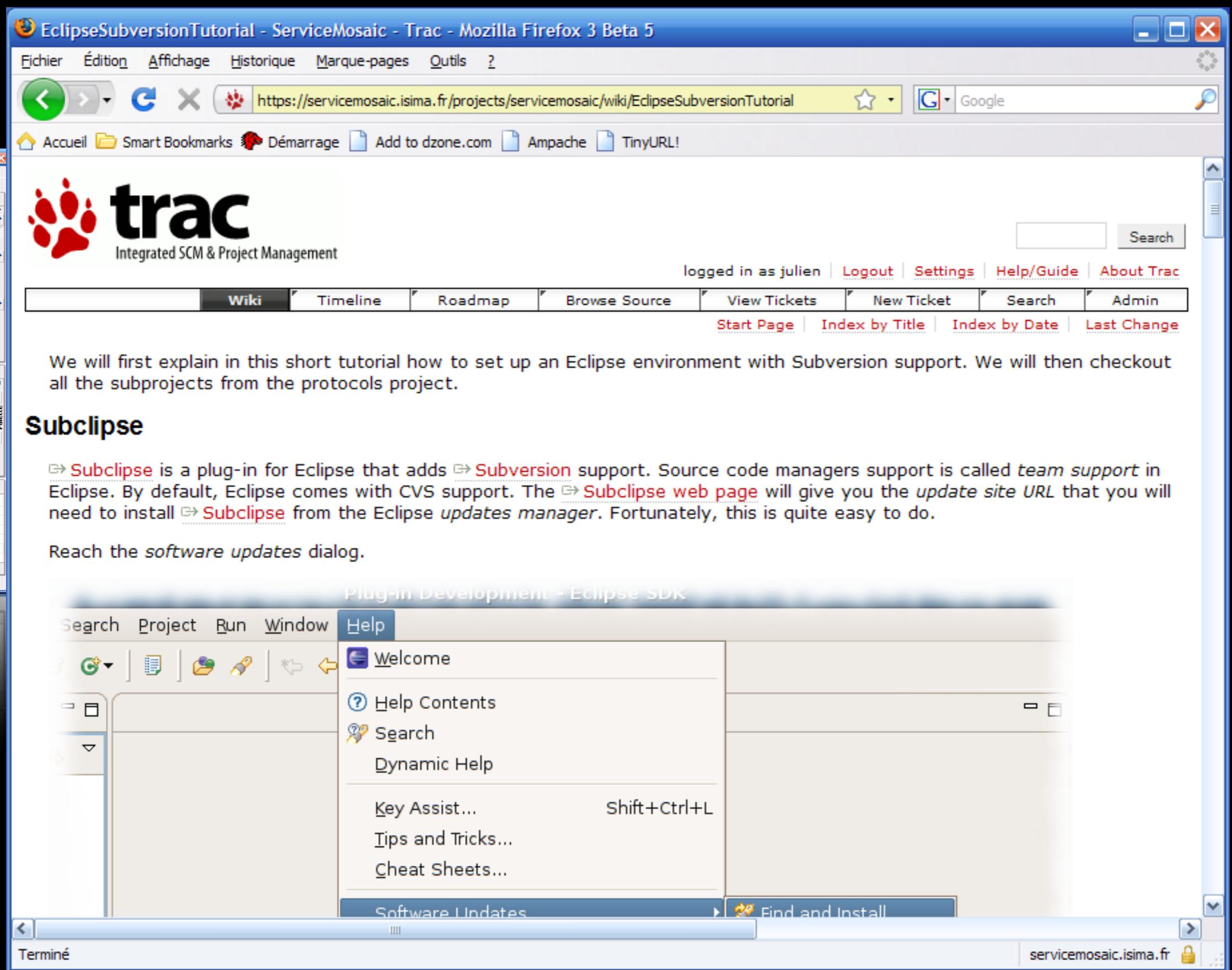
Milestone: v0.5 release Due in 2 months (06/01/08)

Closed tickets: 0 Active tickets: 0

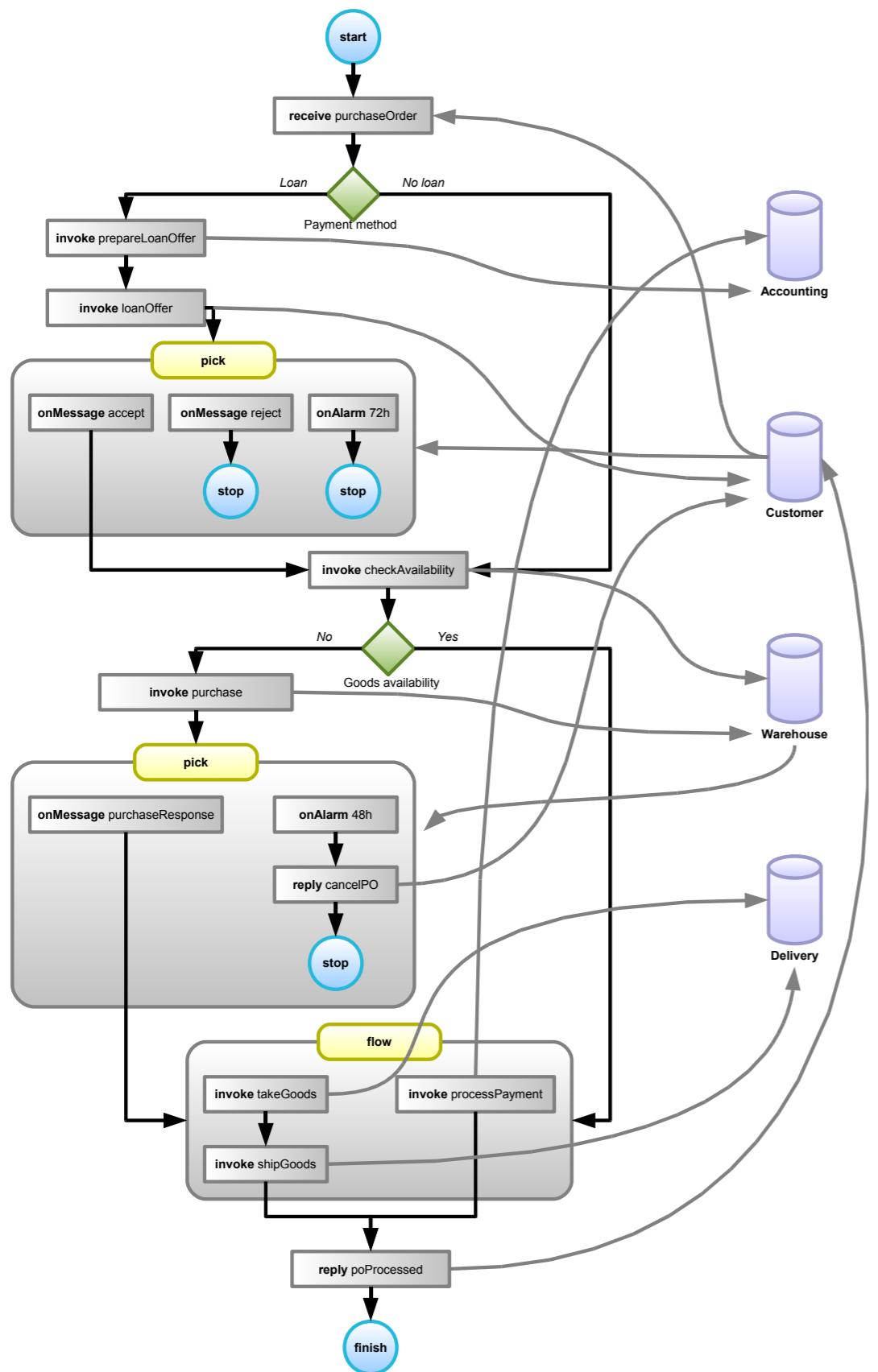
Official public release of the pro...

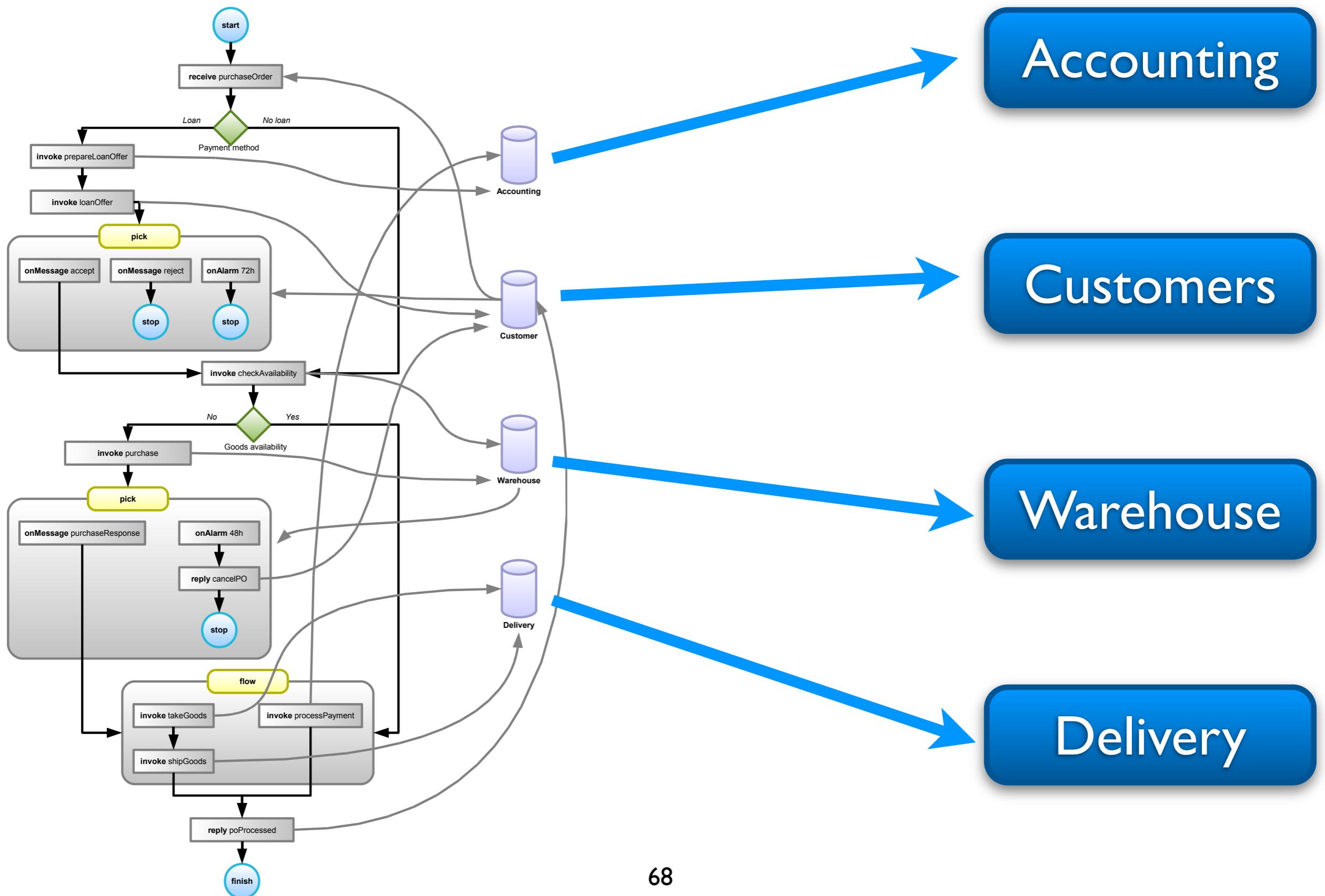
Add new milestone

Terminé



BPEL





Development
environments



Composite
application



Runtime
environments



Development
environments



Composite
application



Runtime
environments



Development
environments



Composite
application



Runtime
environments



Compatibility



Services with protocols

Development
environments



Composite
application



Runtime
environments



Compatibility



Replaceability



Services with protocols

“Agile” composition

Facilitate rapid prototyping



Facilitate hot replacement





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Conclusion





Summary

Formalization of
timing constraints

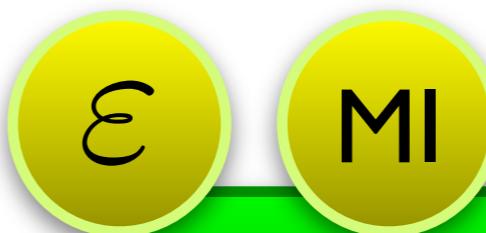
Protocol timed
automata

ServiceMosaic
Protocols



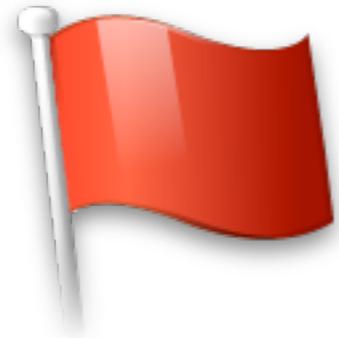
Summary

Formalization of
timing constraints



Protocol timed
automata

ServiceMosaic
Protocols



Limits

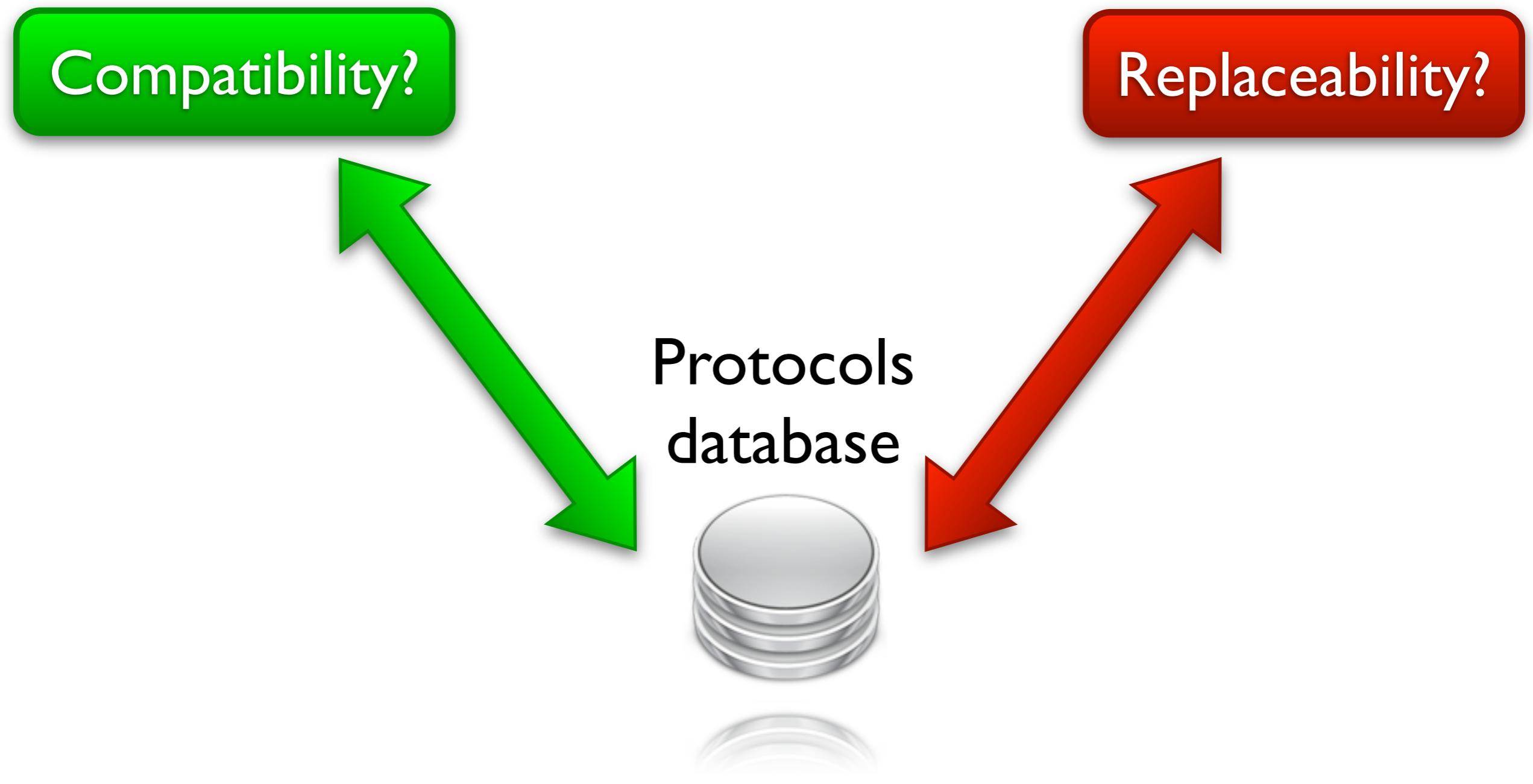
- No network hazard
- No absolute time
- “ $a == a$ ”

Querying

Protocols
database



Querying



Testing

Service



+

Protocol

Testing

Service



+

Protocol



Test cases

Testing

Service



+

Protocol



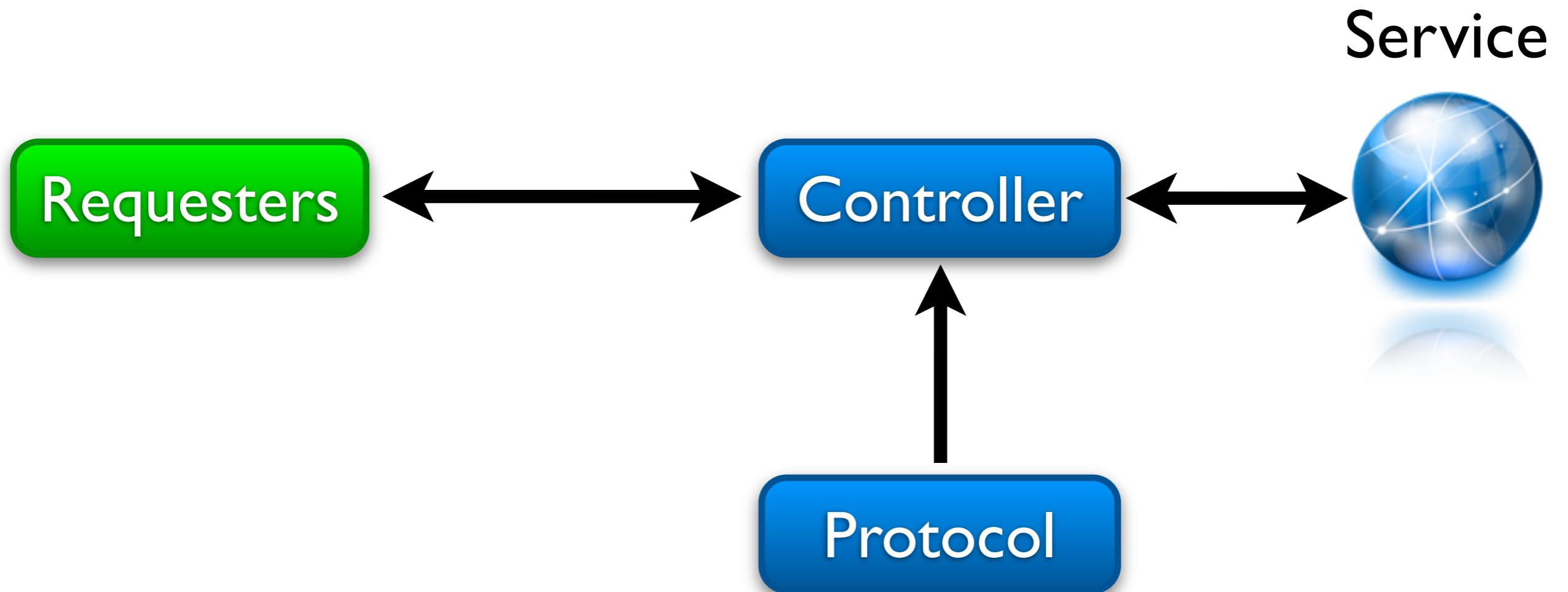
Test cases

Minimal coverage?

Meaningful & bogus data?

Loops handling?

Controllers



Mining

Execution logs



Protocol

Adaptation



Adaptation





Thank you!

[http://www.isima.fr/~ponce/](http://www.isima.fr/~ponge/)

