

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

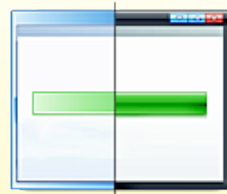
Introduction





databases, new & legacy applications

applications and clients



RPC, MOM, ESB, ...



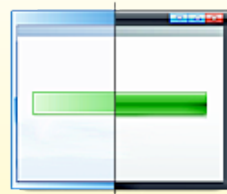
databases, new & legacy applications

partner 1

partner 2

my company

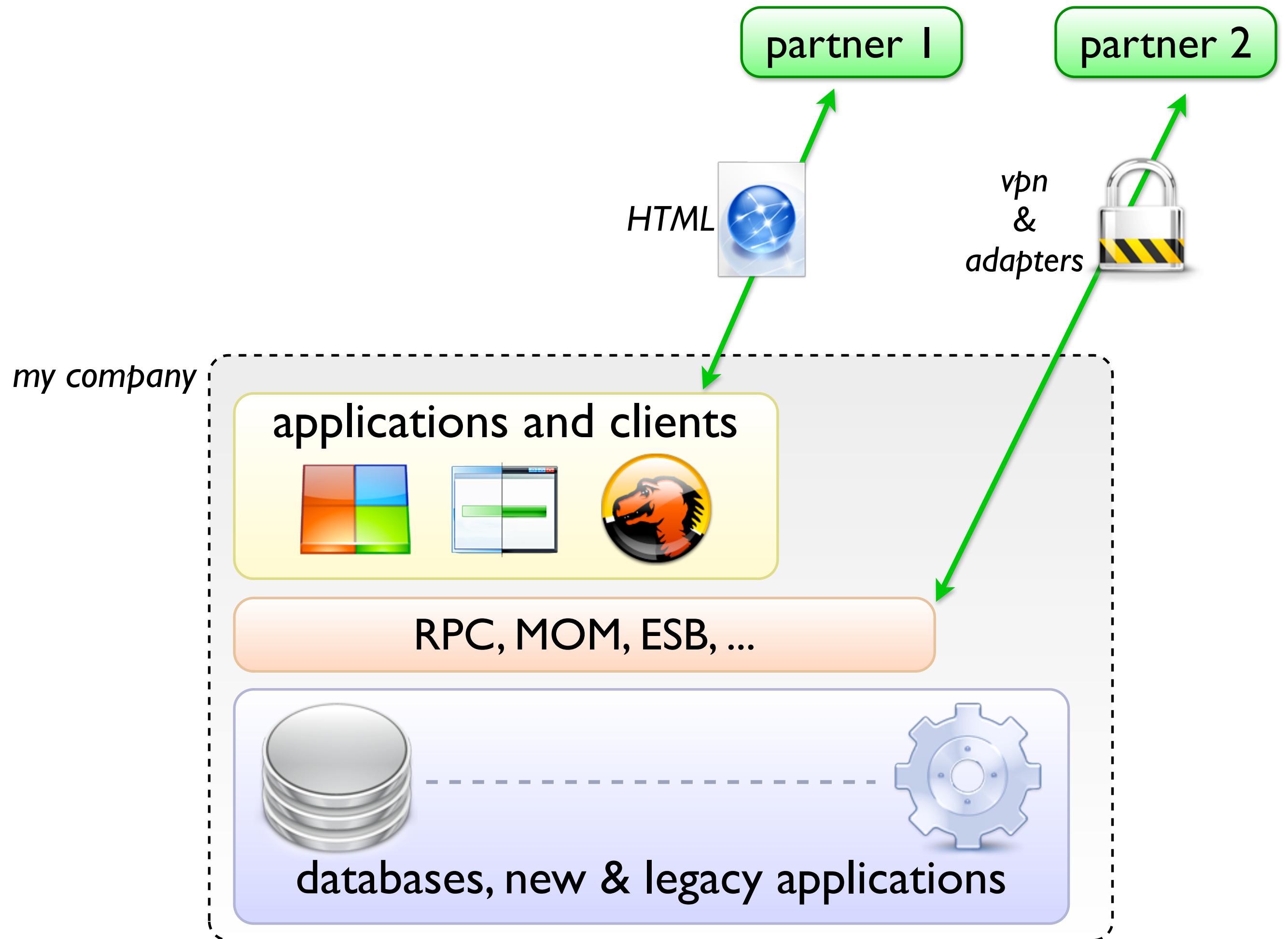
applications and clients



RPC, MOM, ESB, ...



databases, new & legacy applications



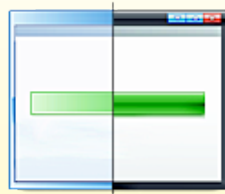
partner 1

partner 2

XML, SOAP, HTTP, ...

my company

applications and clients



Web services

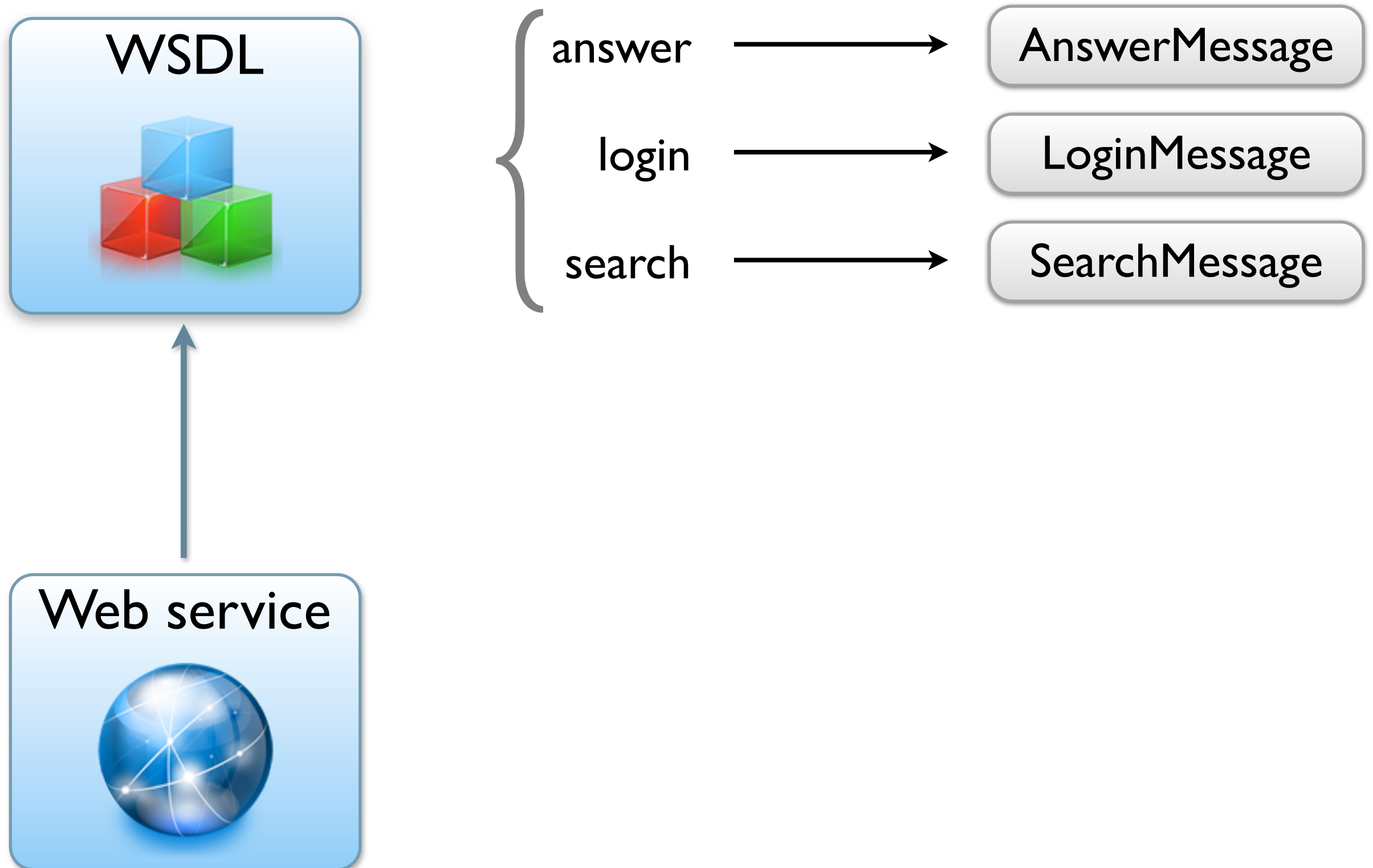


RPC, MOM, ESB, ...

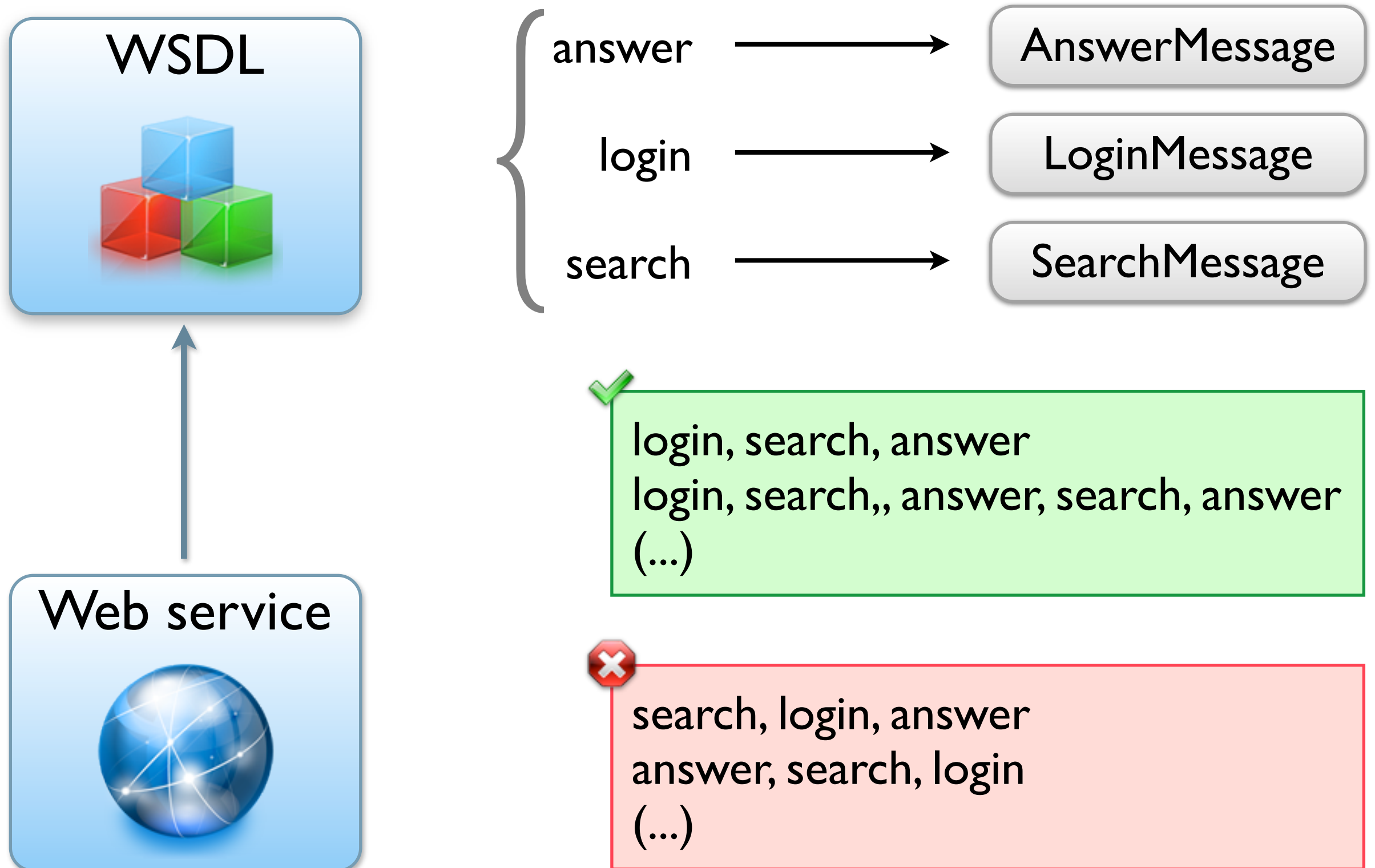


databases, new & legacy applications

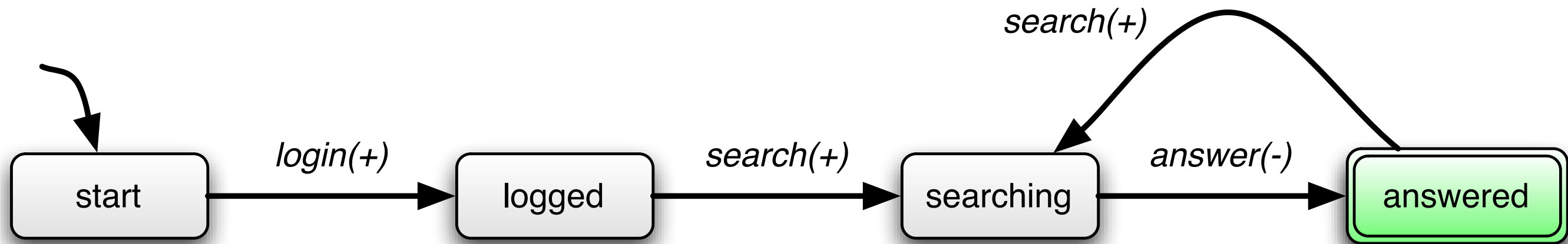
Static vs dynamic interface



Static vs dynamic interface



Business protocols



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

Compatibility

Service



Requester



Compatibility

Service



Requester



Replaceability

Service



Requester

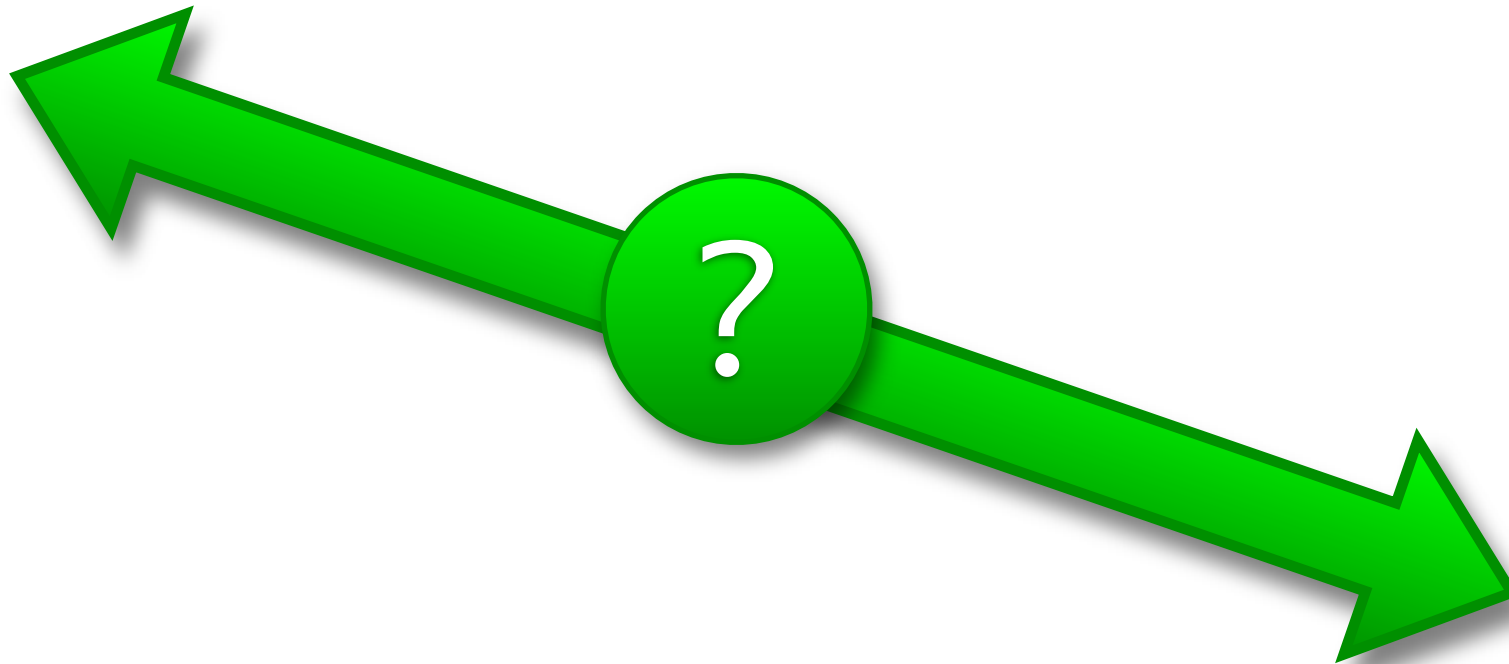


Replaceability



Replaceability

Service



Service



Requester



(flexible) classes

Compatibility

Full

Partial

Replaceability

Full

Partial

Subsumption, equivalence

w.r.t. client protocol

w.r.t. interaction role

It facilitates...

Binding



Discovery

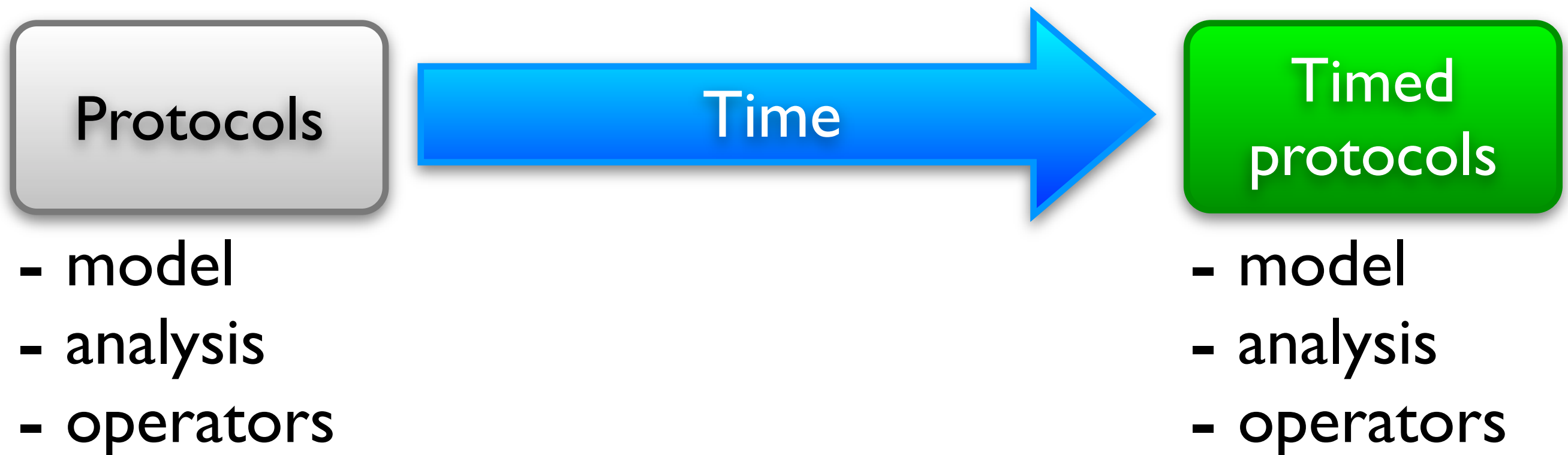


Problem overview

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

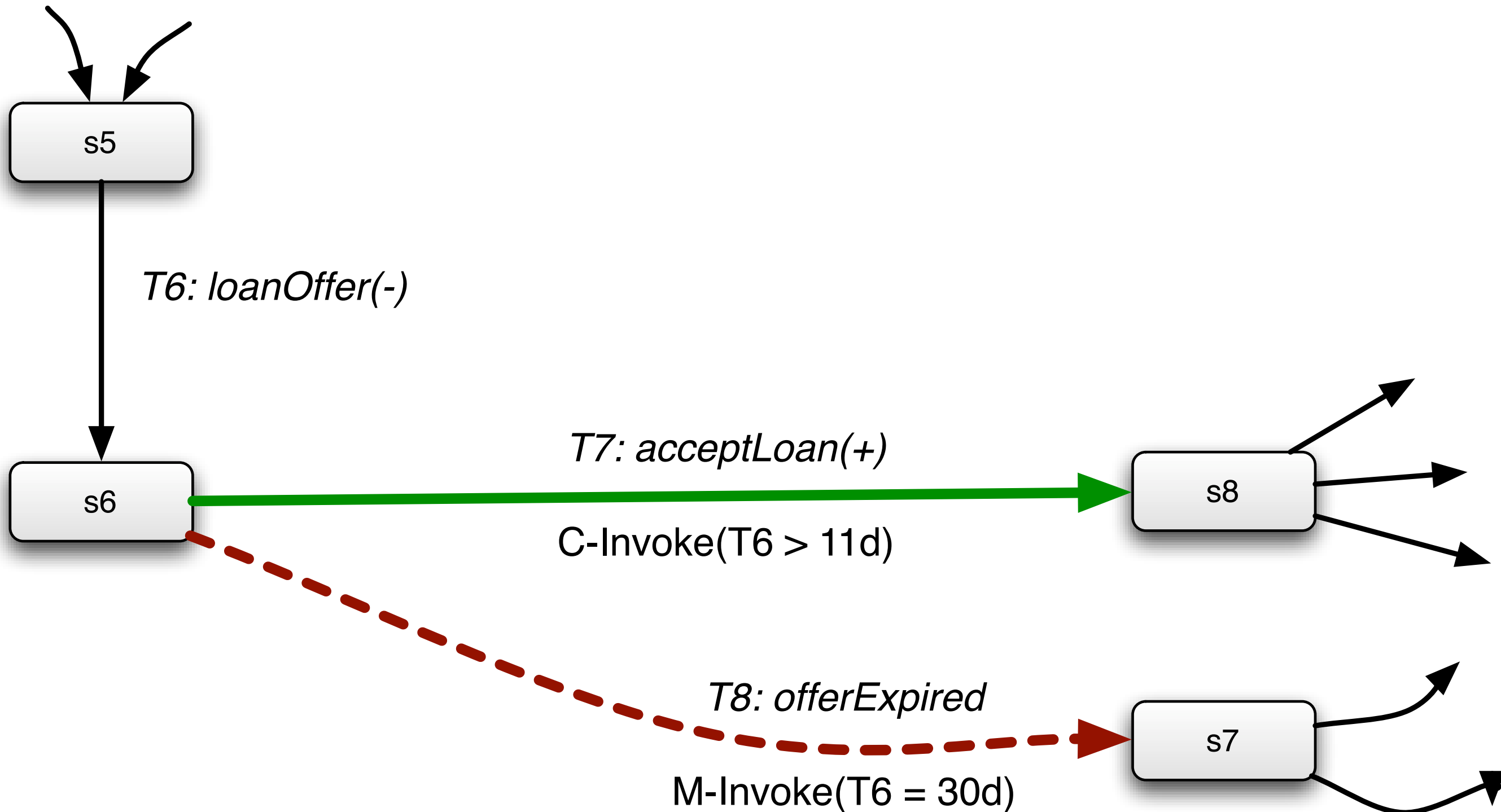


M-Invoke

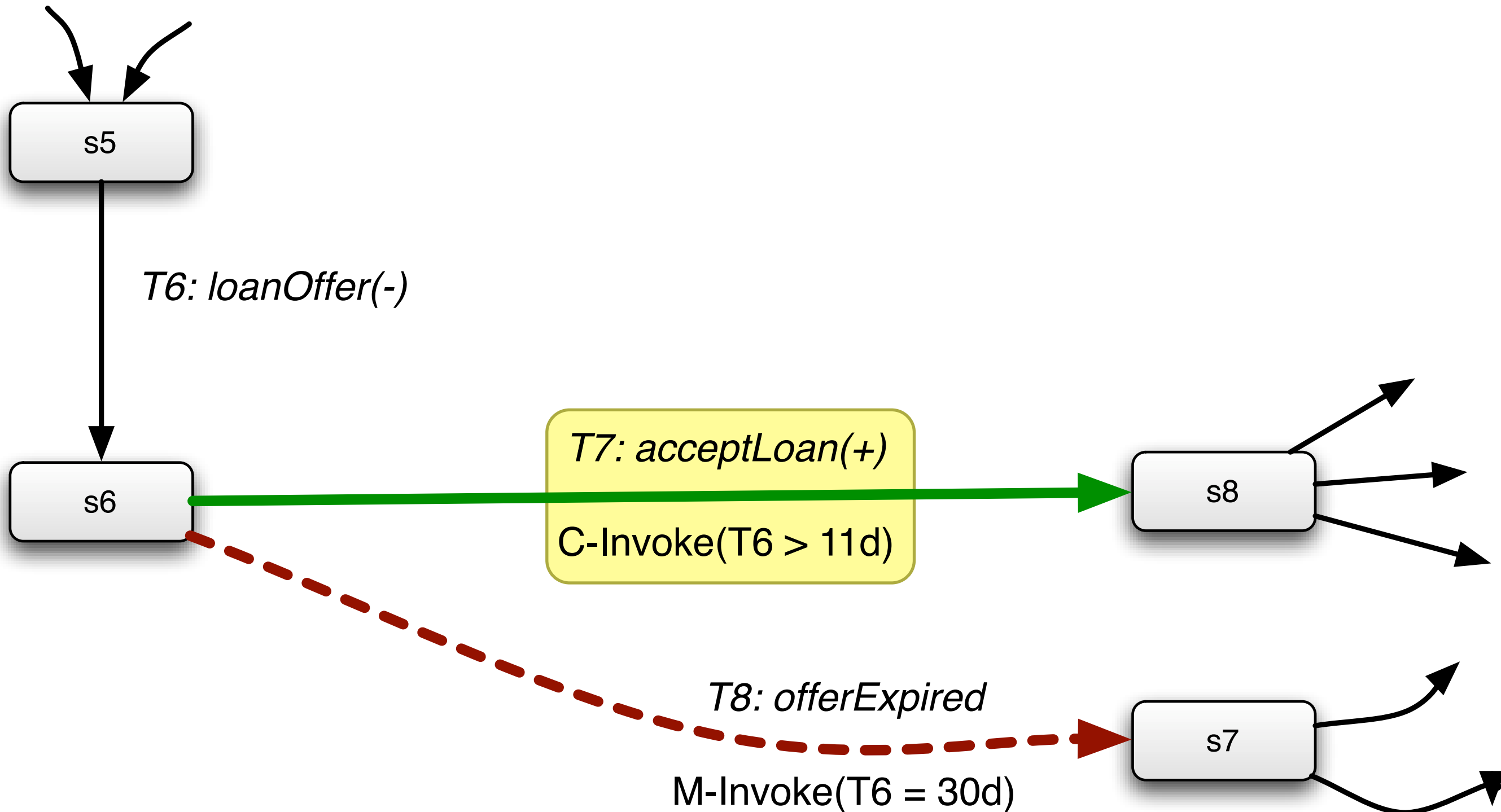


implicit transition

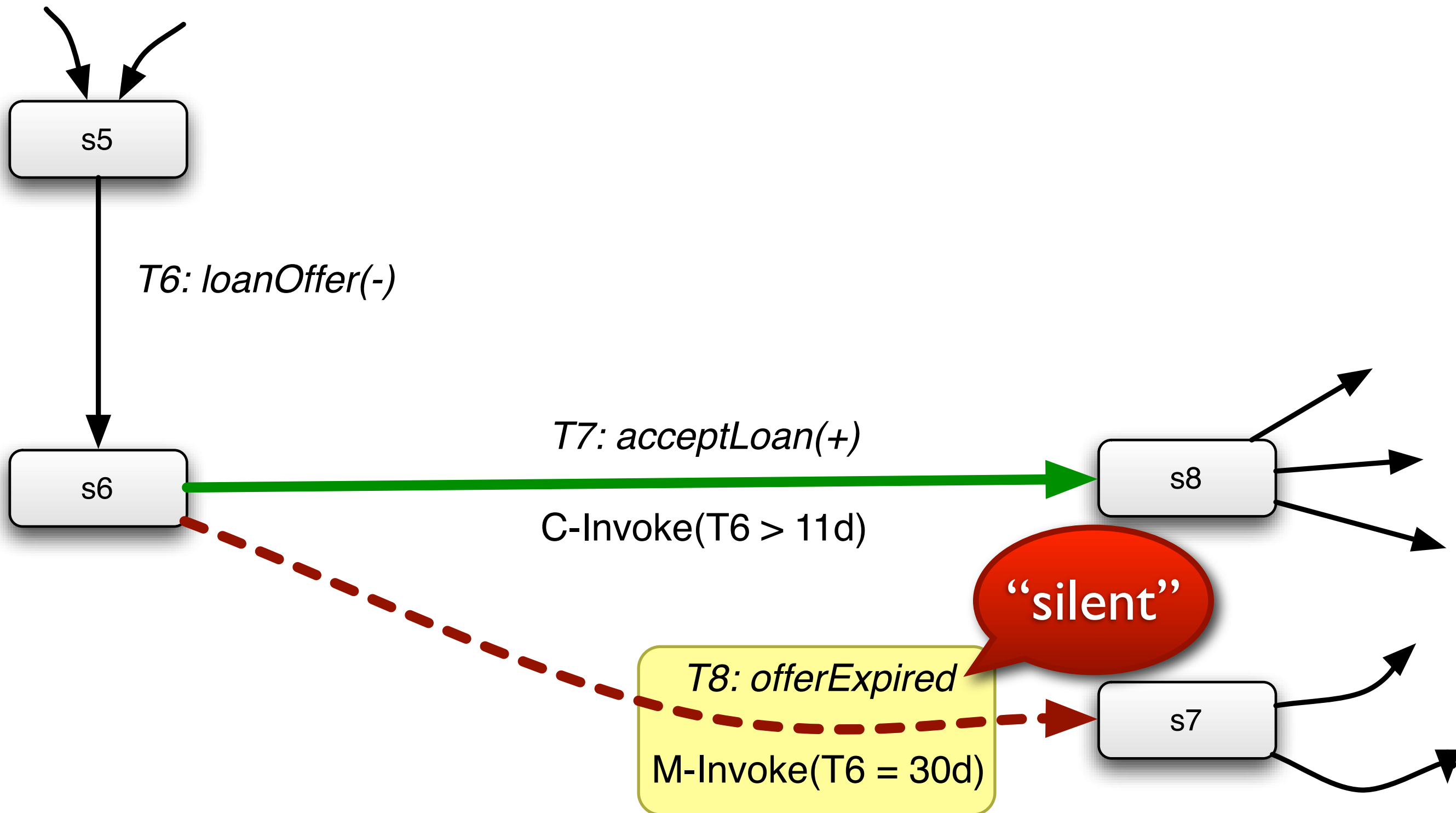
Extensions



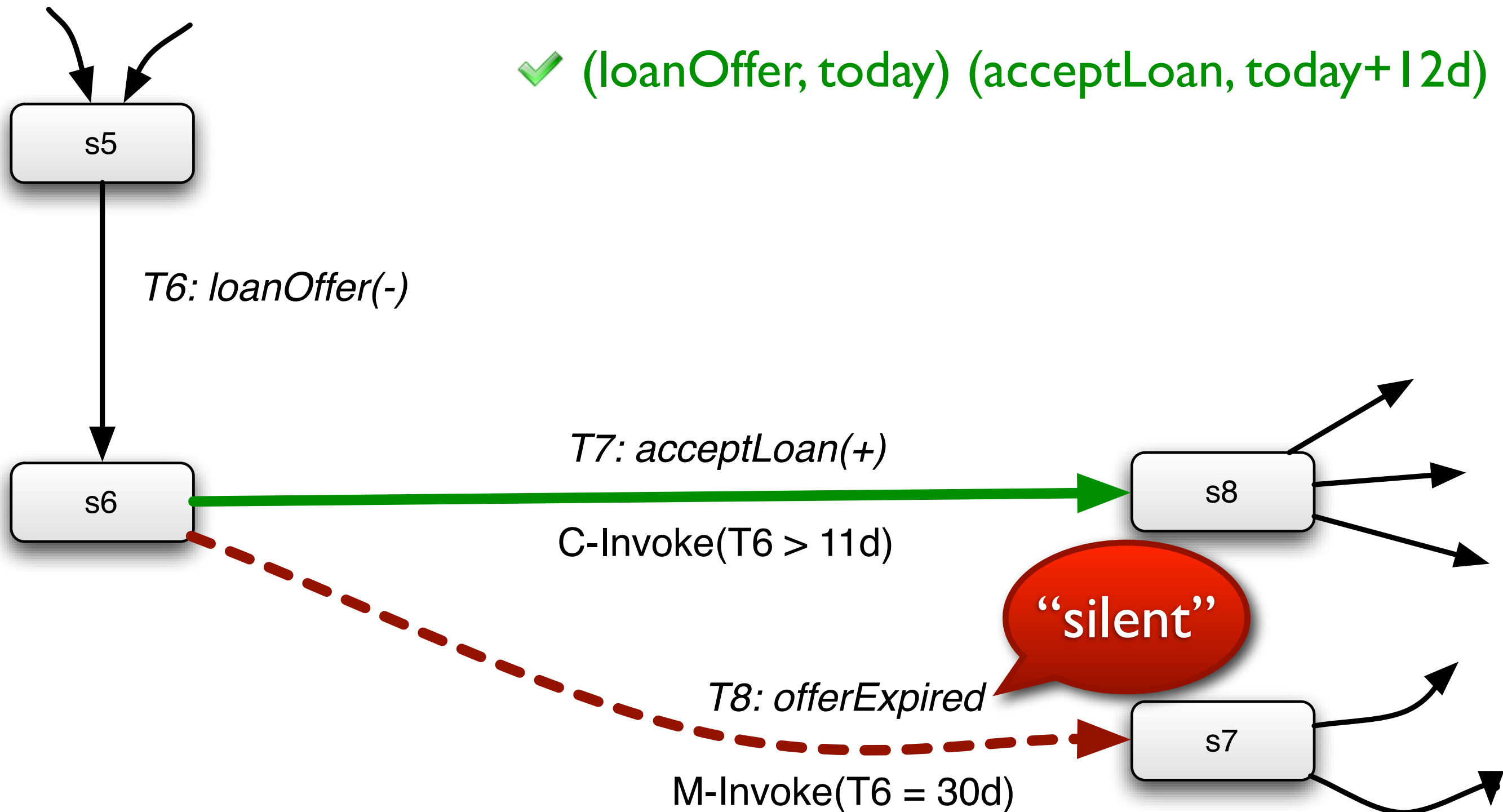
Extensions



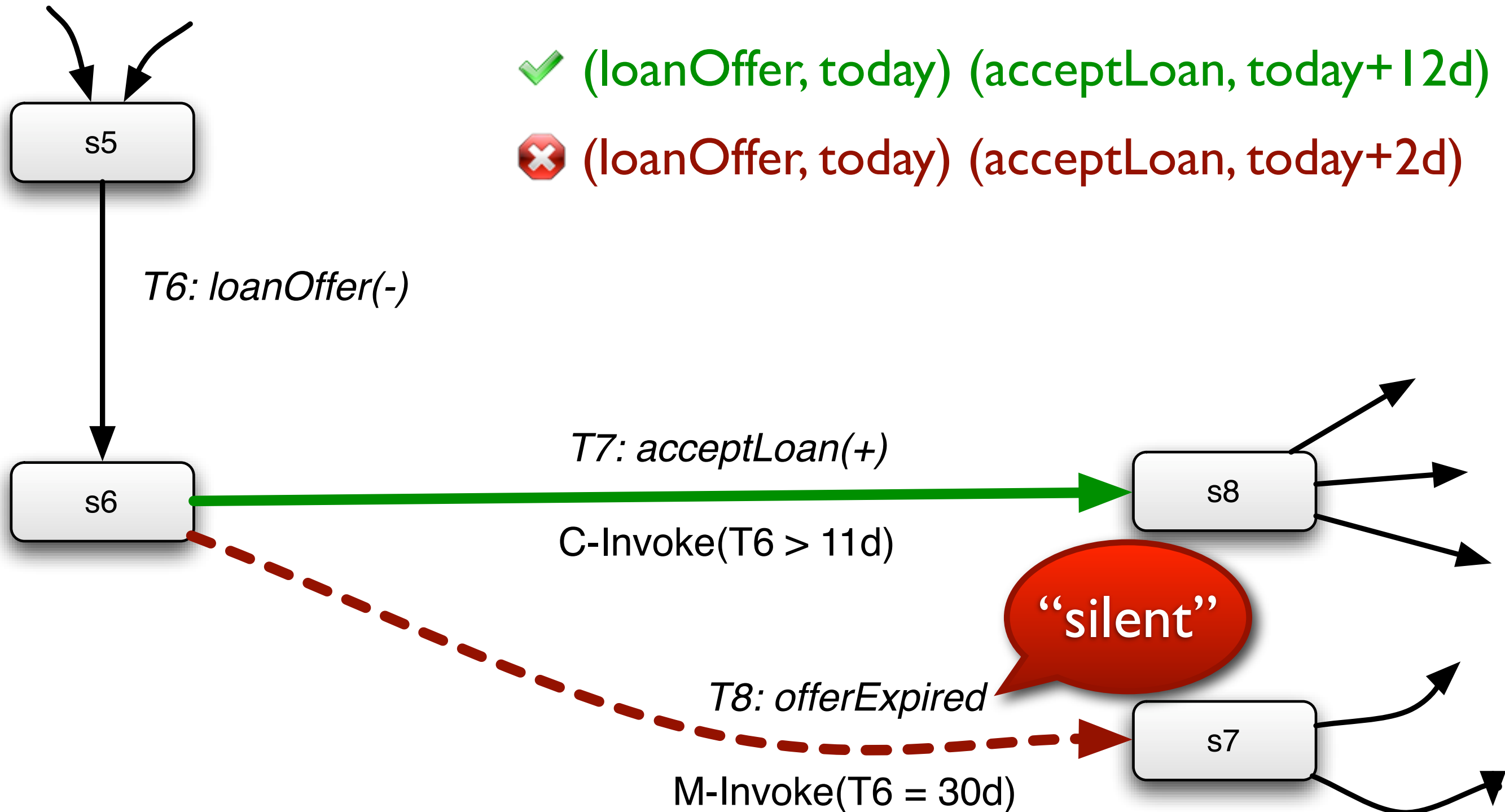
Extensions



Extensions



Extensions



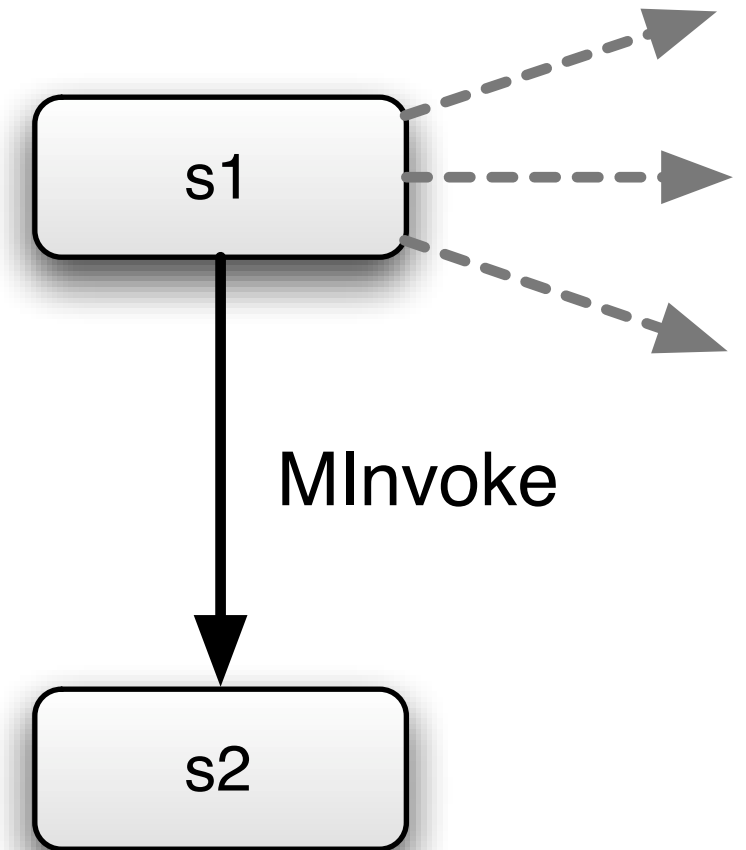


MInvoke semantics

MInvoke($T1 = 1h$)

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

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





MInvoke semantics

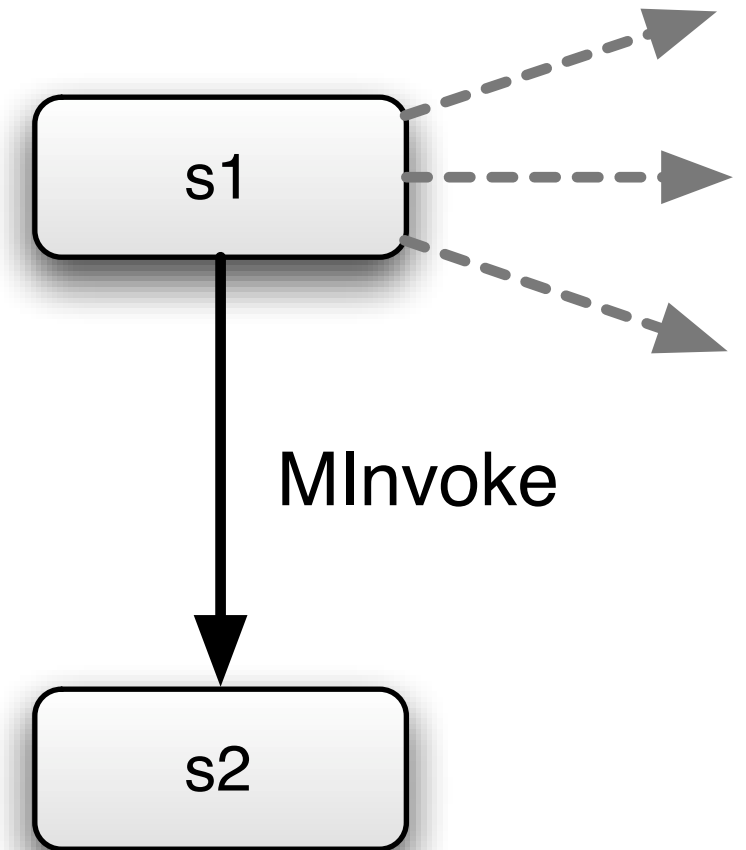
MInvoke($T1 = 1h$)

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

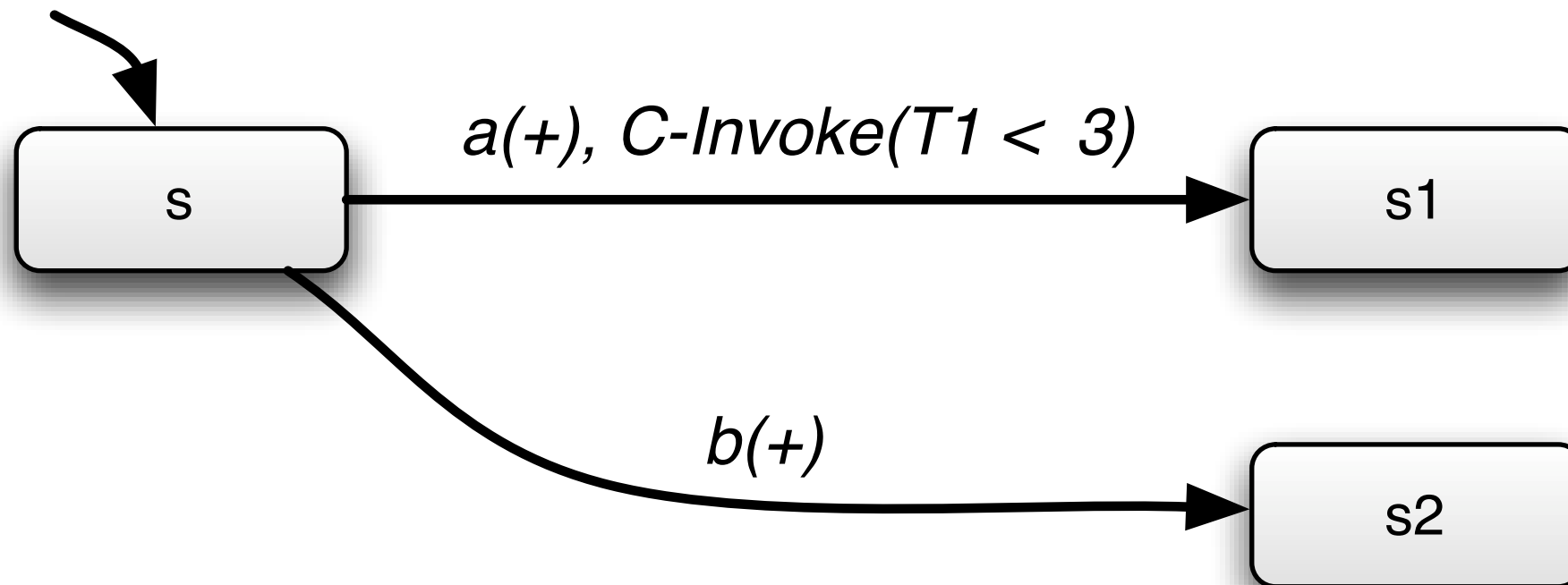
MInvoke($T1 = 1h \ || \ (T2 = 30m \ \&\& \ T3 < 15m)$)



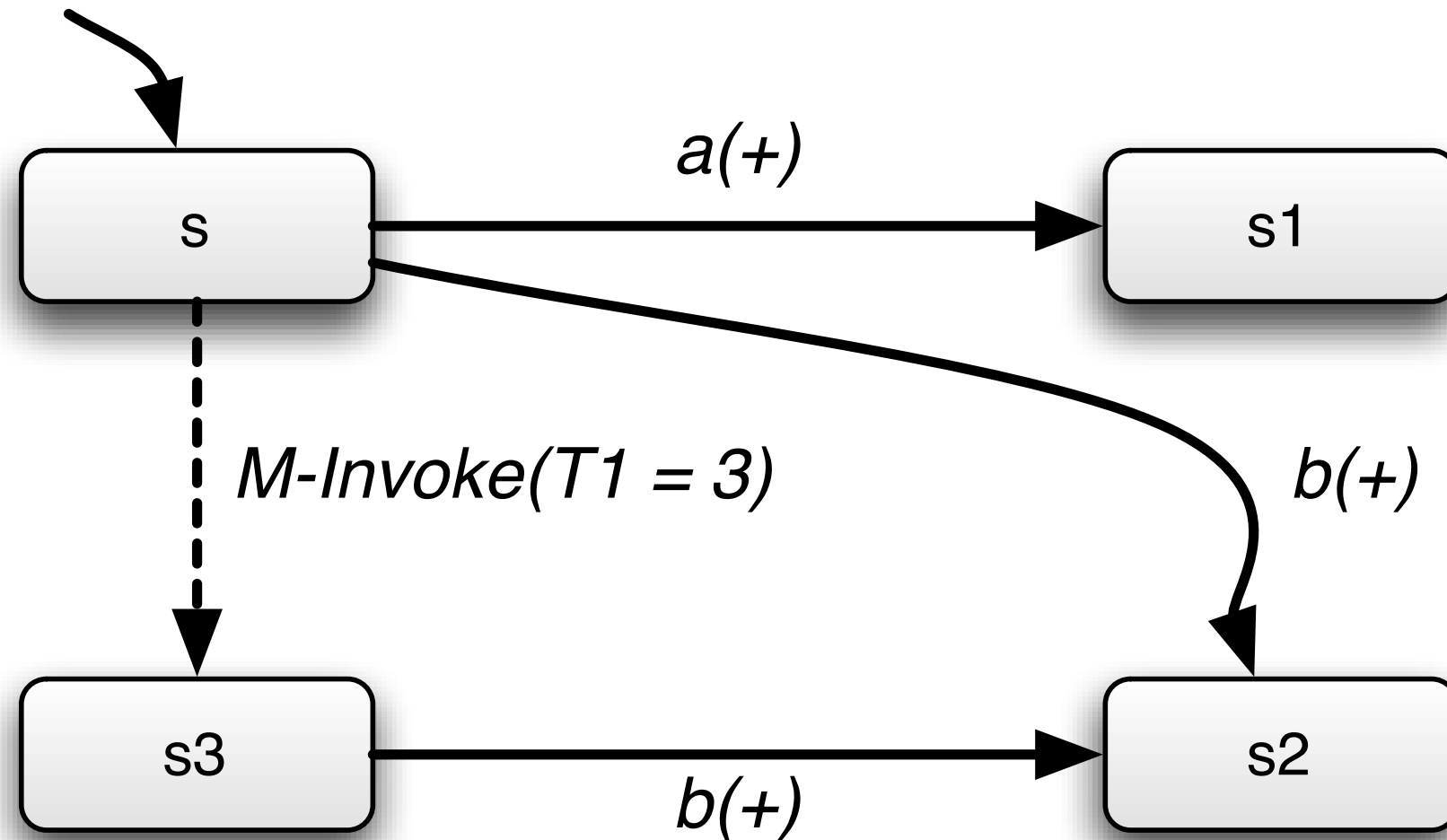
MInvoke($T1 > 1h$)



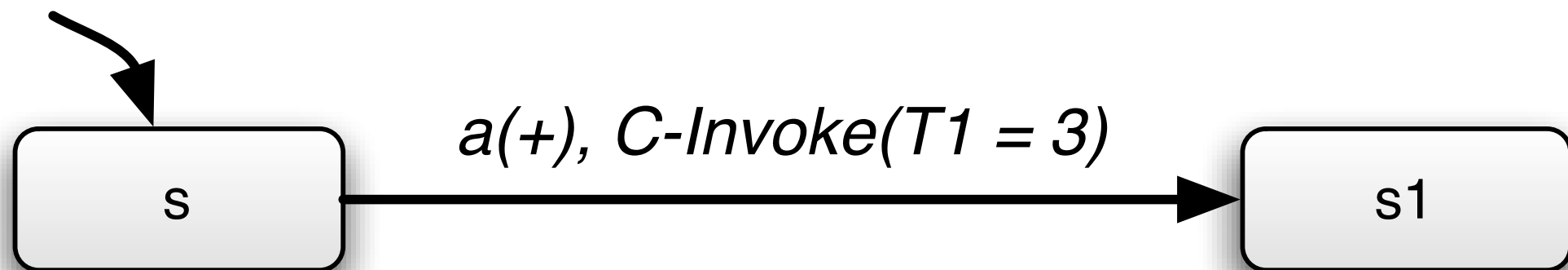
CInvoke vs MInvoke



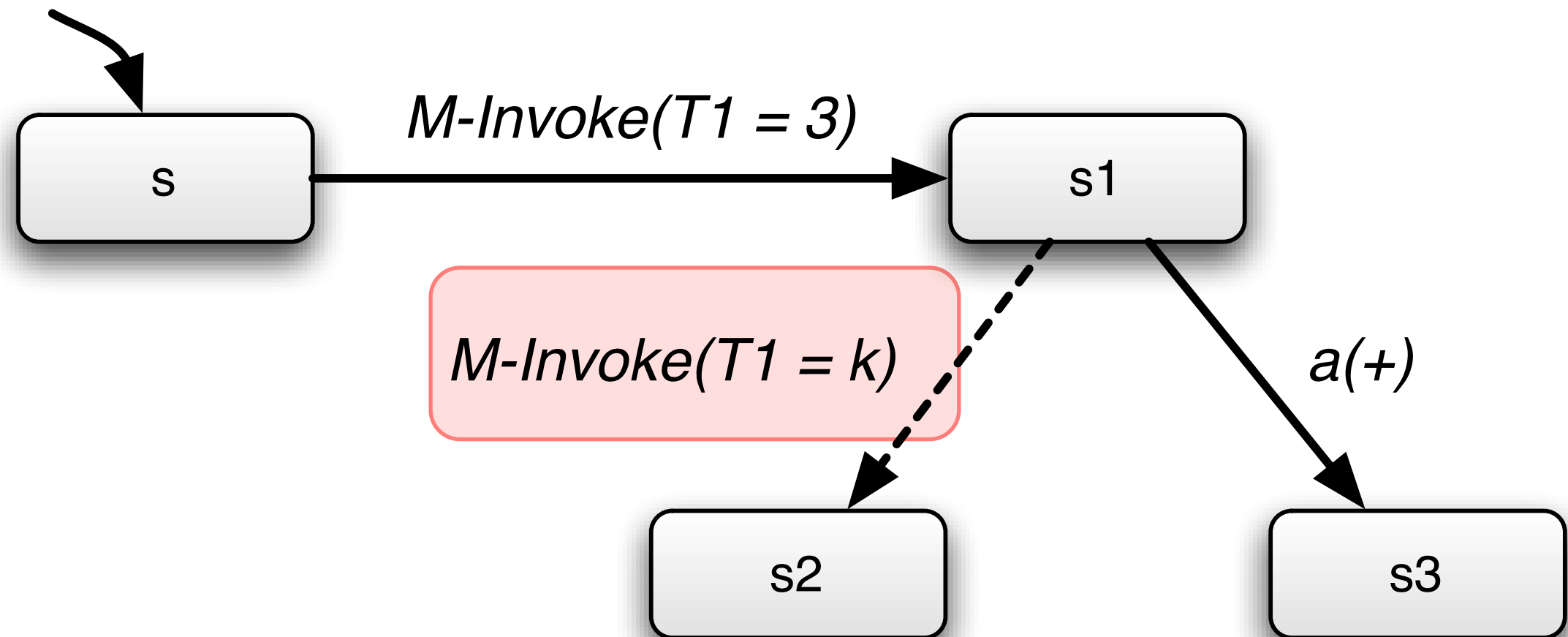
Clnvoke vs Mlnvoke



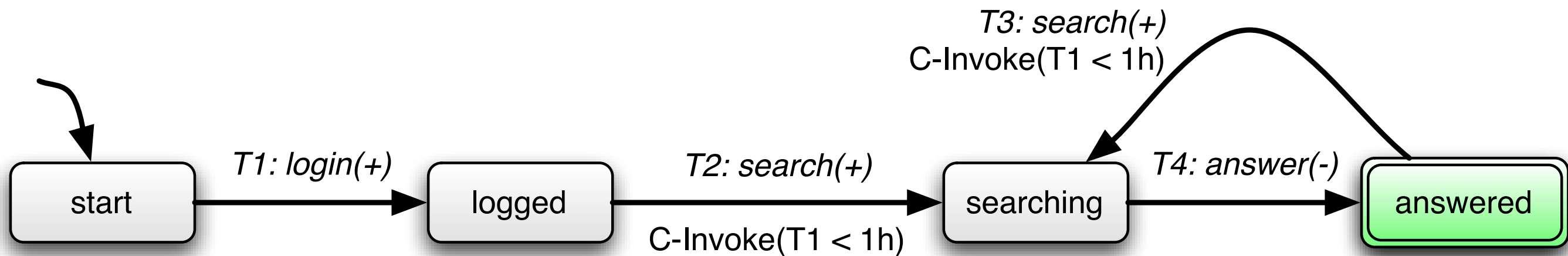
CInvoke vs MInvoke



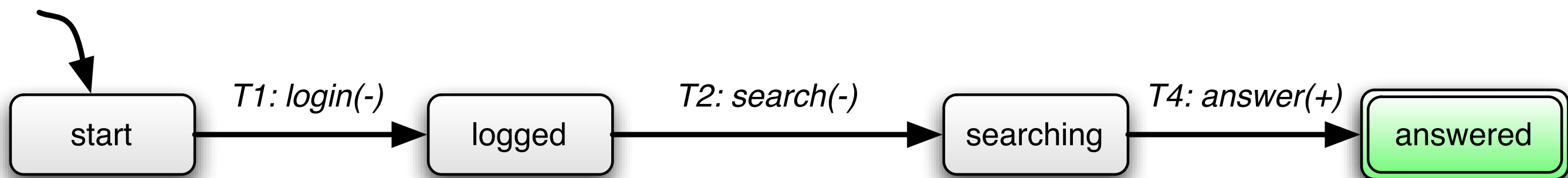
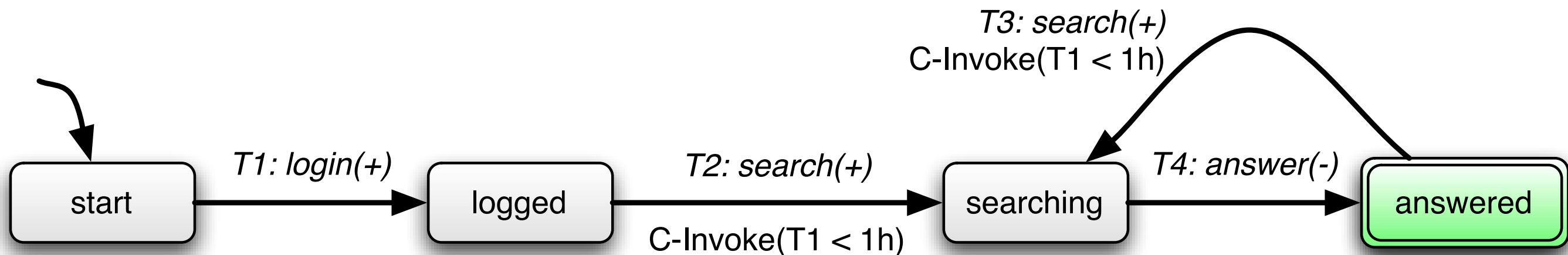
CInvoke vs MInvoke



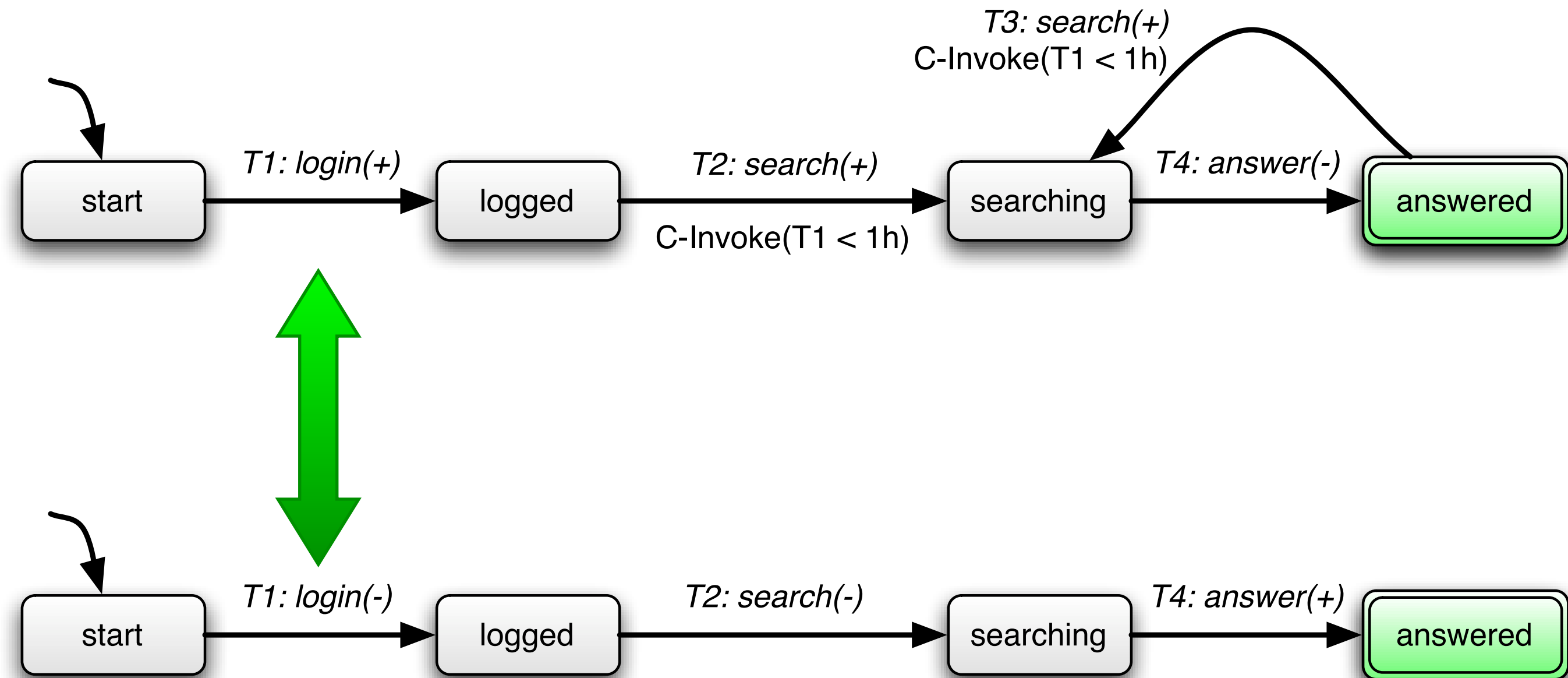
Time-sensitive compatibility



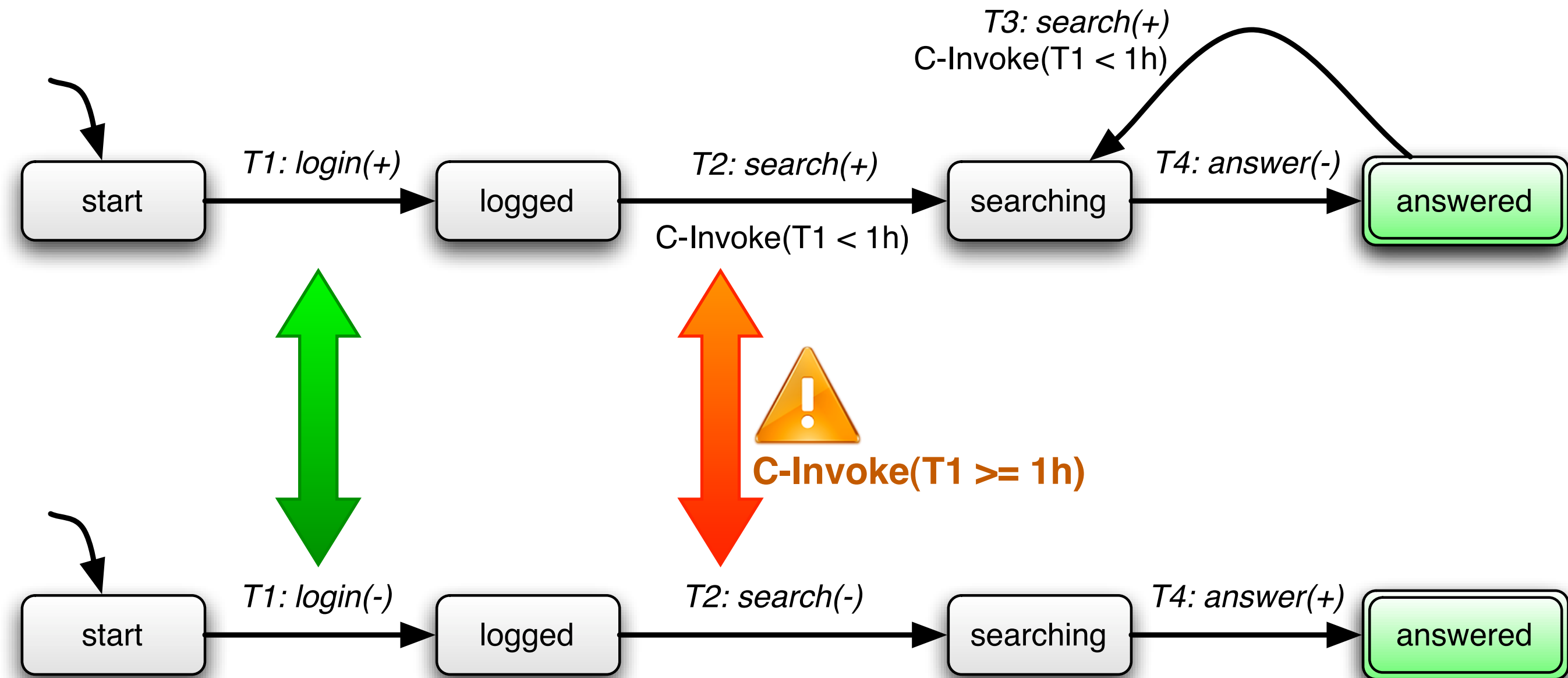
Time-sensitive compatibility



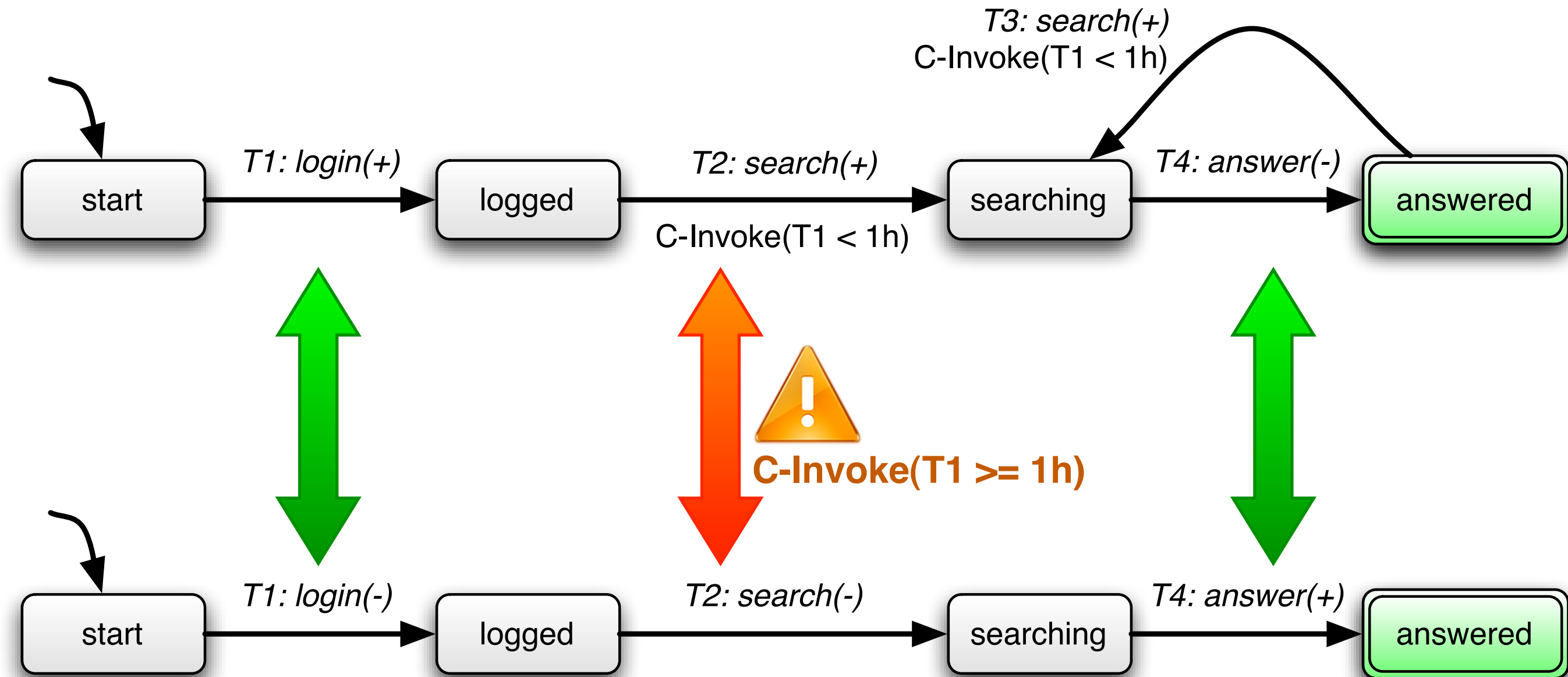
Time-sensitive compatibility



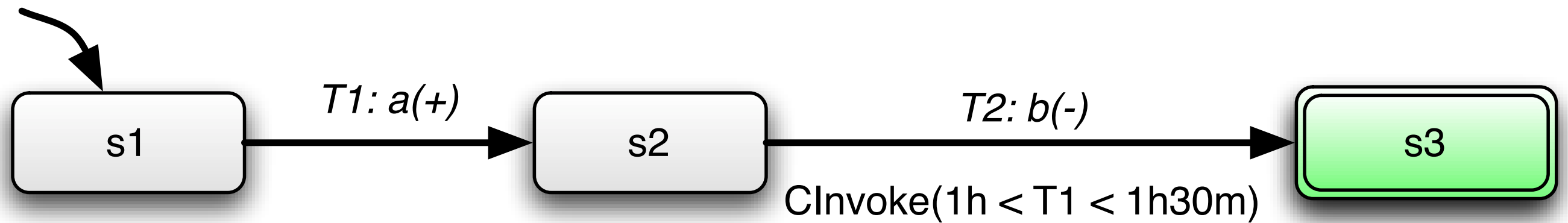
Time-sensitive compatibility



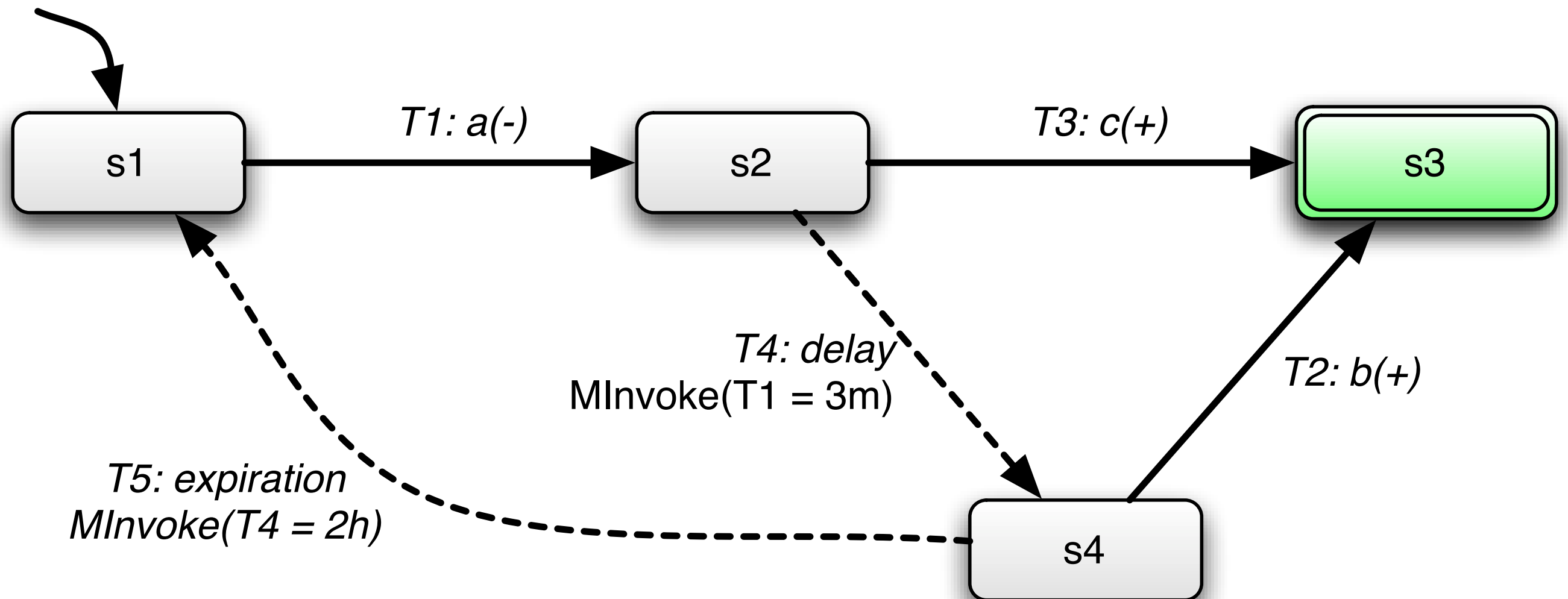
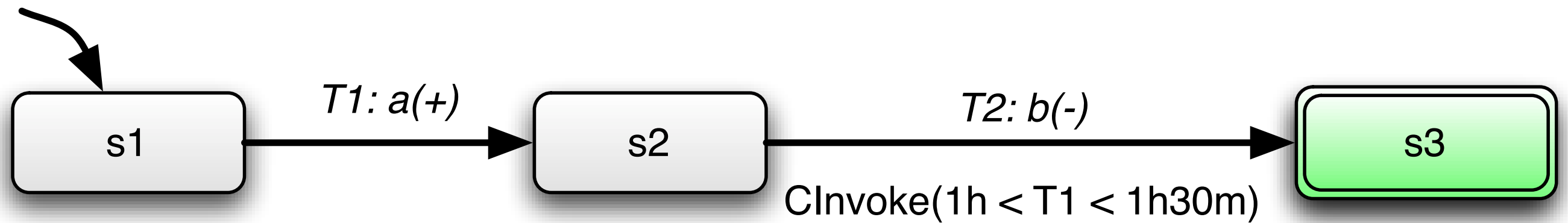
Time-sensitive compatibility



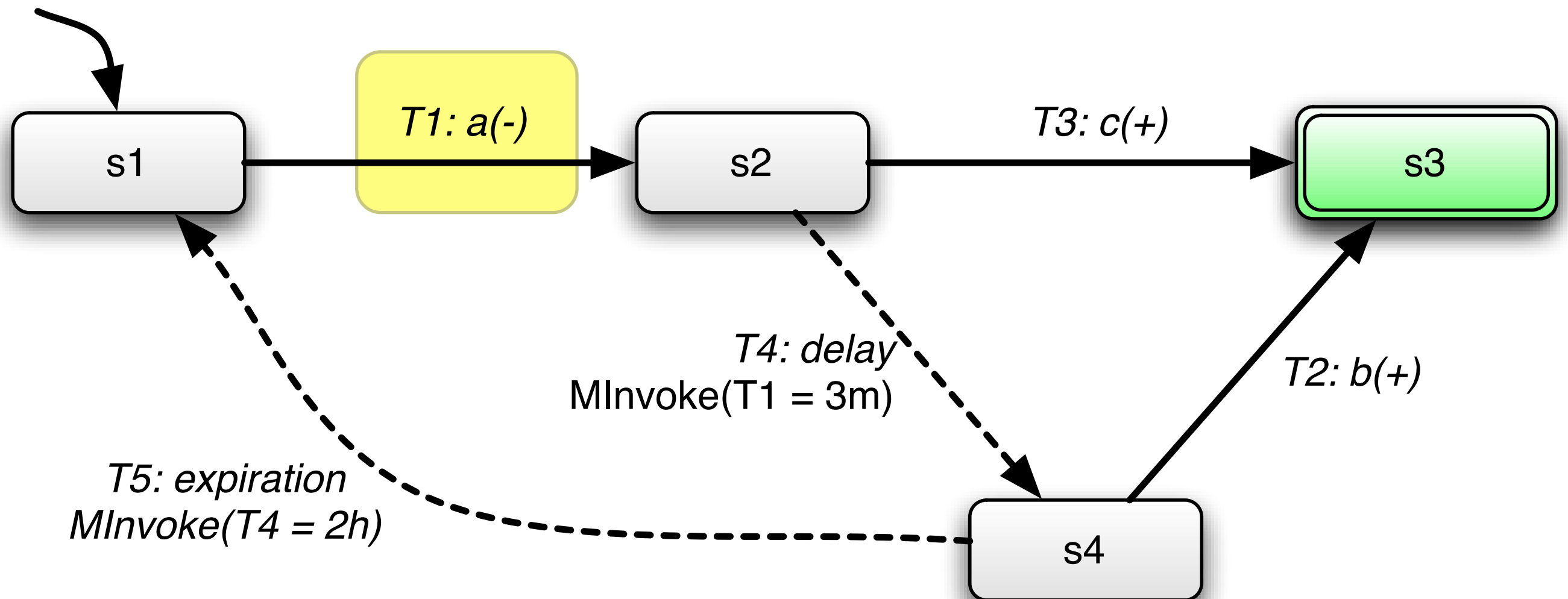
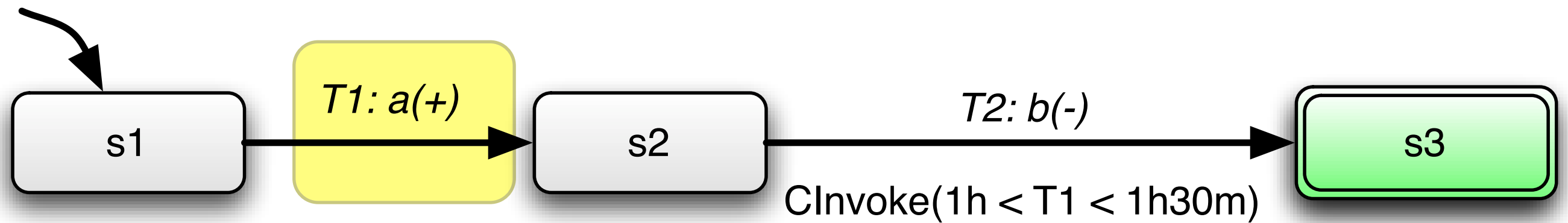
Full compatibility



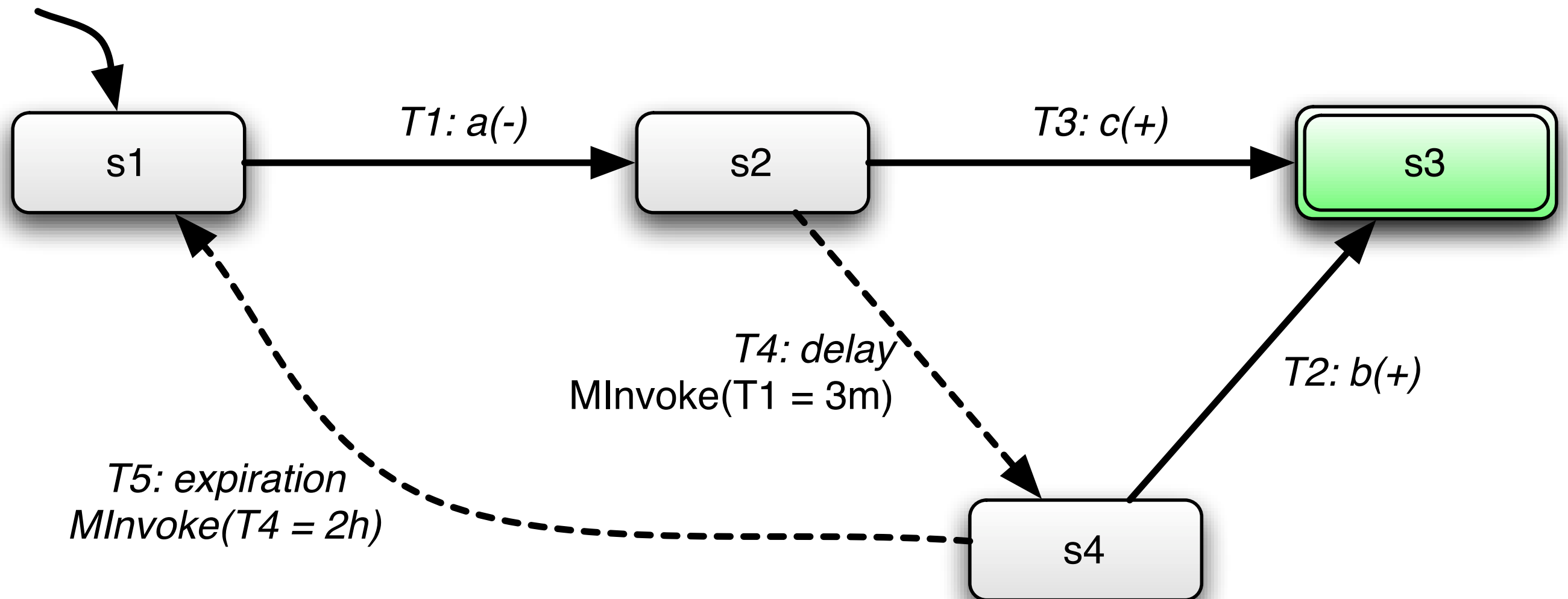
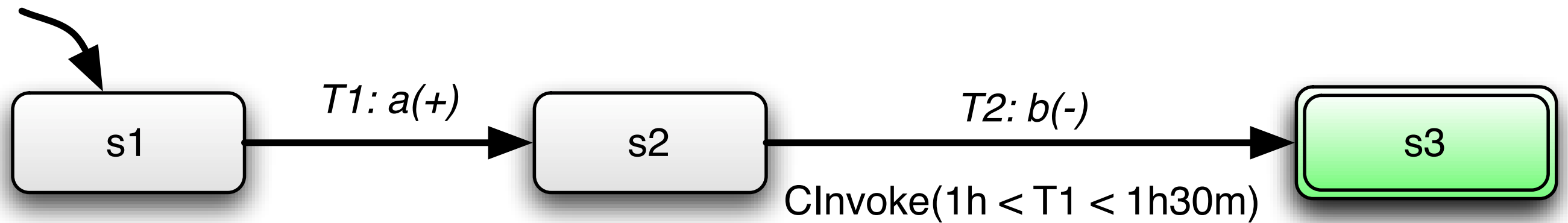
Full compatibility



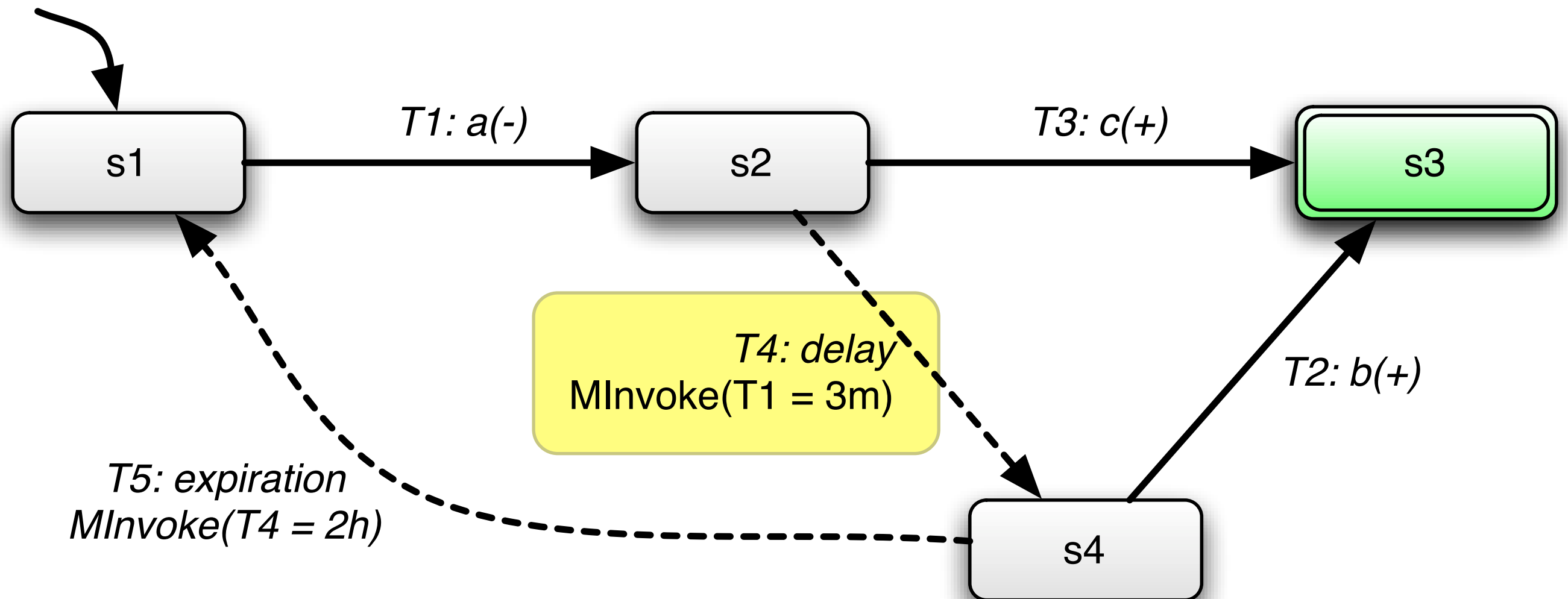
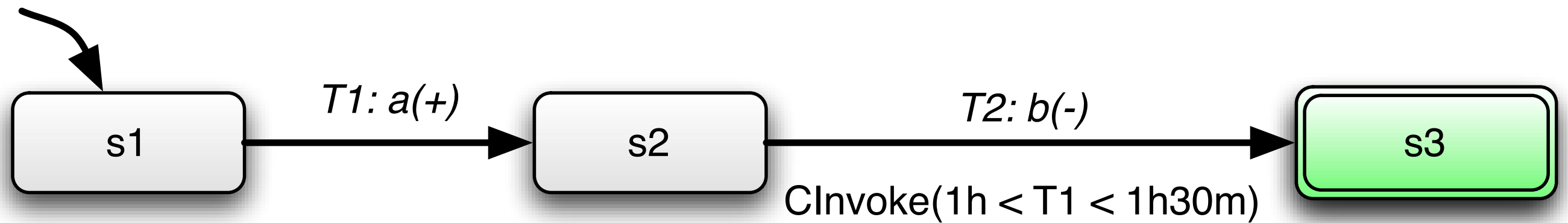
Full compatibility



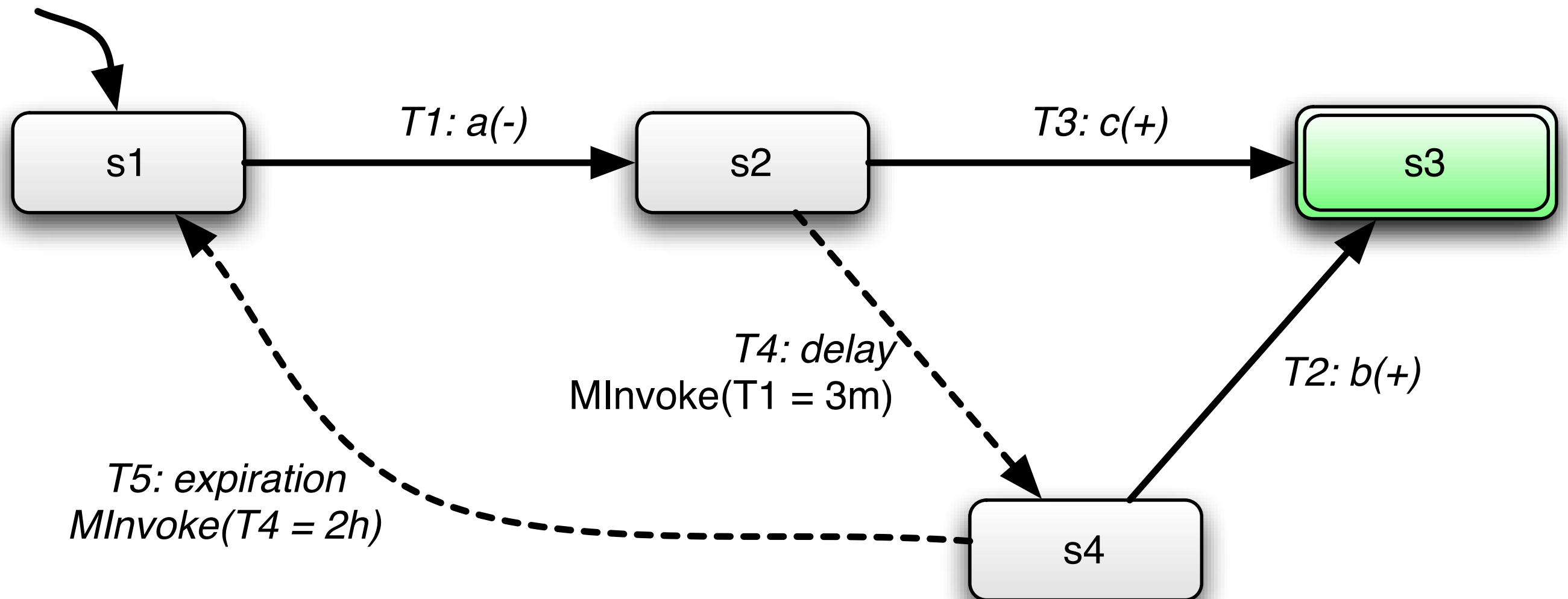
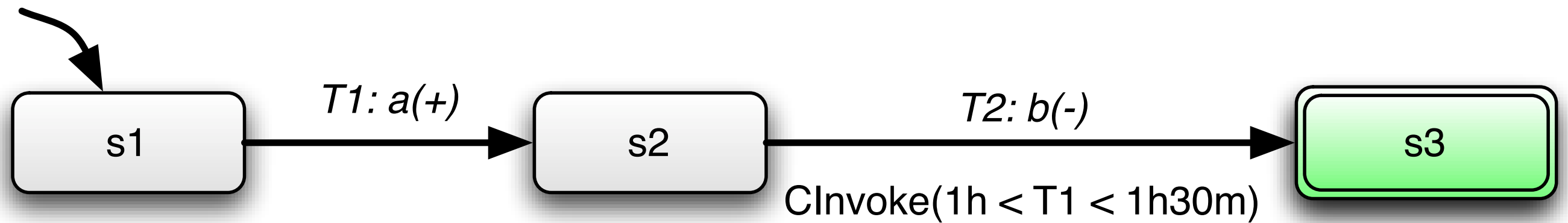
Full compatibility



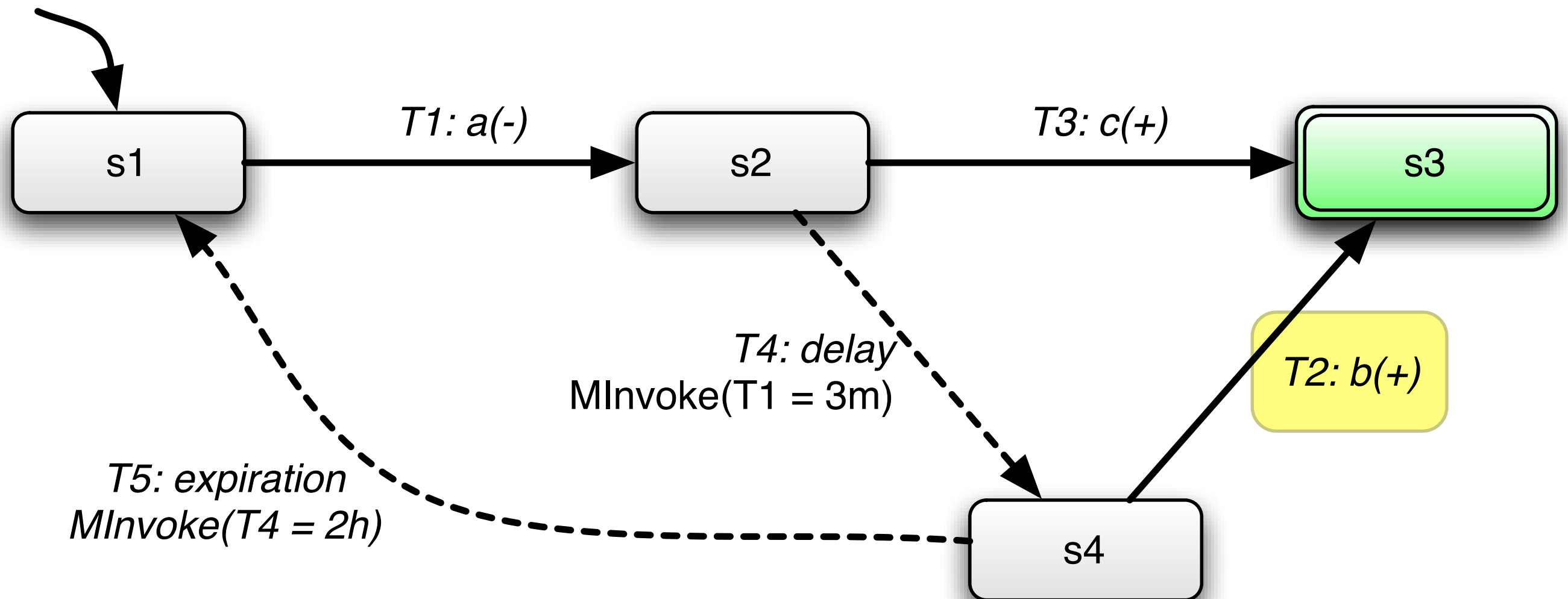
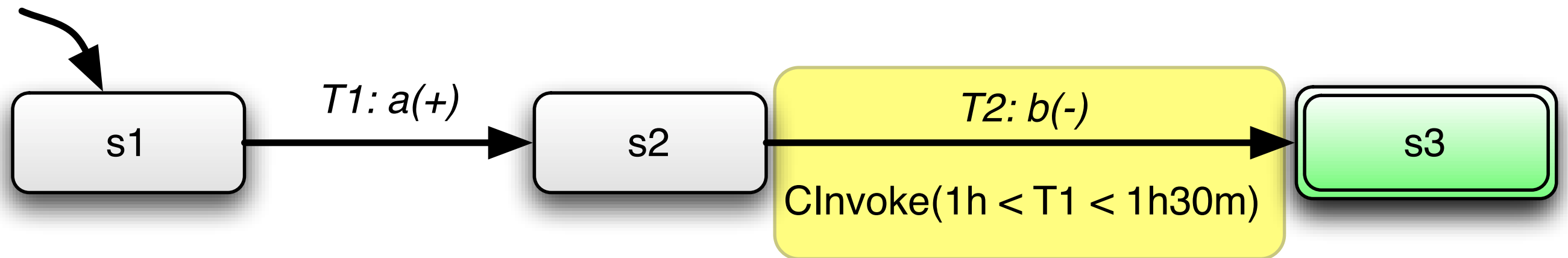
Full compatibility



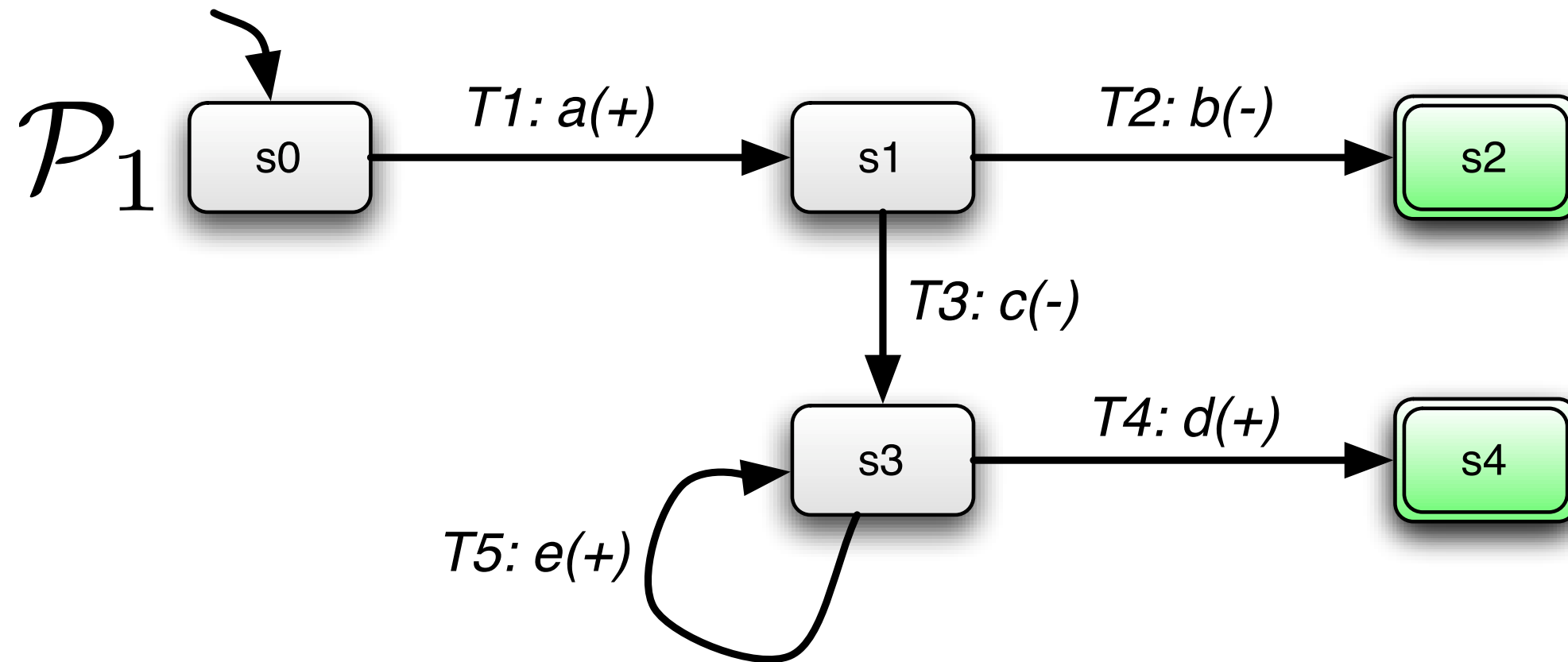
Full compatibility



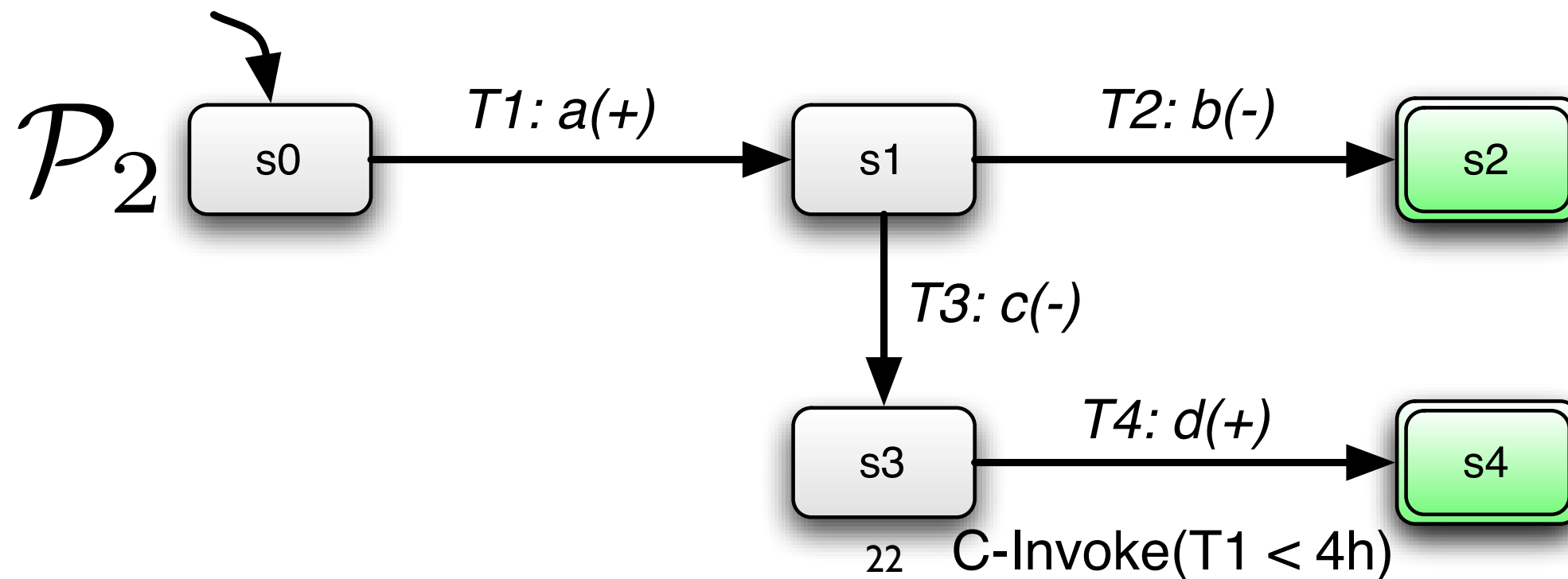
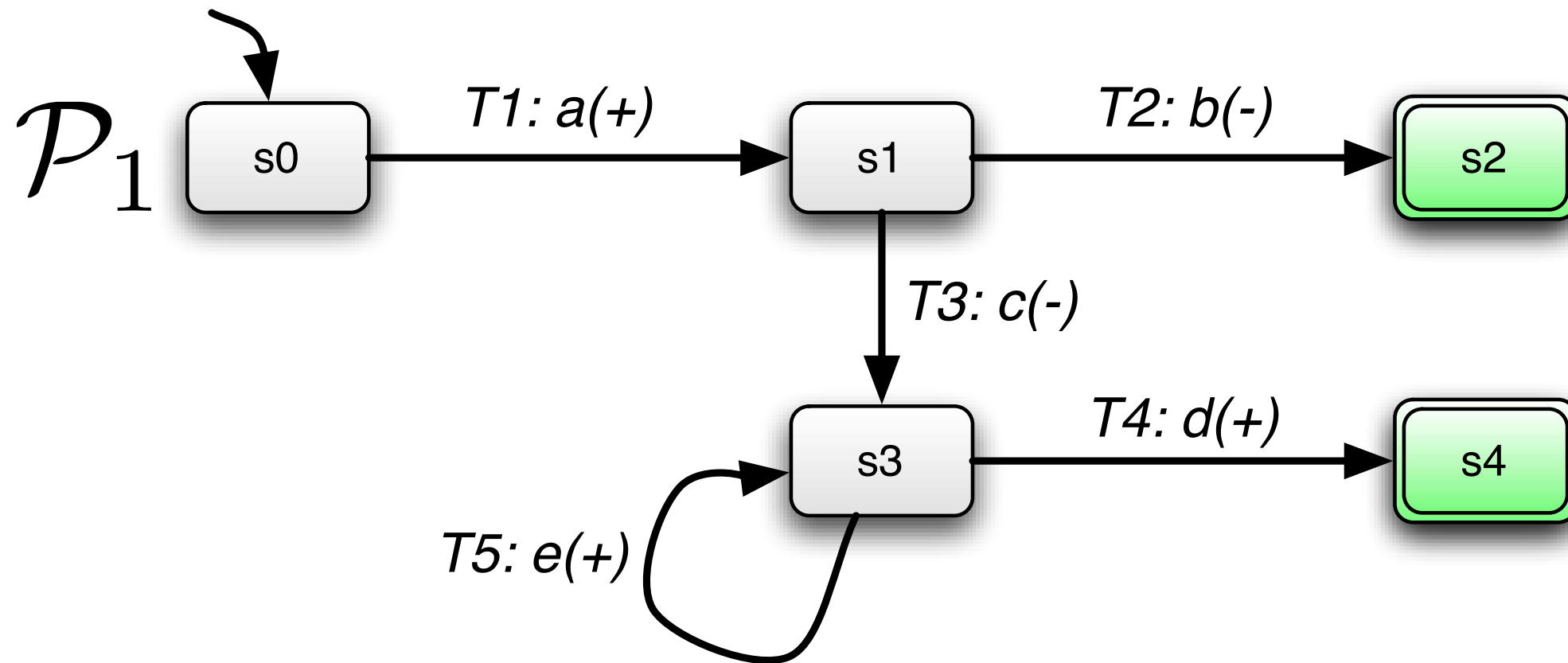
Full compatibility



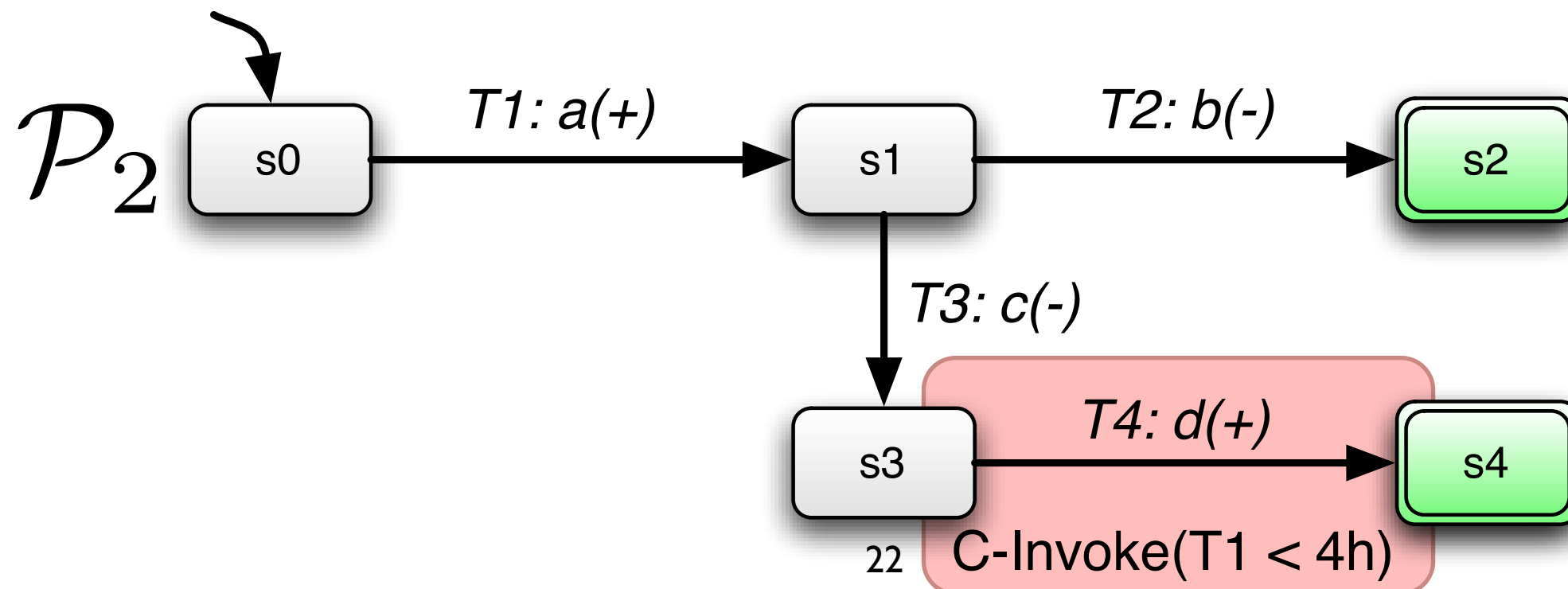
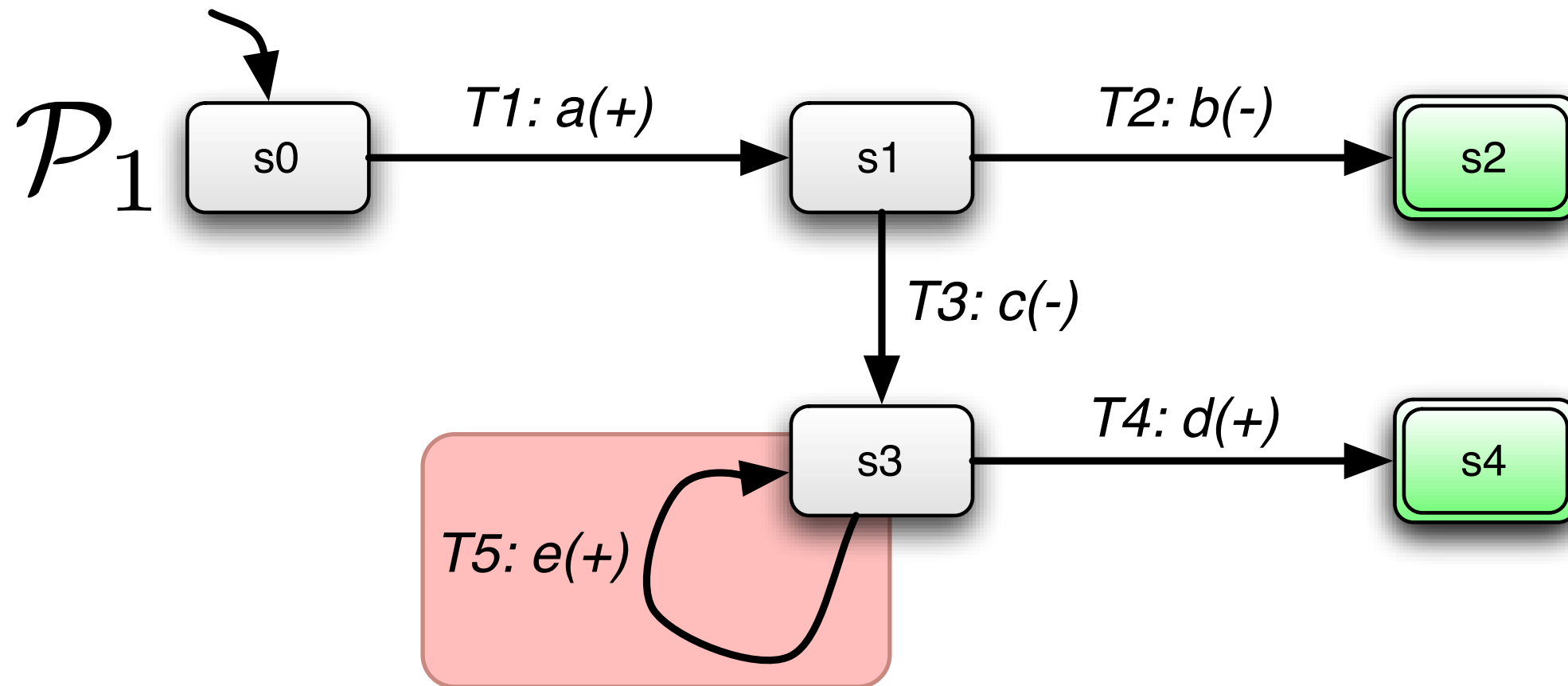
Repl. w.r.t. client protocol



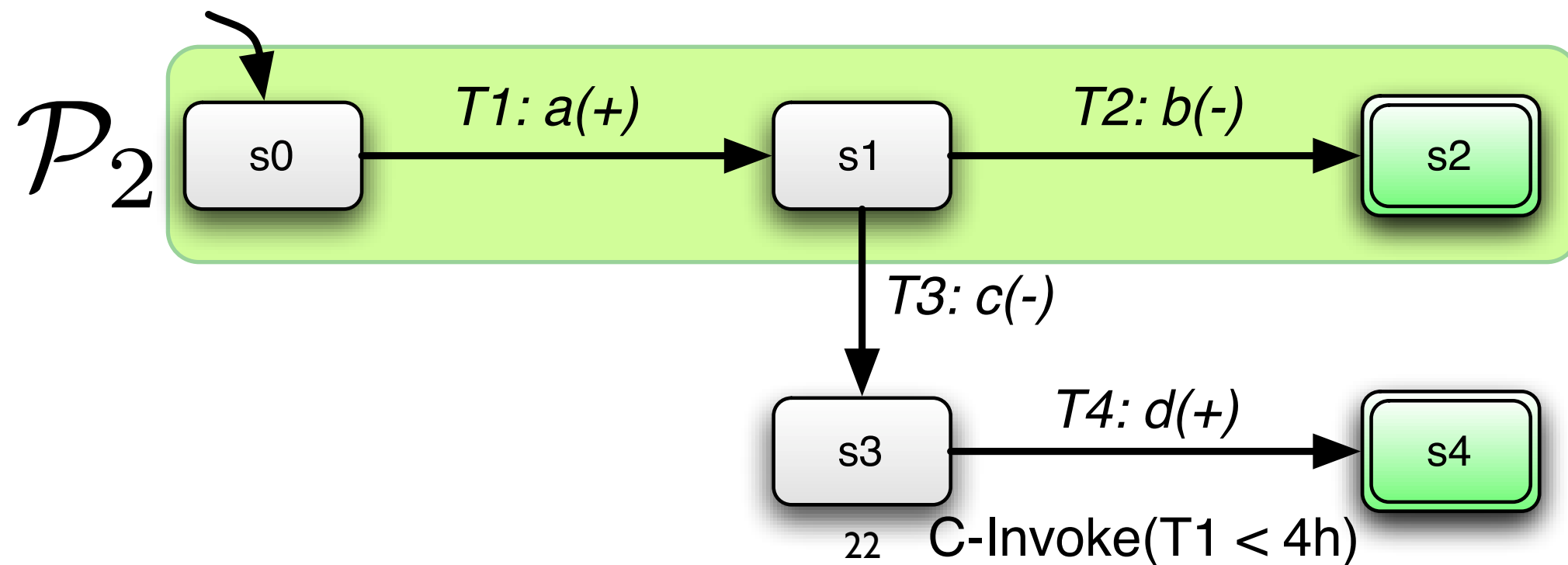
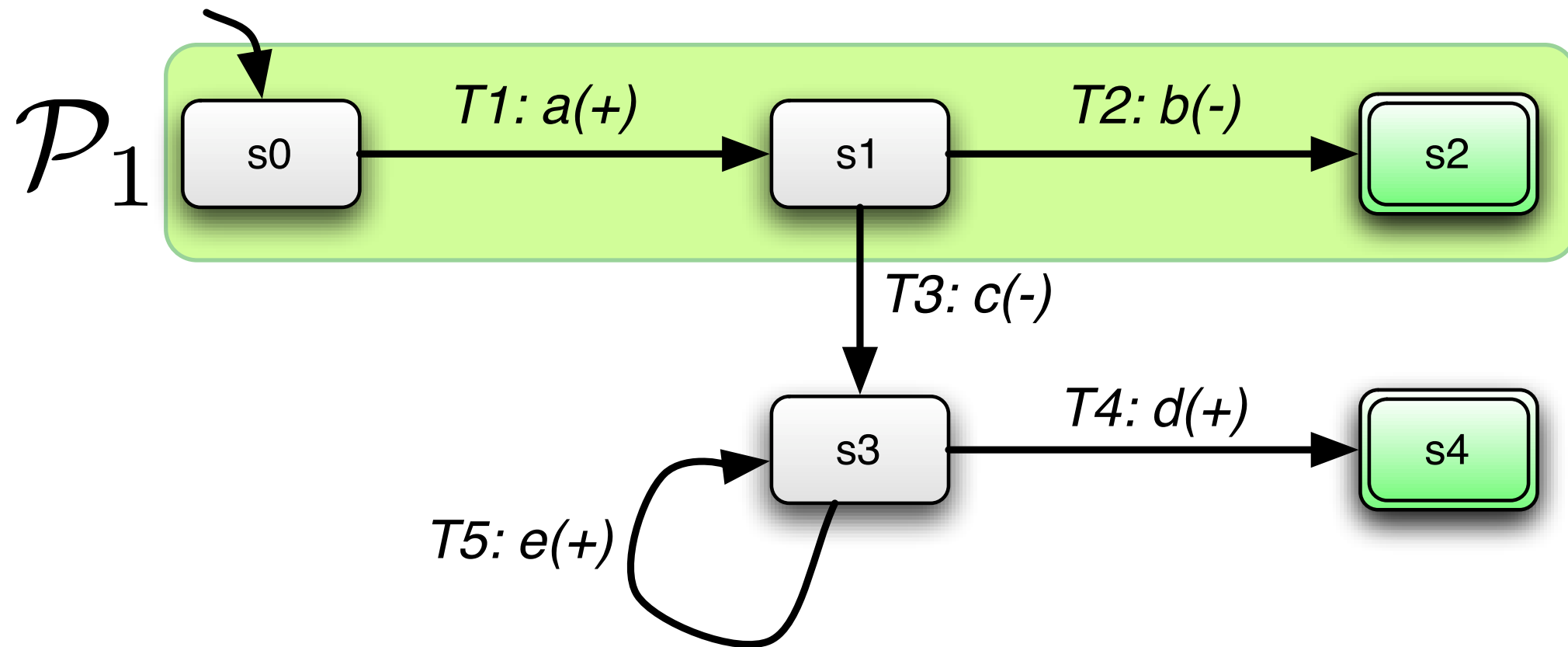
Repl. w.r.t. client protocol



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 $||^{tc}$

Intersection $||^{ti}$

Difference $||^{td}$

Full compatibility

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

Approach

Protocols

- model
- analysis
- operators

CInvoke + MInvoke

Timed
protocols

- model
- analysis
- operators

Approach

decidability
closure

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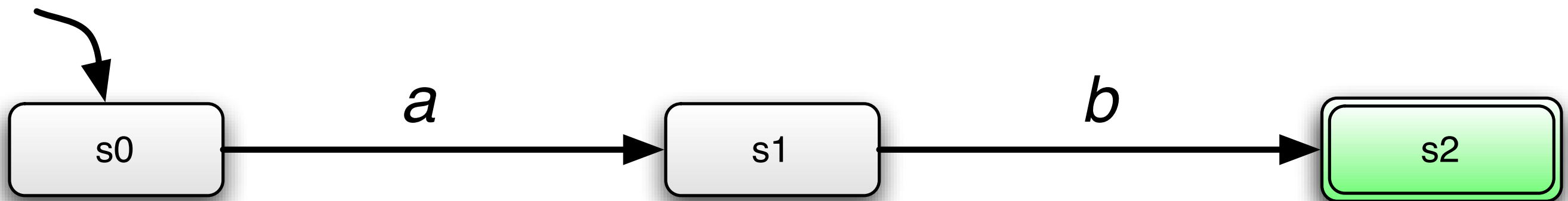
Protocol timed automata

Timed automata (Alur, Dill 94)

Clocks over dense time

Guards and resets

Extensive research in model checking



Timed automata (Alur, Dill 94)

Clocks over dense time

Guards and resets

Extensive research in model checking



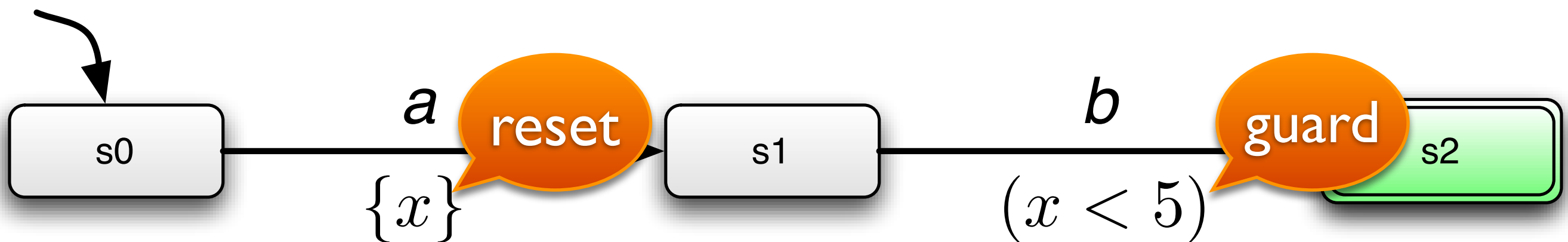
$$L = \{(a, t_1) \cdot (b, t_2) \mid t_2 - t_1 < 5\}$$

Timed automata (Alur, Dill 94)

Clocks over dense time

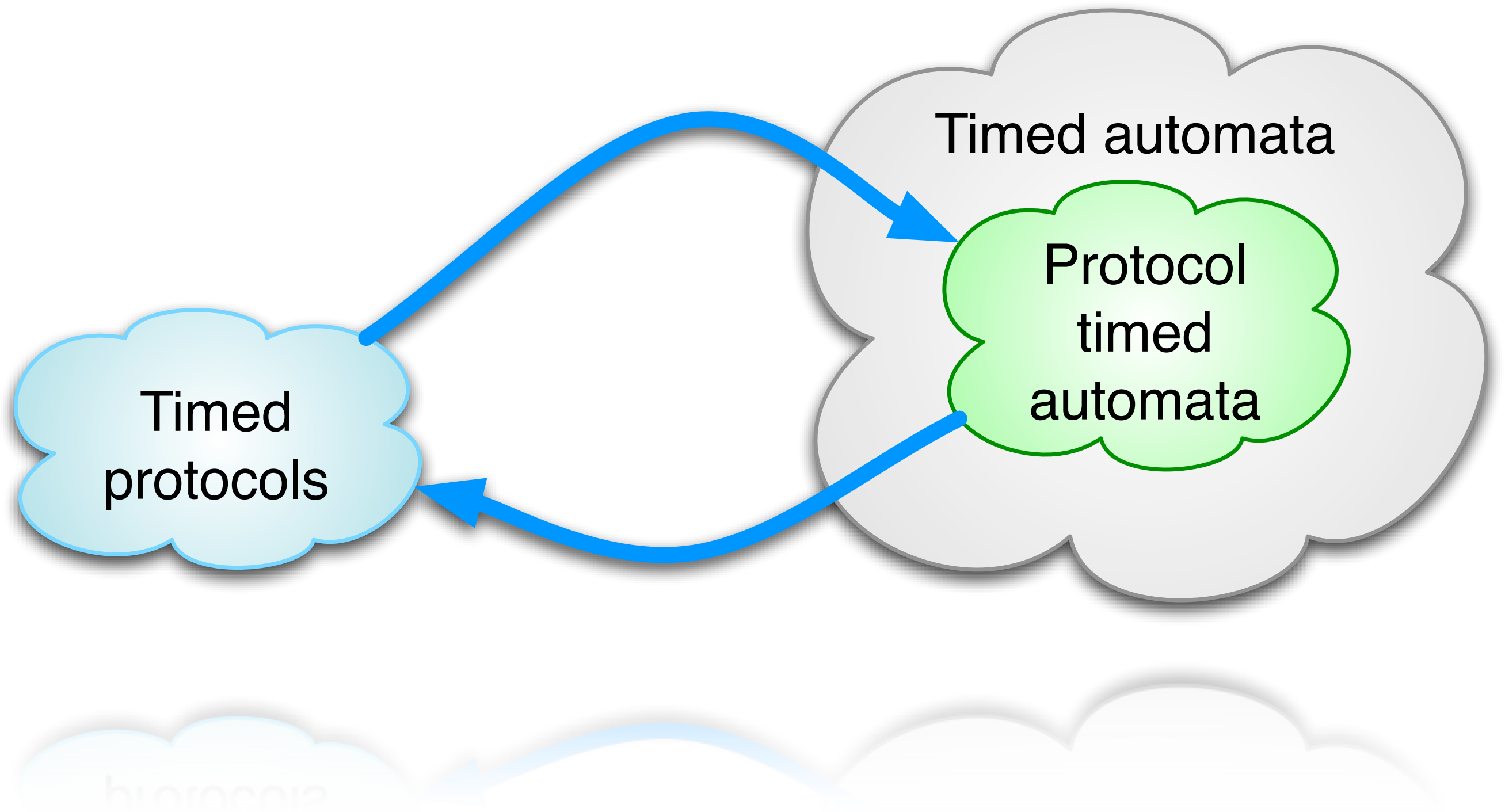
Guards and resets

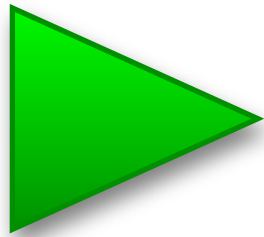
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Approach



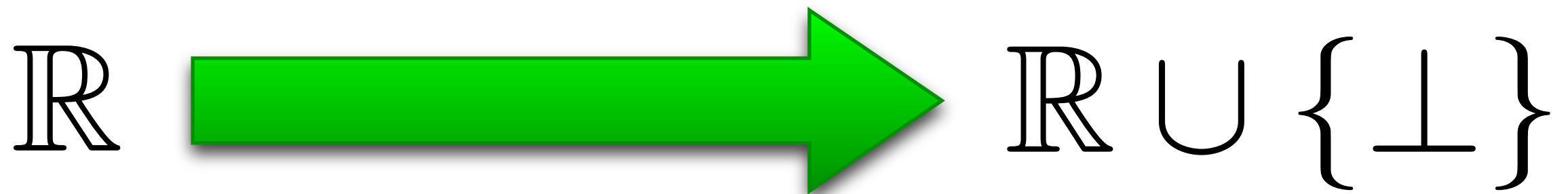


Mapping

Class characterization

New results

Time domain



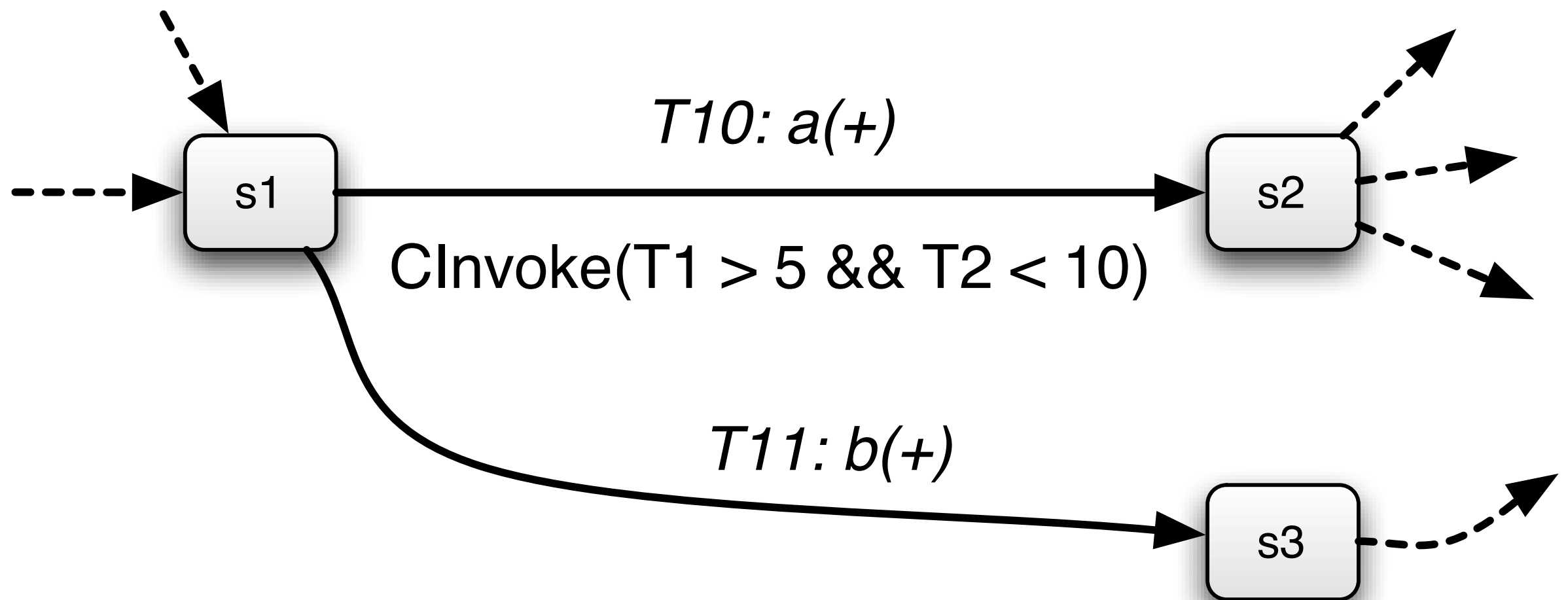
(like event-recording automata)

Time domain

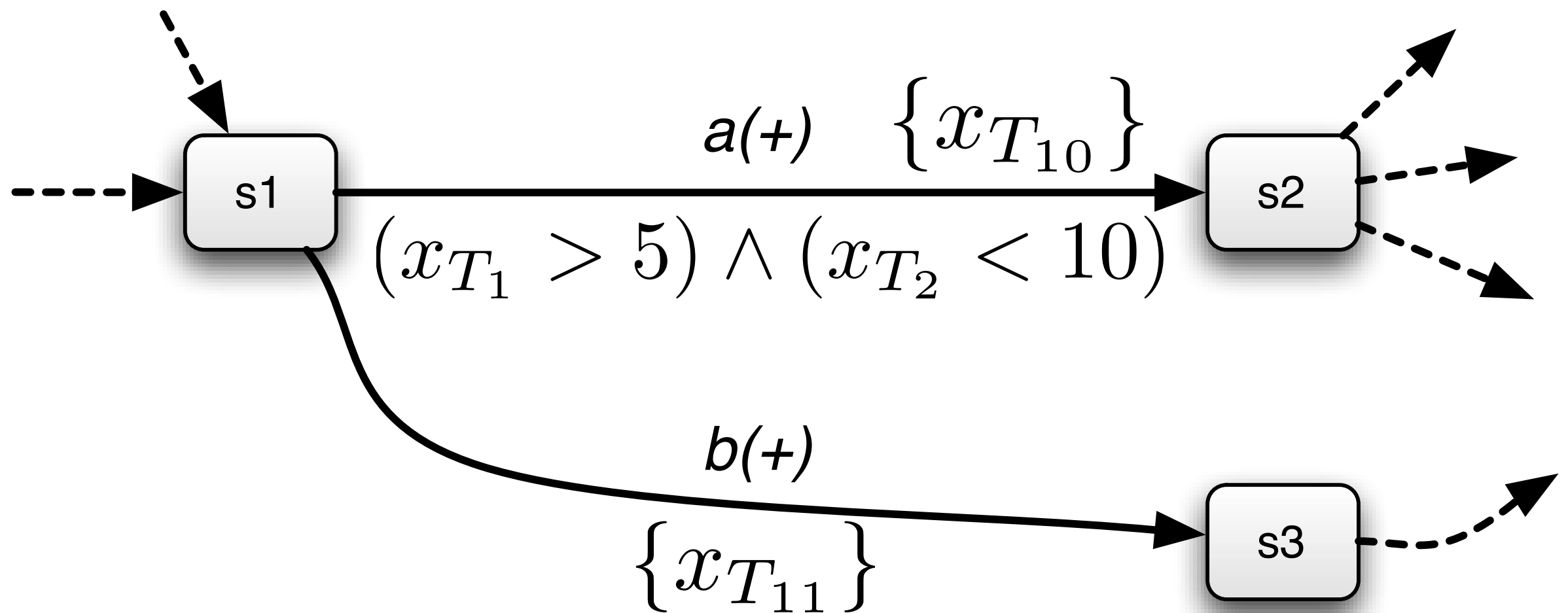


(like event-recording automata)

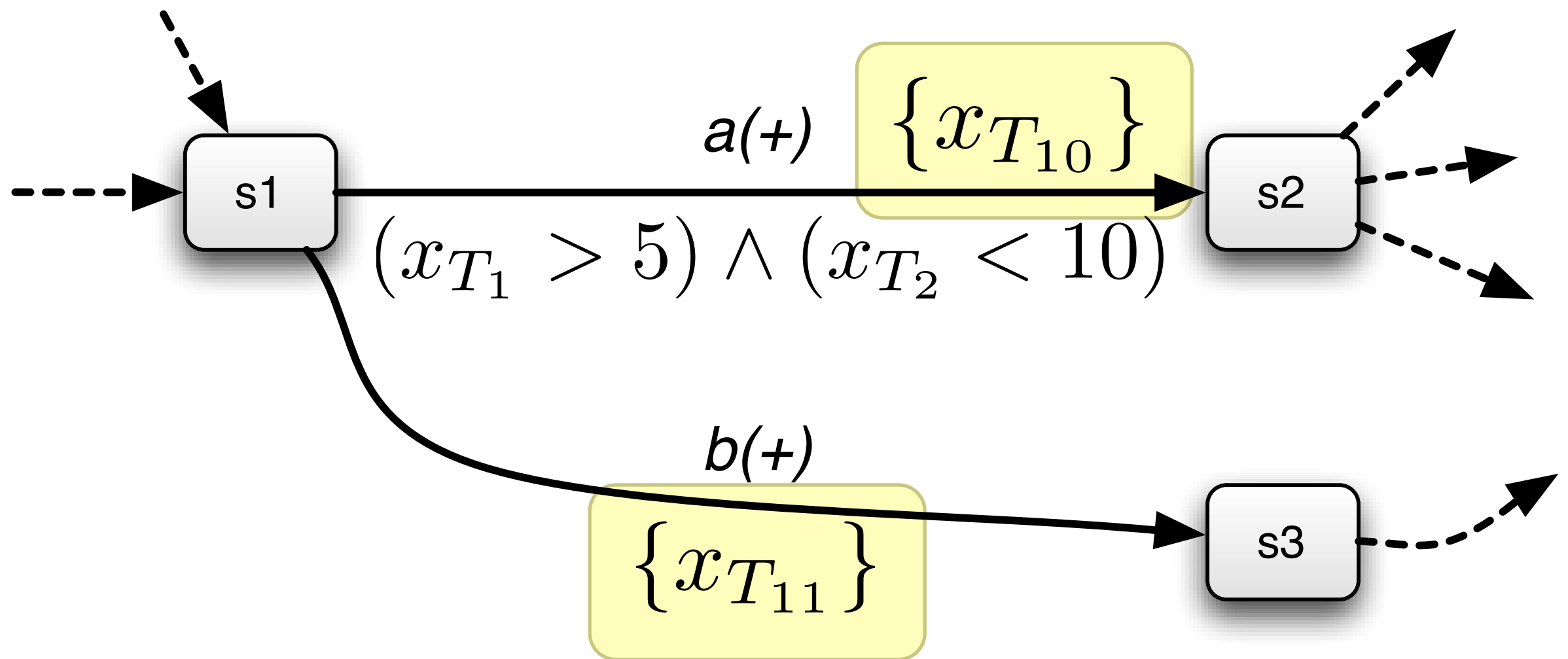
CInvoke mapping



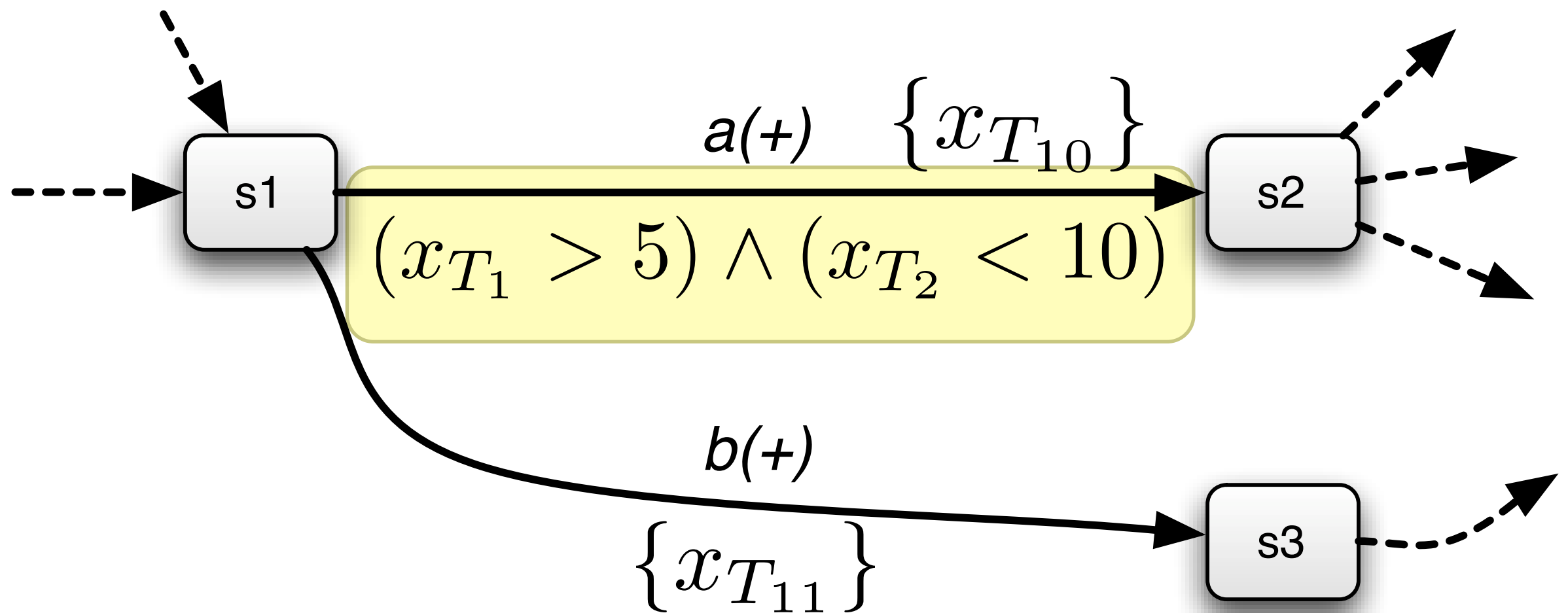
CInvoke mapping



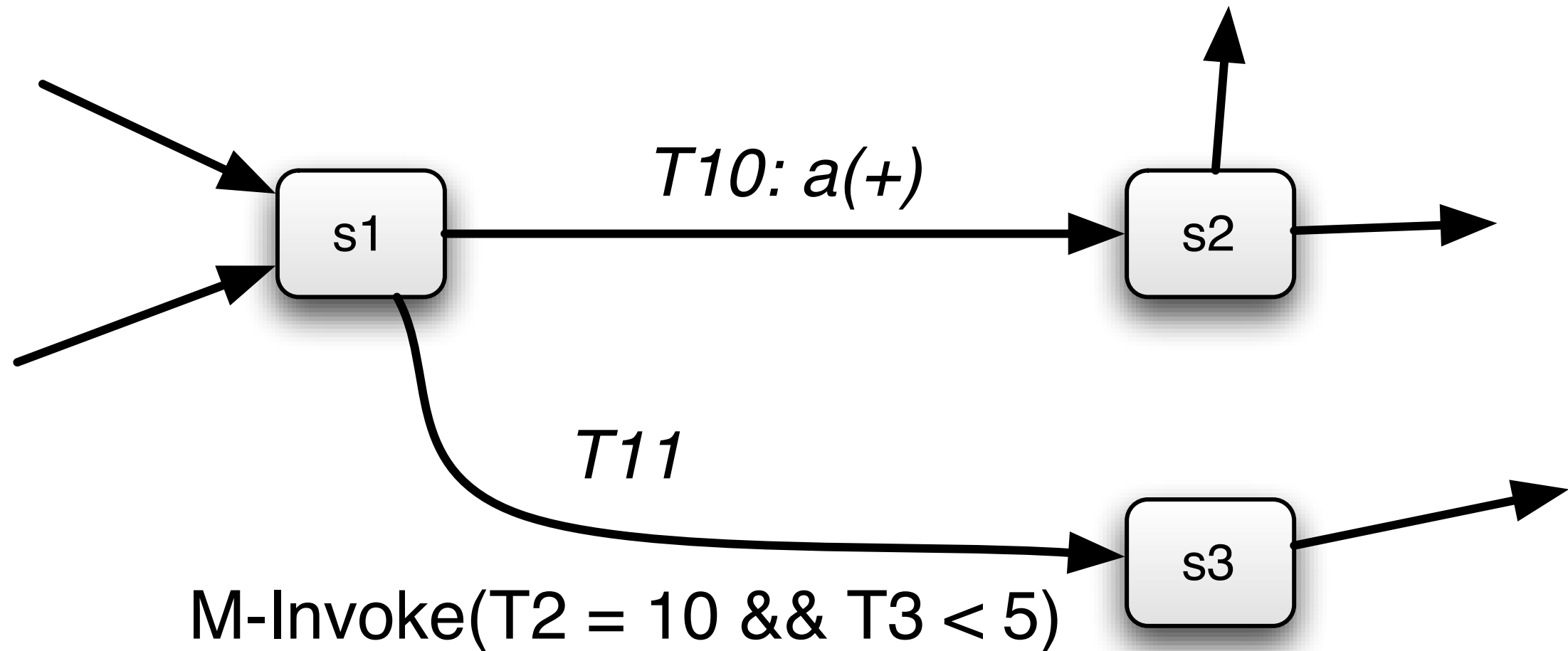
CInvoke mapping



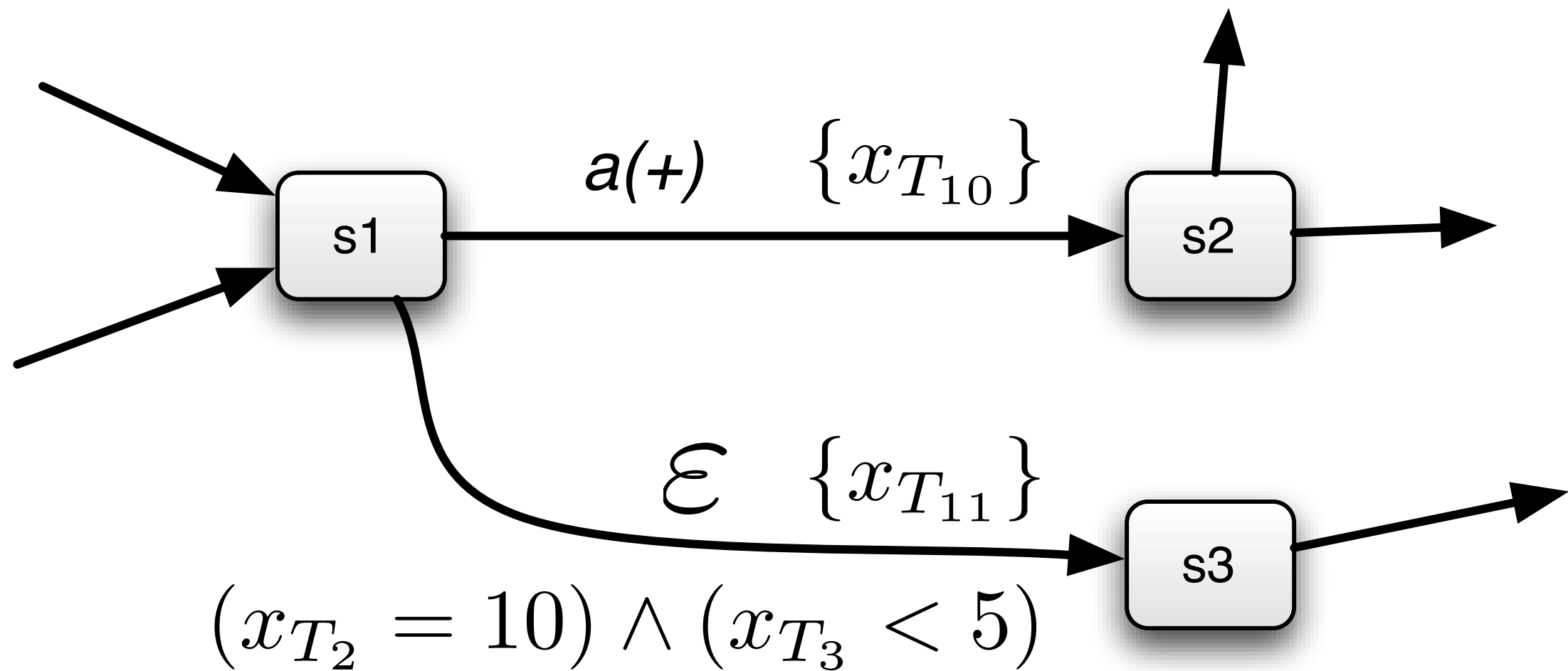
CInvoke mapping



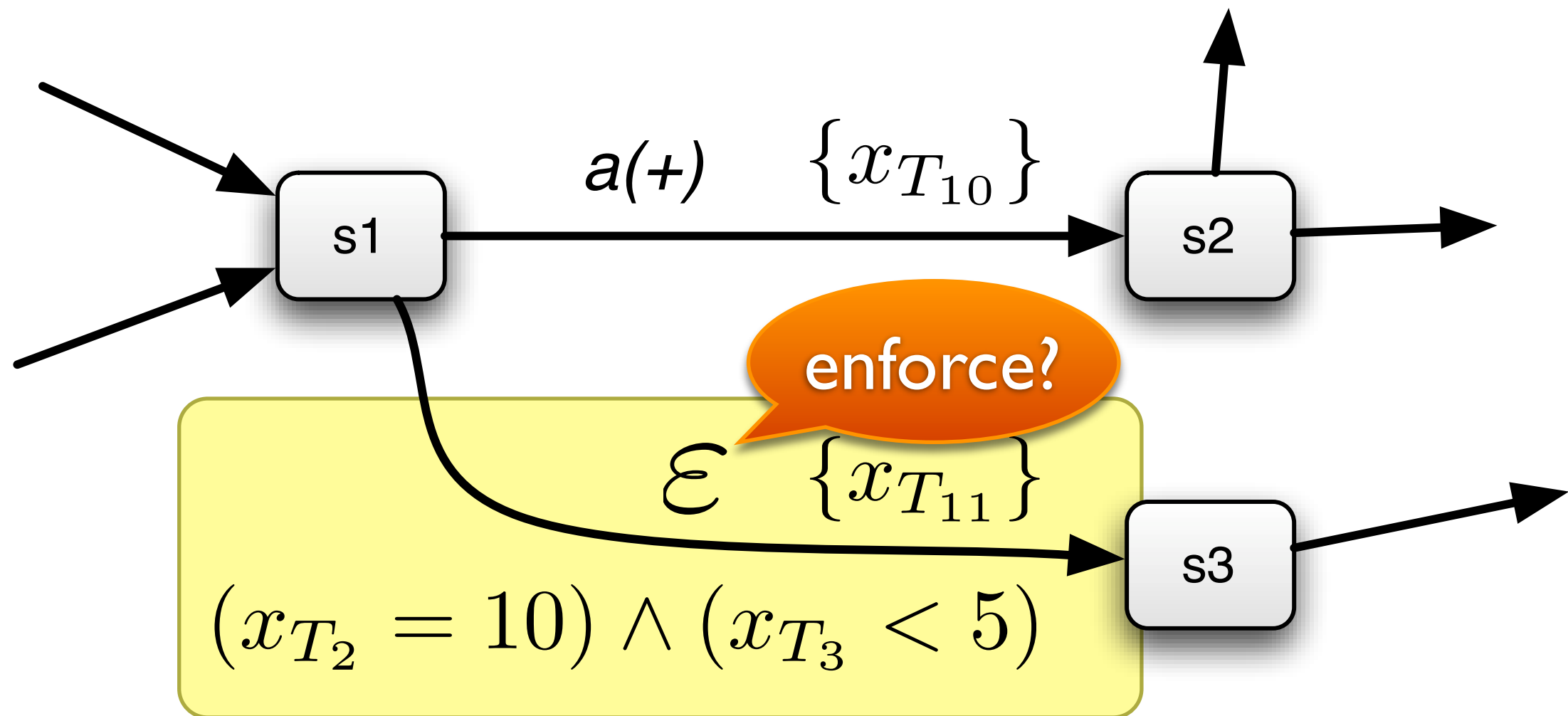
MInvoke mapping



MInvoke mapping



MInvoke mapping

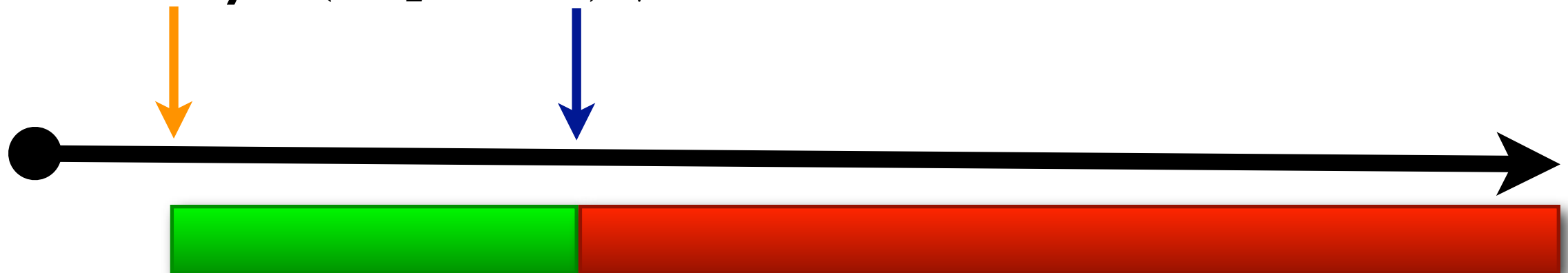


MInvoke behavior

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

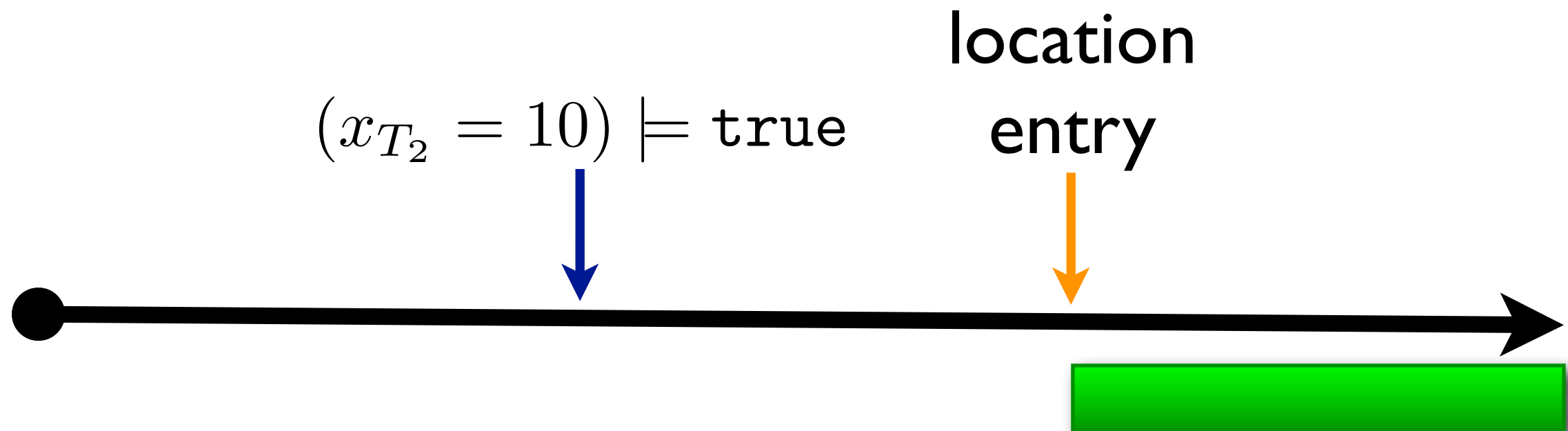
location

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



MInvoke behavior

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

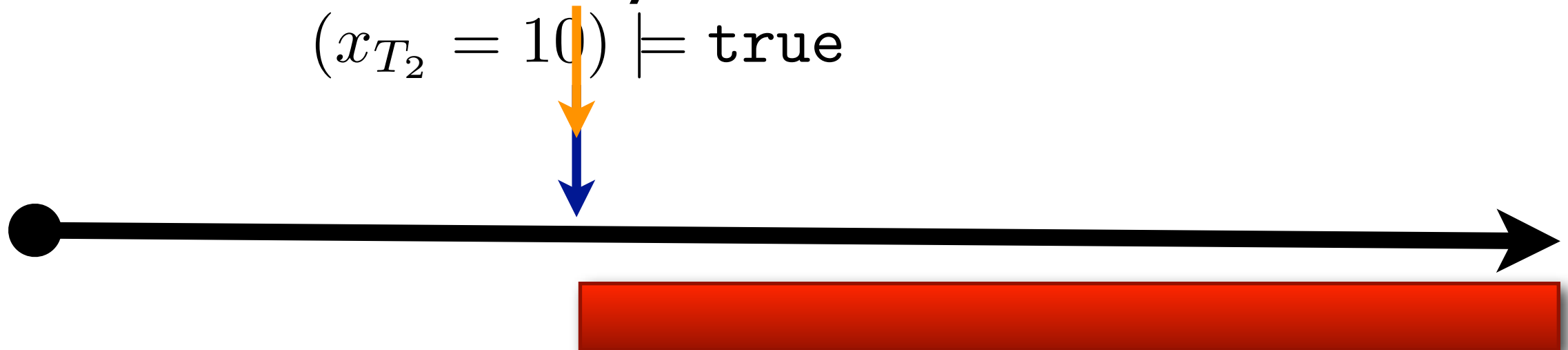


MInvoke behavior

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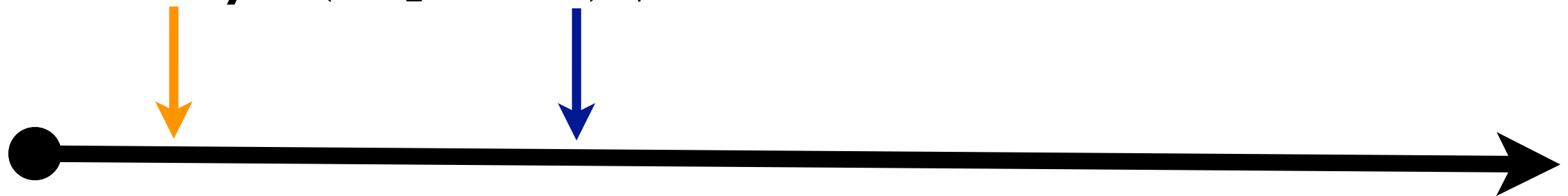


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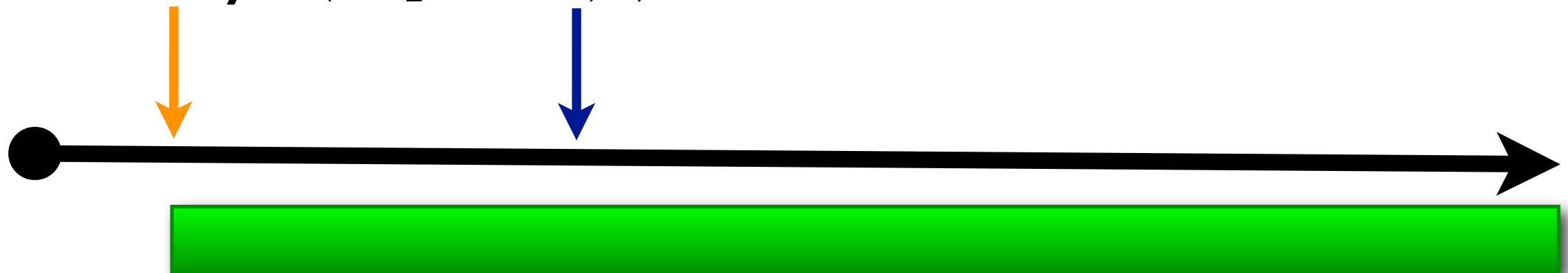


MInvoke behavior

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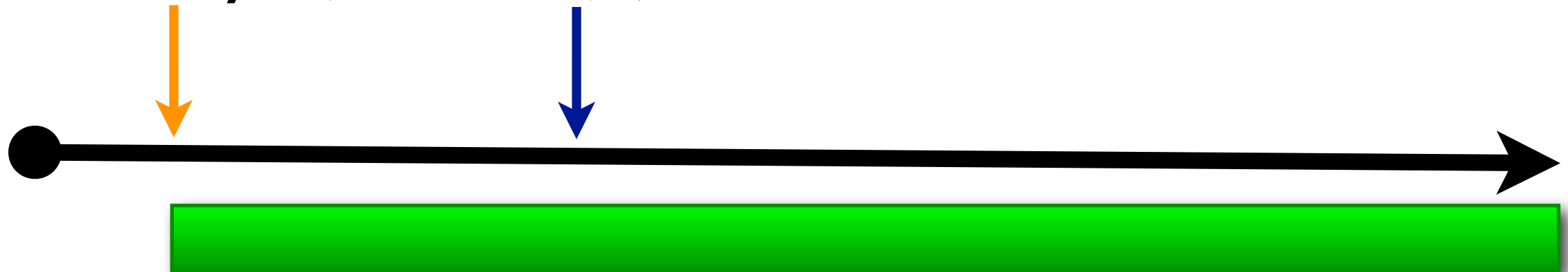
MInvoke behavior

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

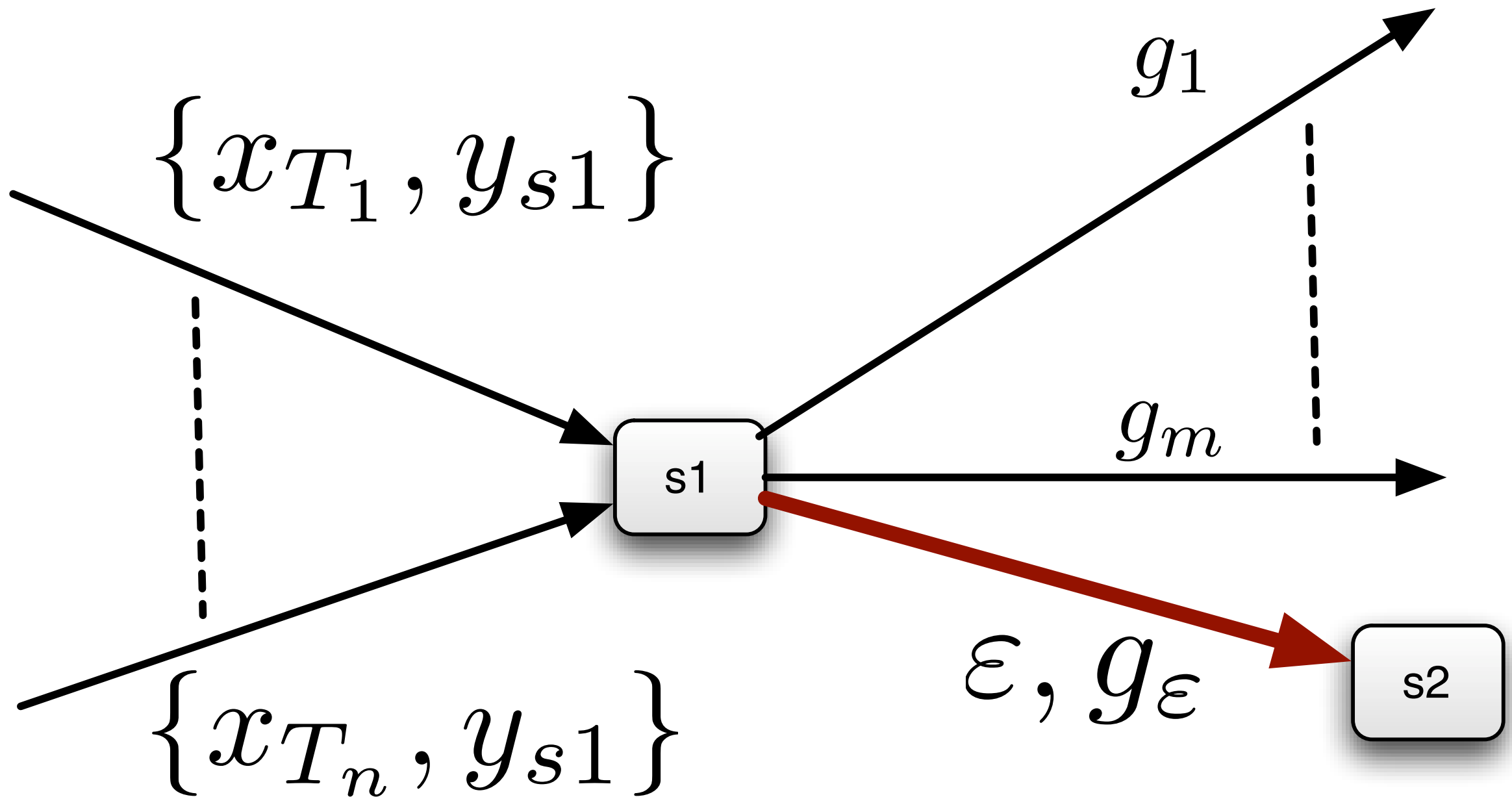
not satisfied

location

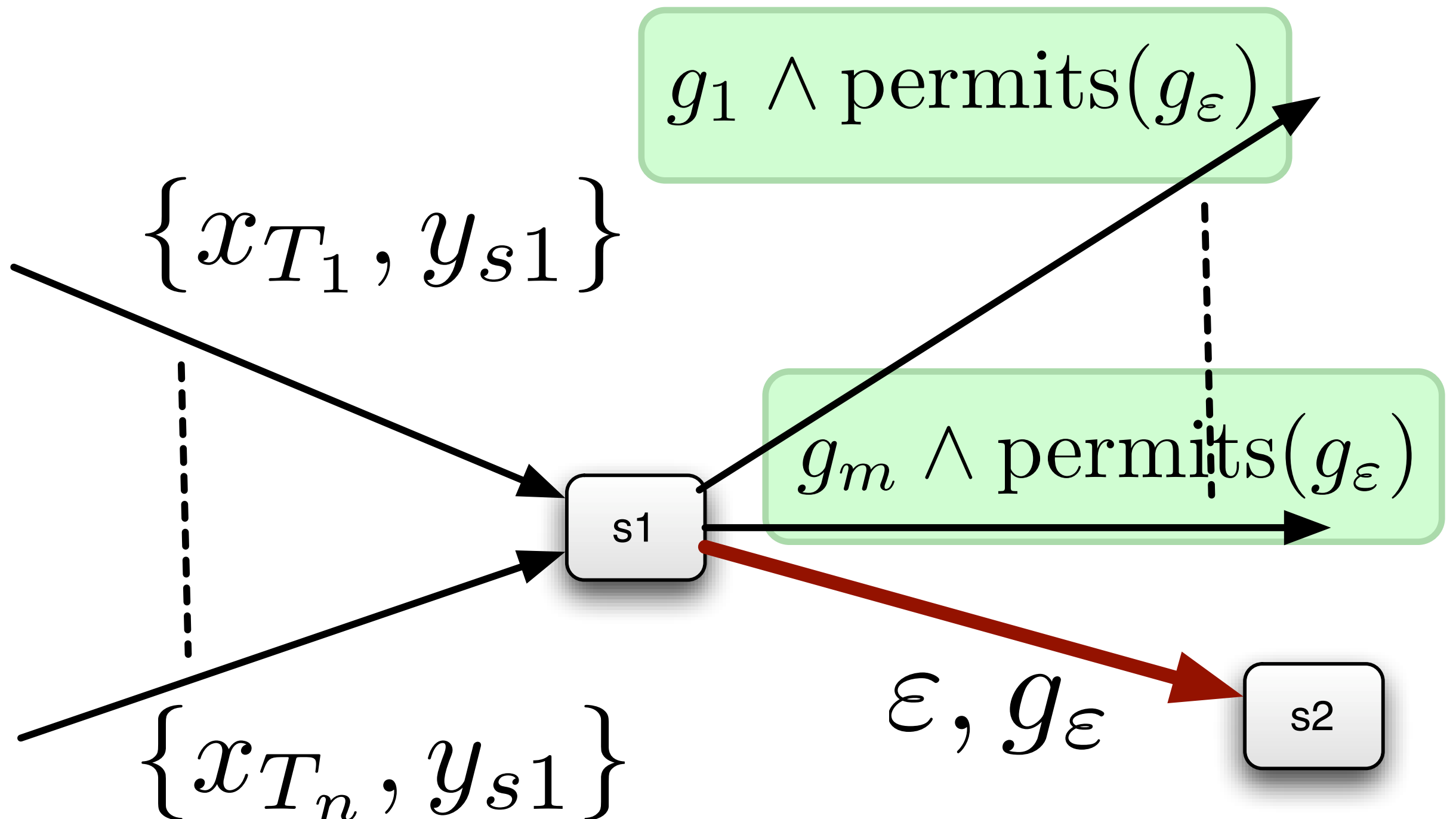
entry $(x_{T_2} = 10) \models \text{true}$



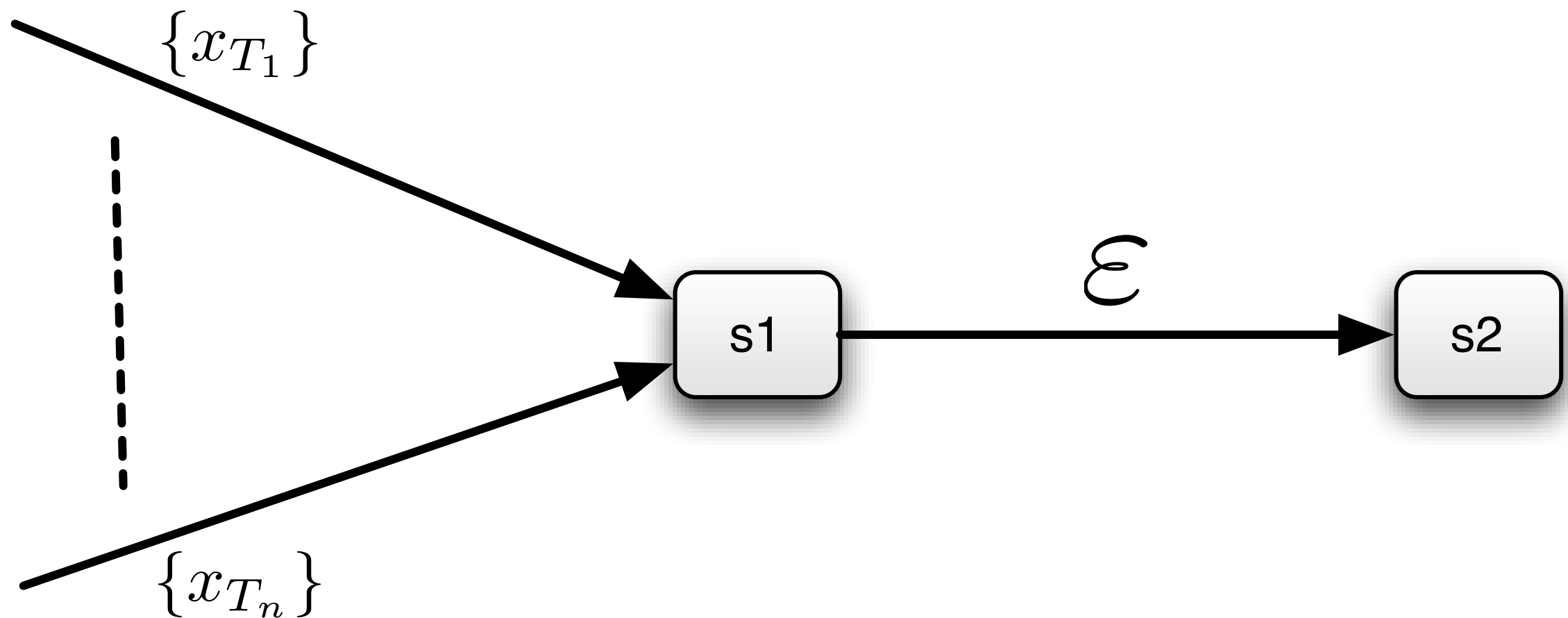
Rewriting



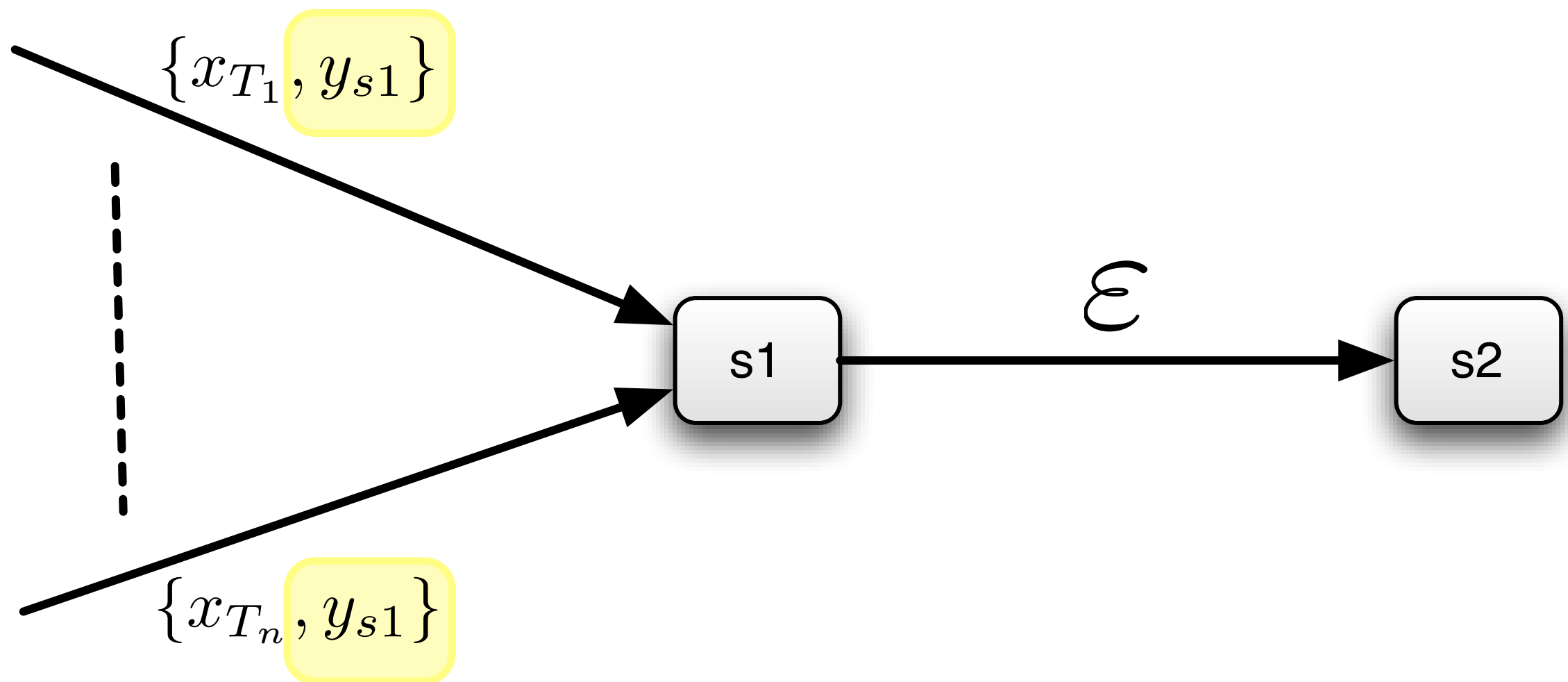
Rewriting



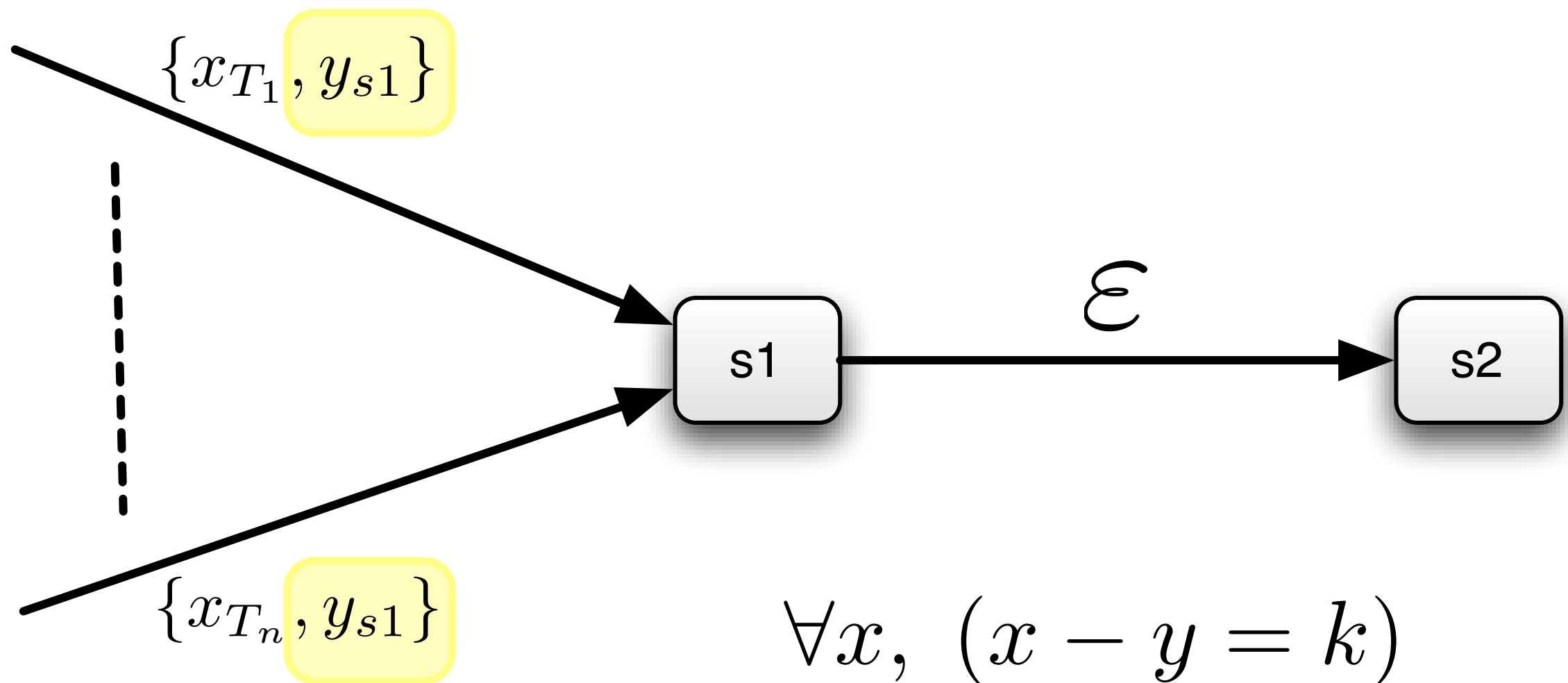
Capturing valuations



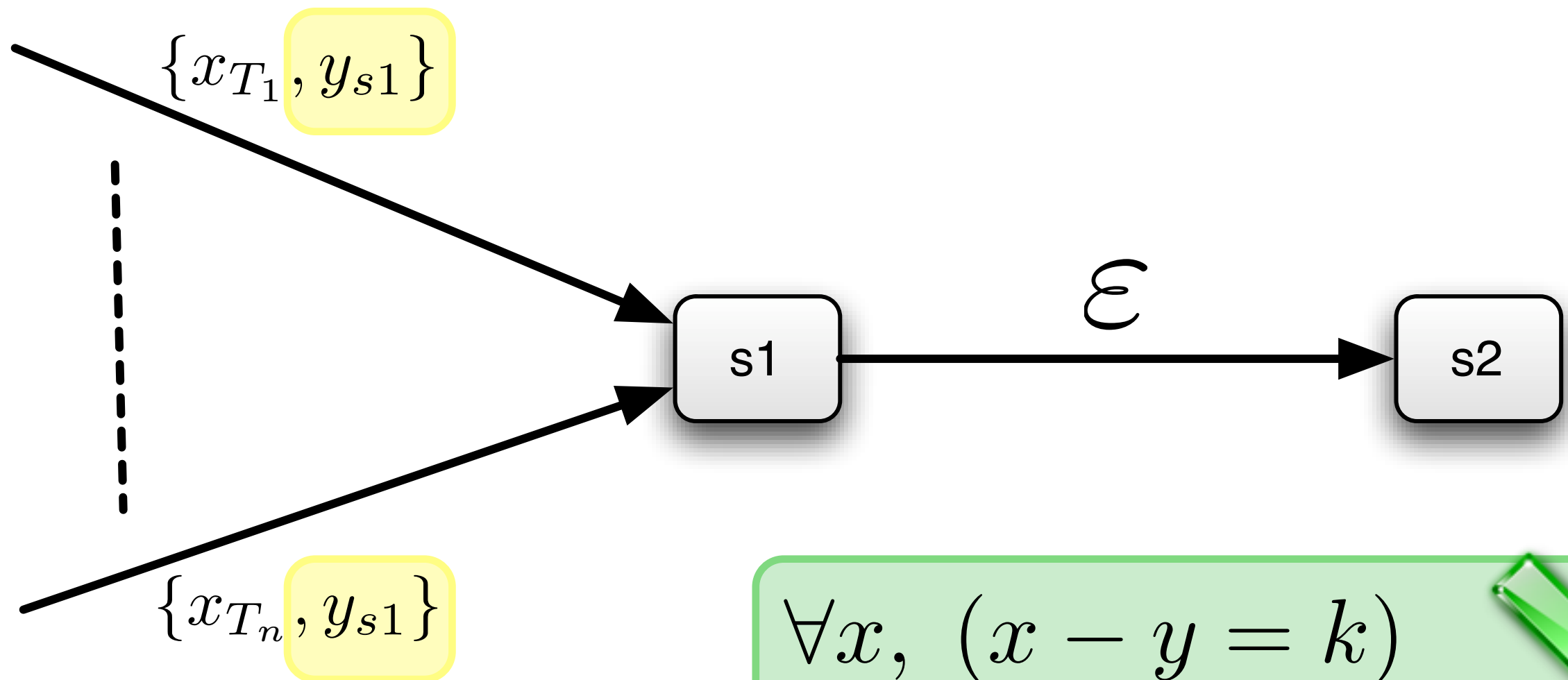
Capturing valuations



Capturing valuations



Capturing valuations



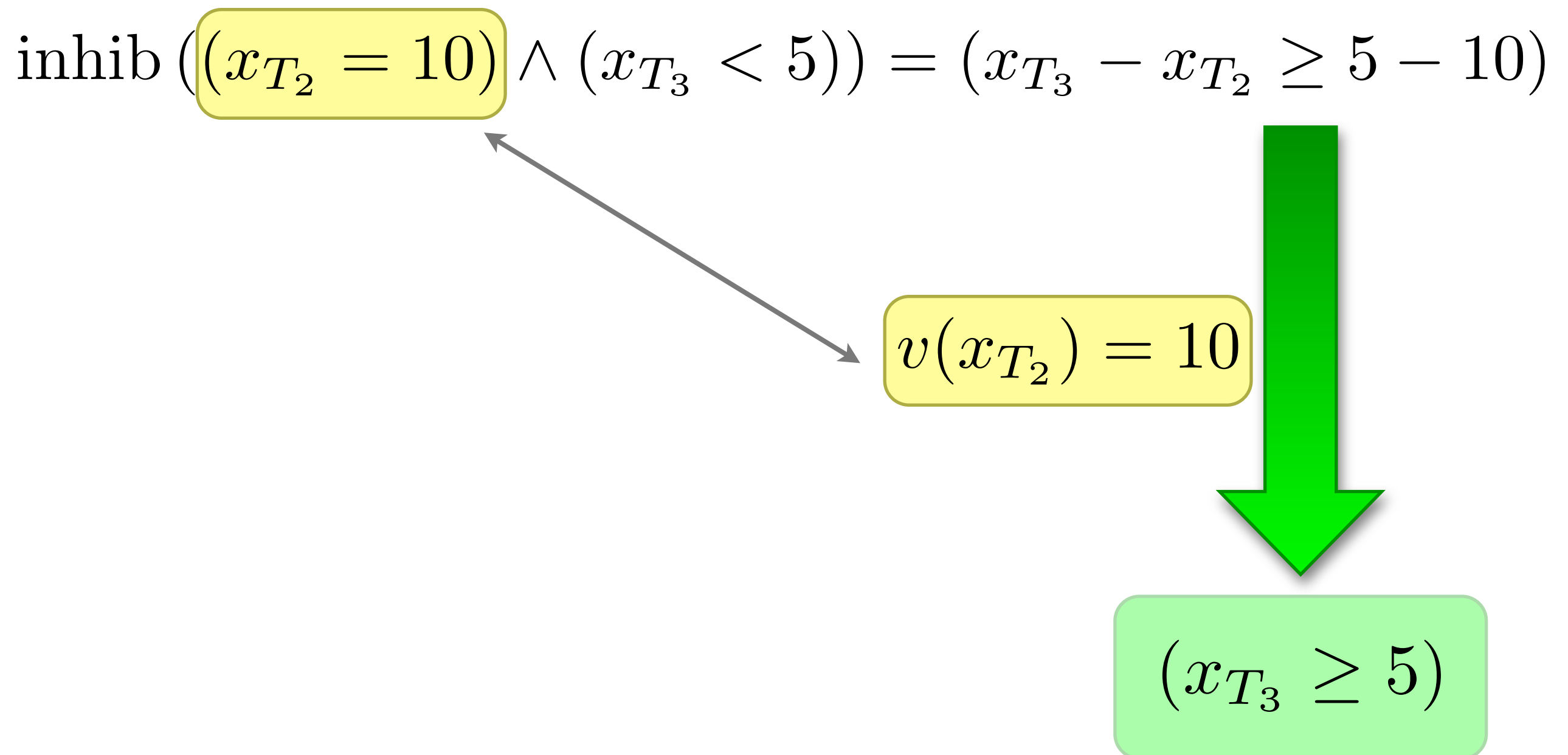
$$\forall x, (x - y = k)$$
$$(v(y) = 0) \implies (x = k)$$



MInvoke inhibitor

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

MInvoke inhibitor





Please note that...

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

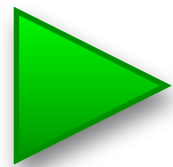
Permitting / disabling

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

Permitting / disabling

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

permits(g)



$$S_1 = (x < k)$$

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

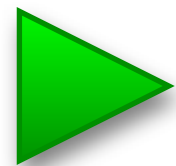
$$S_3 = (x > k) \wedge (x - y \leq k) \wedge \text{inhib}(g)$$

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

Permitting / disabling

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

permits(g)



$$S_1 = (x < k)$$

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

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

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

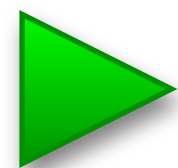
Permitting / disabling

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

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

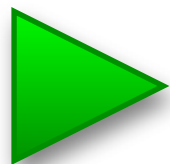
$$\xrightarrow{\mathcal{E}} g := (x = k) \wedge g'$$

permits(g)

$$S_1 = (x < k)$$

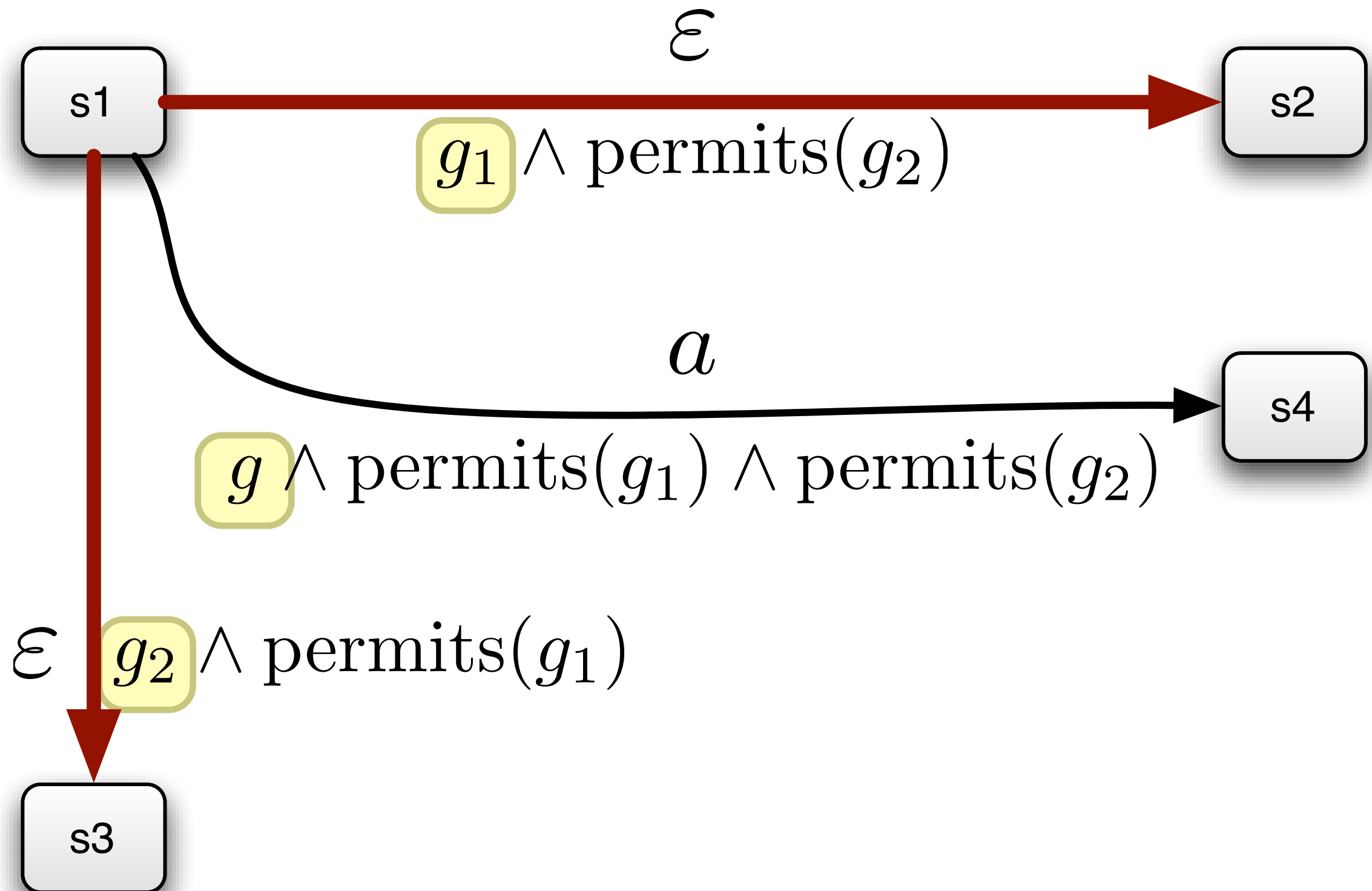
$$S_2 = (x > k) \wedge (x - y > k)$$

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

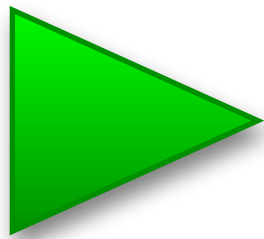


$$S_4 = (x = k) \wedge \text{inhib}(g)$$

Generalization



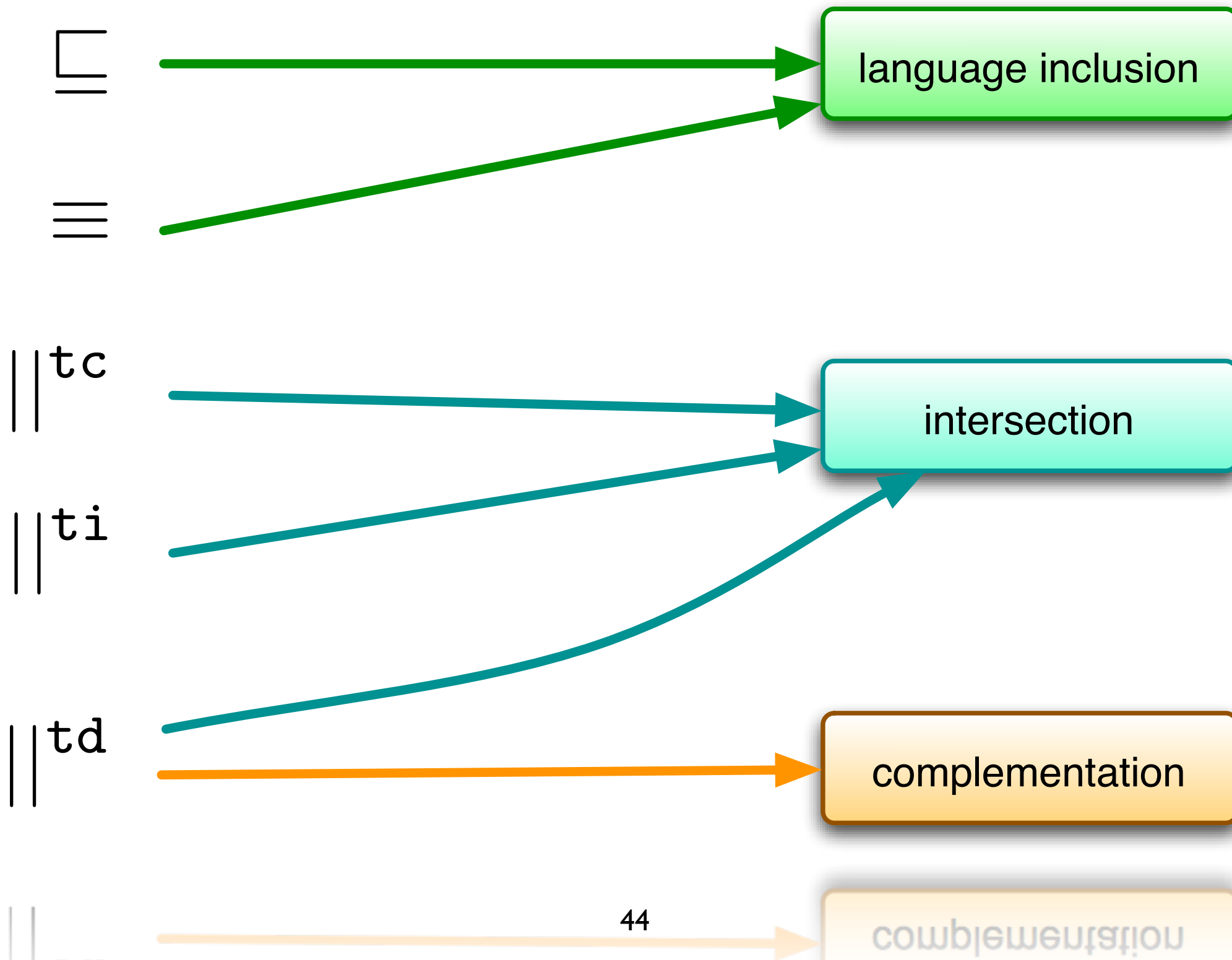
Mapping



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

	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

Problem		Result
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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
 Event-clock TA	Closed
(others)	Not closed

Better classes?

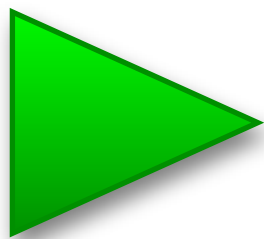
Class	Complementation
 Deterministic TA	Closed
 Event-clock TA	Closed
(others)	Not closed



Silent transitions!

Mapping

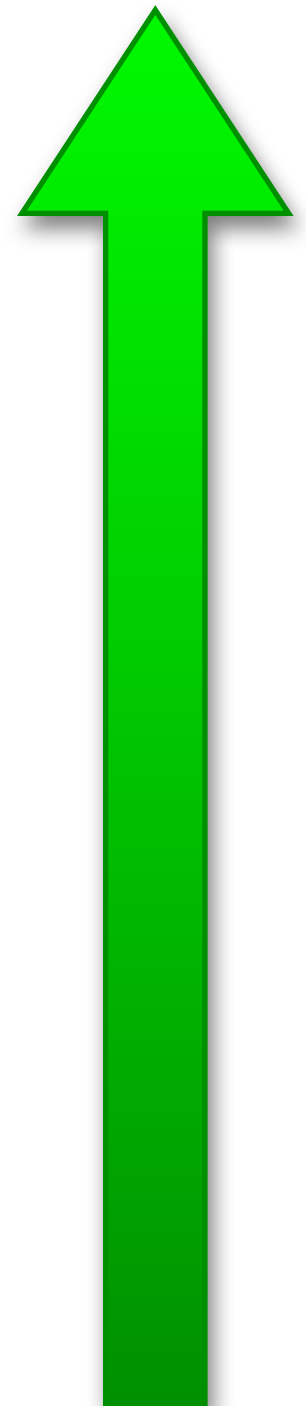
Class characterization



New results

Expressiveness

Silent transitions cannot be removed!

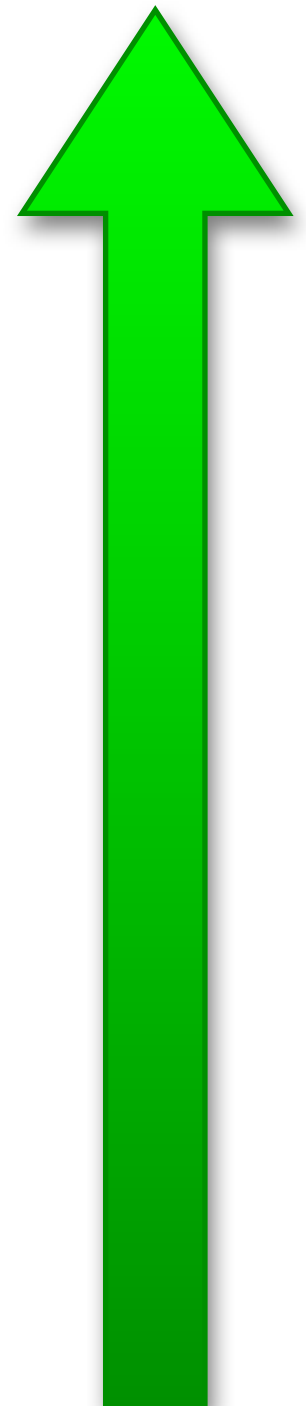


Expressiveness

Silent transitions cannot be removed!



Clocks resets



Expressiveness

Silent transitions cannot be removed!



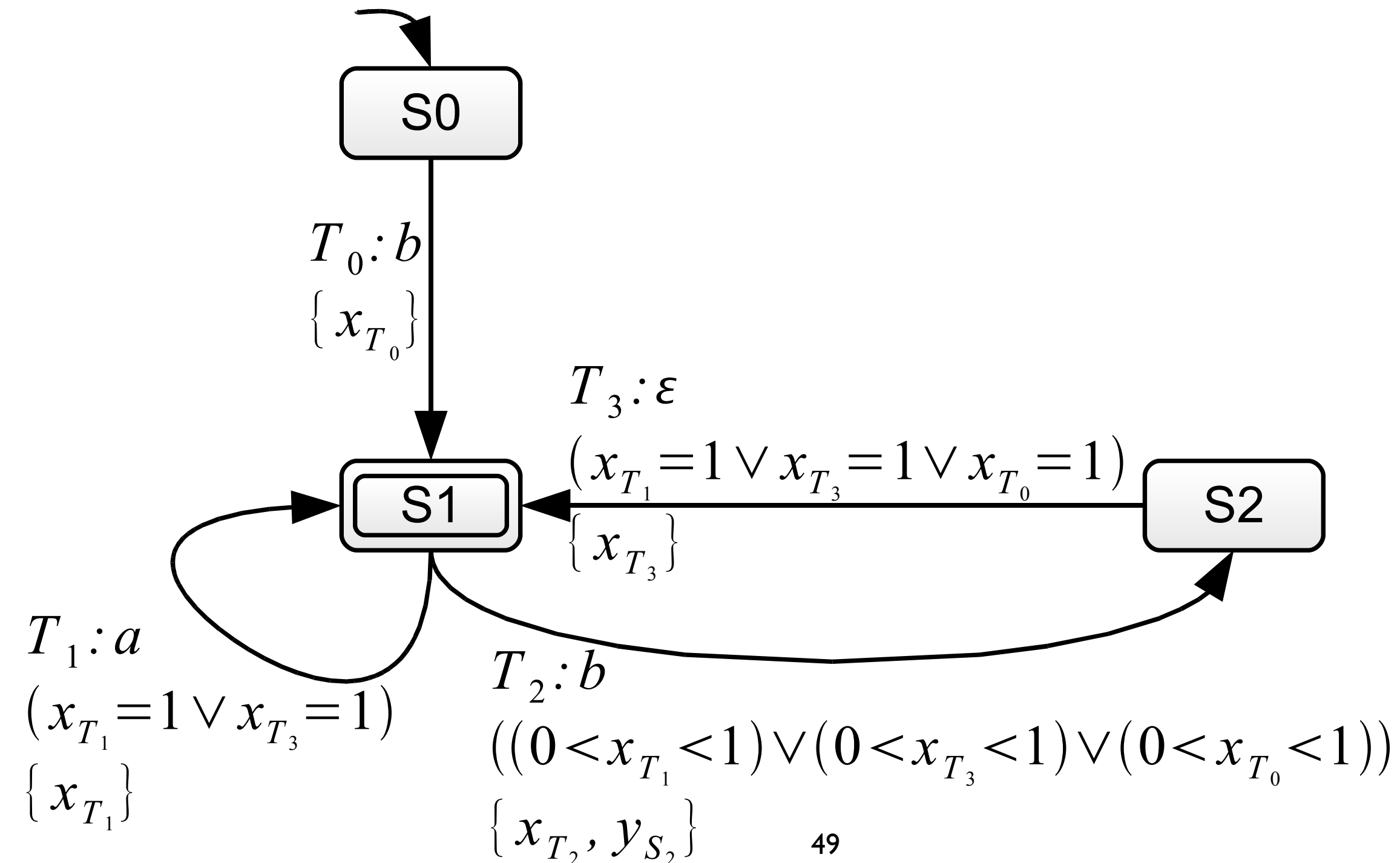
Clocks resets

Precise actions

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

Proof sketch

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



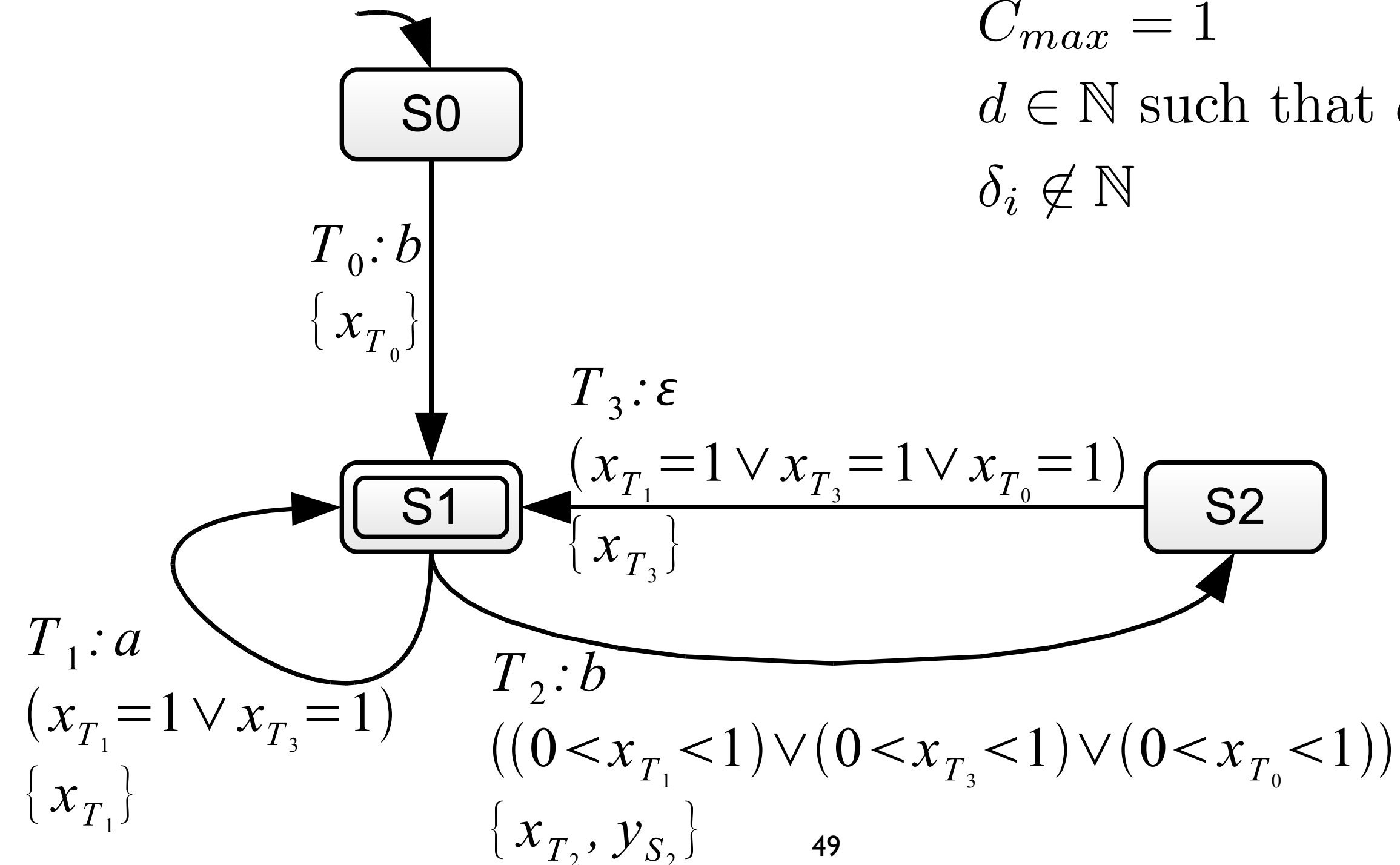
Proof sketch

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

$$C_{max} = 1$$

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

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



Proof sketch

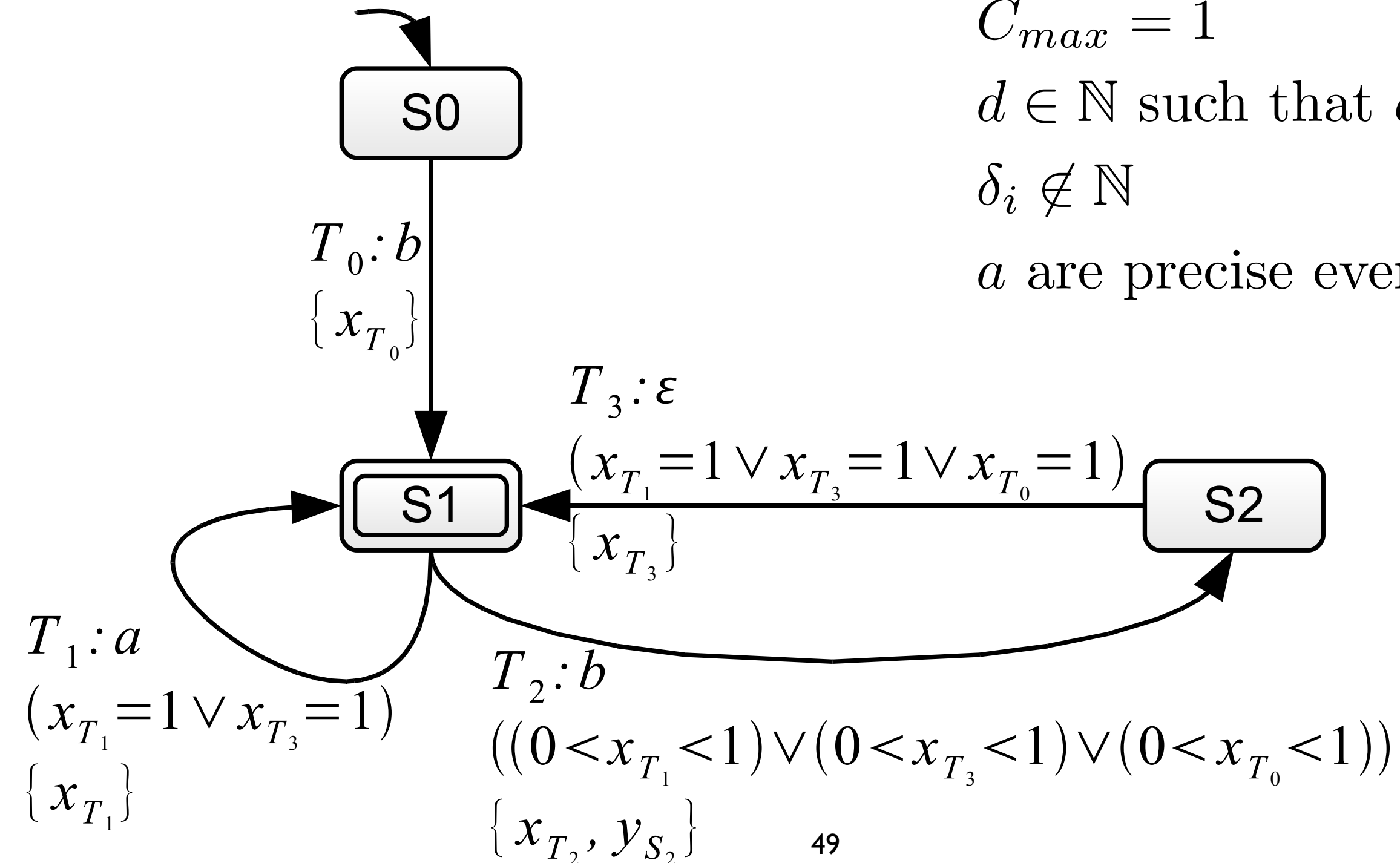
$$(b, \delta_1) \cdot (b, \delta_2) \cdots (b, \delta_{d-1}) \cdot (a, d) \cdot (a, d+1) \cdots$$

$$C_{max} = 1$$

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

a are precise events



Proof sketch

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

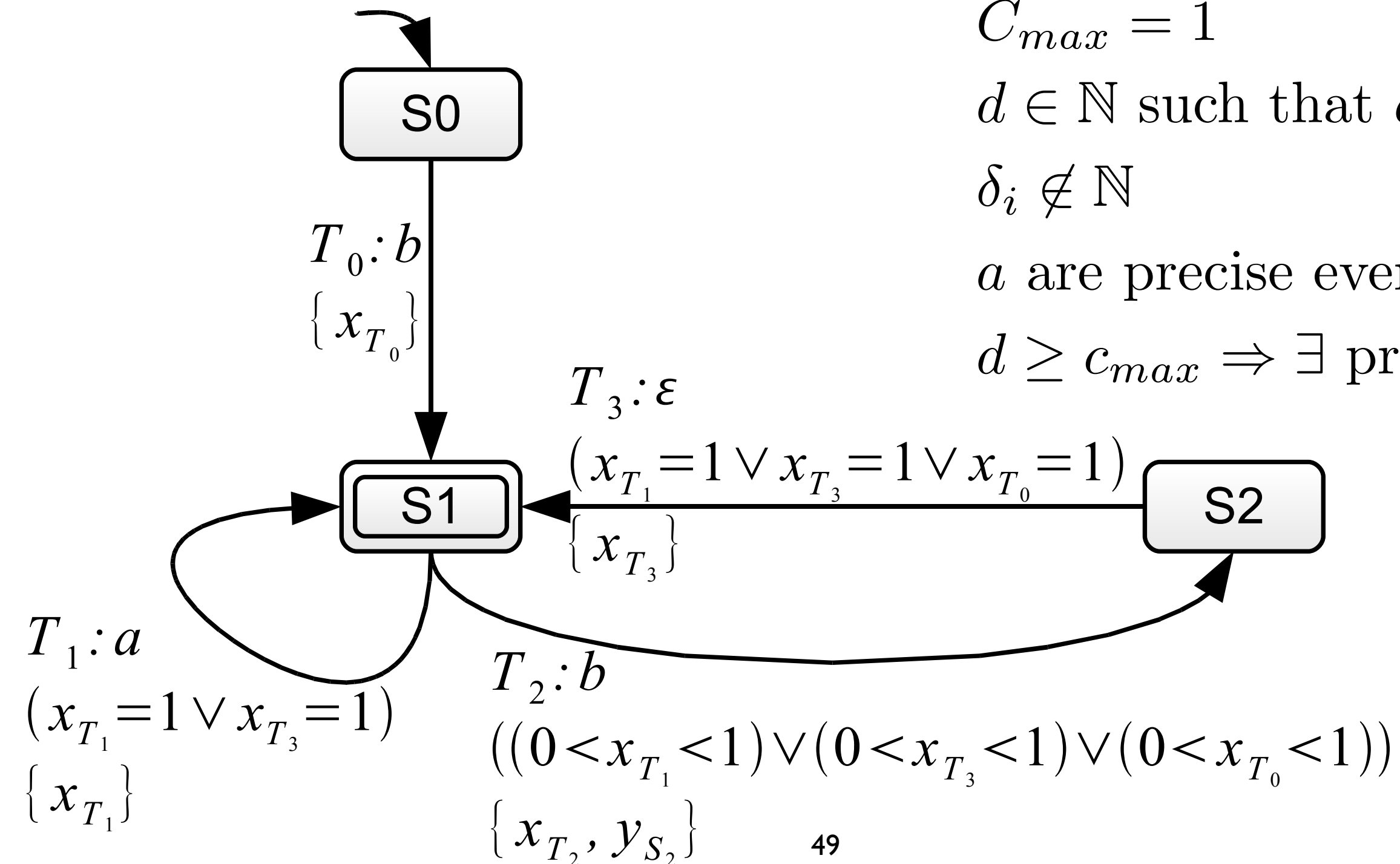
$$C_{max} = 1$$

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

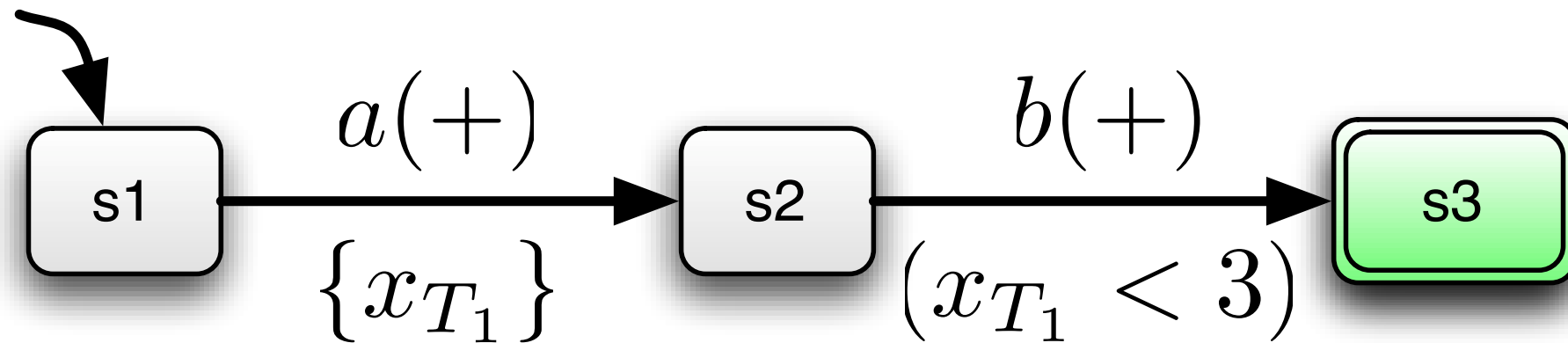
$$\delta_i \notin \mathbb{N}$$

a are precise events

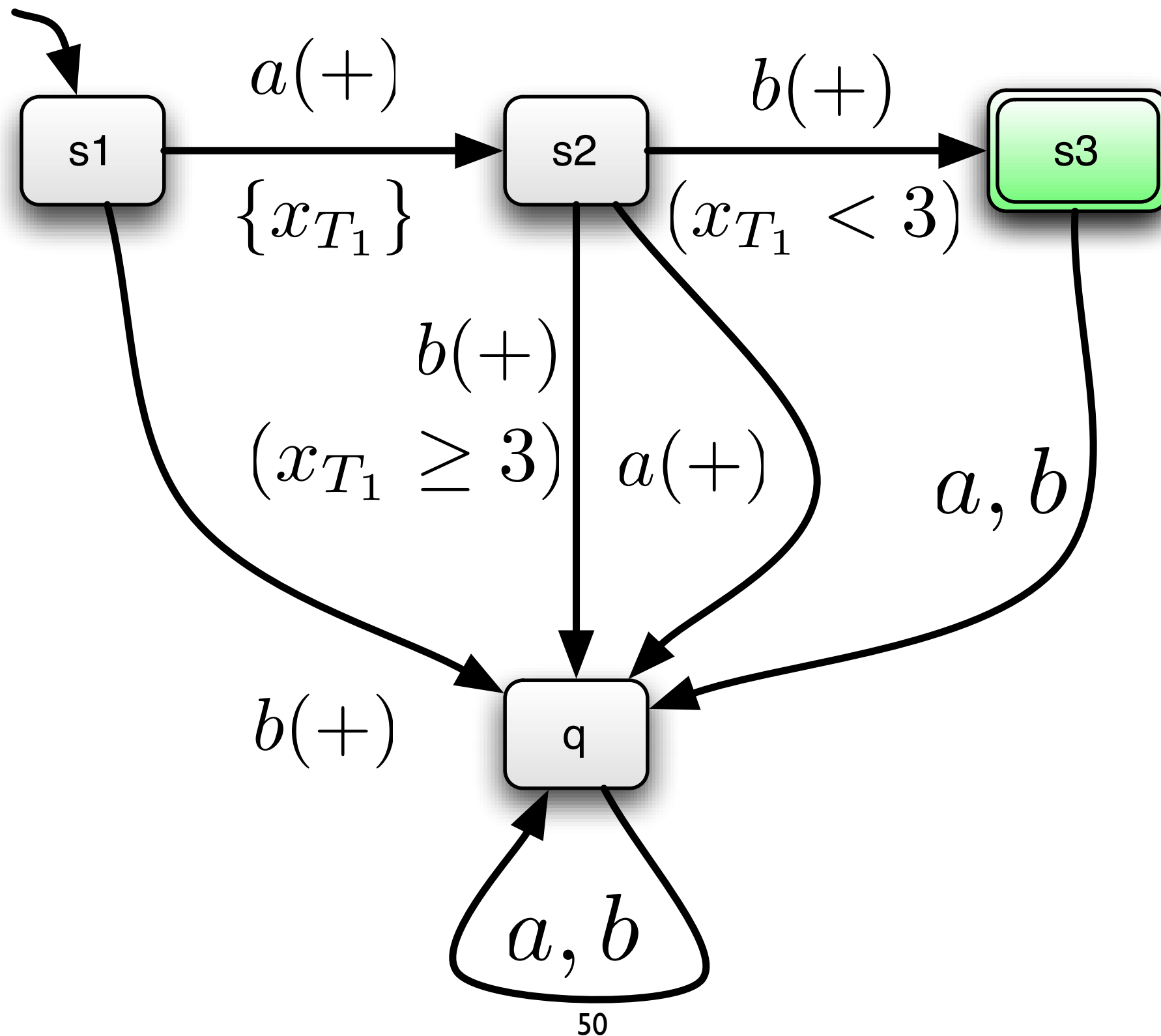
$$d \geq c_{max} \Rightarrow \exists \text{ precise } b$$



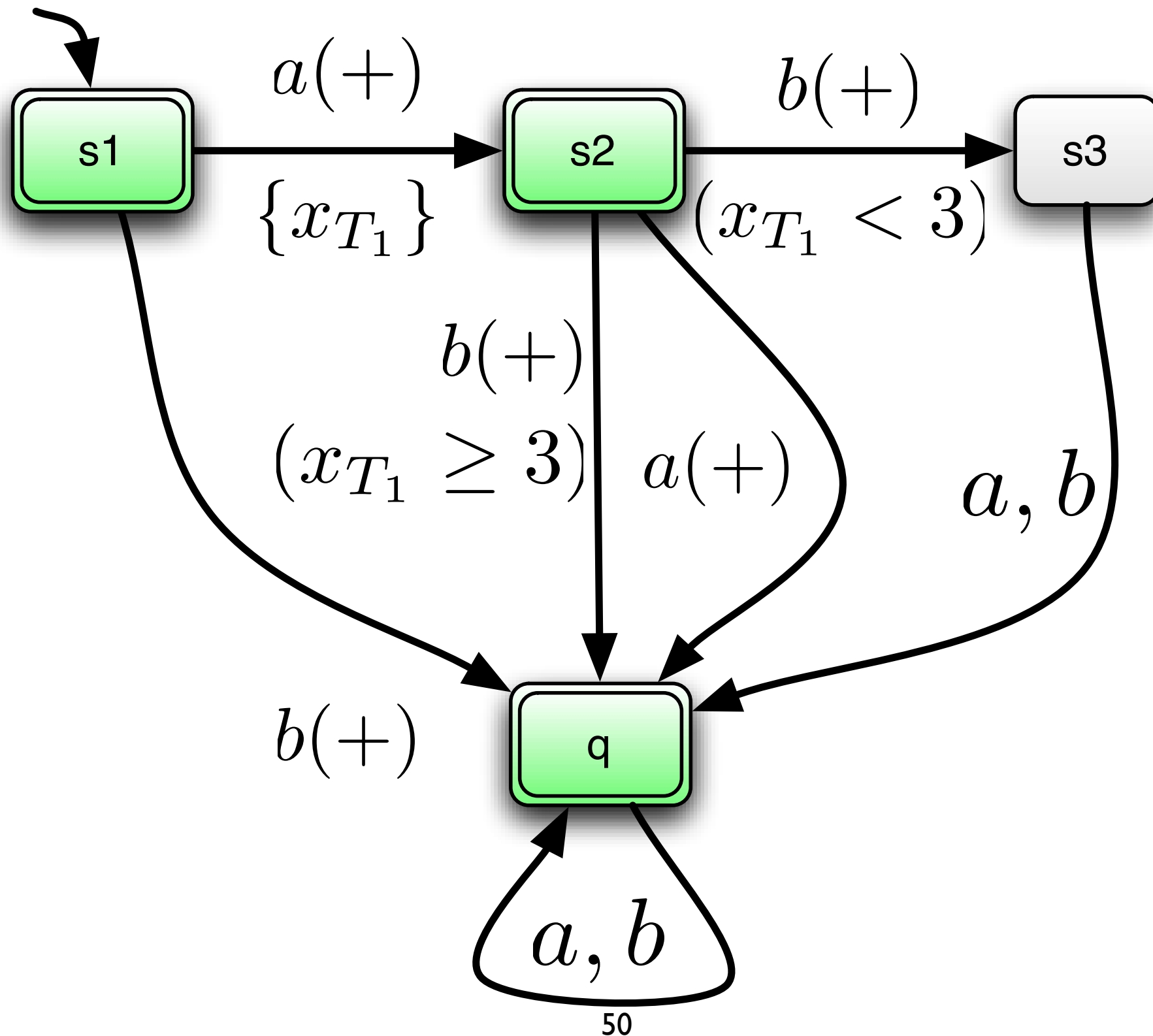
Complementation



Complementation



Complementation



Closure: complementation

“one run per
timed word”



Closure: complementation

“one run per
timed word”



MInvoke make
precise!



MInvoke(**T1 = 3h** and $T2 < 25m$)

Protocol timed automata



1 clock per switch

“1 clock per location”

Restricted form of unremovable silent transitions

Deterministic behavior

Closed under complementation!

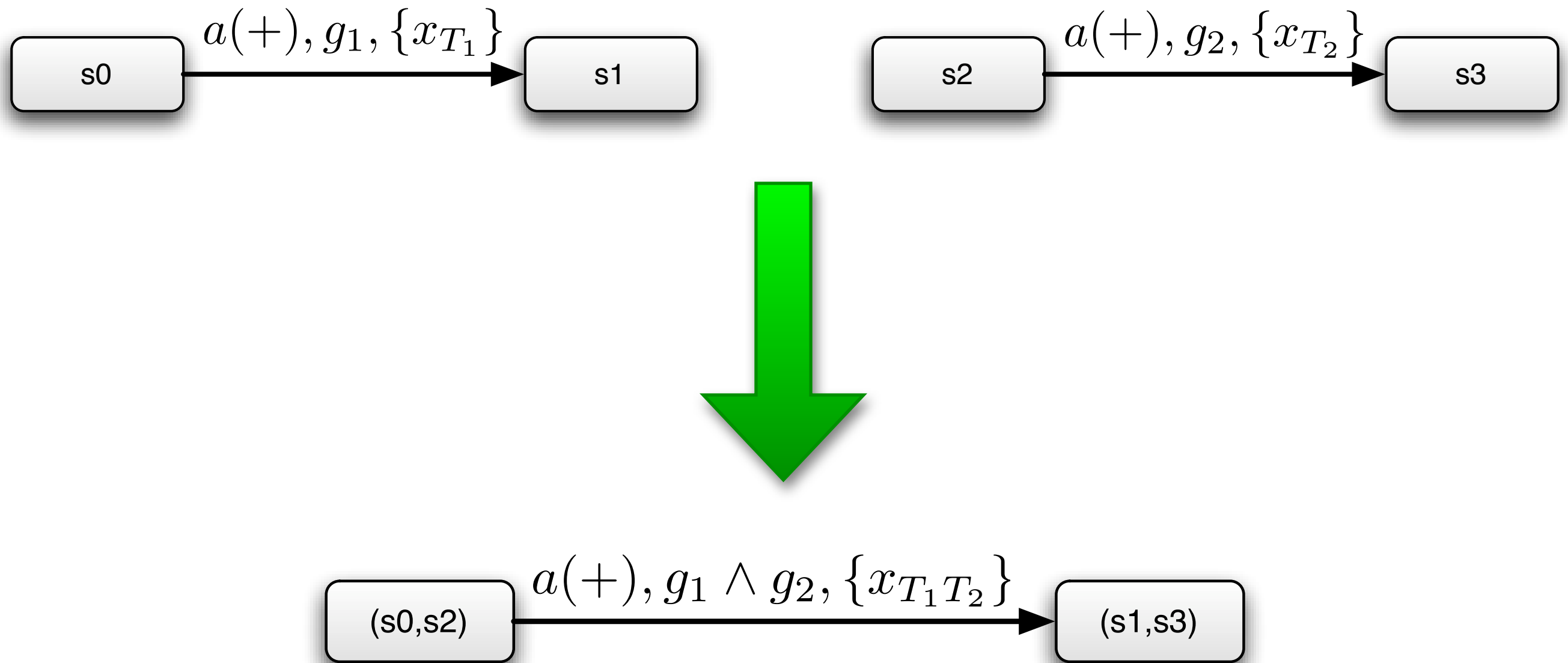
Protocol operators



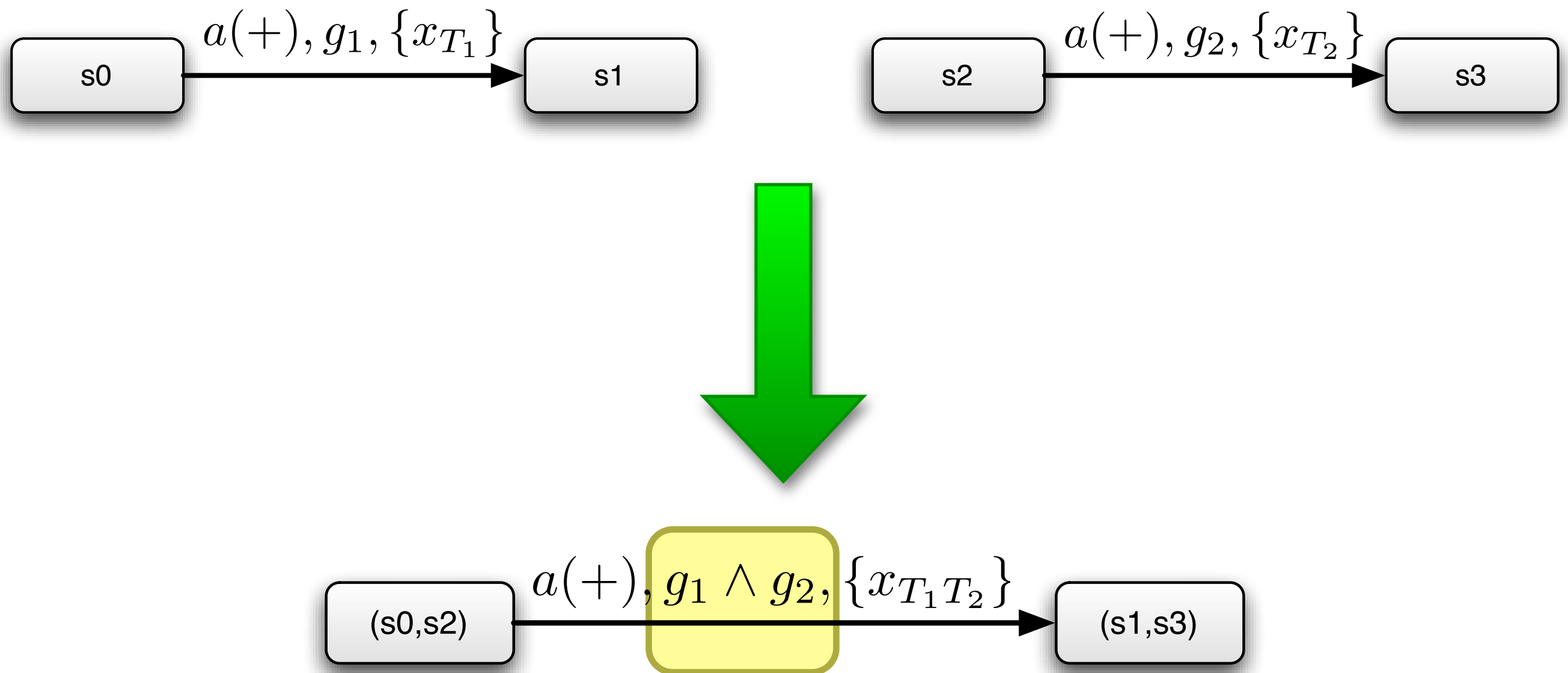
Intersection



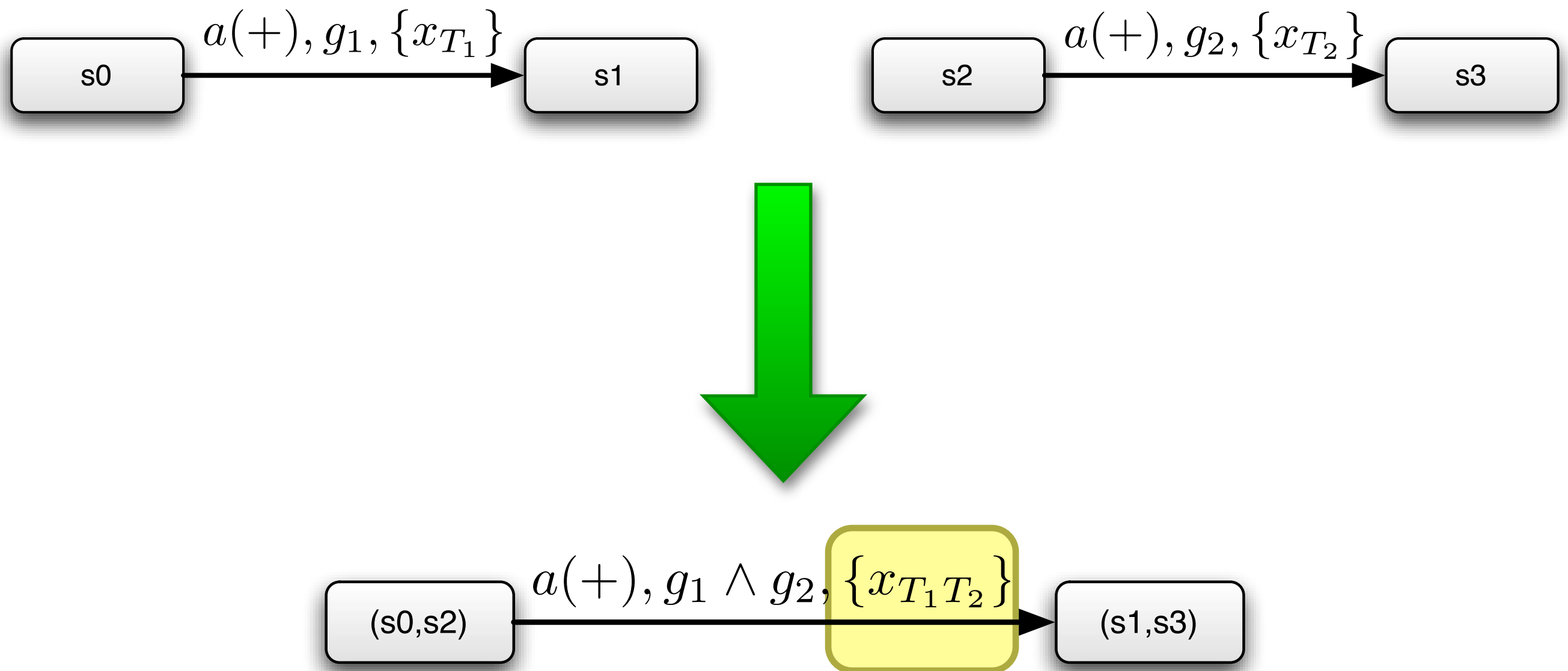
Intersection



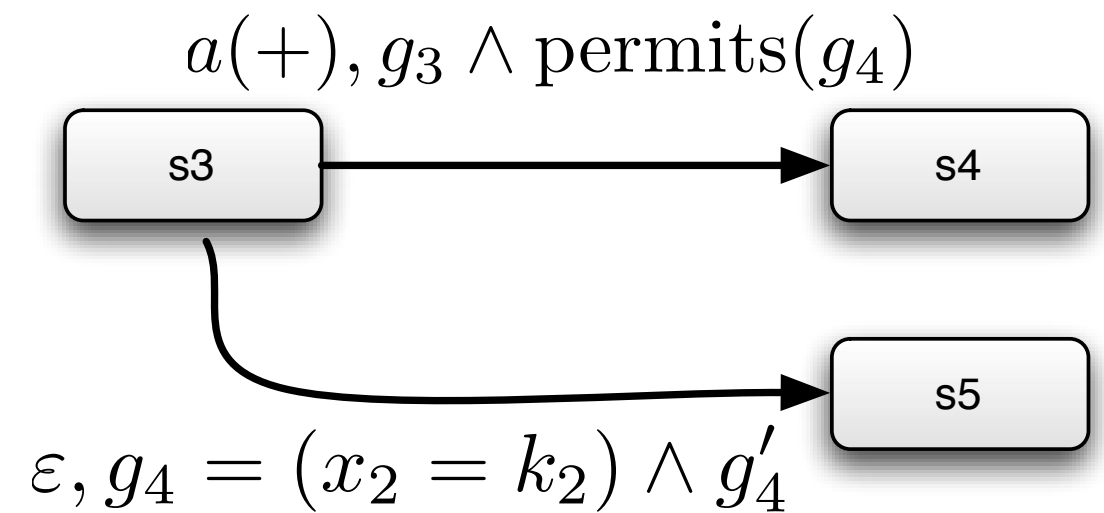
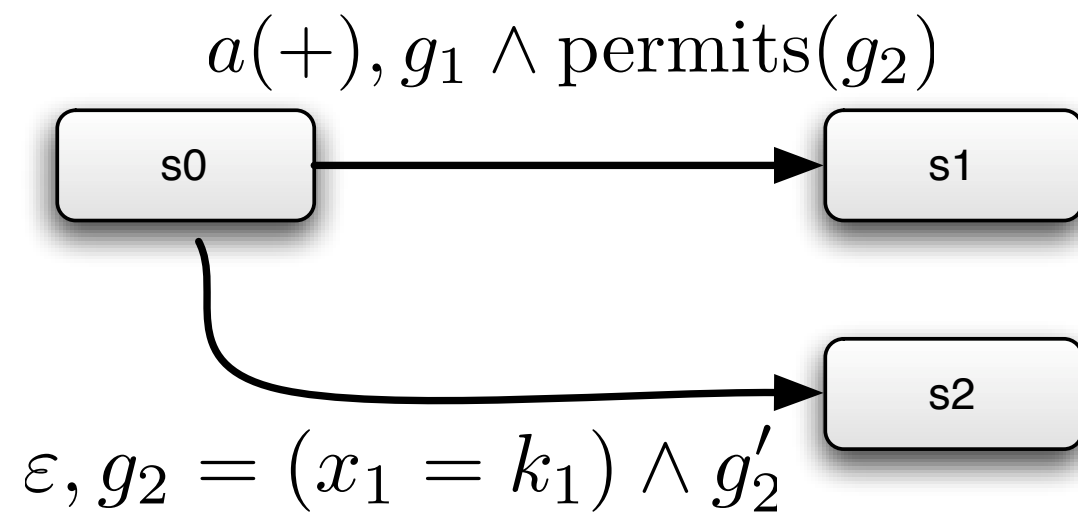
Intersection



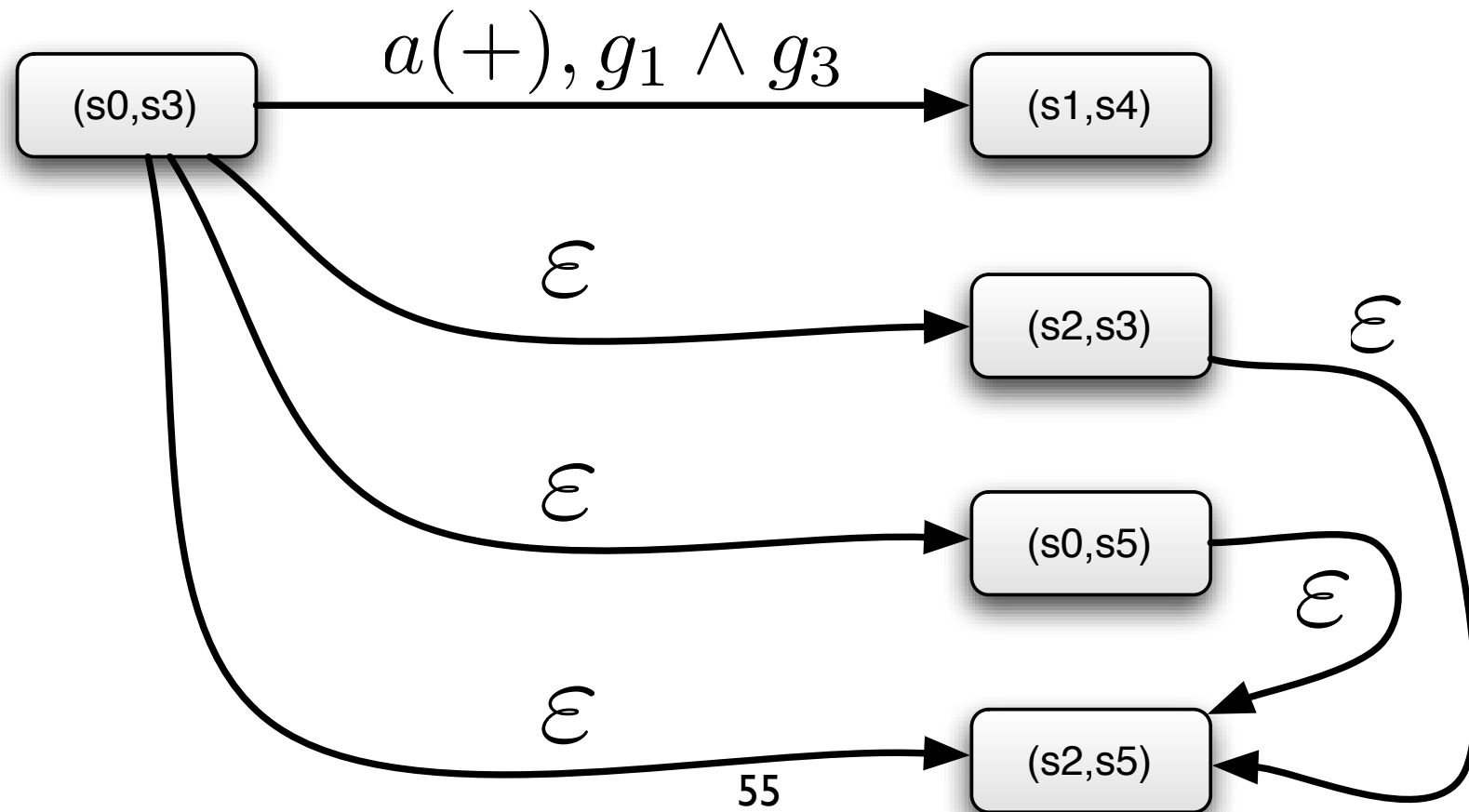
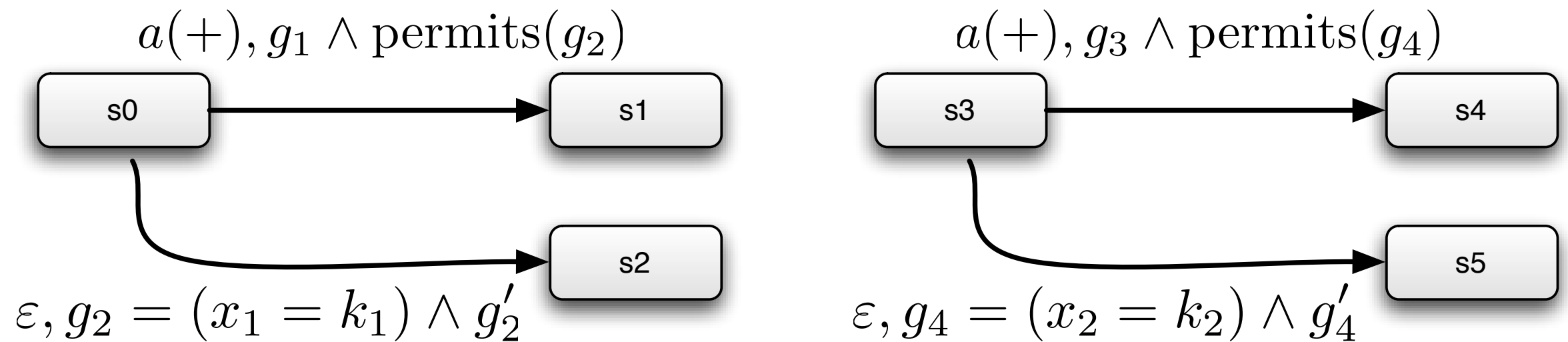
Intersection



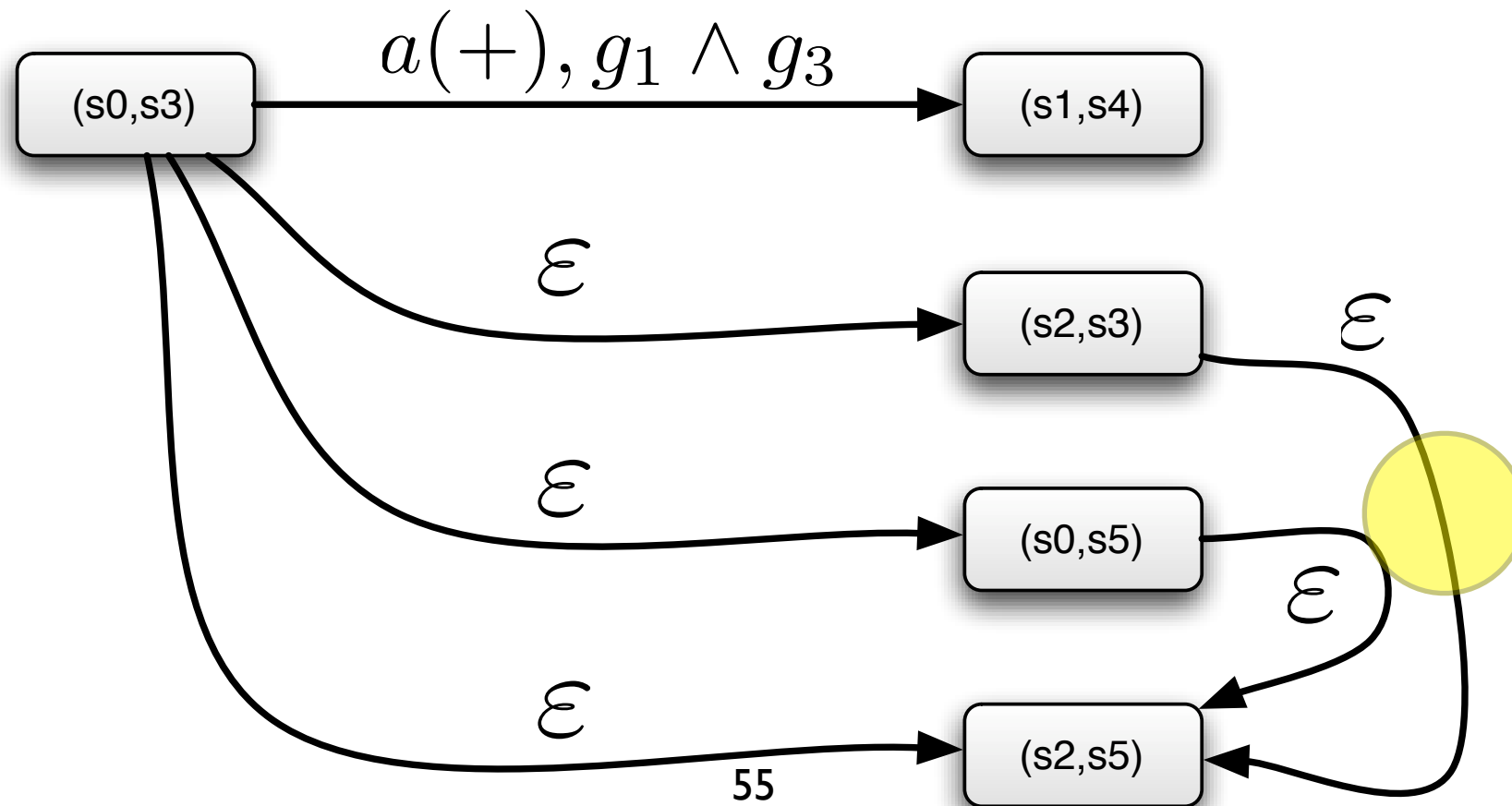
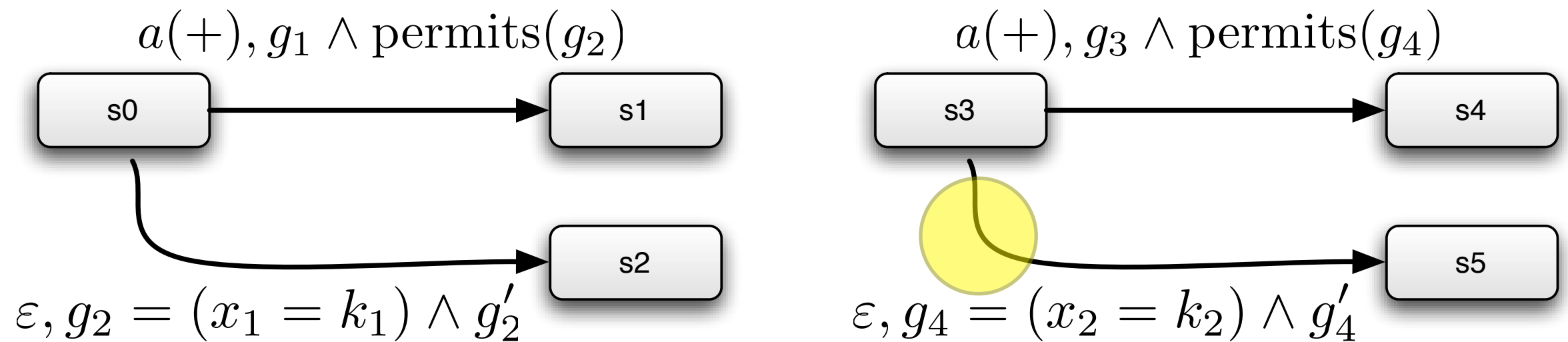
Intersection



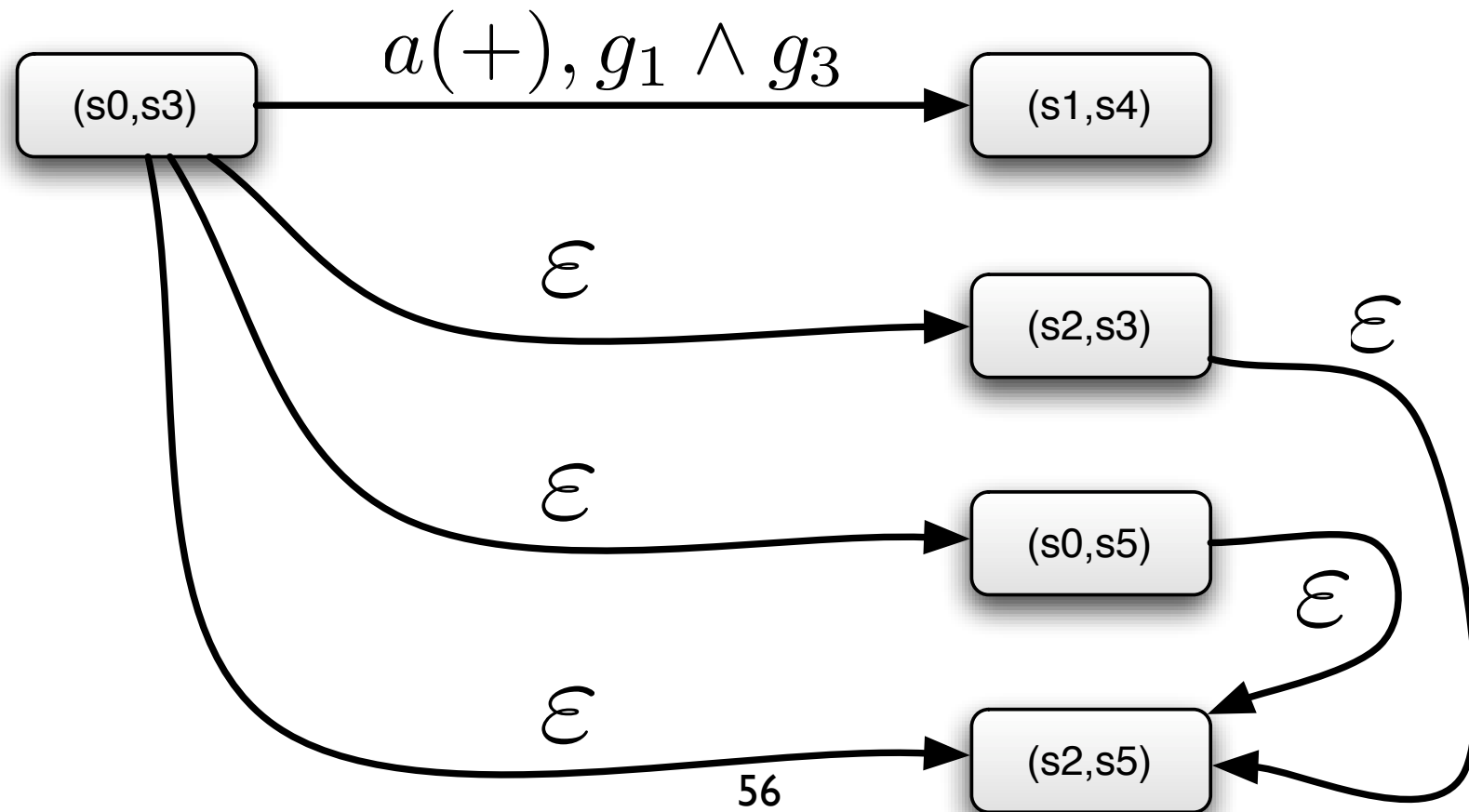
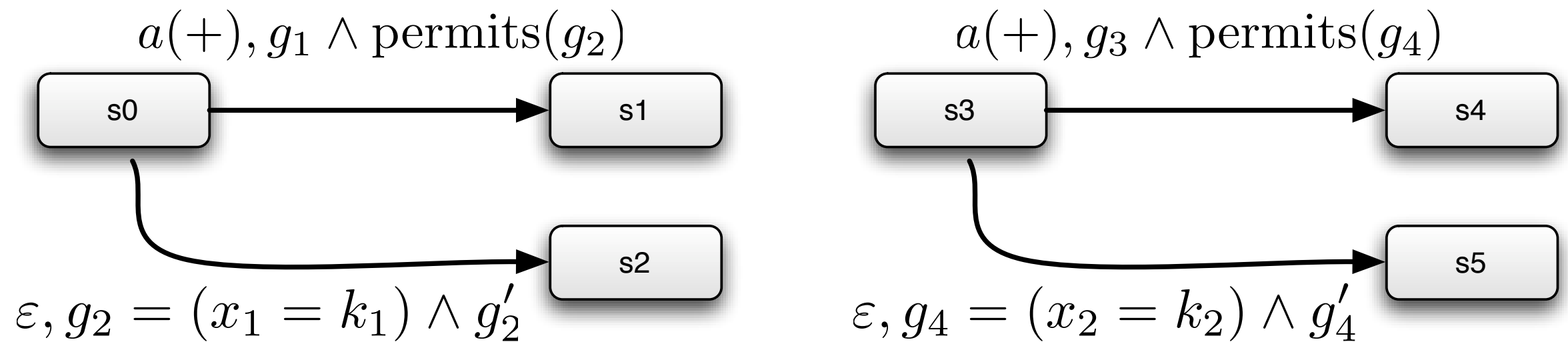
Intersection



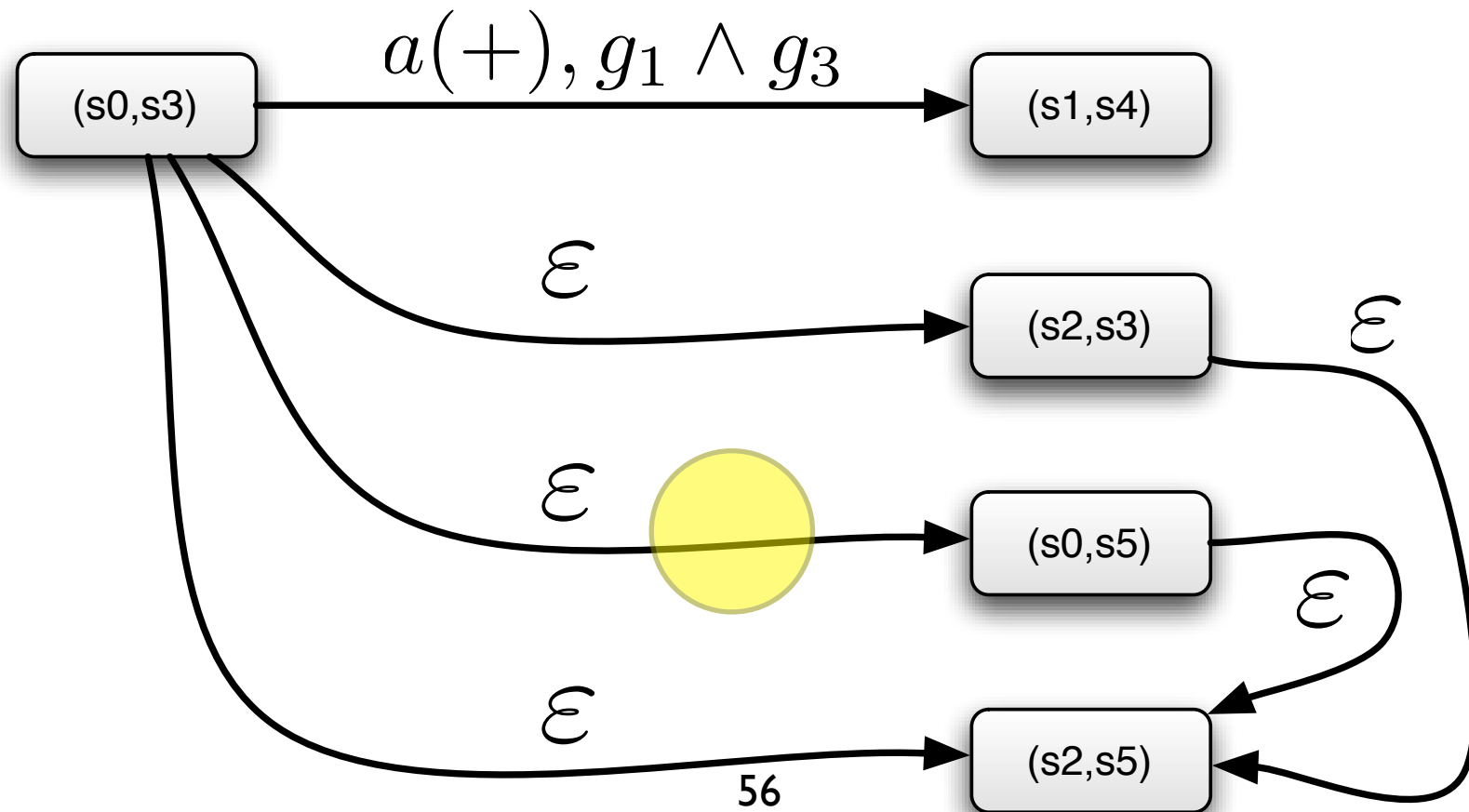
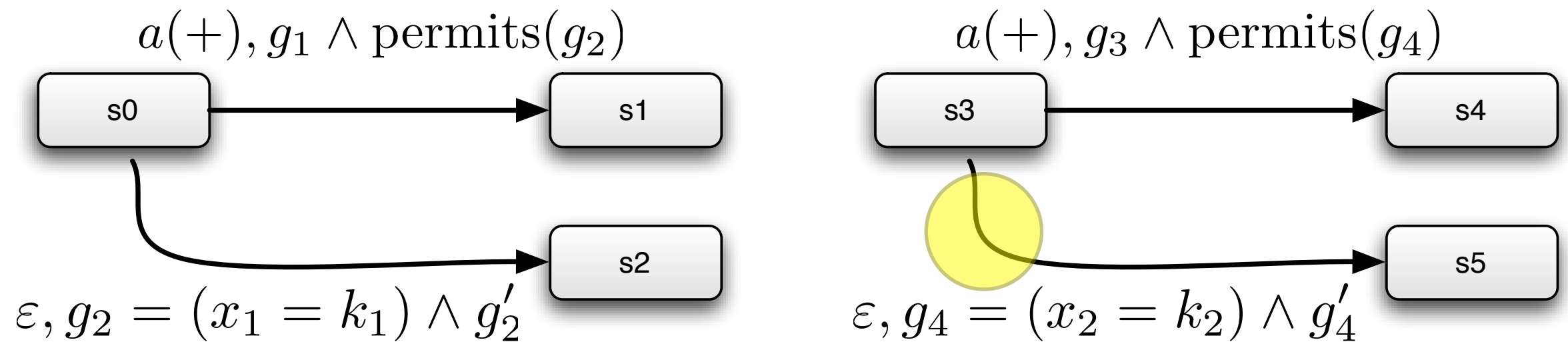
Intersection



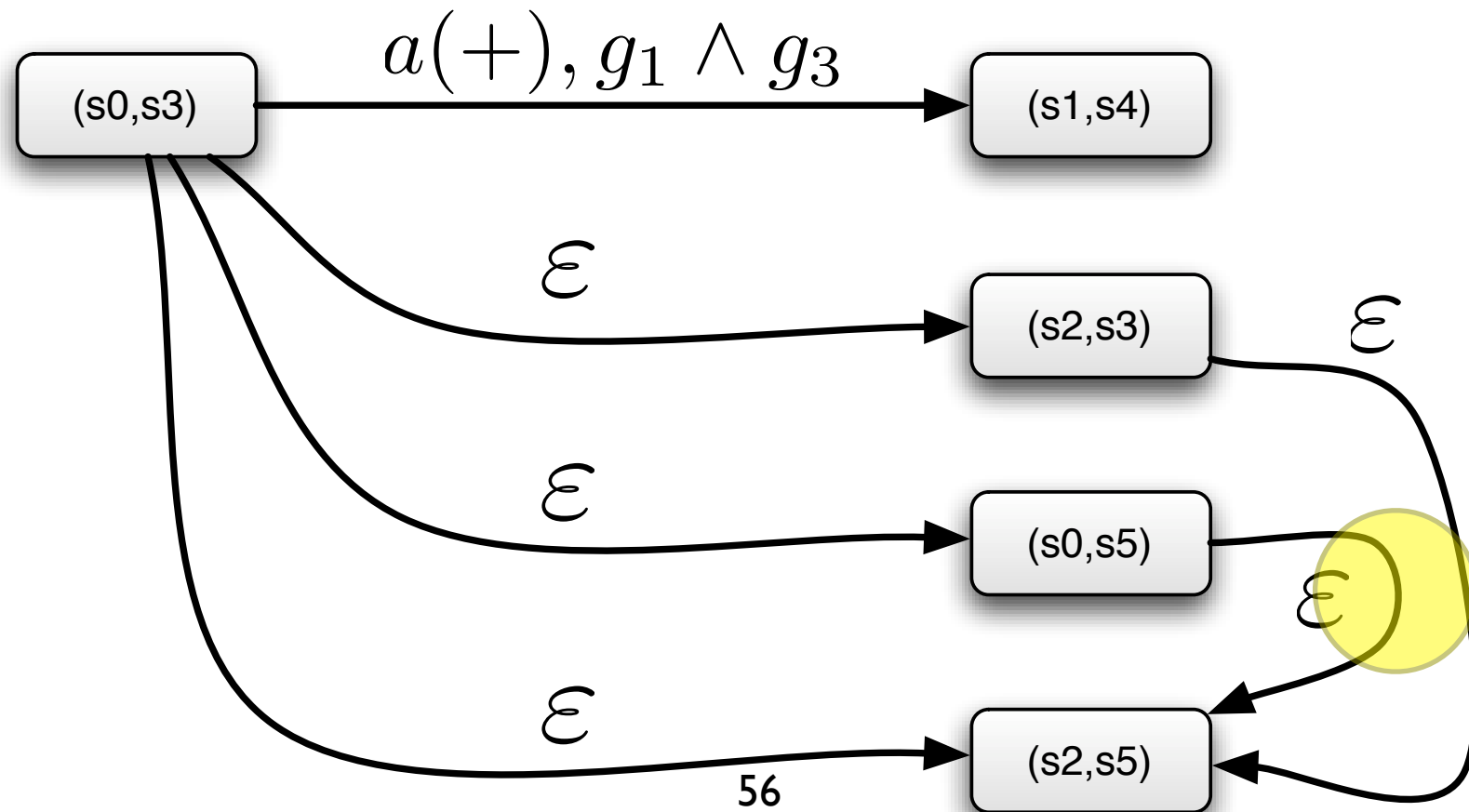
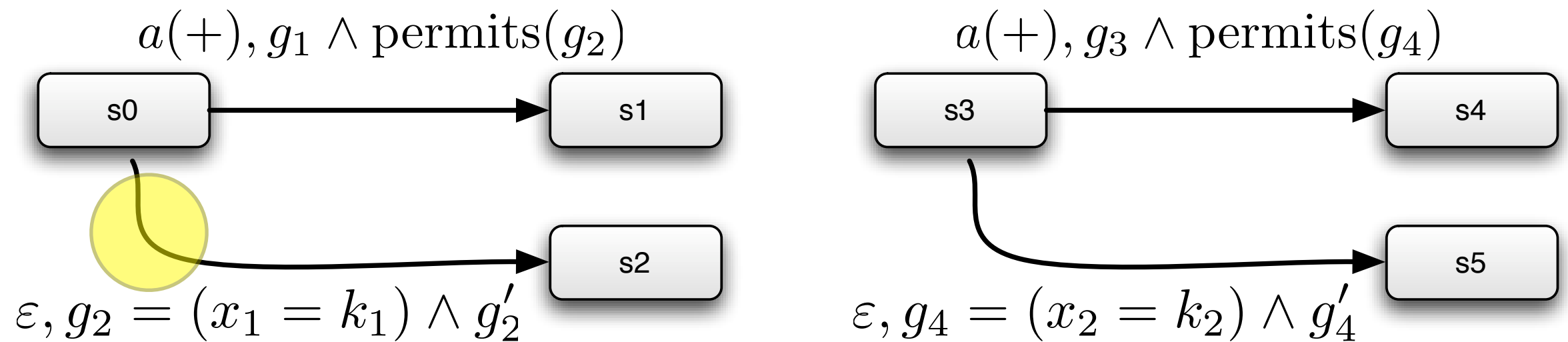
Intersection



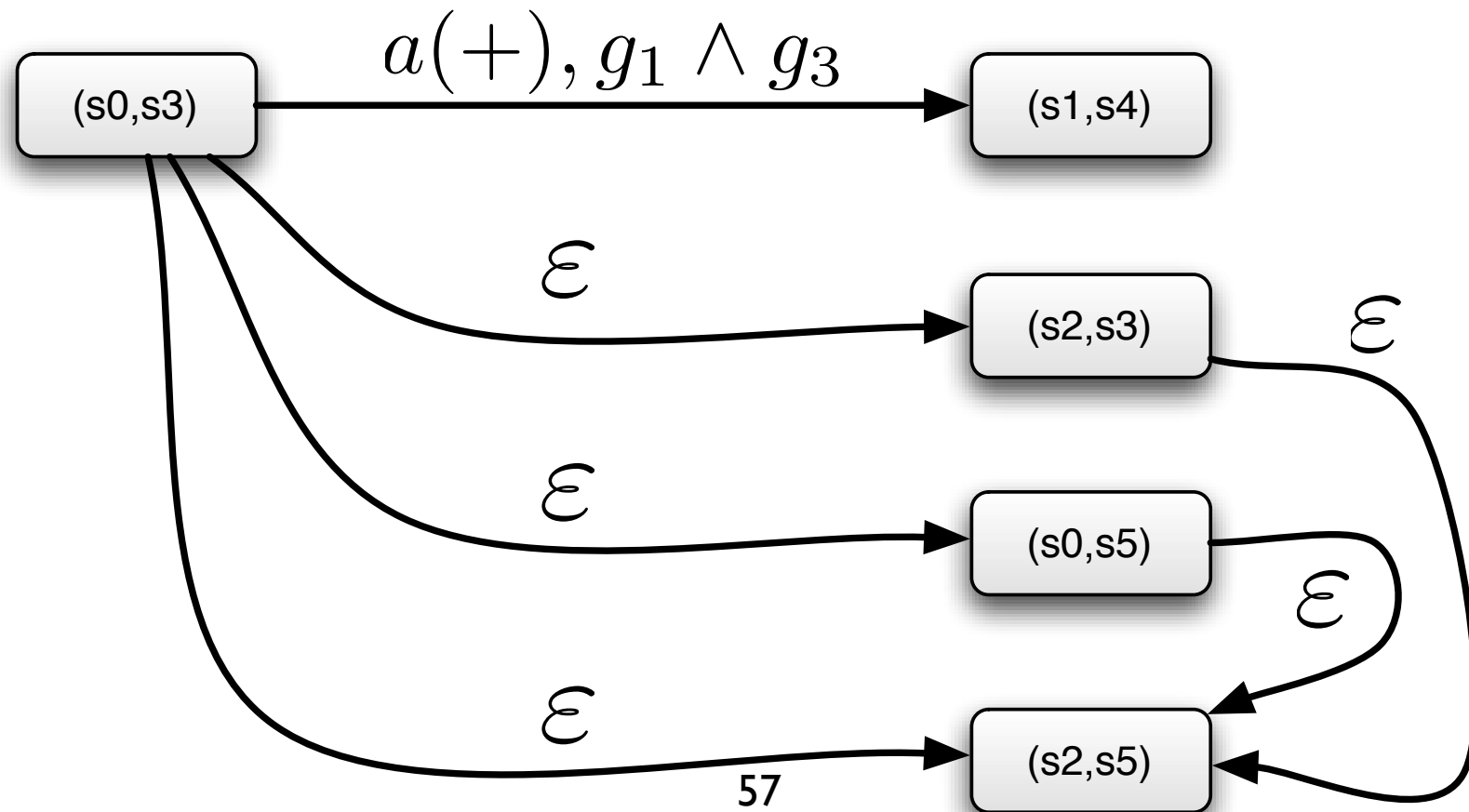
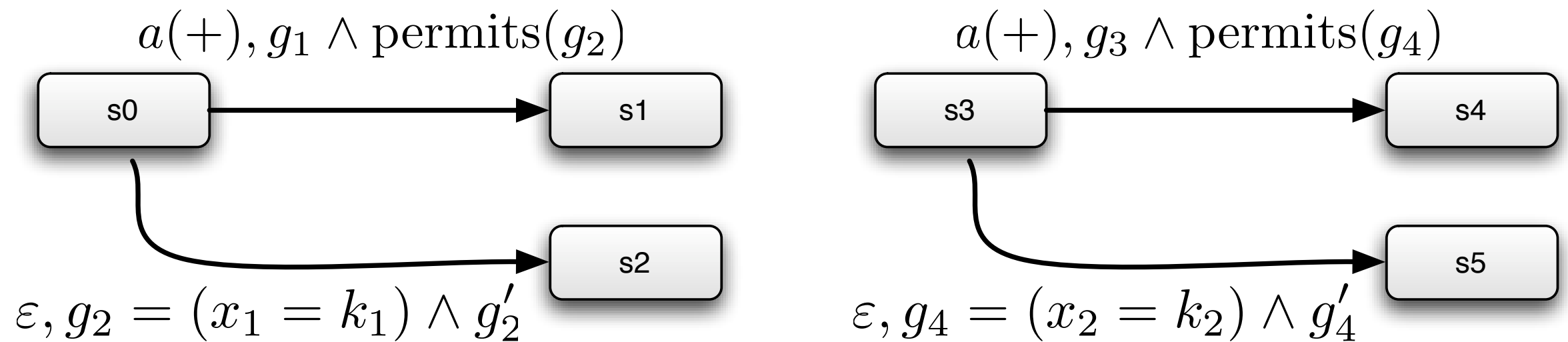
Intersection



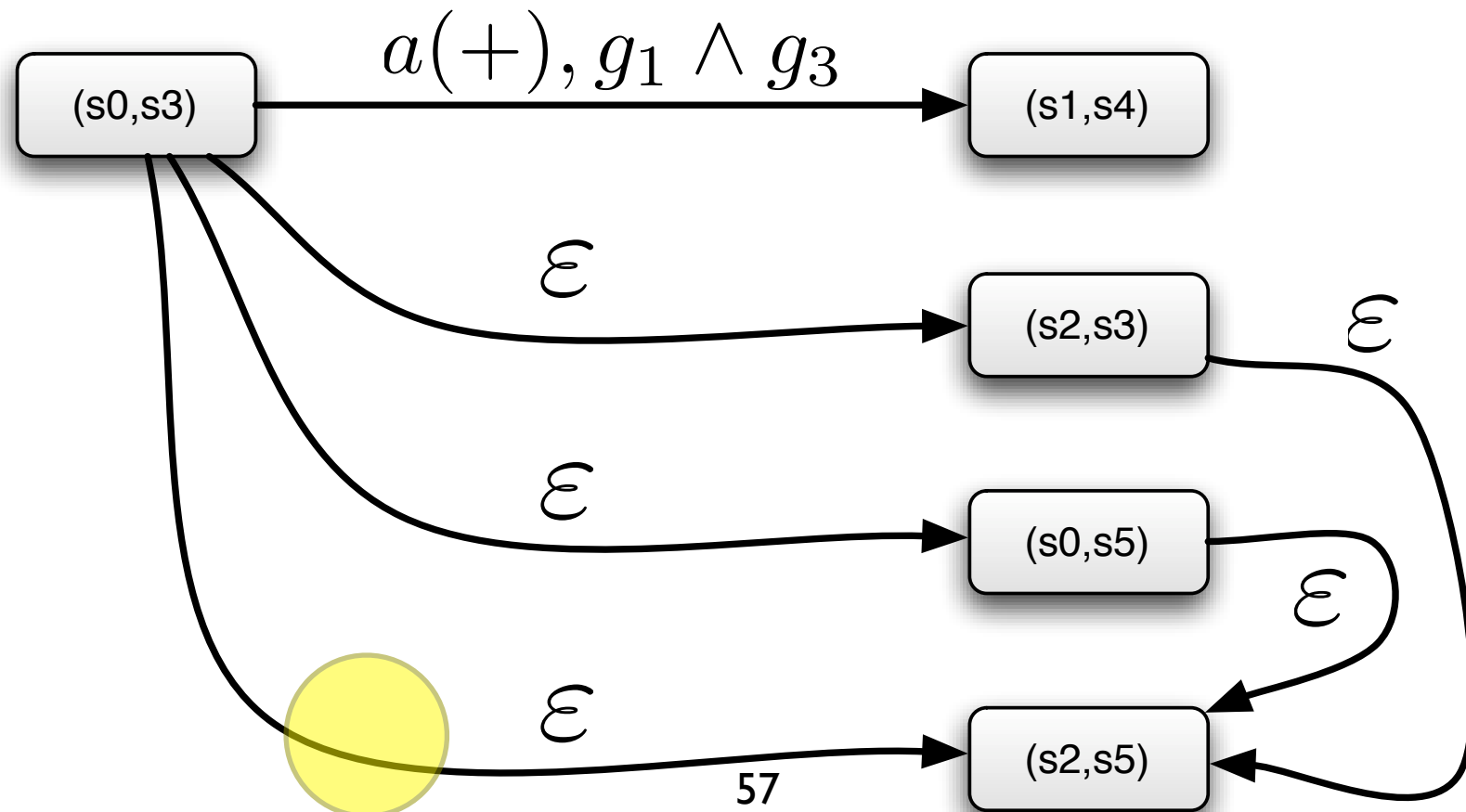
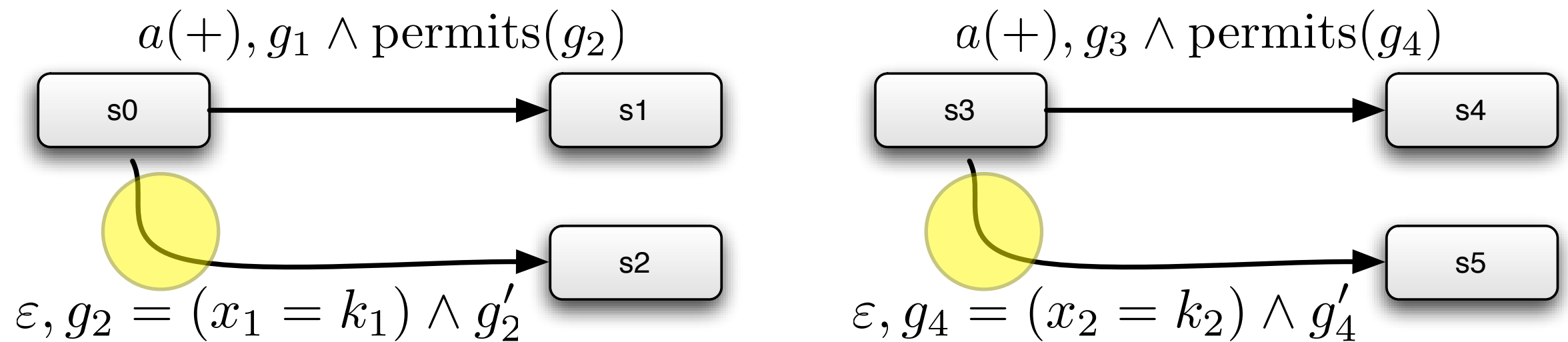
Intersection



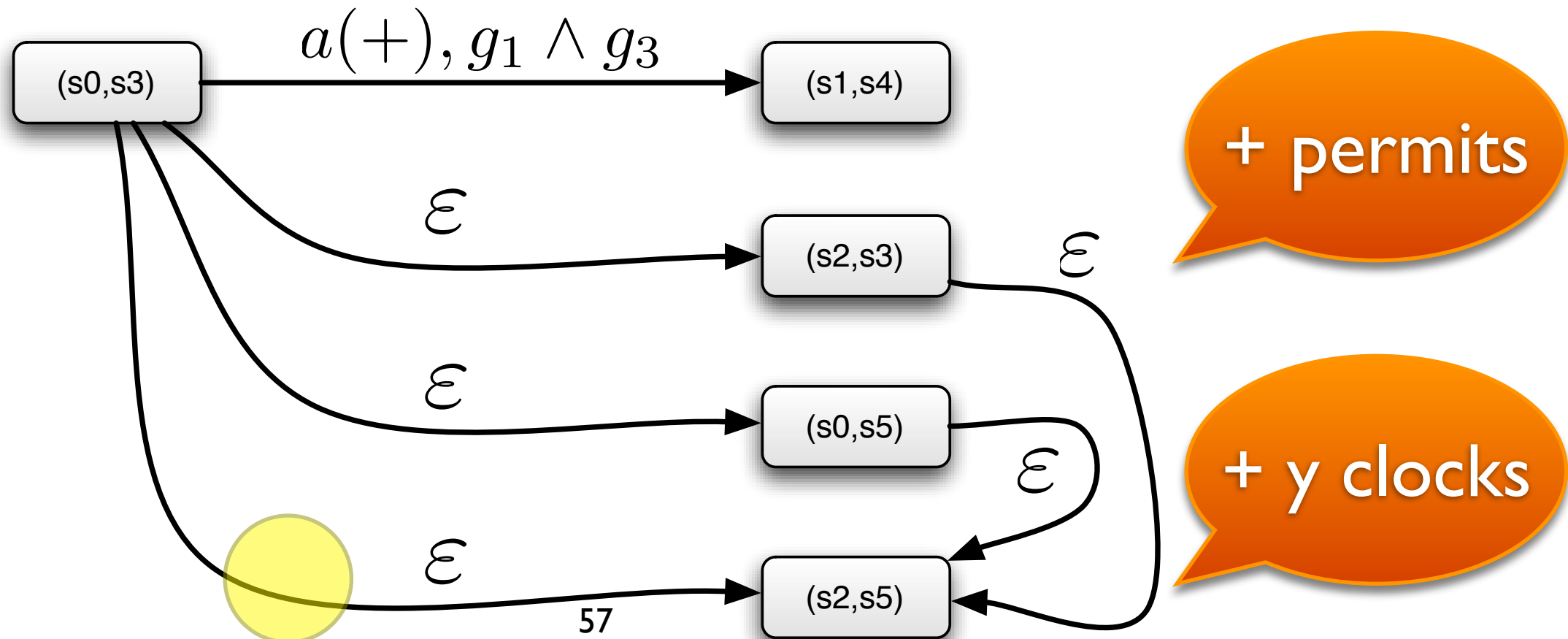
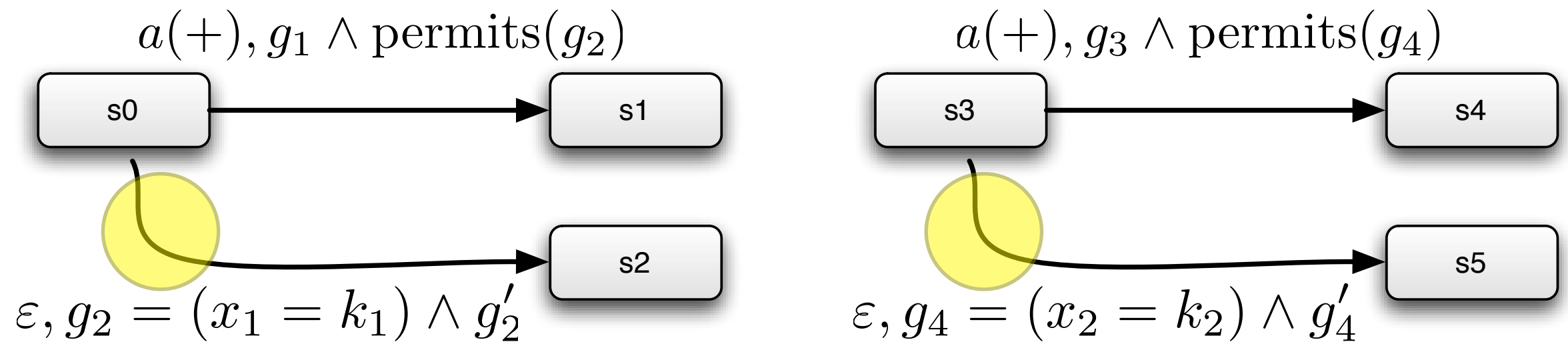
Intersection



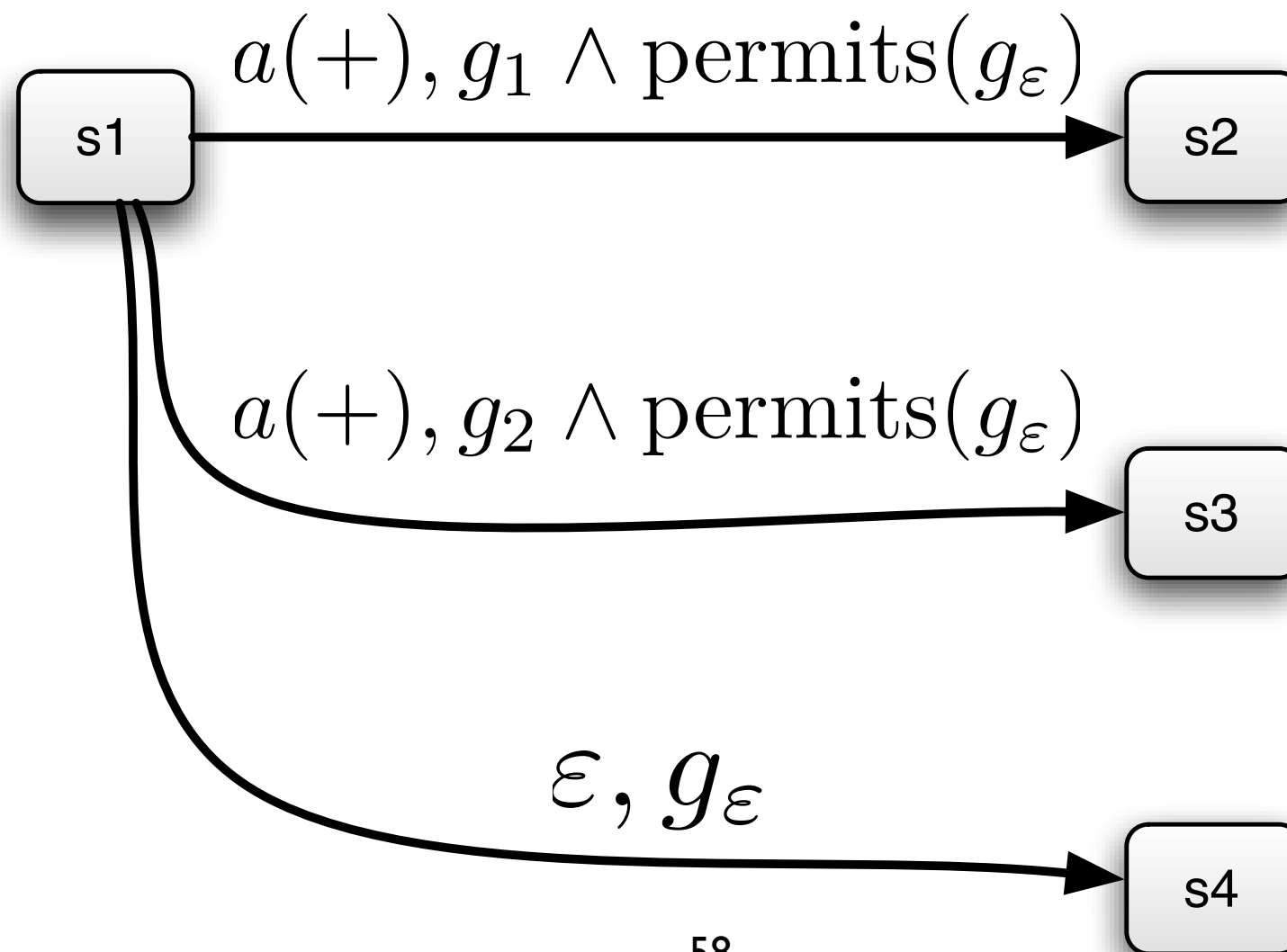
Intersection



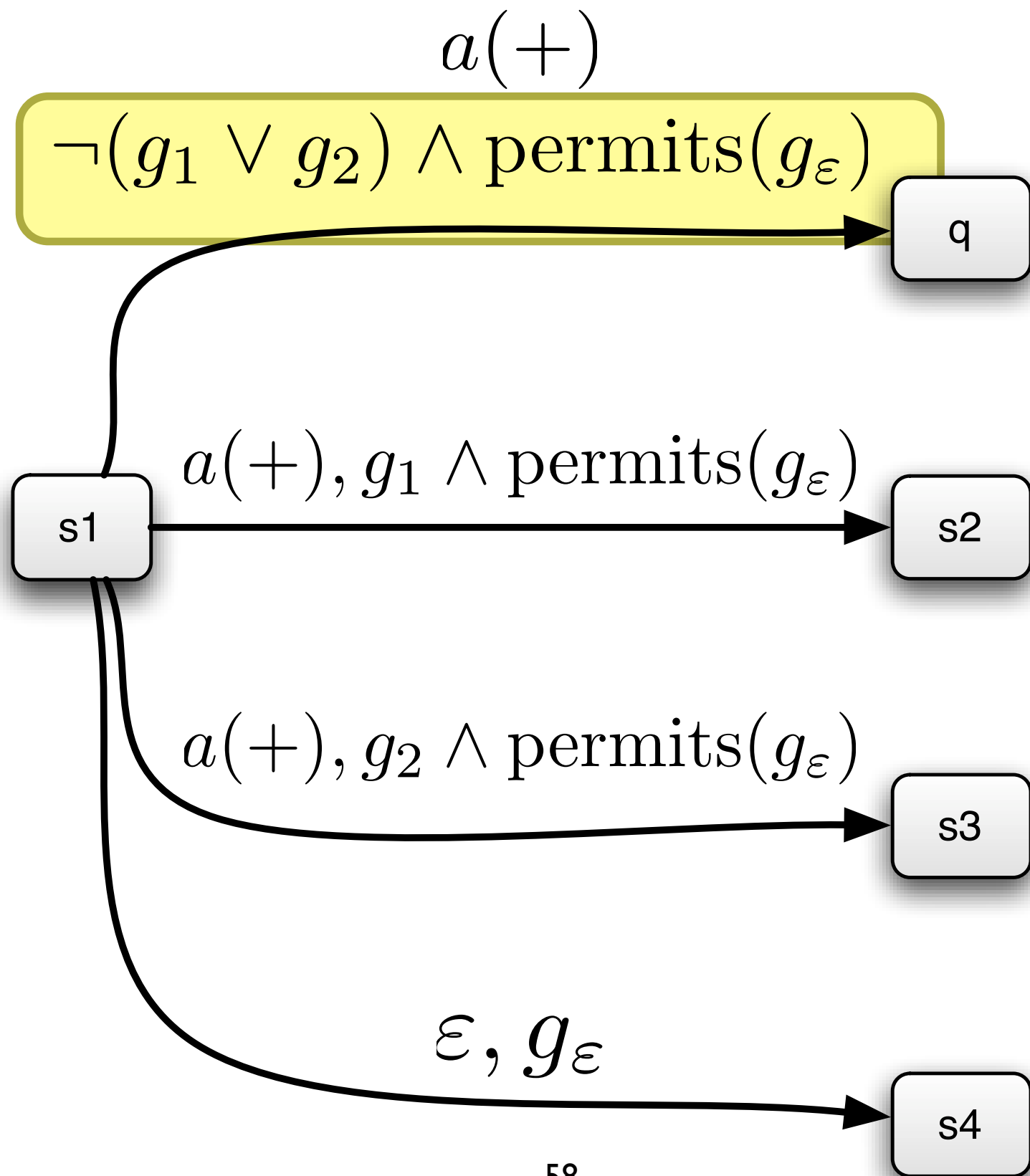
Intersection



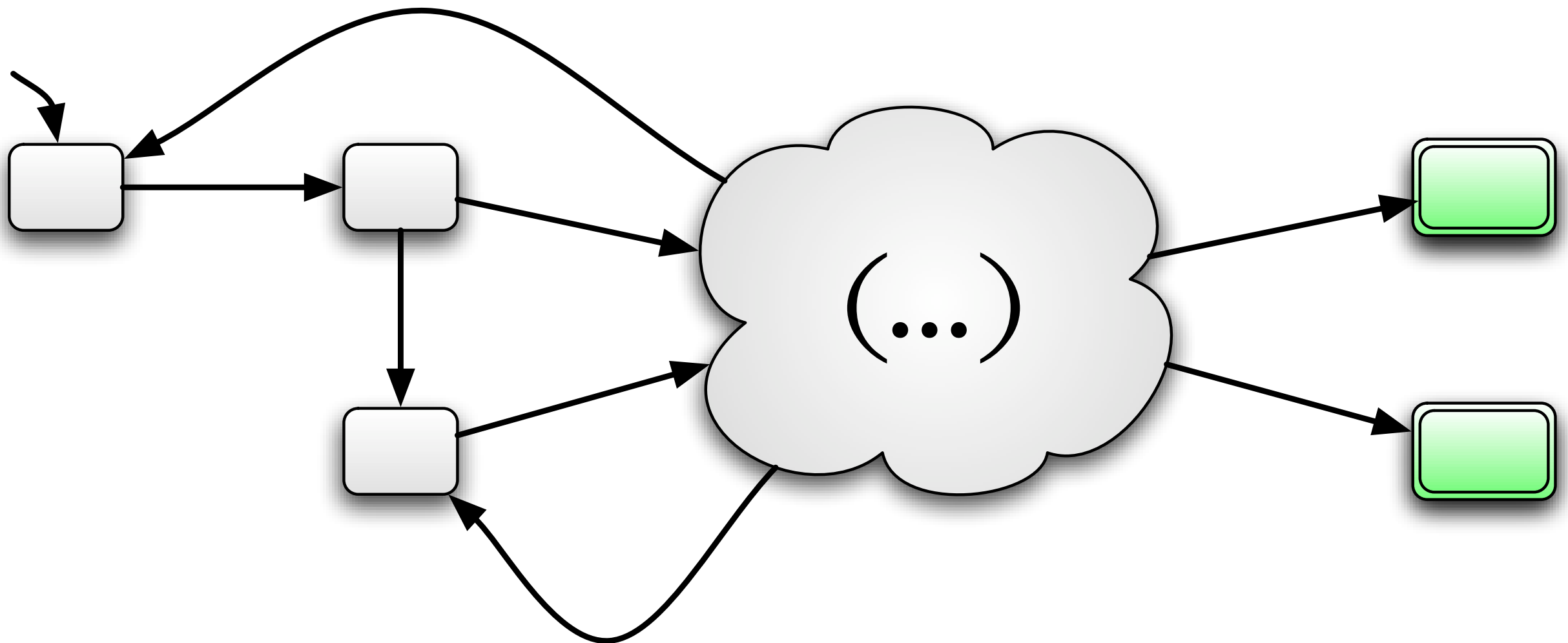
Complementation



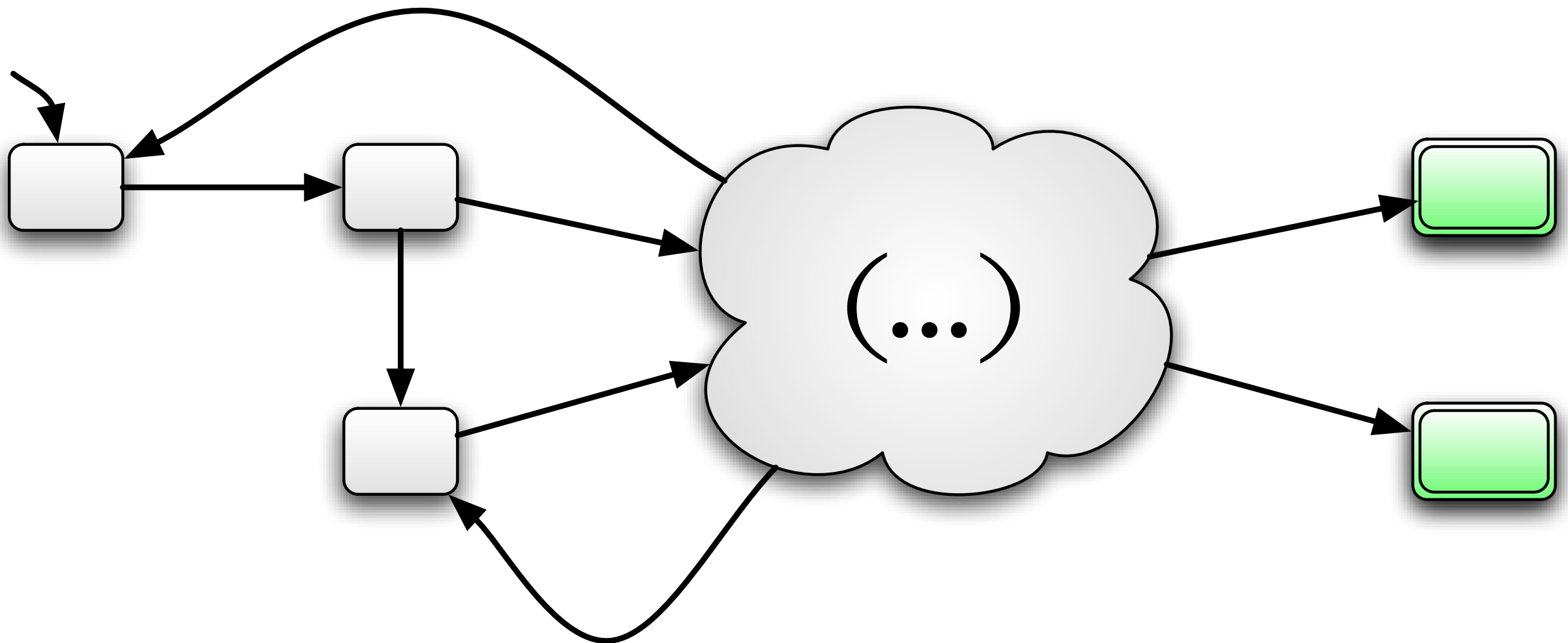
Complementation



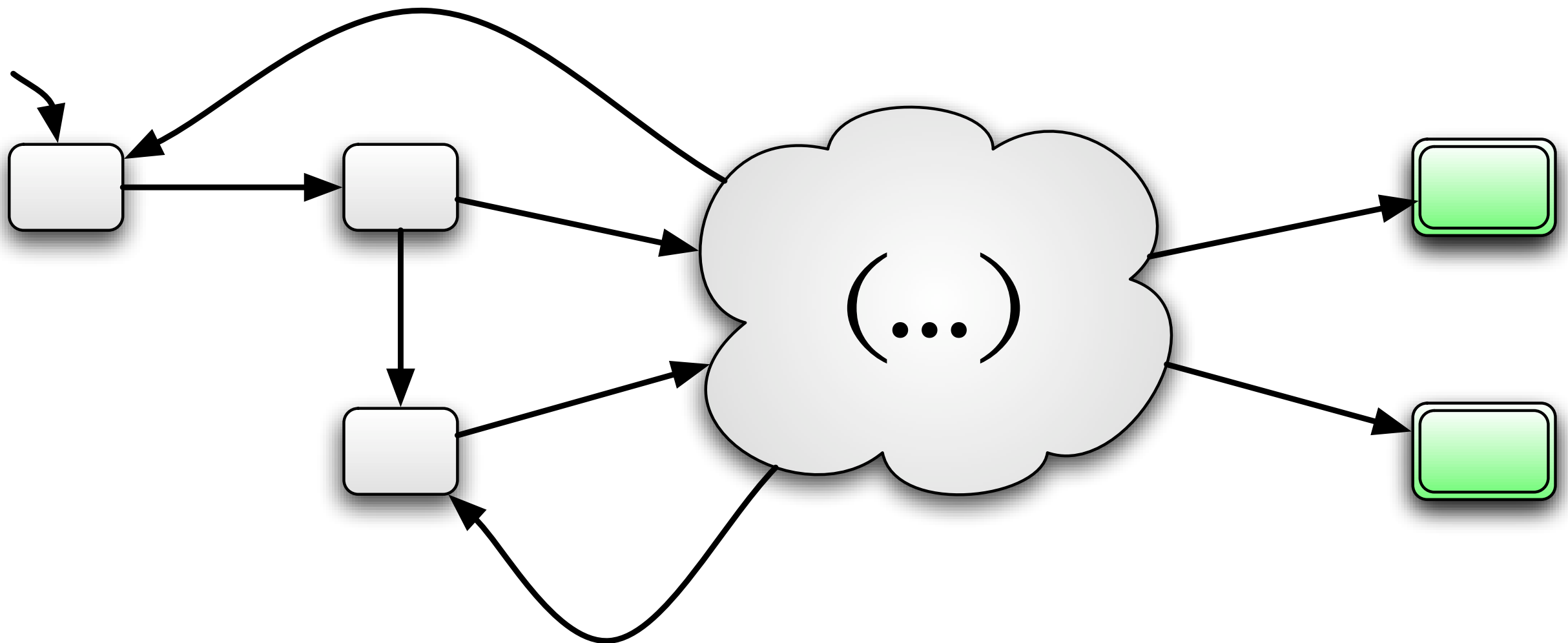
Emptiness checking



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)

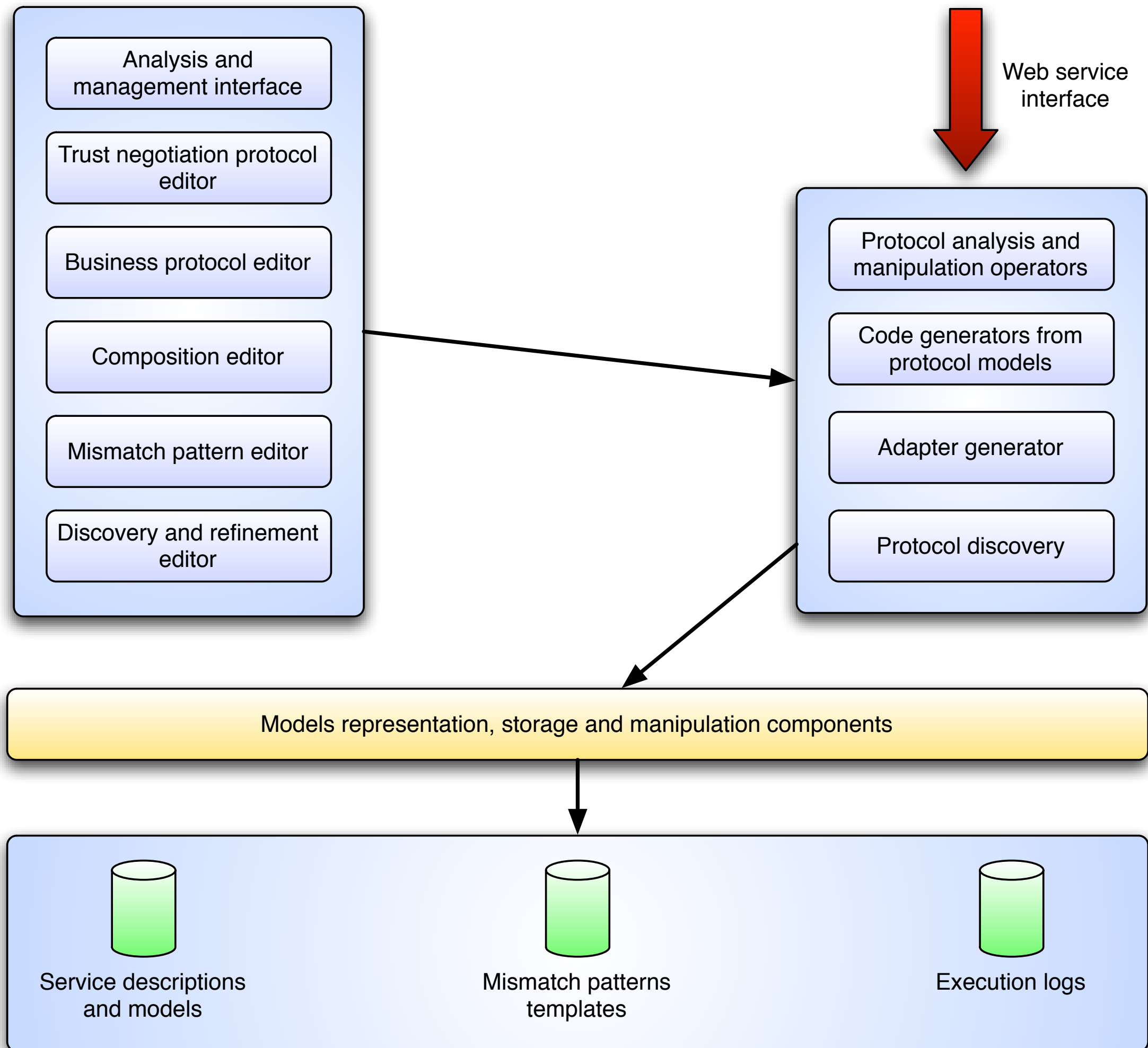
LIMOS (France)

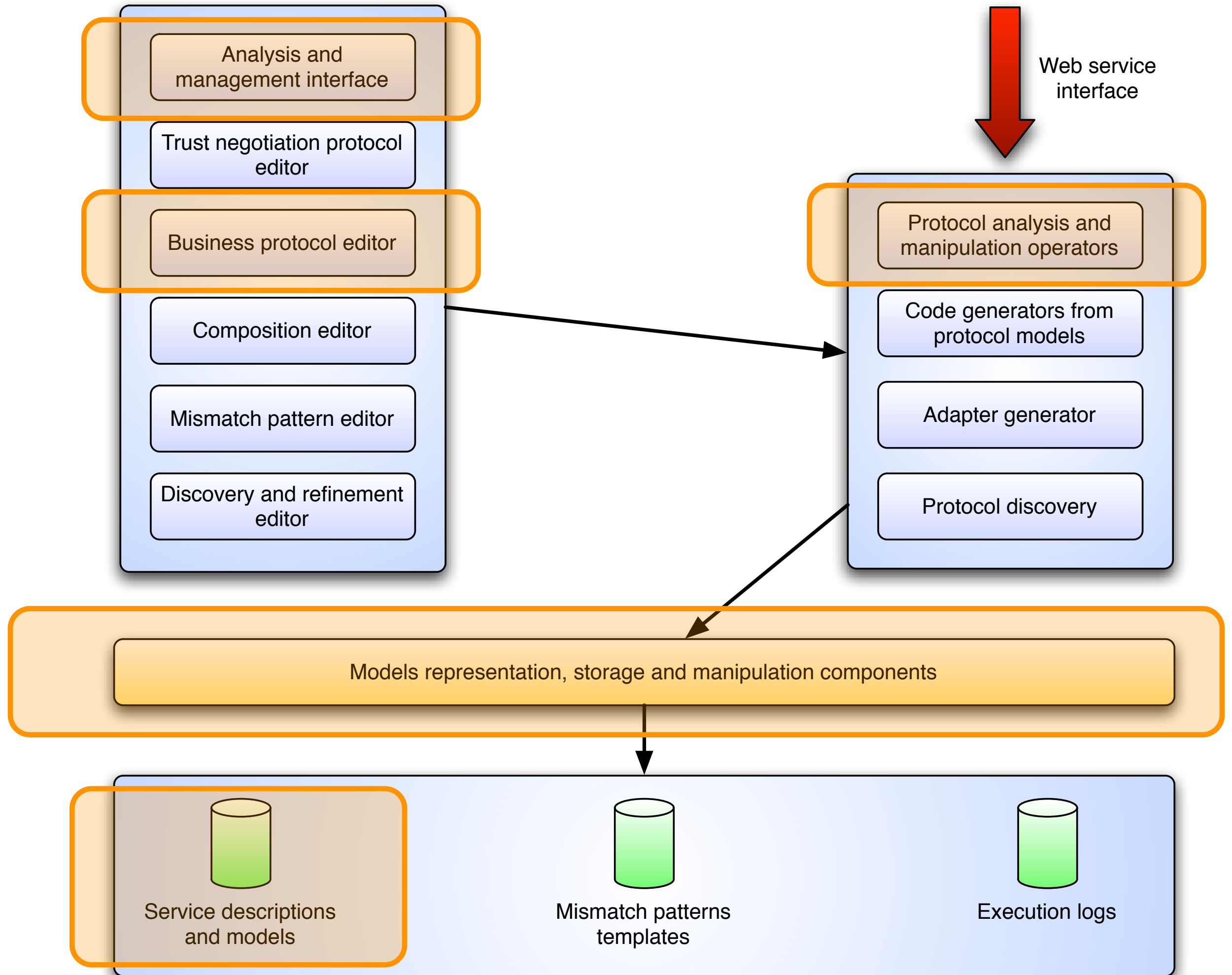
U.Trento (Italy)

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

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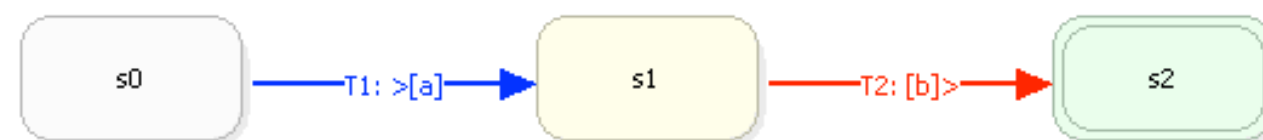


Navigator

 Testing

- .project
- P1.wsprotocol
- P2.wsprotocol
- P2-td-P1.wsprotocol

P1.wsprotocol X



Palette

Tools

Select

Marquee

States

☐ Initial state☐ Normal state☒ Final state

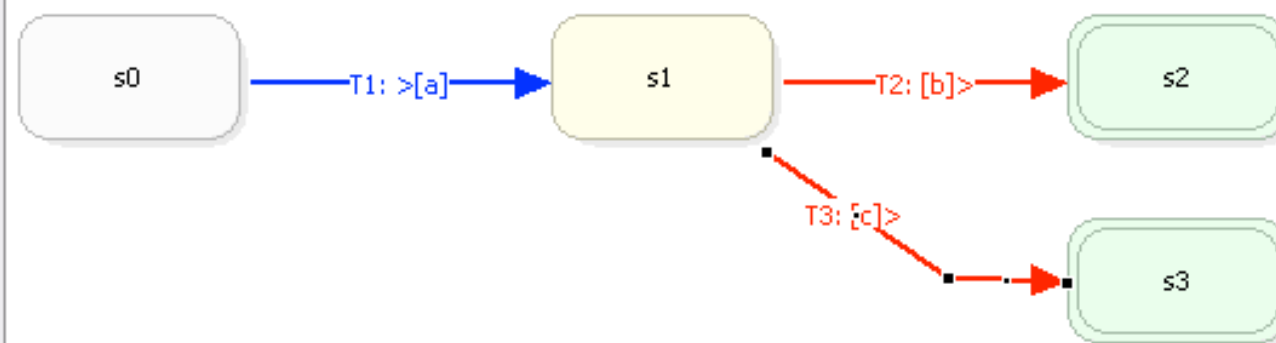
Operations

Input operation

Output operation

Implicit operation

P2.wsprotocol X



Outline

- s2
- s0
- s1
 - T3: c
 - T2: b
- s3

Properties

Property	Value
Message name	c
Message polarity	output
Name	T3
Operation kind	explicit
Temporal constraint	C-Invoke(T1 < 8)

Properties Tasks Problems

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

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https://servicemosaic.isima.fr/projects/protocols/report/3

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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 servicemosaic.isima.fr

Roadmap - Protocols - Trac - Mozilla Firefox 3 Beta 5

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https://servicemosaic.isima.fr/projects/protocols/roadmap

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 **trac**
Integrated SCM & Project Management

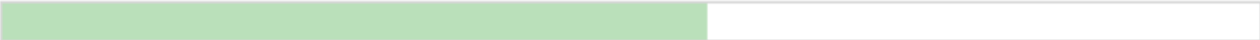
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Wiki Timeline **Roadmap** Browse Source View Tickets New Ticket Search Admin

Roadmap

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

☐ Show already completed milestones [Update](#)

 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 servicemosaic.isima.fr

{3} All Tickets by Milestone - Protocols - Trac

Fichier Édition Affichage Historique

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{3} All Tickets by Milestone

This report shows how to color tickets by milestone.

Last modification time, description, and status of tickets.

[Edit report](#) [Copy report](#)

v0.5 release Release

Ticket	Summary
#30	Licensing before the public release
#2	Add the protocols operation arrow
#28	Eclipse update site
#29	Trimmed-down Eclipse IDE
#34	Add package-info.java

v0.5 release candidate Release

Ticket	Summary
#25	Update the temporal-a
#27	Update the Eclipse plug
#33	Randomize position of f
#26	Compatibility and repla

Terminé

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

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https://servicemosaic.isima.fr/projects/protocols/browser/ProtocolsLibrary/trunk

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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: * Embbed 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

servicemosaic.isima.fr

Roadmap - Protocols - Trac - Mozilla Firefox 3 Beta 5

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https://servicemosaic.isima.fr/projects/protocols/browser/ProtocolsLibrary/trunk

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trac
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Wiki Timeline Roadmap **Browse Source** View Tickets New Ticket Search Admin

[Last Change](#) | [Revision Log](#)

View revision:

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

EclipseSubversionTutorial - ServiceMosaic - Trac - Mozilla Firefox 3 Beta 5

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https://servicemosaic.isima.fr/projects/servicemosaic/wiki/EclipseSubversionTutorial

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 **trac**
Integrated SCM & Project Management

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We will first explain in this short tutorial how to set up an Eclipse environment with Subversion support. We will then checkout all the subprojects from the protocols project.

Subclipse

⇒ **Subclipse** is a plug-in for Eclipse that adds ⇒ **Subversion** support. Source code managers support is called *team support* in Eclipse. By default, Eclipse comes with CVS support. The ⇒ **Subclipse web page** will give you the *update site URL* that you will need to install ⇒ **Subclipse** from the Eclipse *updates manager*. Fortunately, this is quite easy to do.

Reach the *software updates* dialog.

Plug-in Development - Eclipse SDK

Search Project Run Window Help

Welcome

Help Contents

Search

Dynamic Help

Key Assist... Shift+Ctrl+L

Tips and Tricks...

Cheat Sheets...

Software Updates Find and Install

Terminé servicemosaic.isima.fr

ProtocolsLibrary/trunk - Protoc...

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Wiki

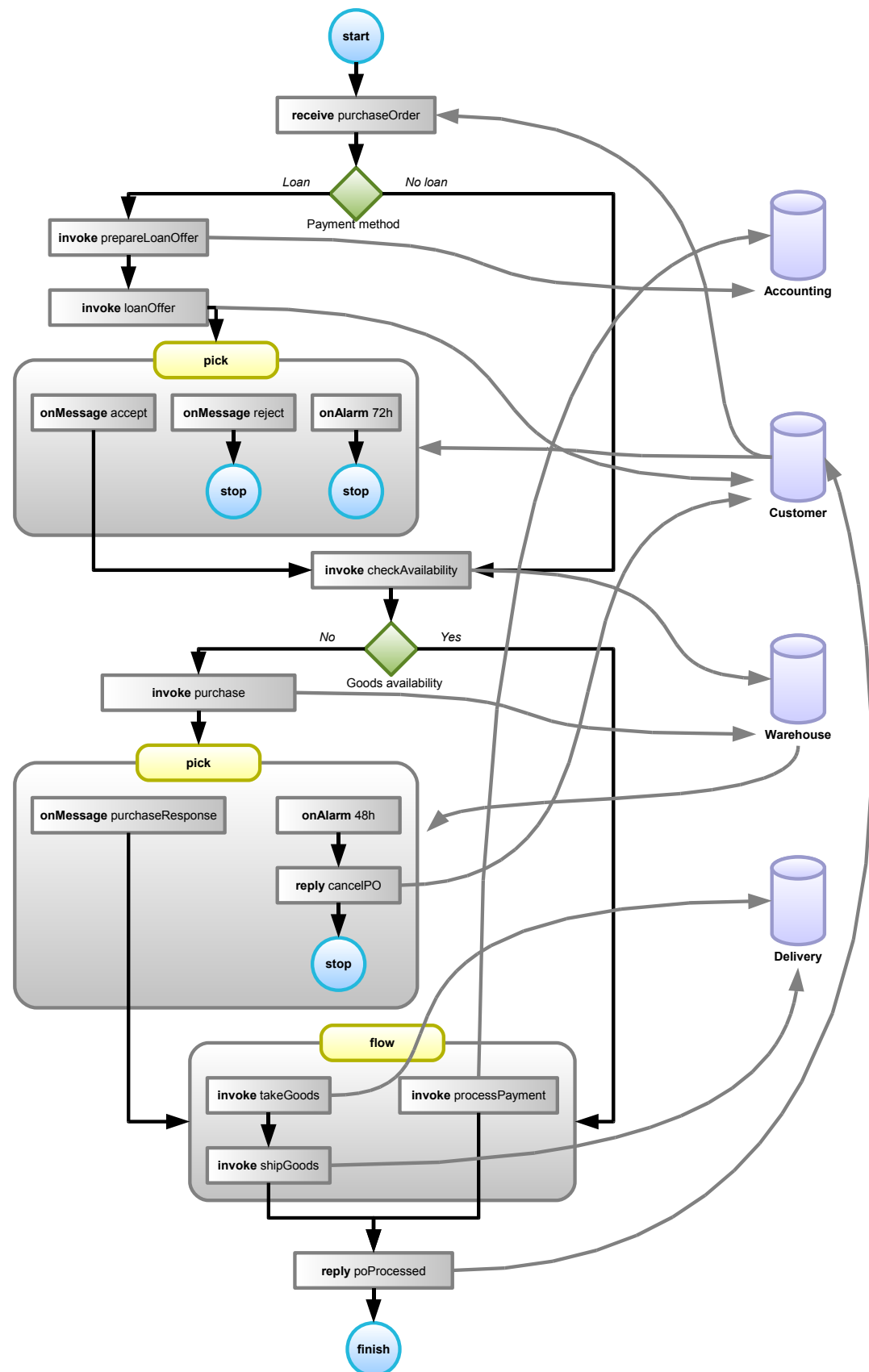
root / ProtocolsLibrary

Name

- ../
- .settings
- doc
- lib
- src
- tests
- .antlr-eclipse
- .classpath
- .project
- ant.properties
- build.xml
- Changes.txt
- LICENSE.antlr
- LICENSE.apache-libraries.txt

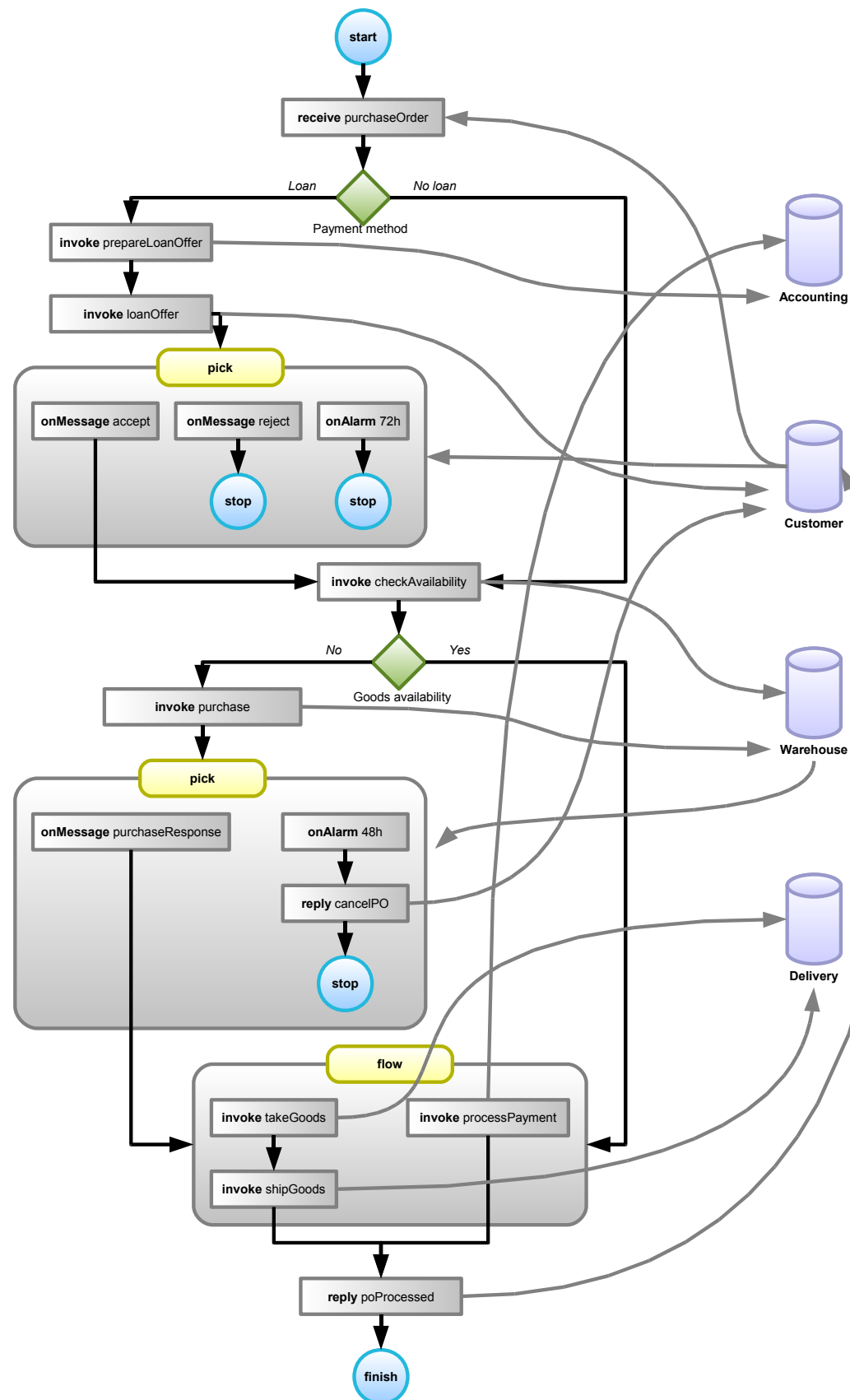
Terminé

BPEL



BPEL

Protocols



Accounting

Customers

Warehouse

Delivery

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



“Agile” composition

Facilitate rapid
prototyping



Facilitate hot
replacement





Outline

1

Introduction

2

Timed protocols modeling

3

Theoretical study of time impacts

4

Prototyping, applications

5

Conclusion

Conclusion





Summary

Formalization of
timing constraints

Protocol timed
automata

ServiceMosaic
Protocols



Summary

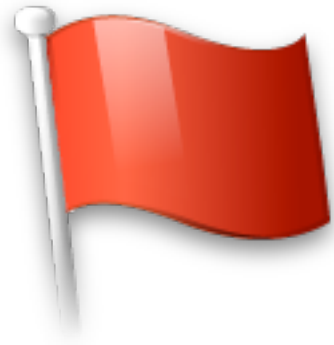
Formalization of
timing constraints

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MI

Protocol timed
automata

ServiceMosaic
Protocols



Limits

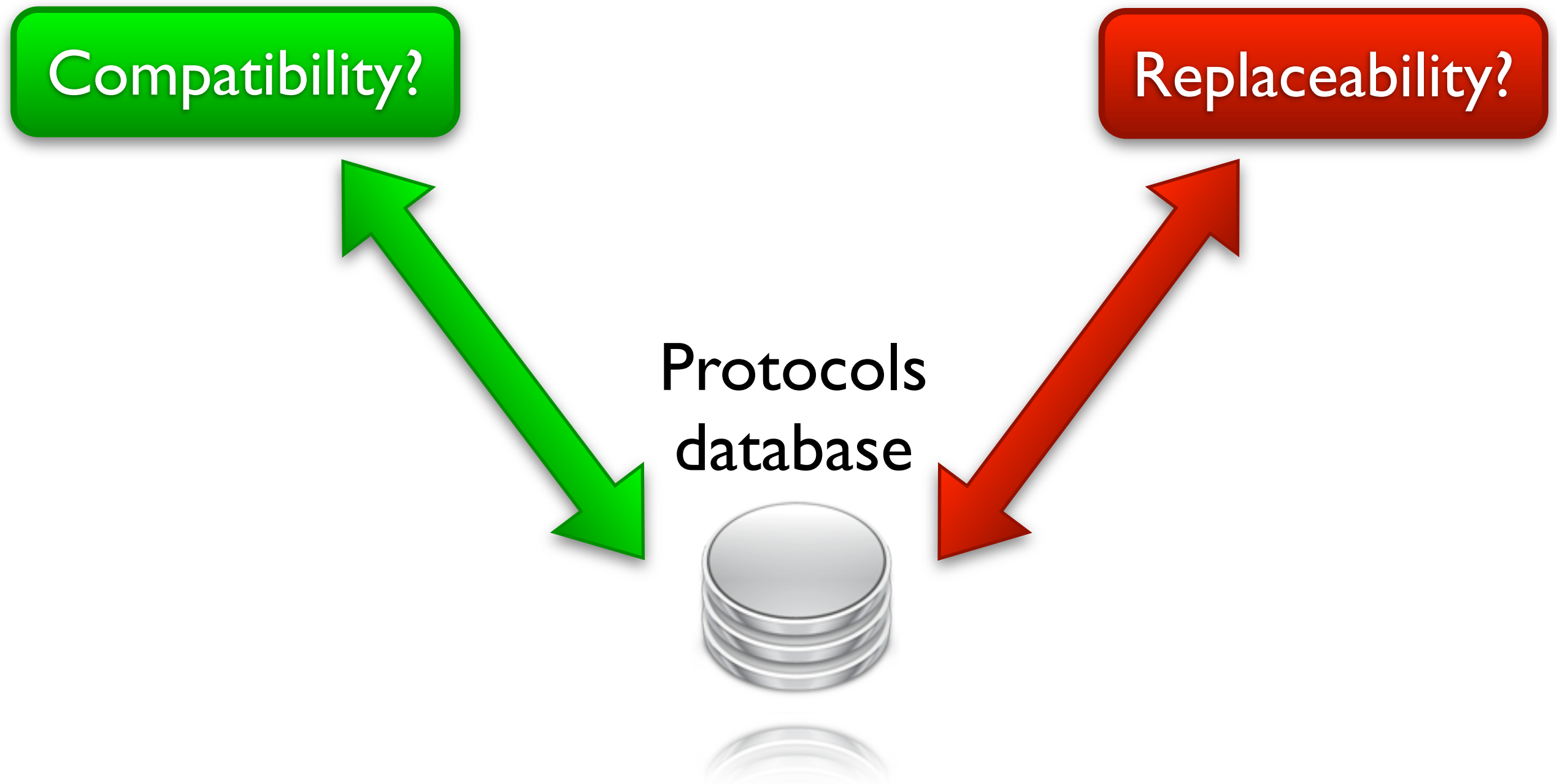
- No network hazard
- No absolute time
- “a == a”

Querying

Protocols
database



Querying



Testing

Service



+

Protocol

Testing

Service



+

Protocol



Test cases

Testing

Service



+

Protocol



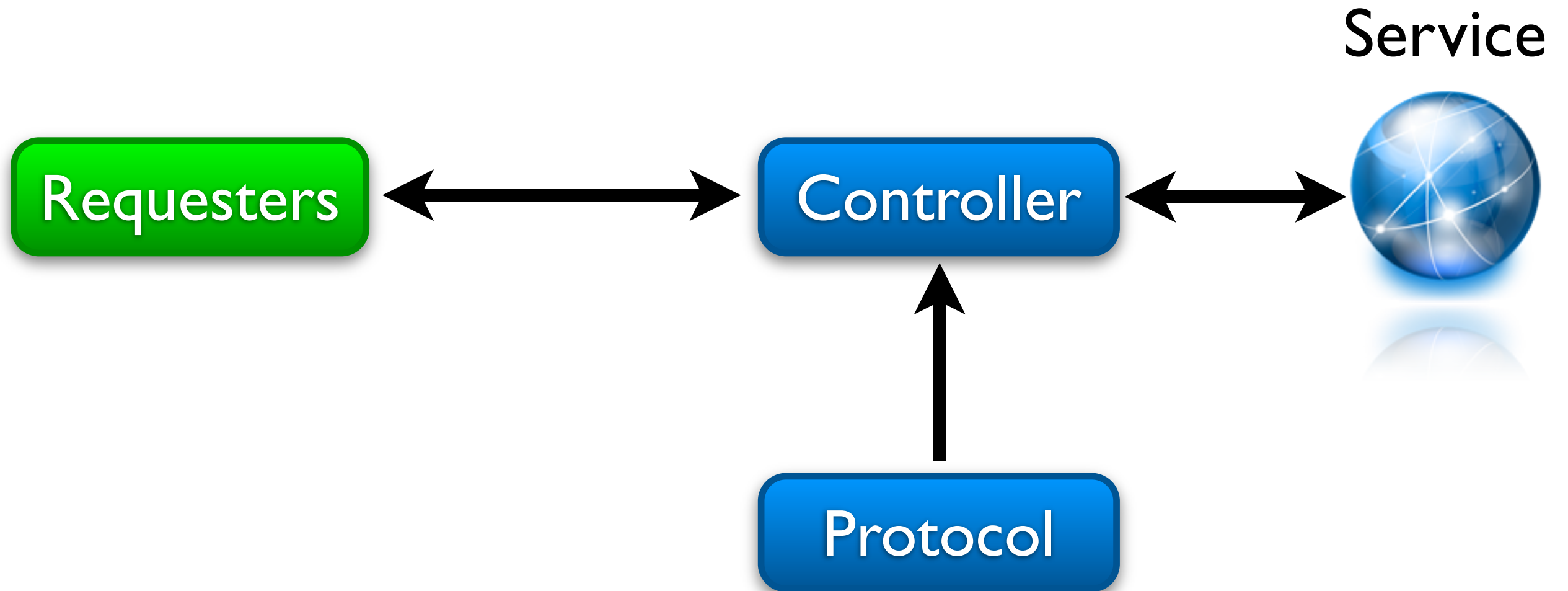
Test cases

Minimal coverage?

Meaningful & bogus data?

Loops handling?

Controllers



Mining

Execution logs

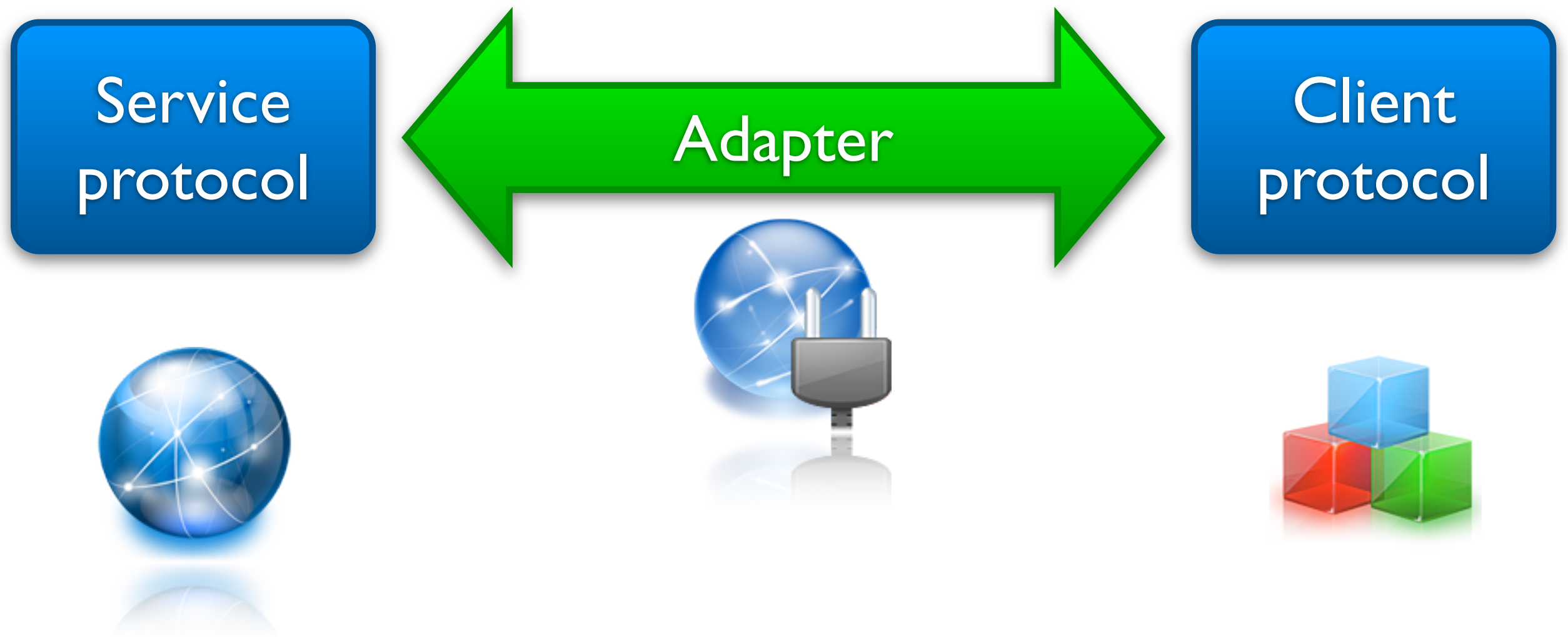


Protocol

Adaptation



Adaptation





Thank you!

<http://www.isima.fr/~ponge/>

