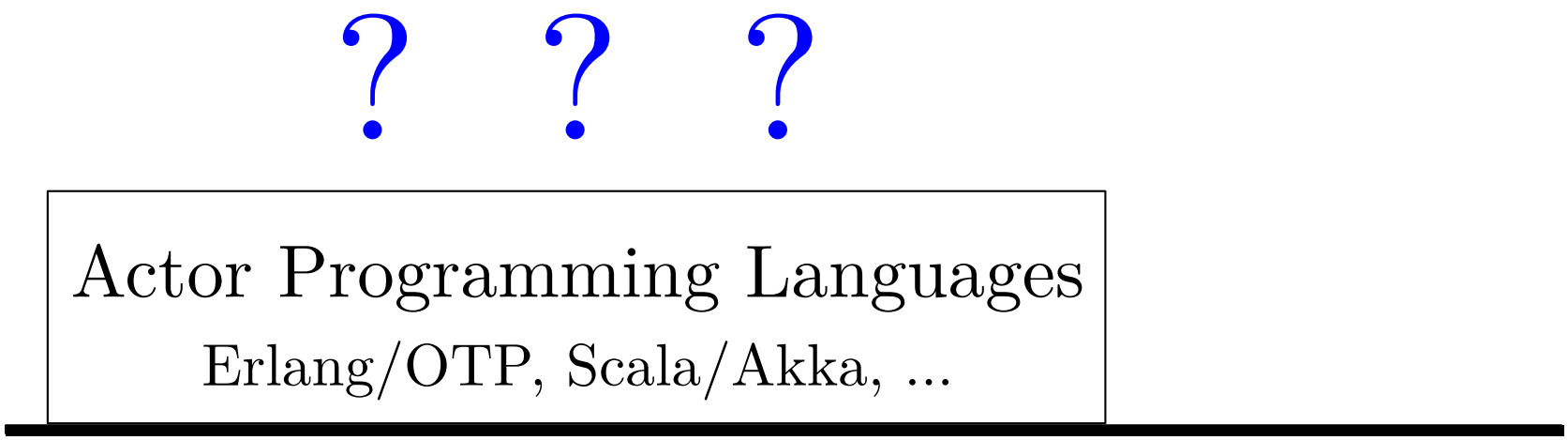
ESOP 2014, Grenoble, France; 20140410

The Network as a Language Construct

Tony Garnock-Jones Sam Tobin-Hochstadt Matthias Felleisen

Actor Programming Languages

Erlang/OTP, Scala/Akka, ...


? ? ?
Actor Programming Languages
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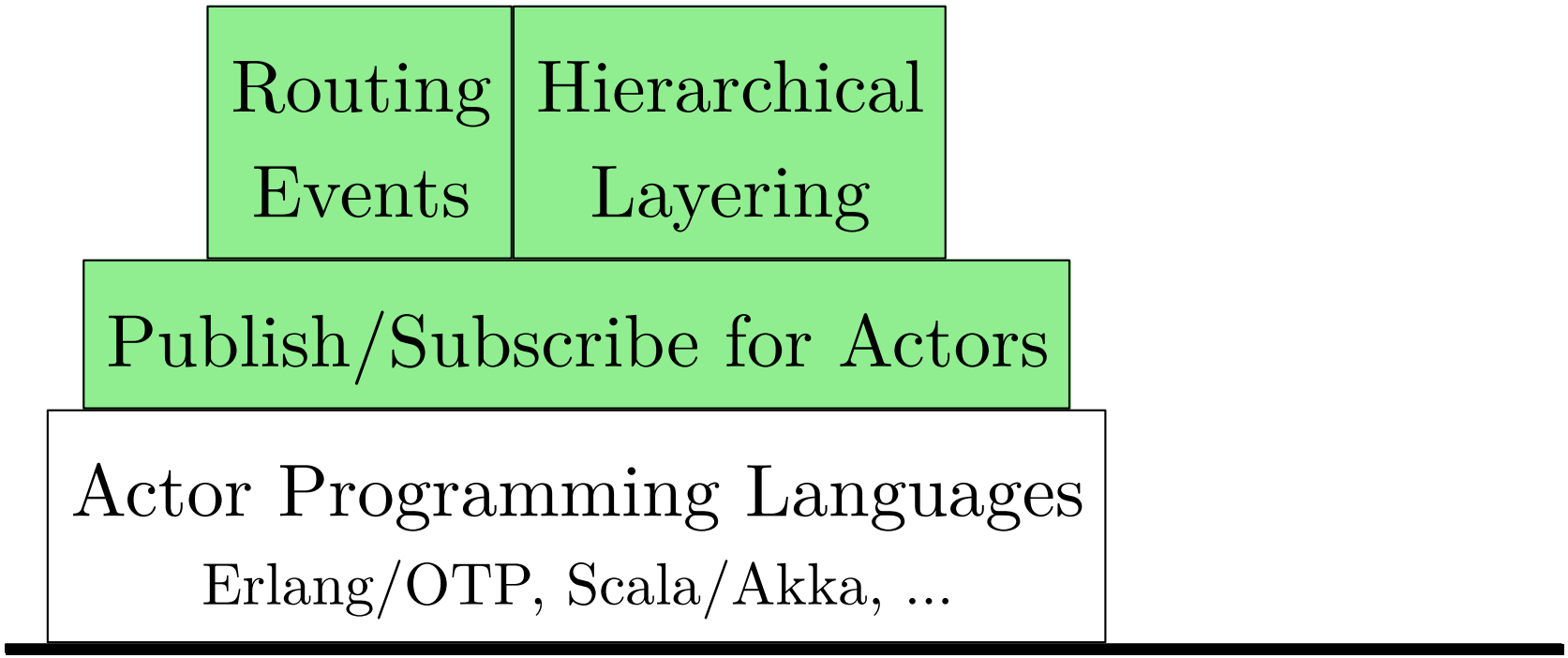
Routing
Events
Hierarchical
Layering
Publish/Subscribe for Actors
Actor Programming Languages
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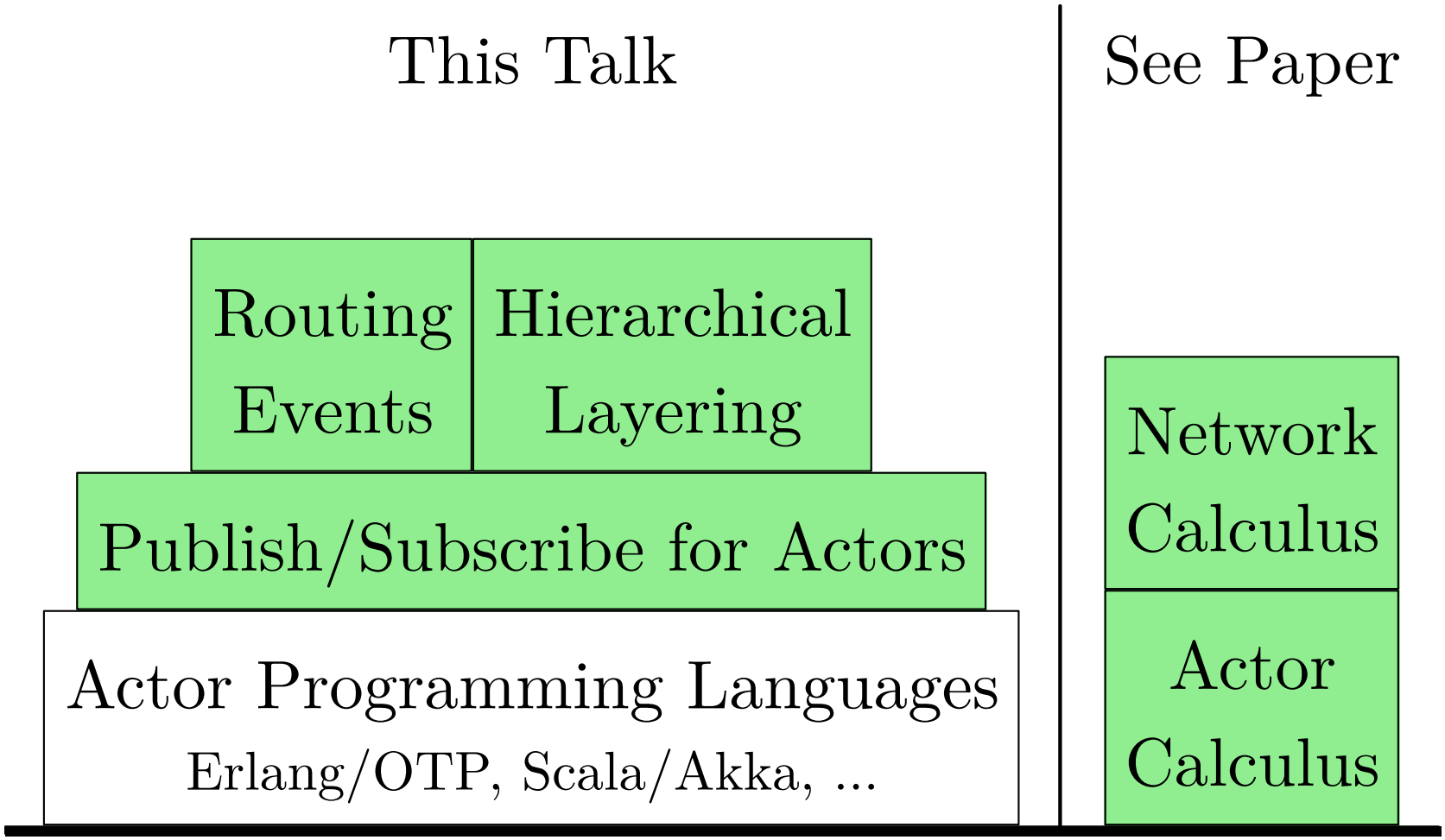
This Talk
See Paper
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Actor Programming Languages
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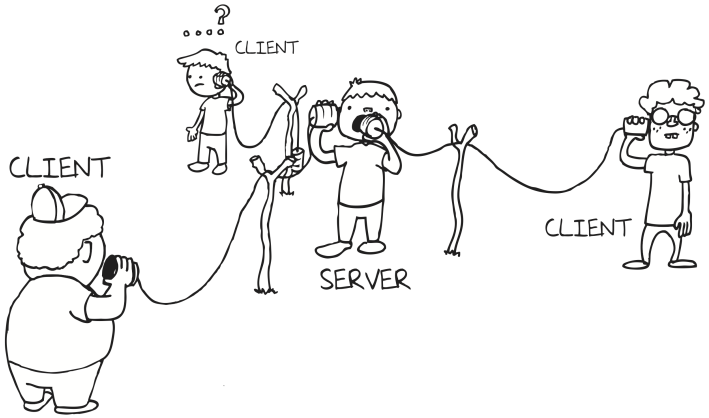
Network Calculus
Actor Calculus

PART I: The Problem

Functional I/O

Scaling up **big-bang** from domain-specific to general functional I/O



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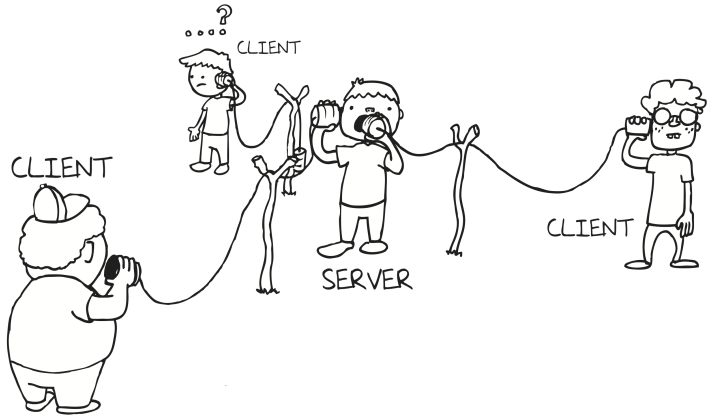

Apps in a functional I/O style:

- echo server
- multi-user chat
- DNS server
- SSH server

Functional I/O

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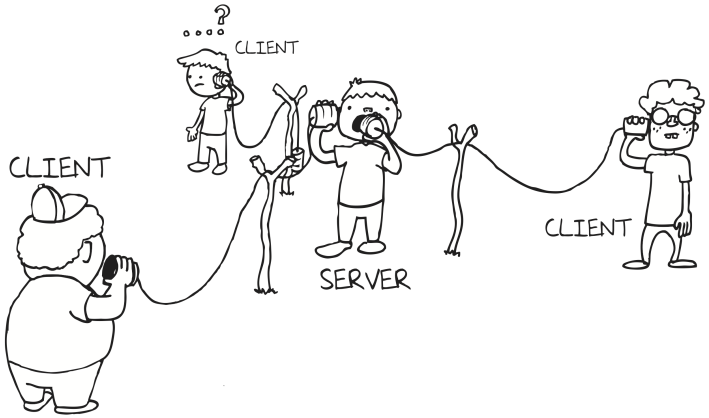

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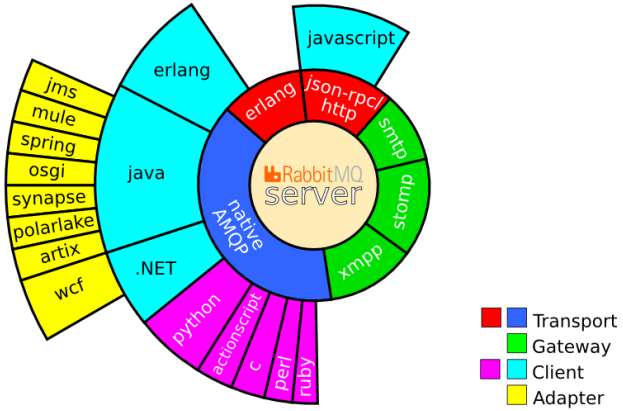
Distributed Systems

Implementing **RabbitMQ** and using it to build distributed systems



Functional I/O

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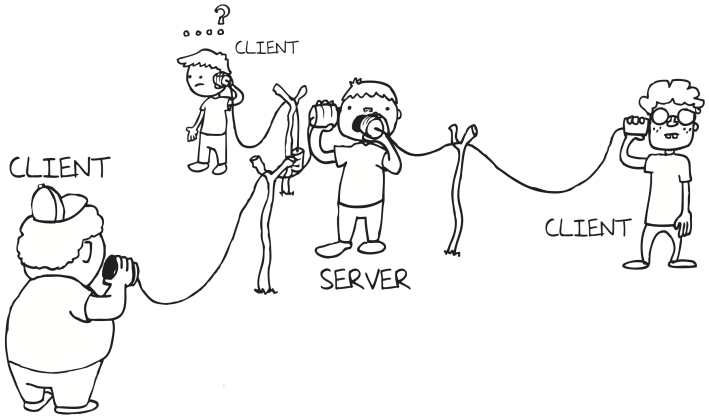

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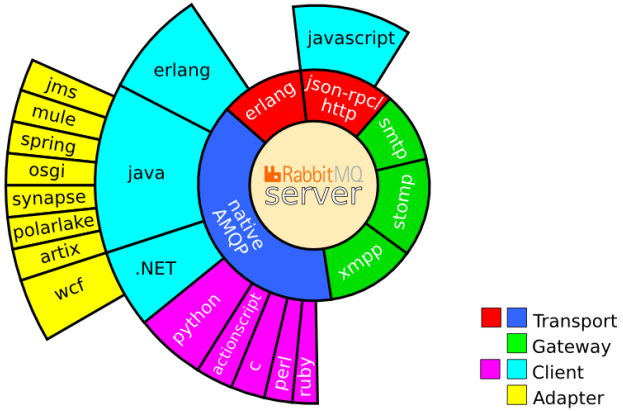


Investigated other paradigms:

- OO languages
- Network architecture
- CORBA services
- Erlang applications

Ubiquitous Patterns and Problems

Event broadcasting

Naming service

Service discovery

Startup ordering

Crash/exit signalling

Conversation management

Ubiquitous Patterns and Problems

Event broadcasting

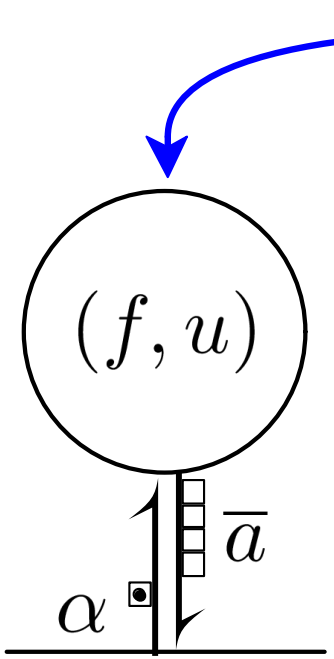
Naming service

Uniform Linguistic Solution

Crash/exit signalling

Conversation management

Recipe for Actor Languages



Base language actor

$$f(\alpha, u) = (\overline{a}, u')$$

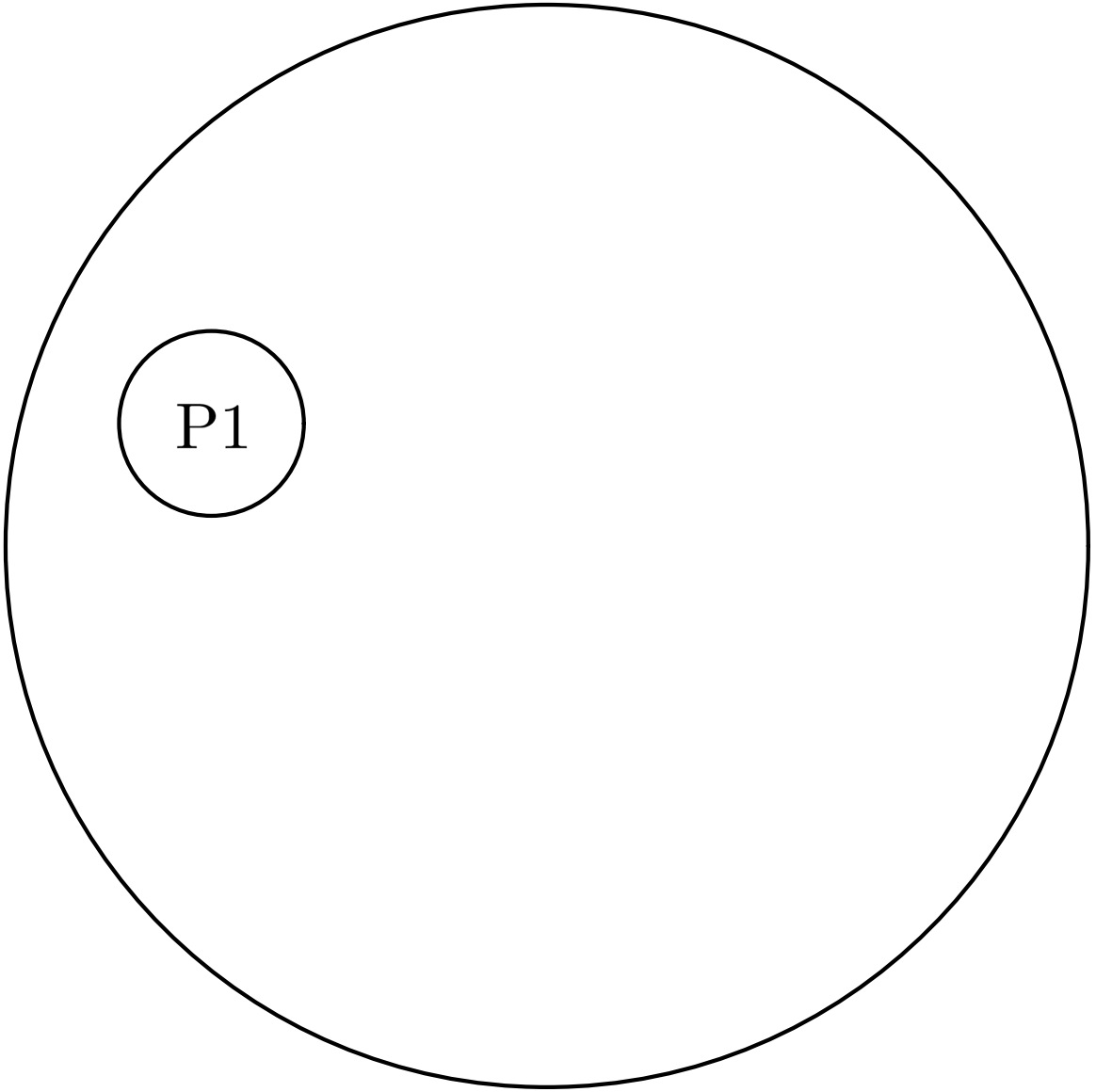
α = event, a = action

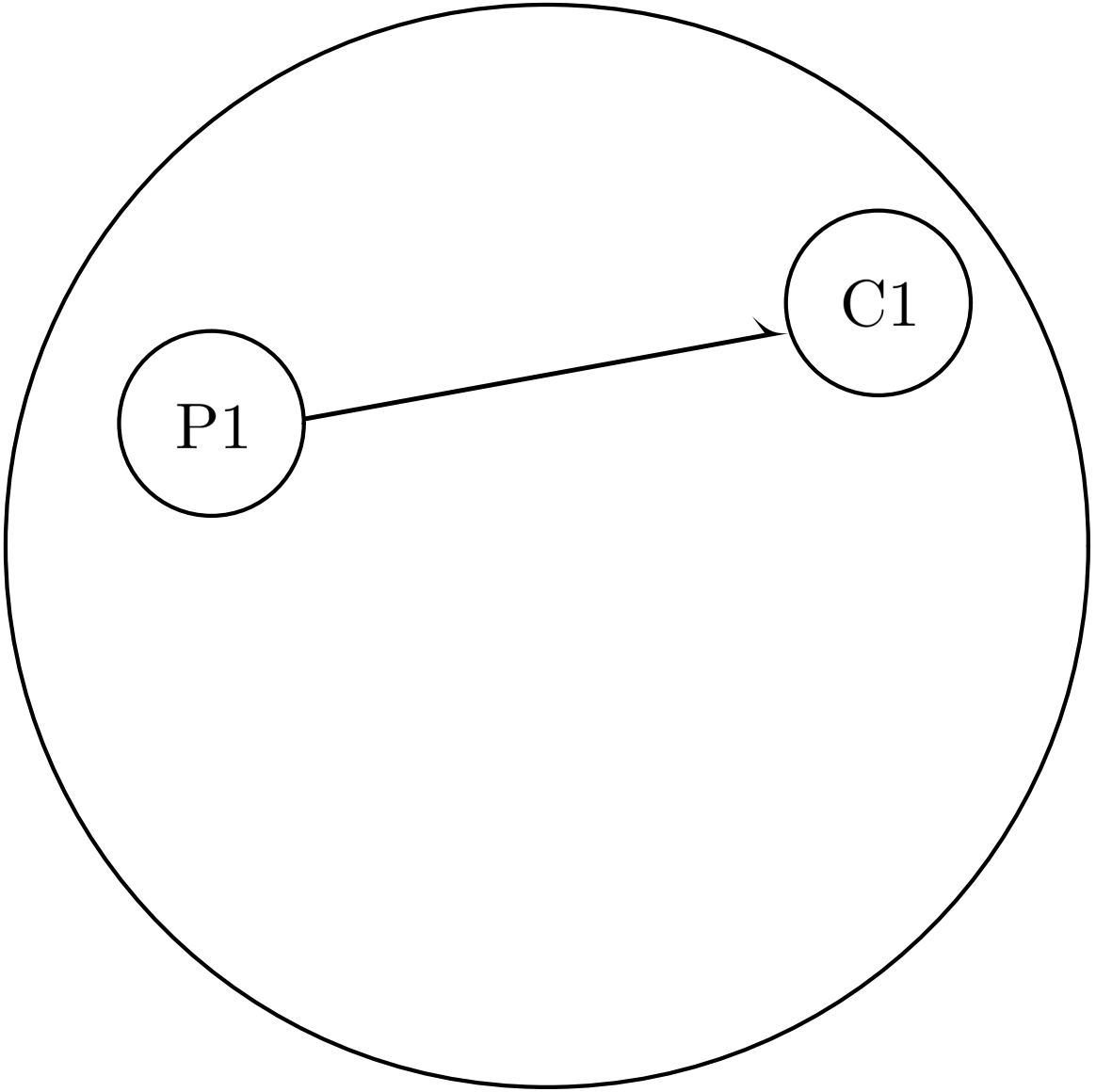
"Network"

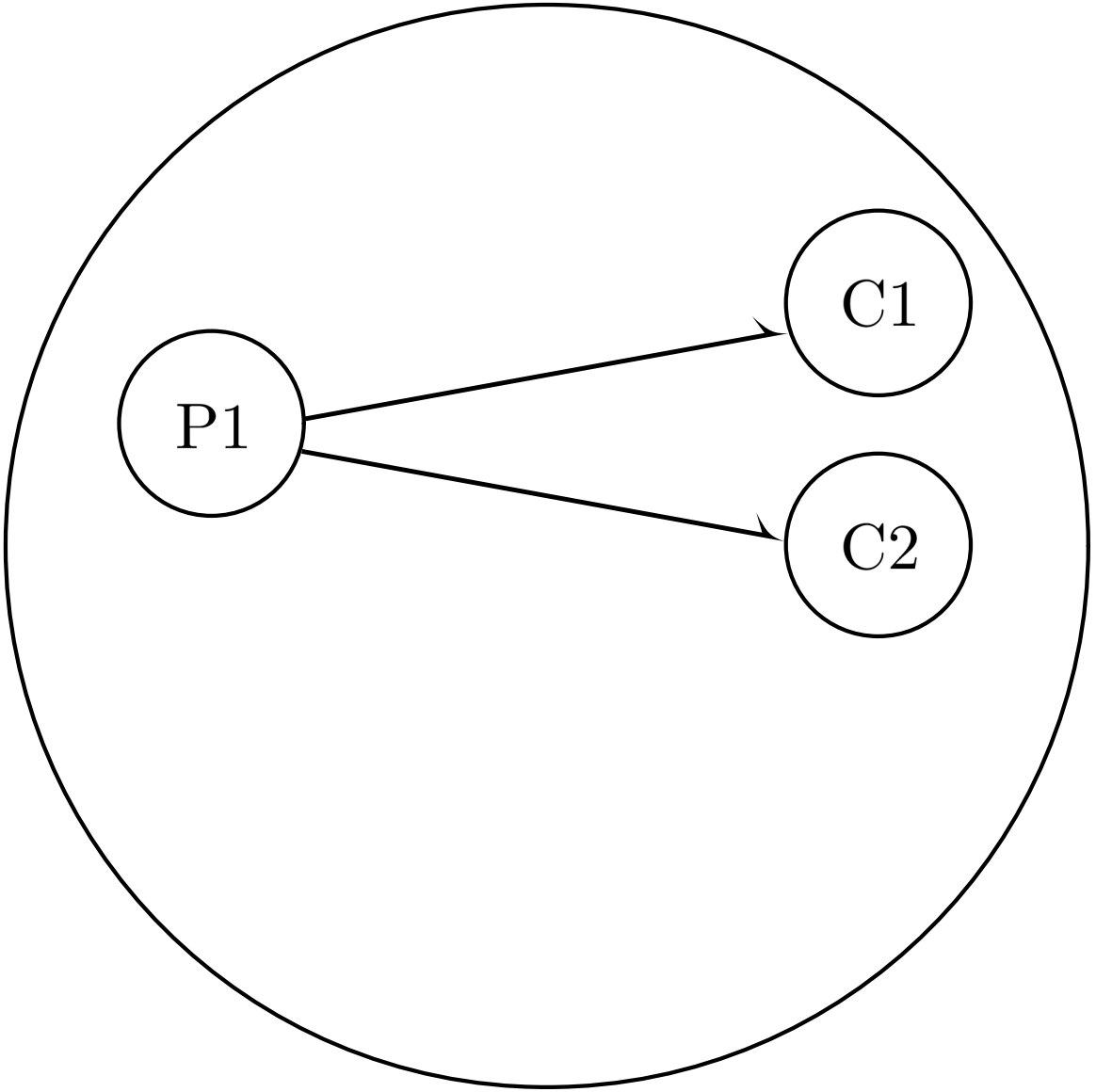
Log producers $\overset{\text{log messages}}{\longrightarrow}$ Log consumers

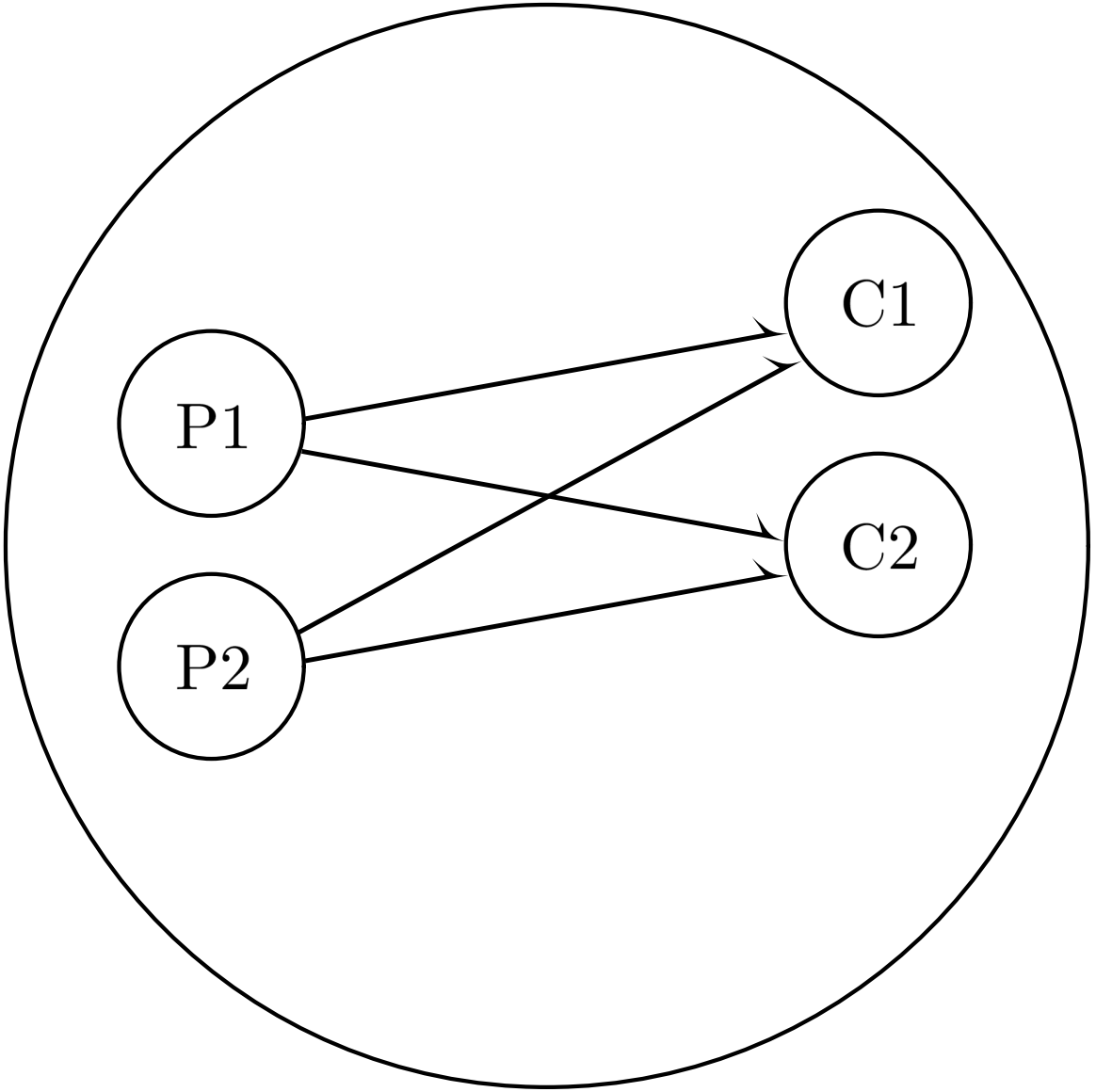
$\langle \mathsf{log}, [subsystem, severity, data] \rangle$

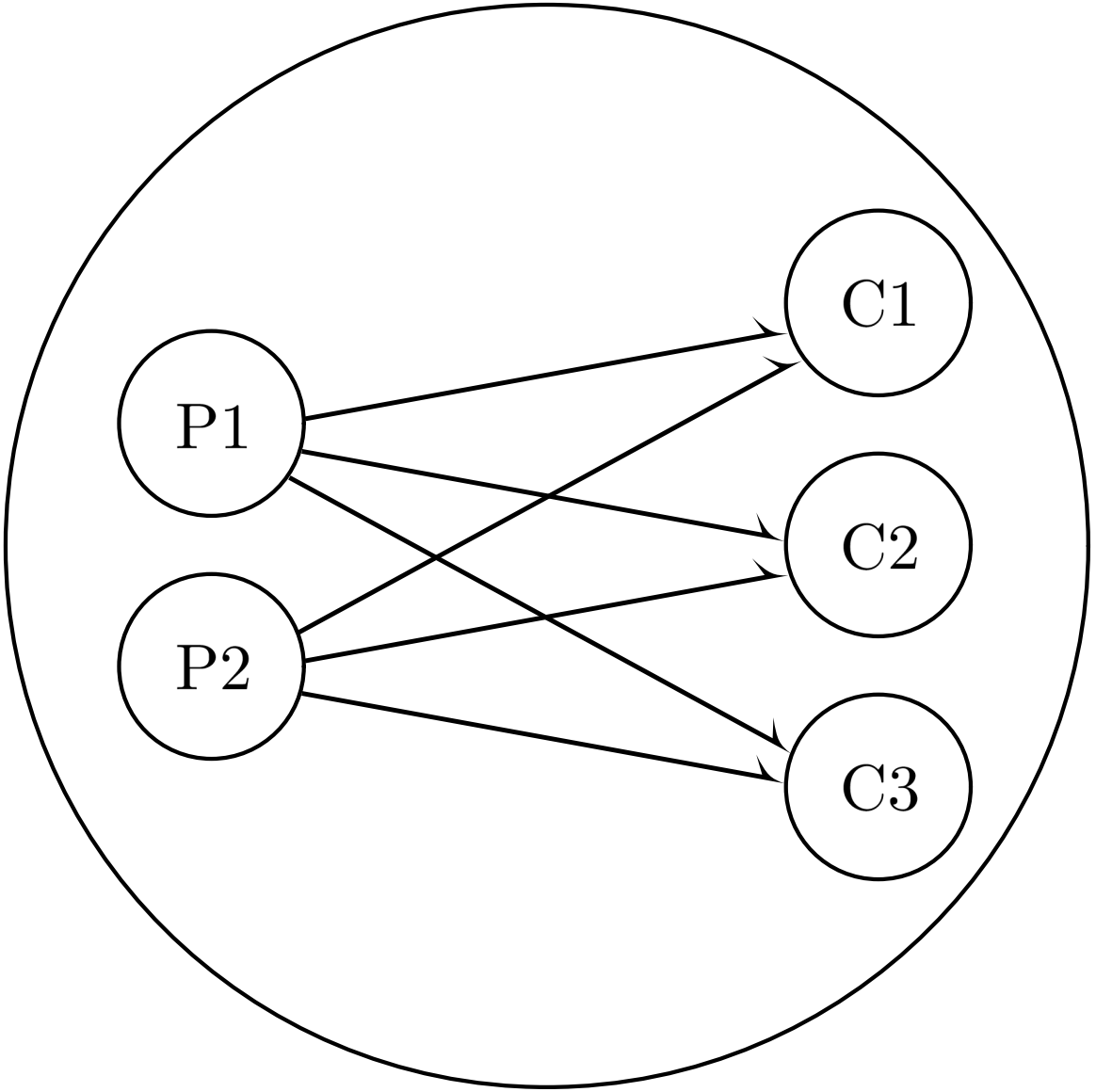
Consumers filter by subsystem, severity


P1


C1
P1


C1
P1
C2

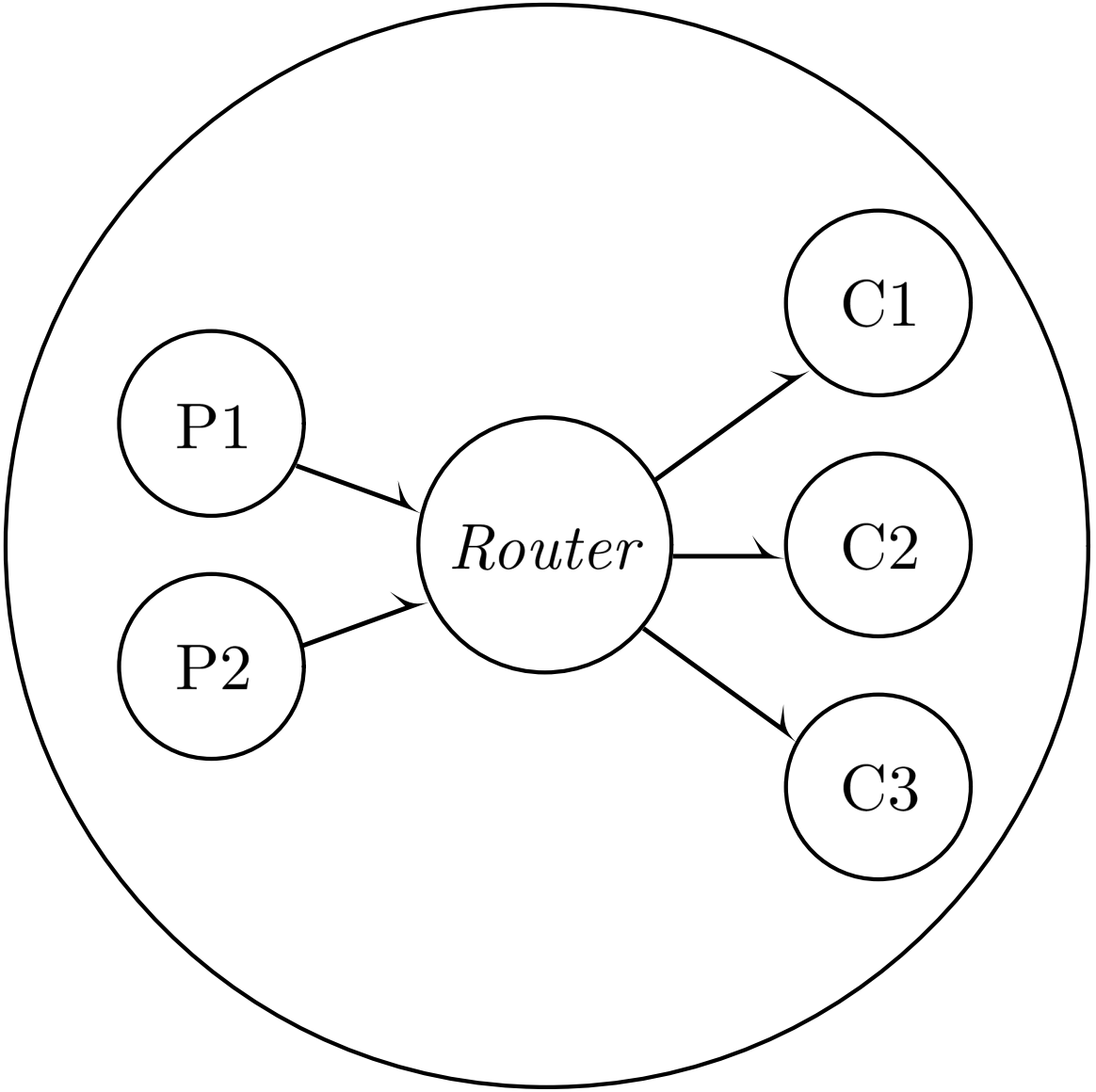

C1
P1
C2
P2


P1
P2
C1
C2
C3

Logging: Requirements Scorecard

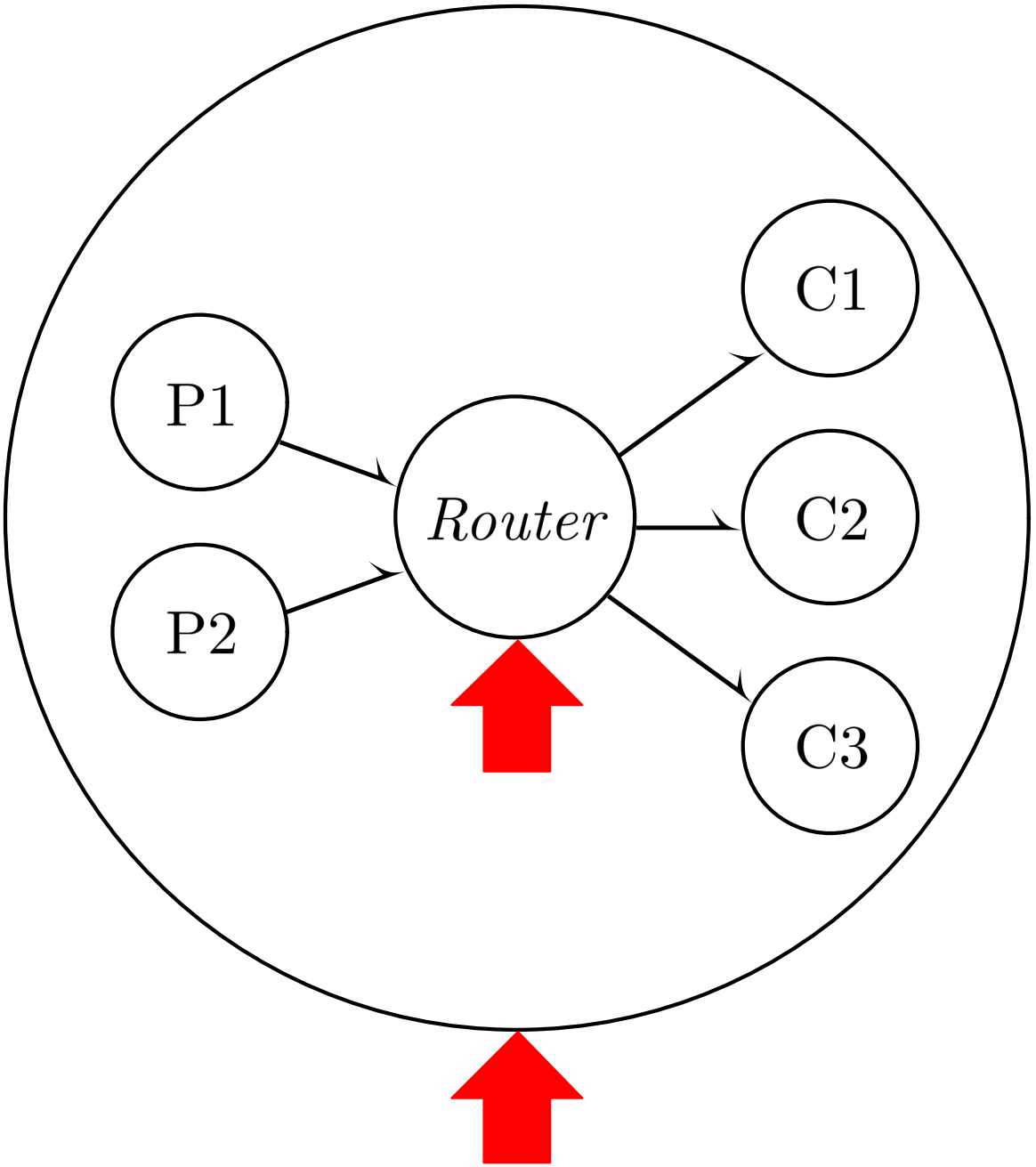
Route log entries from producers to consumers	☐
Consumers filter log messages	☐
Decouple producers from consumers	☐
Avoid shared-state explosion	☐
Discovery of logging service	☐
Only produce if someone's listening	☐
Alert when a producer crashes/exits	☐
Uniform treatment of I/O	☐

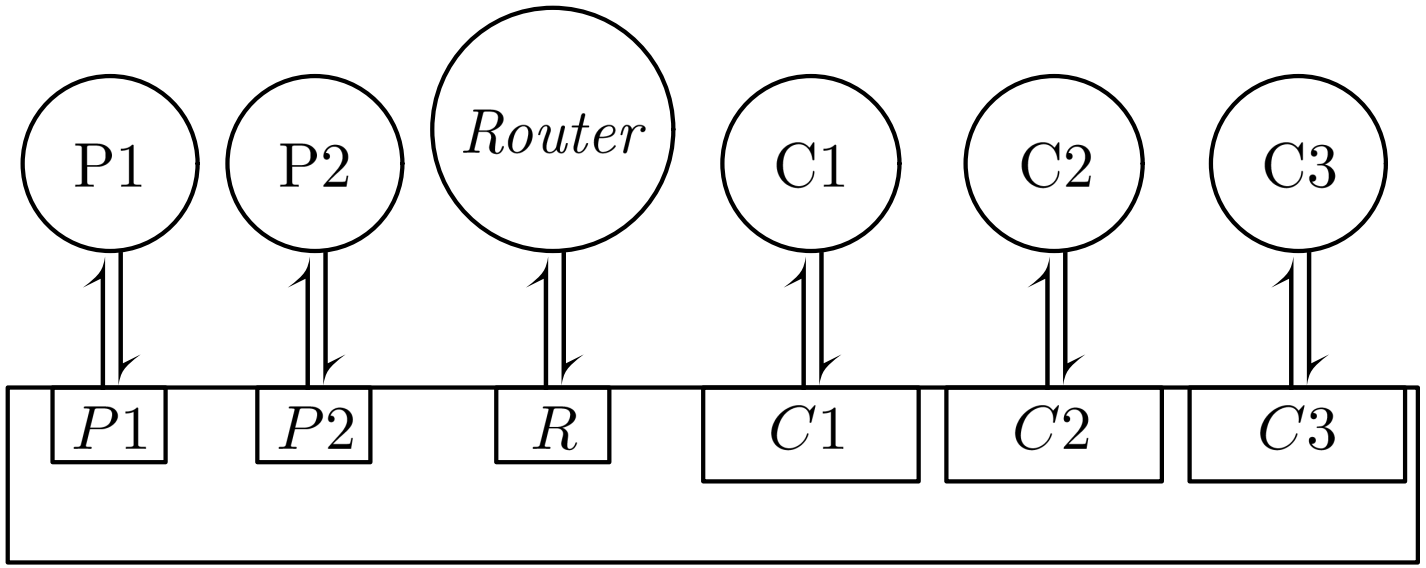
PART II: Why Publish/Subscribe? How?

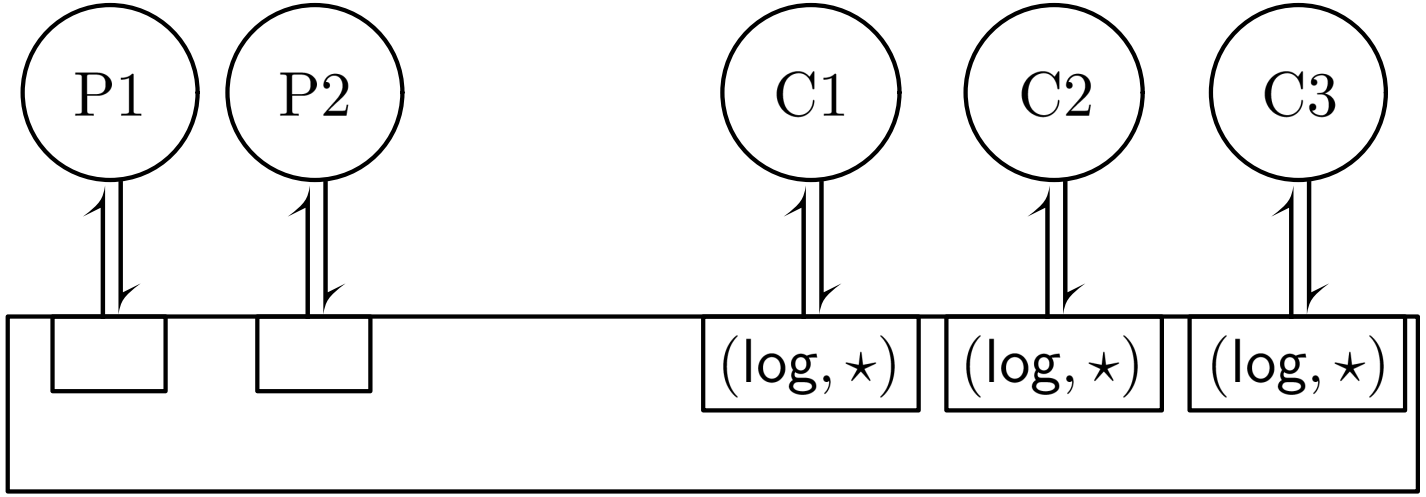

P1
P2
Router
C1
C2
C3

Logging: Requirements Scorecard

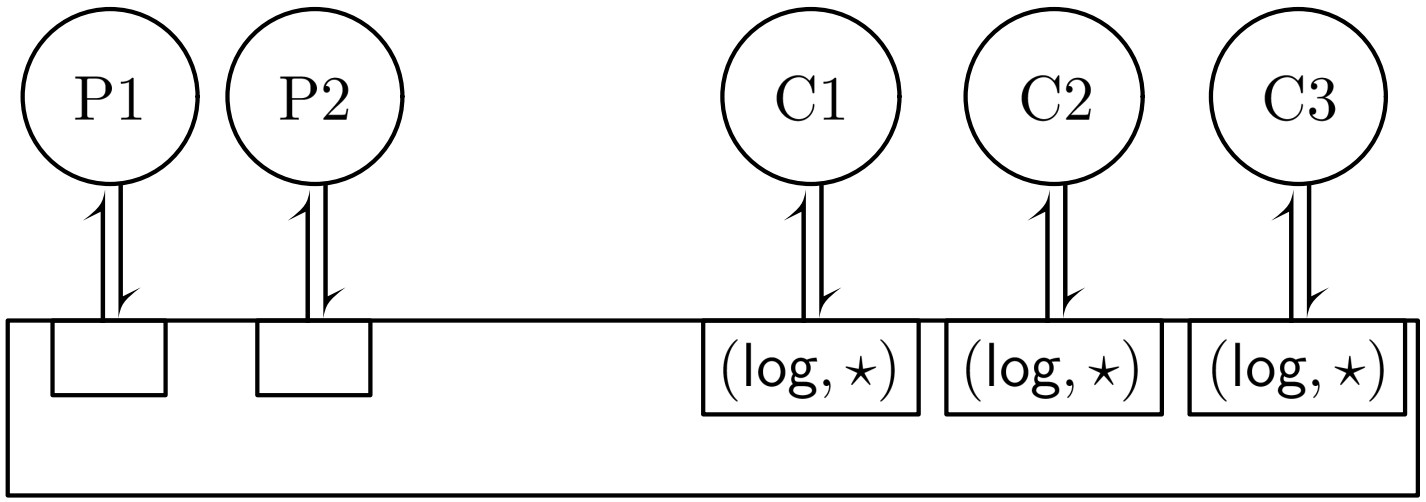
Route log entries from producers to consumers	☑ "Router" actor
Consumers filter log messages	☑ "Router" actor
Decouple producers from consumers	☑ "Router" actor
Avoid shared-state explosion	☑ "Router" actor
Discovery of logging service	☐
Only produce if someone's listening	☐
Alert when a producer crashes/exits	☐
Uniform treatment of I/O	☐


P1
P2
Router
C1
C2
C3

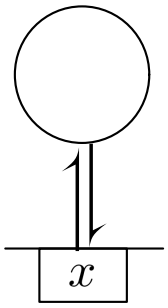

P1
P2
Router
C1
C2
C3
P1
P2
R
C1
C2
C3



See Eugster's 2003 pub/sub survey

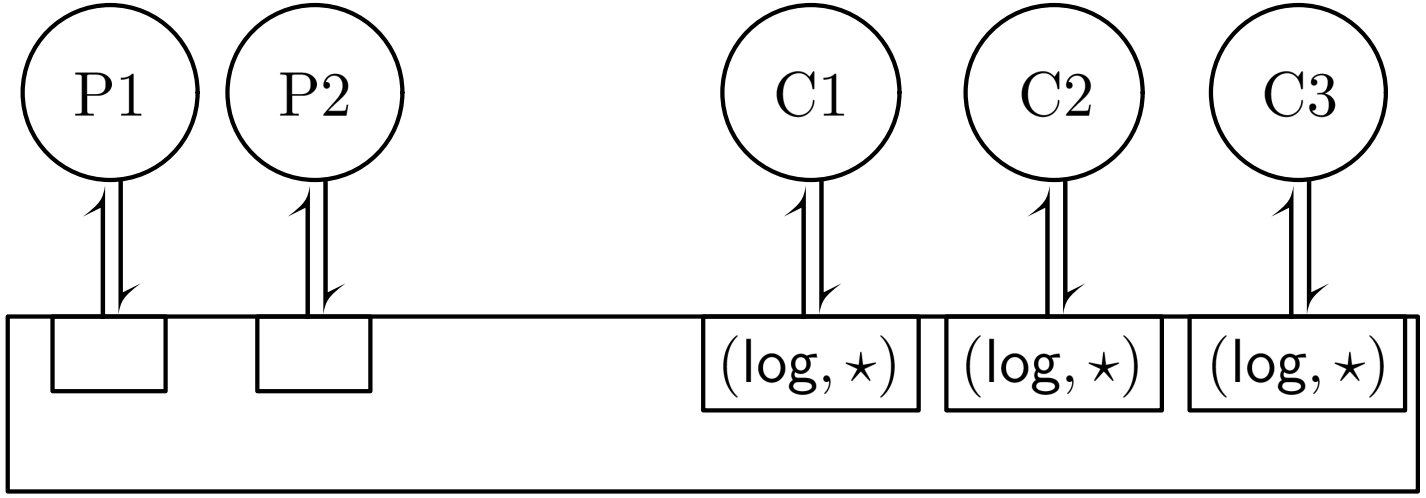


Route by address



Messages $m = \langle x, v \rangle$

$x \in$ Addresses



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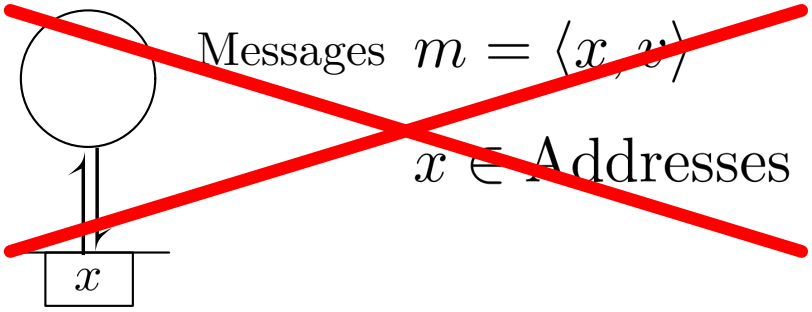
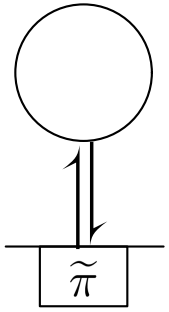


Route by content

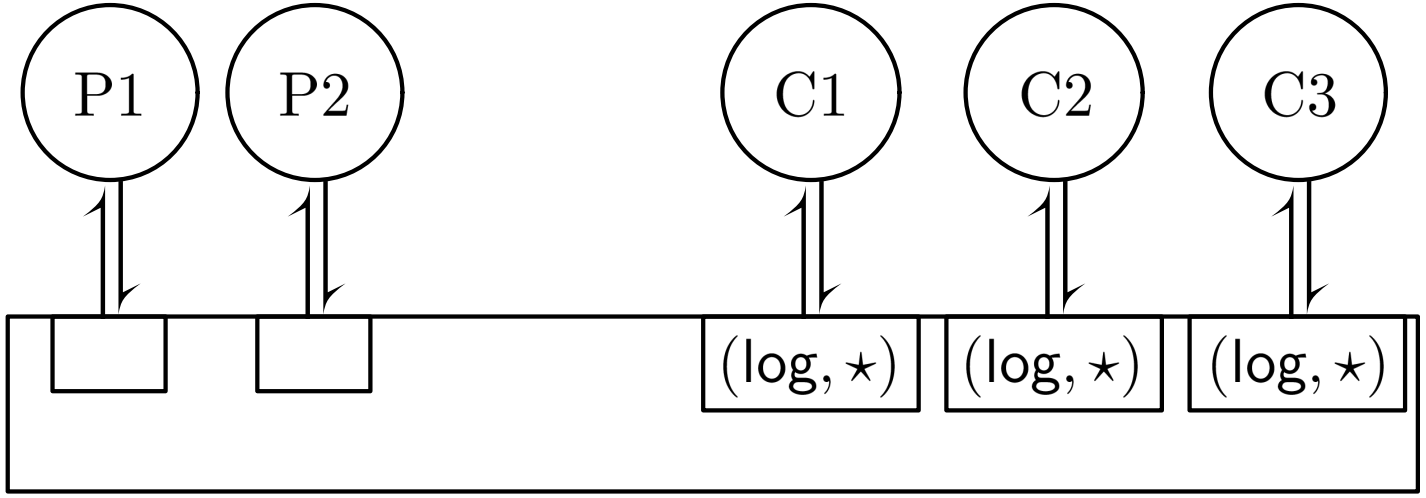


$$m = \langle v \rangle$$

$$v = u \mid v, v$$

Patterns $$p = u \mid p, p \mid \star$$

Interests $$\pi = (p)$$



Route by address

$(C1, \star)$

Route by content

$(\mathsf{log}, \star)$

or

$(\mathsf{log}, [\star, \mathsf{error}, \star])$

or

$(\mathsf{log}, [\mathrm{P1}, \star, \star])$

or

...

Logging: Requirements Scorecard

Route log entries from producers to consumers	☑ pub/sub
Consumers filter log messages	☑ pub/sub
Decouple producers from consumers	☑ pub/sub
Avoid shared-state explosion	☑ pub/sub
Discovery of logging service	⊟ no need!
Only produce if someone's listening	☐
Alert when a producer crashes/exits	☐
Uniform treatment of I/O	☑ pub/sub

PART III: Why Routing Events? How?

Logging: Requirements Scorecard

Route log entries from producers to consumers	☑
Consumers filter log messages	☑
Decouple producers from consumers	☑
Avoid shared-state explosion	☑
Discovery of logging service	☐
Only produce if someone's listening	☐
Alert when a producer crashes/exits	☐
Uniform treatment of I/O	☑

Shared Conversational Interest

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$$\underset{\text{Interests}}{\pi} \quad = \quad \underset{\text{Subscription}}{(p)}$$

Shared Conversational Interest

$$\underset{\text{Interests}}{\pi} = \underset{\text{Subscription}}{(p)} \mid \underset{\text{Advertisement}}{\langle p \rangle}$$

Shared Conversational Interest

Interests: π = Subscription: (p) | Advertisement: $\langle p \rangle$

$$\langle p \rangle \curlywedge \langle p' \rangle = \emptyset$$
$$(q) \curlywedge (q') = \emptyset$$

$$\langle p \rangle \curlywedge (q) = \langle p \cap q \rangle$$
$$(q) \curlywedge \langle p \rangle = (p \cap q)$$

Shared Conversational Interest

$$\underset{\text{Interests}}{\pi} = \underset{\text{Subscription}}{(p)} \mid \underset{\text{Advertisement}}{\langle p \rangle}$$

$$\langle p \rangle \pitchfork \langle p' \rangle = \emptyset$$
$$(q) \pitchfork (q') = \emptyset$$

$$\langle p \rangle \pitchfork (q) = \langle p \cap q \rangle$$
$$(q) \pitchfork \langle p \rangle = (p \cap q)$$

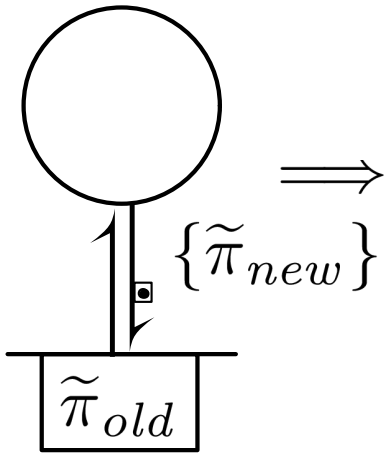
Any pattern language will do — if it supports $\cap$

What is a Routing Event?

$$\{\widetilde{\pi}\}$$

What is a Routing Event?

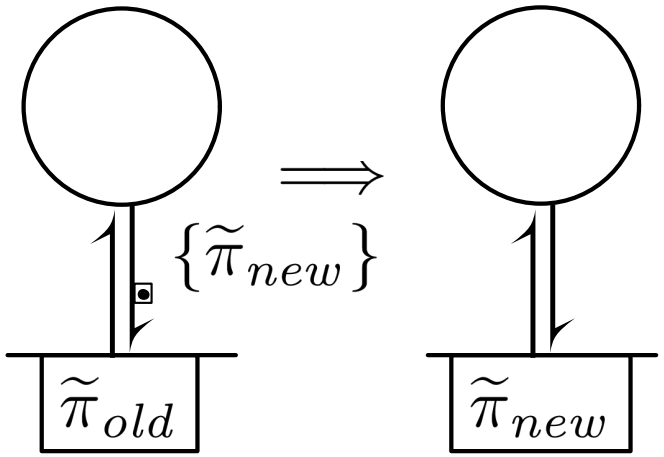
$$\{\widetilde{\pi}\}$$



From Actor to Network

What is a Routing Event?

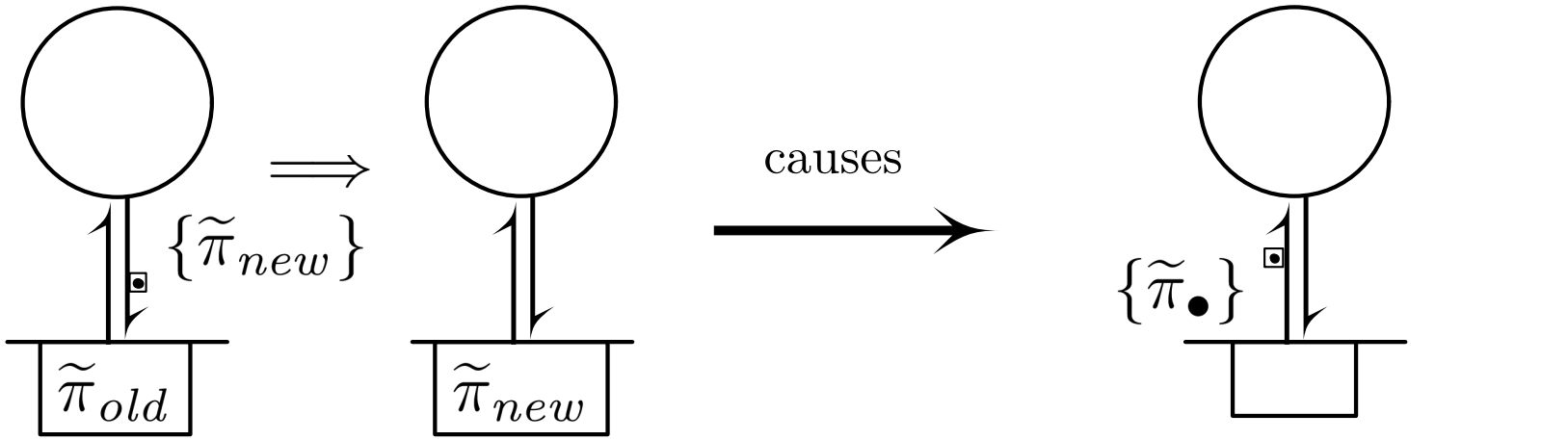
$$\{\widetilde{\pi}\}$$



From Actor to Network

What is a Routing Event?

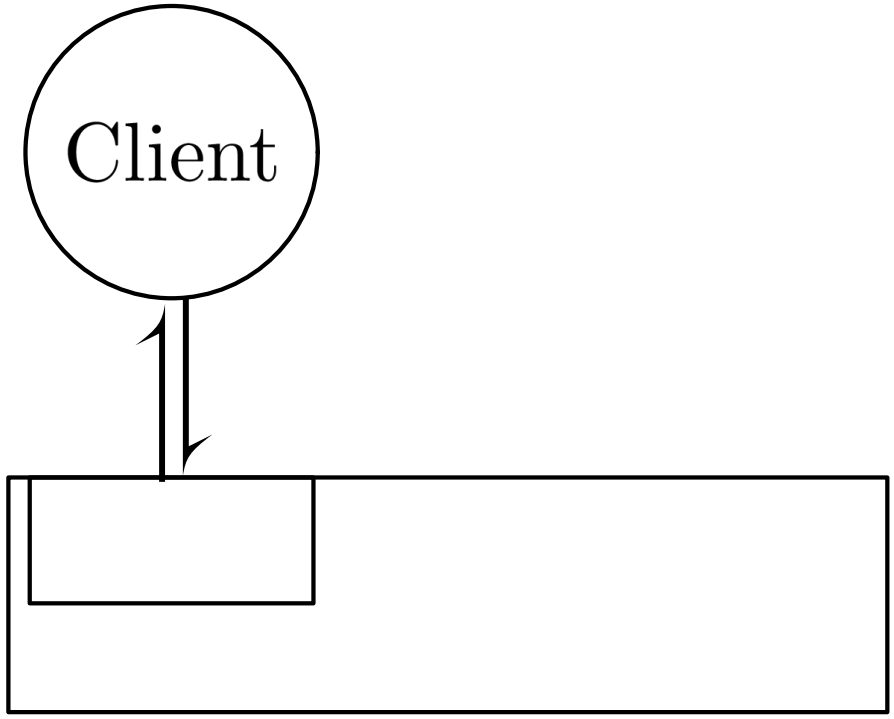
$\{\widetilde{\pi}\}$



From Actor to Network

From Network to Actor

Routing Events for Service Discovery



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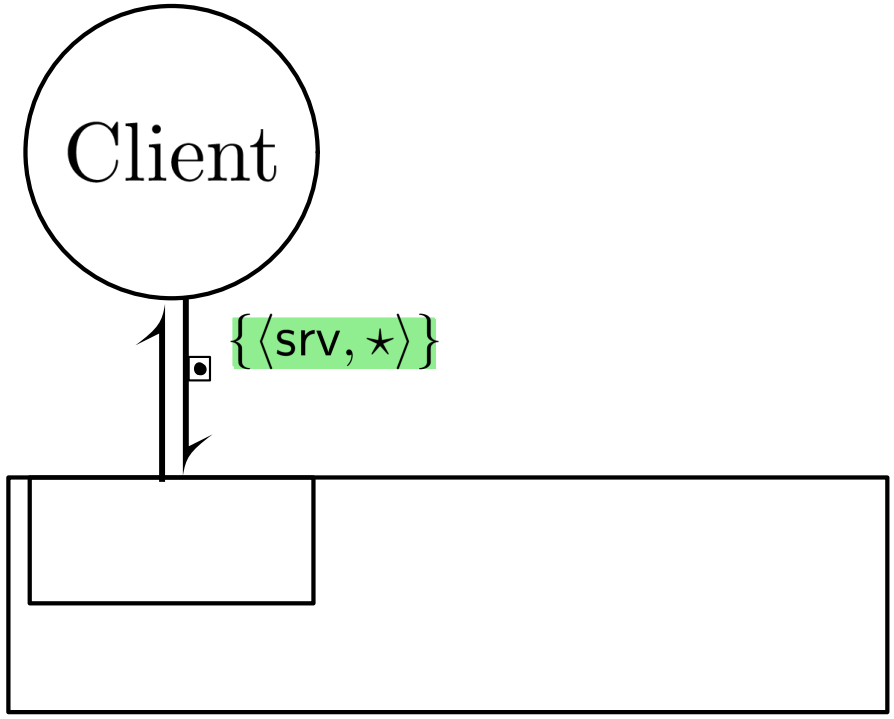

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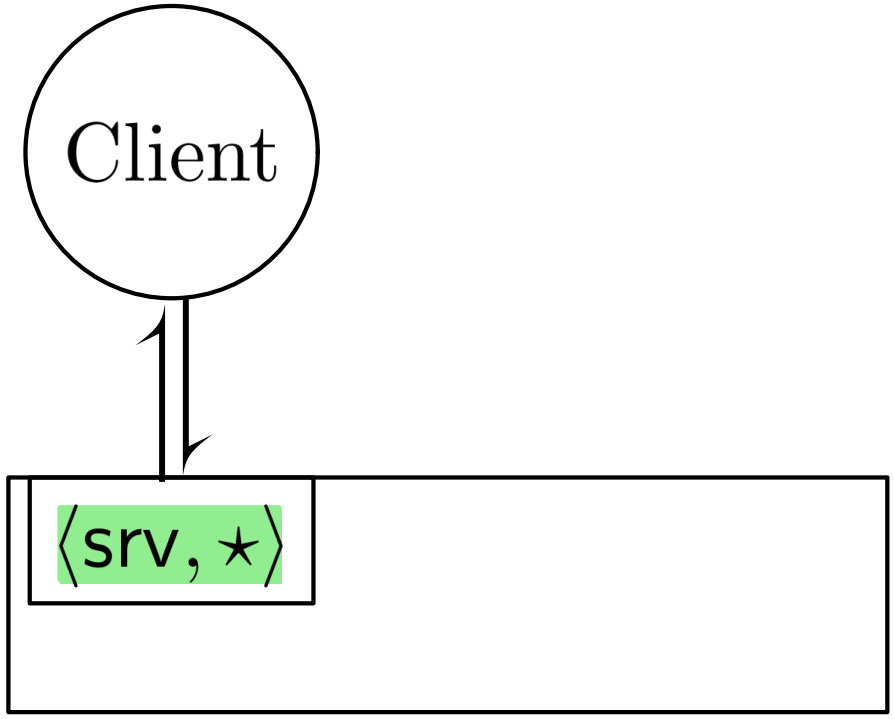

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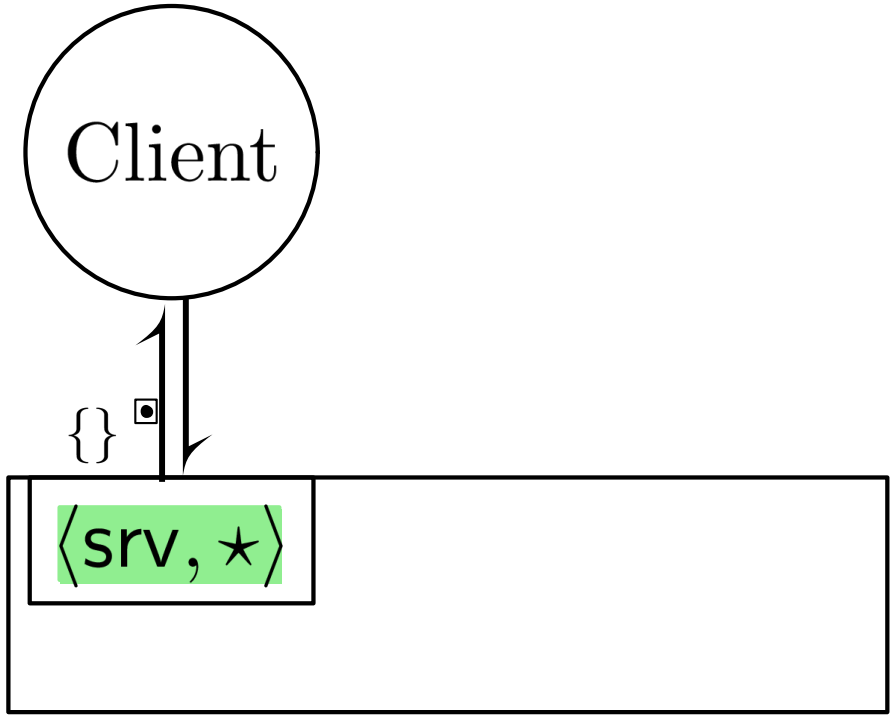

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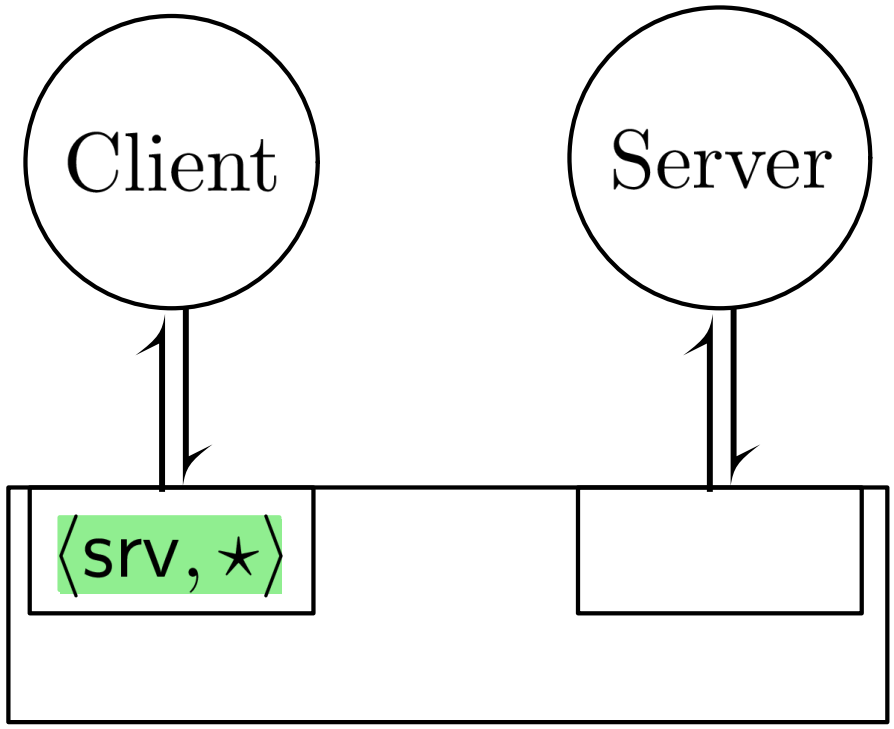

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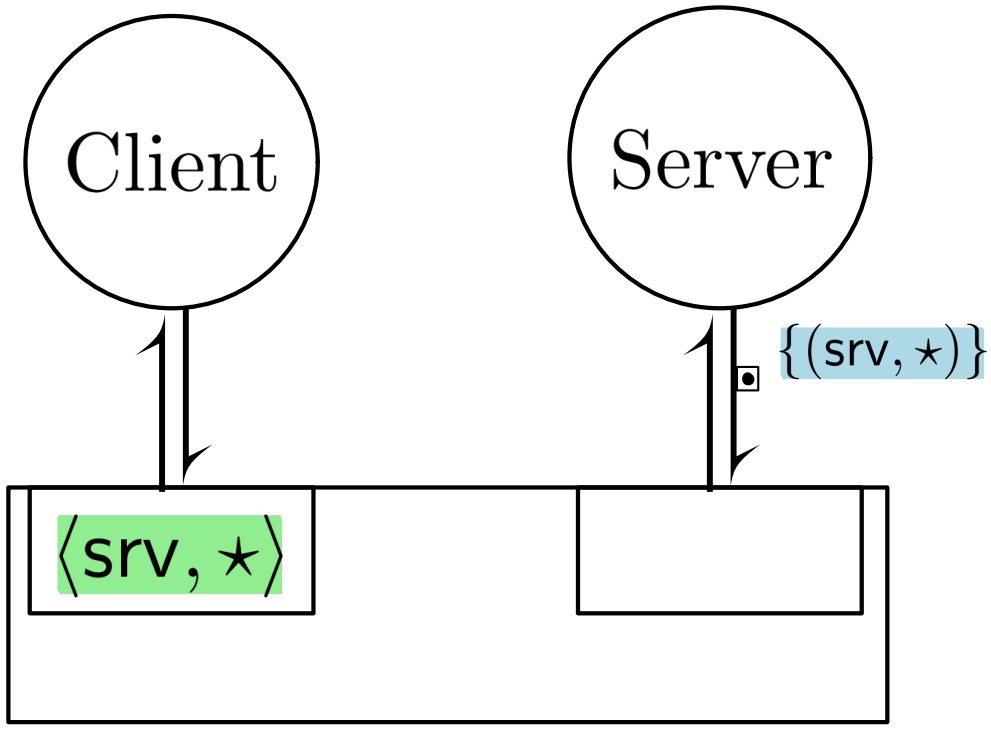

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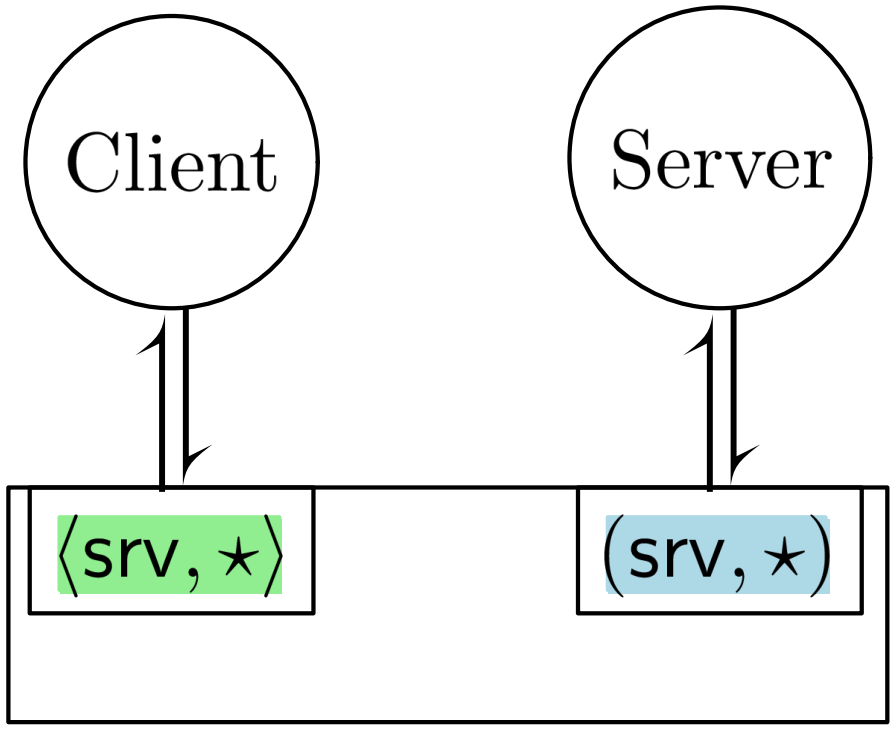

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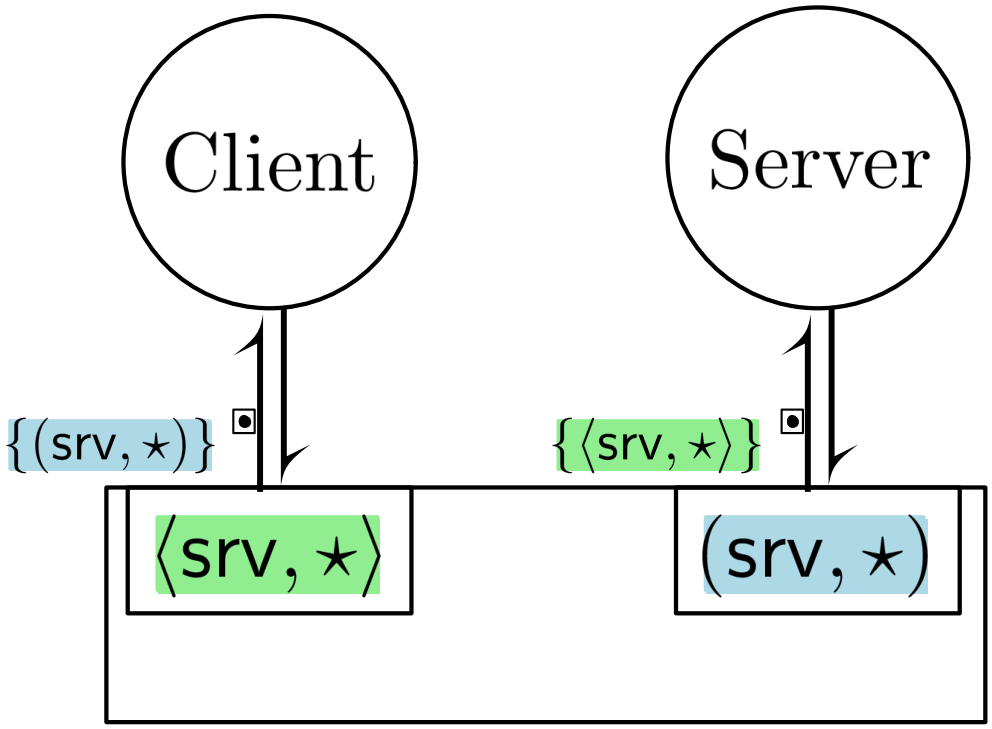

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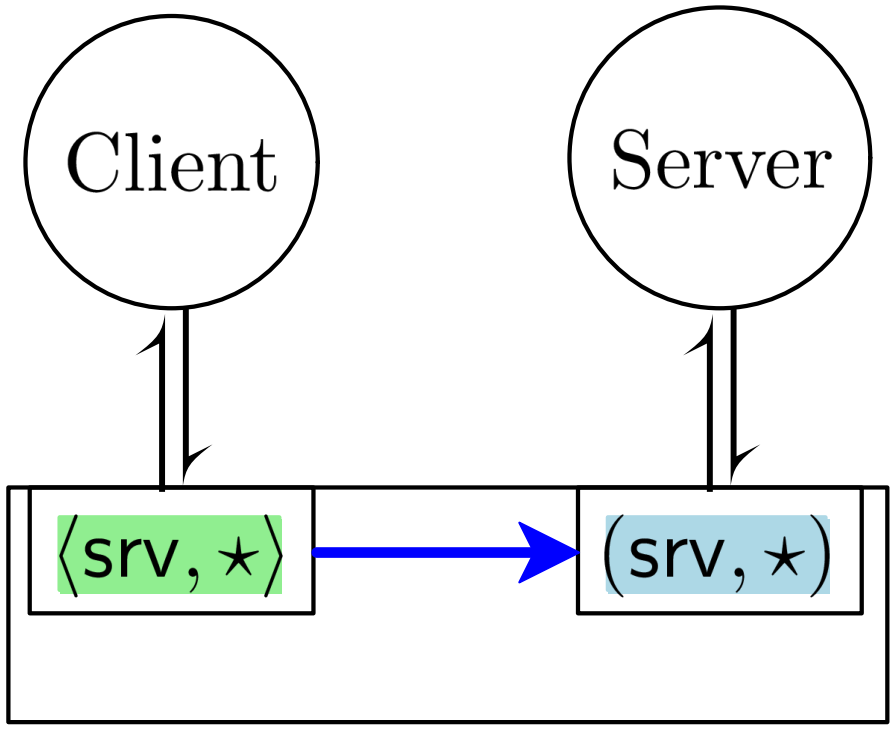
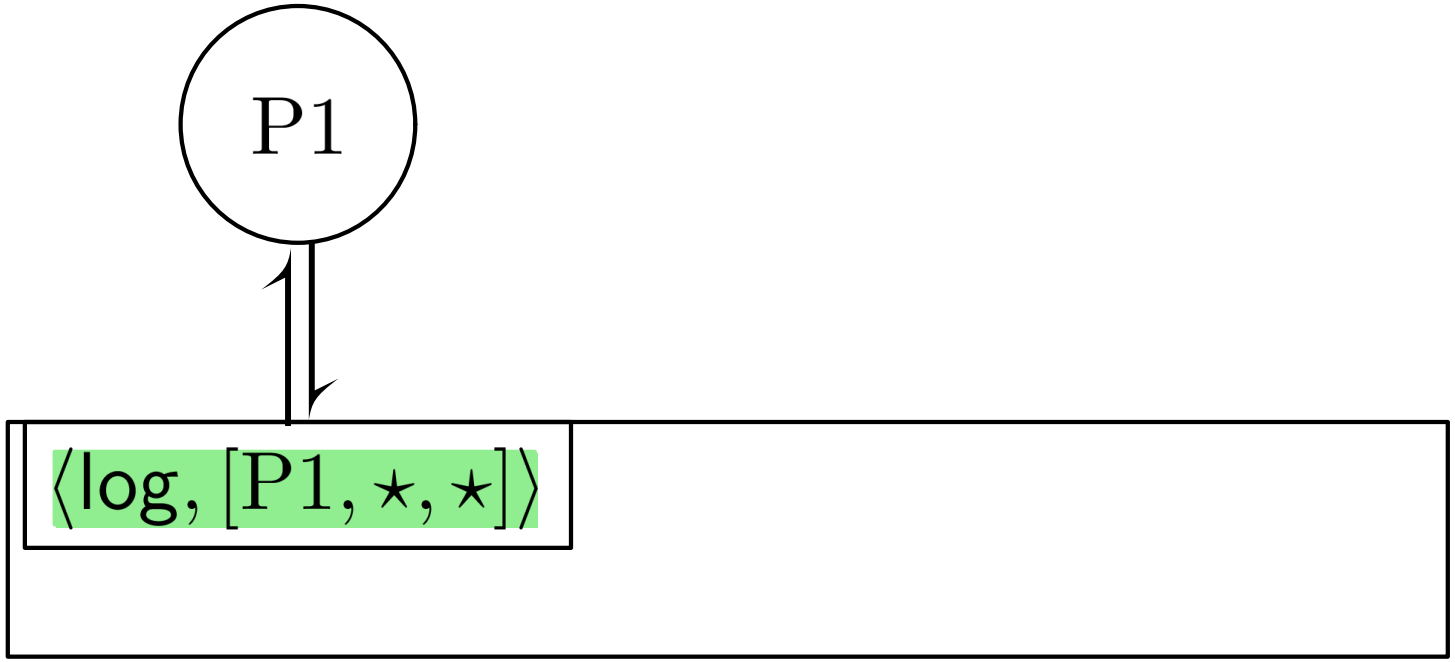


Routing Events for Presence Detection



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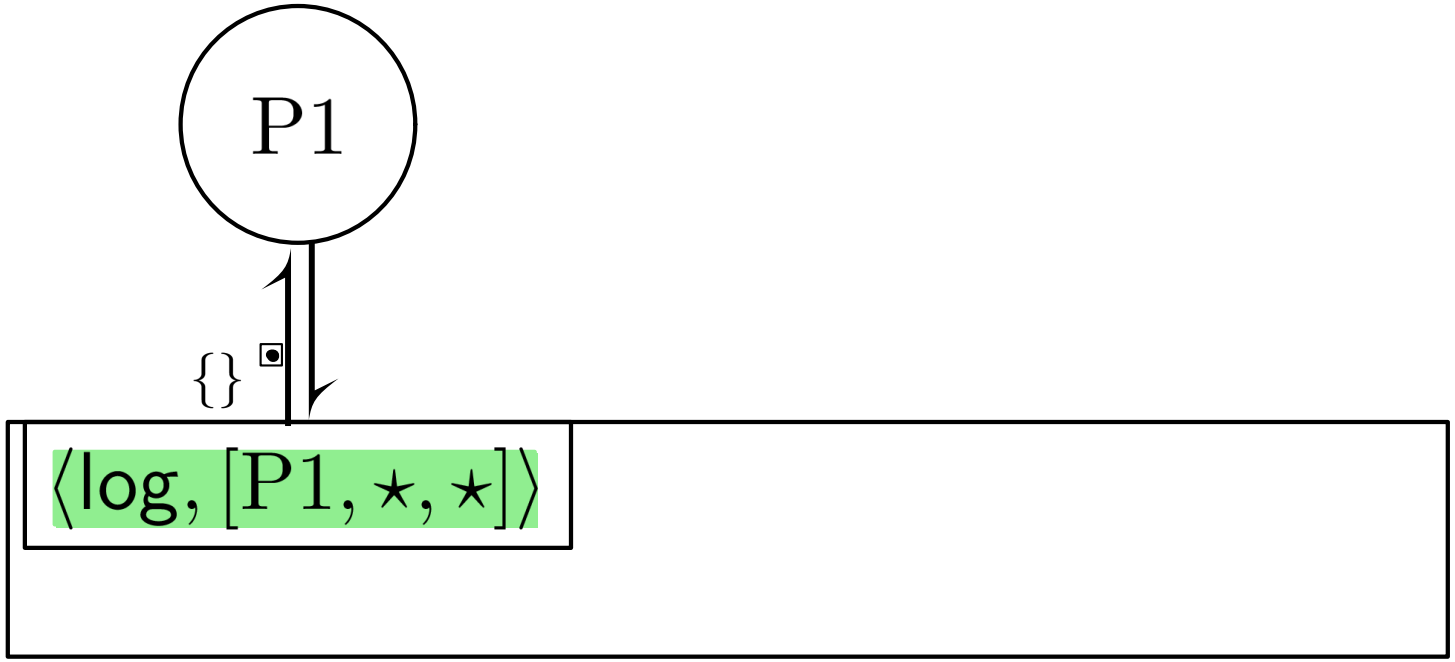

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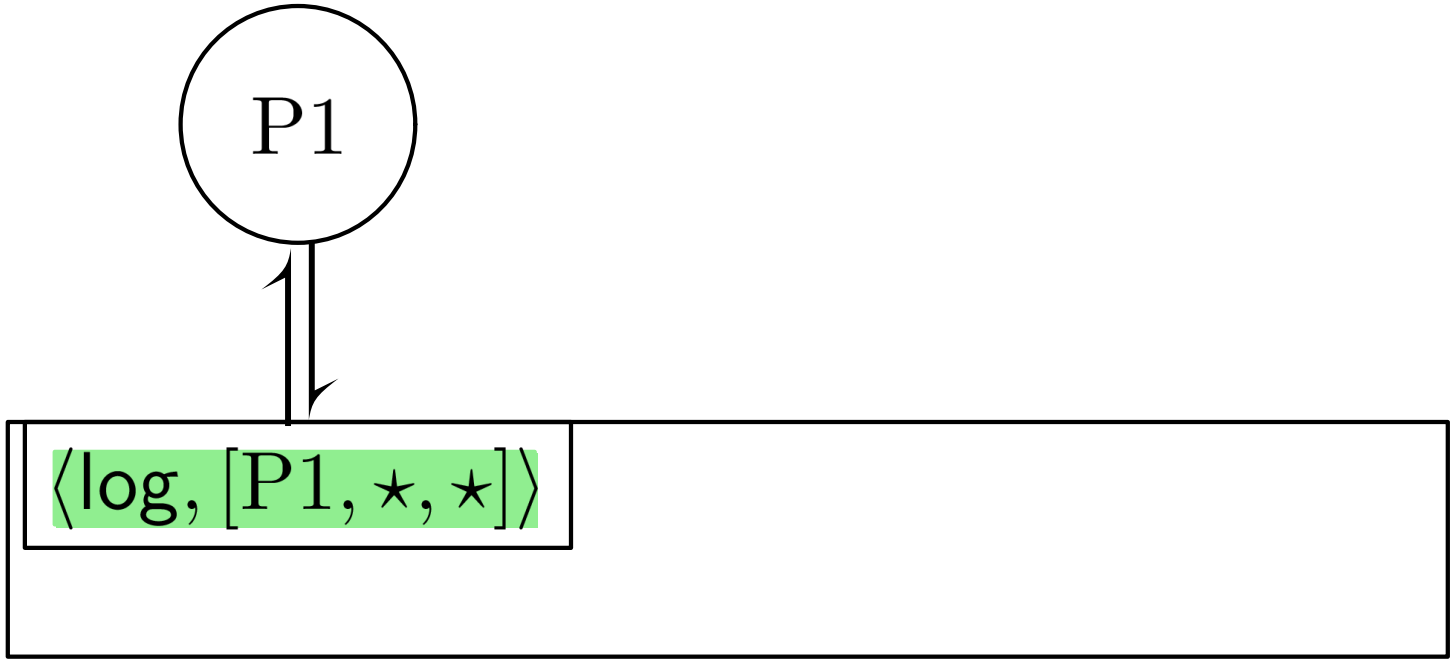

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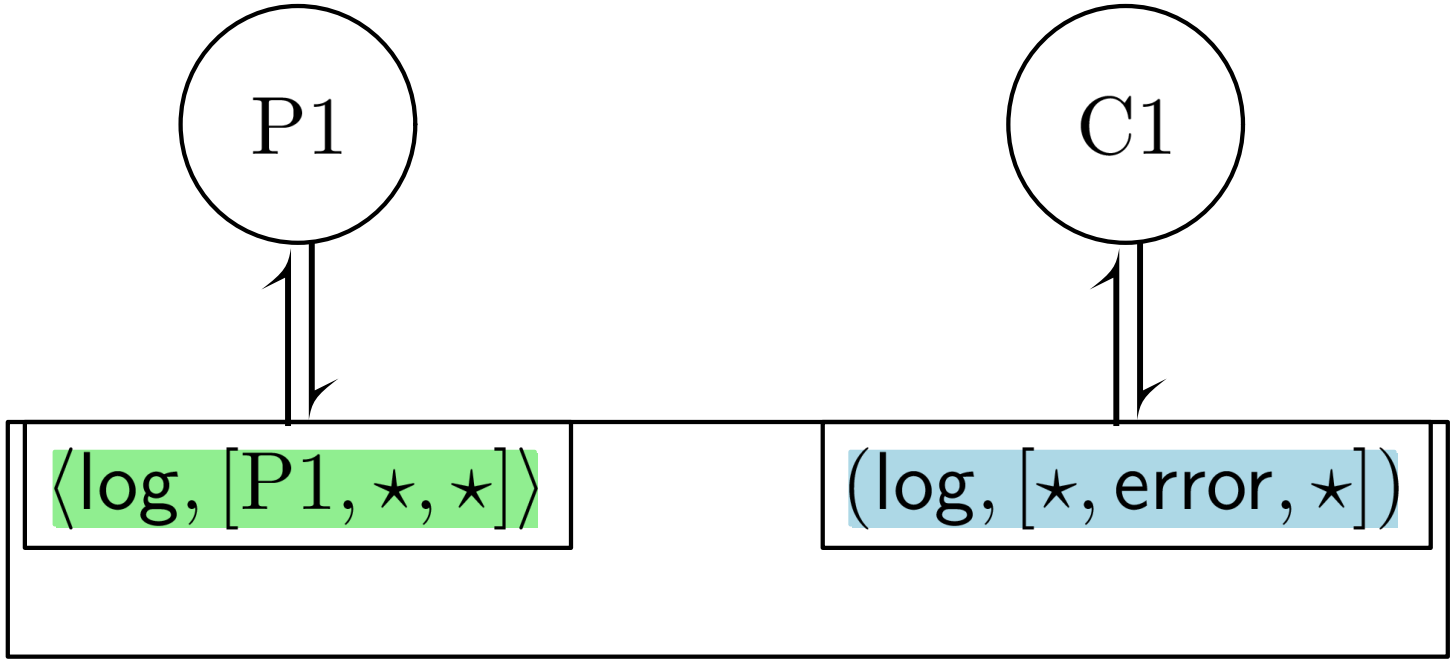

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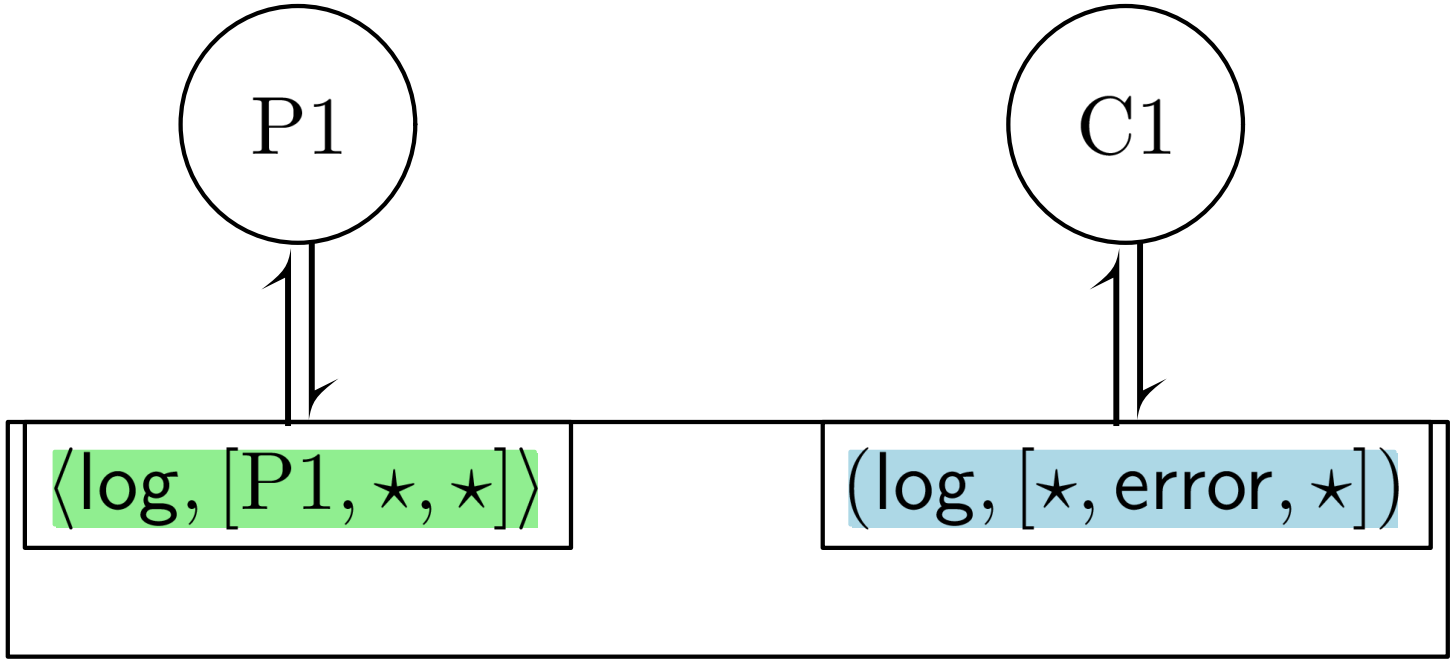
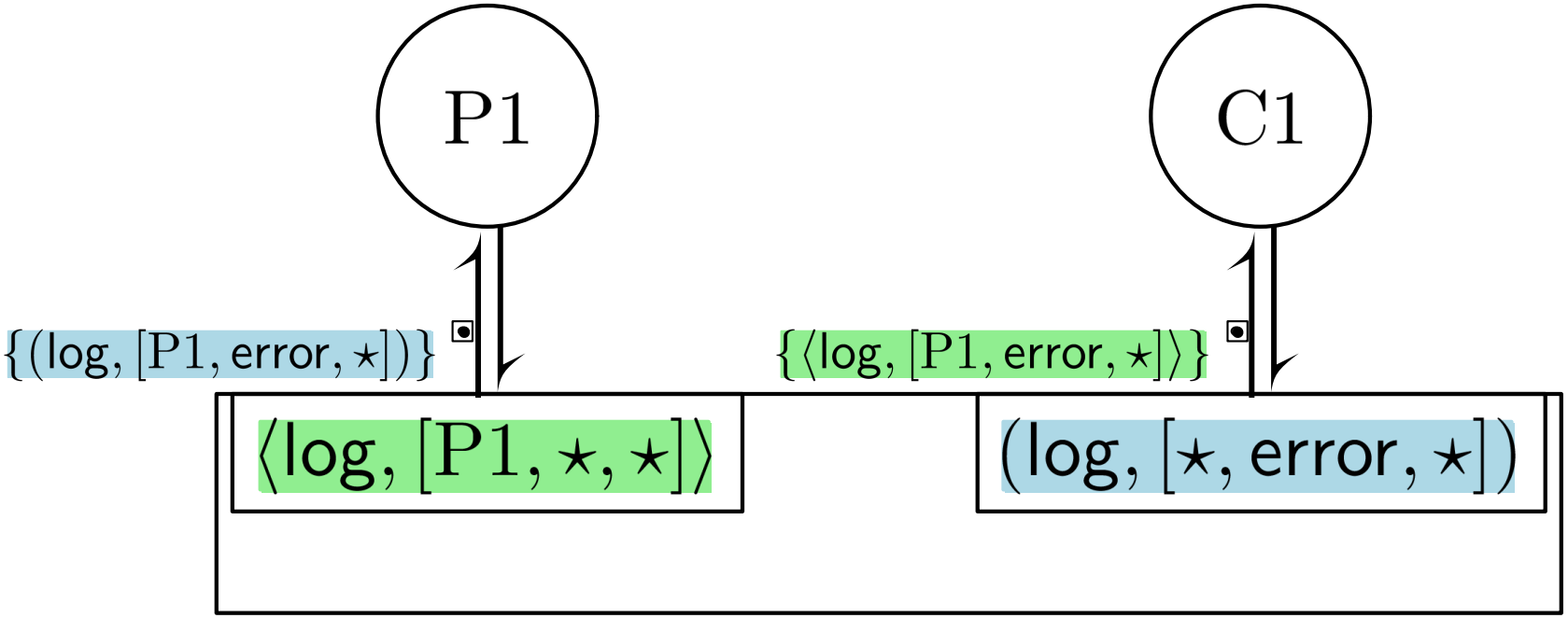


$$\mathsf{log}, [\mathrm{P1}, \star, \star] \quad \cap \quad \mathsf{log}, [\star, \mathsf{error}, \star] \quad = \quad \mathsf{log}, [\mathrm{P1}, \mathsf{error}, \star]$$

Routing Events for Presence Detection



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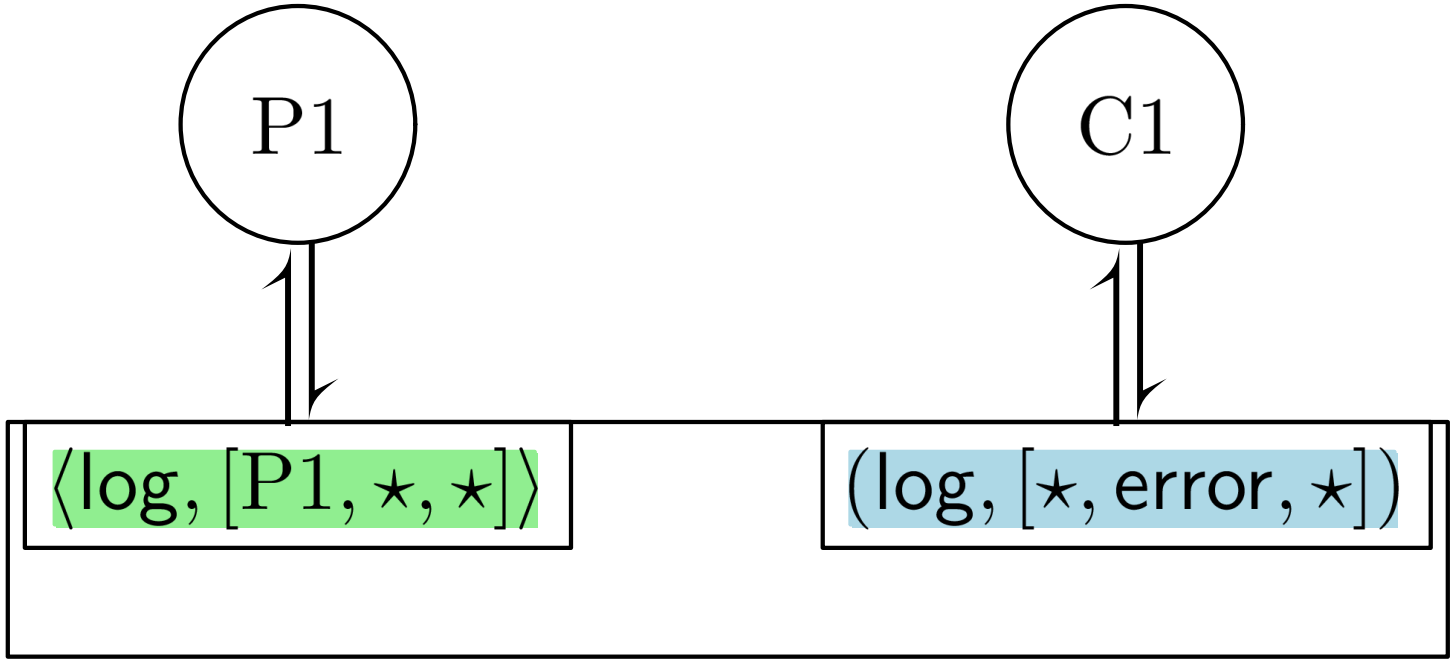
Routing Events for Presence Detection



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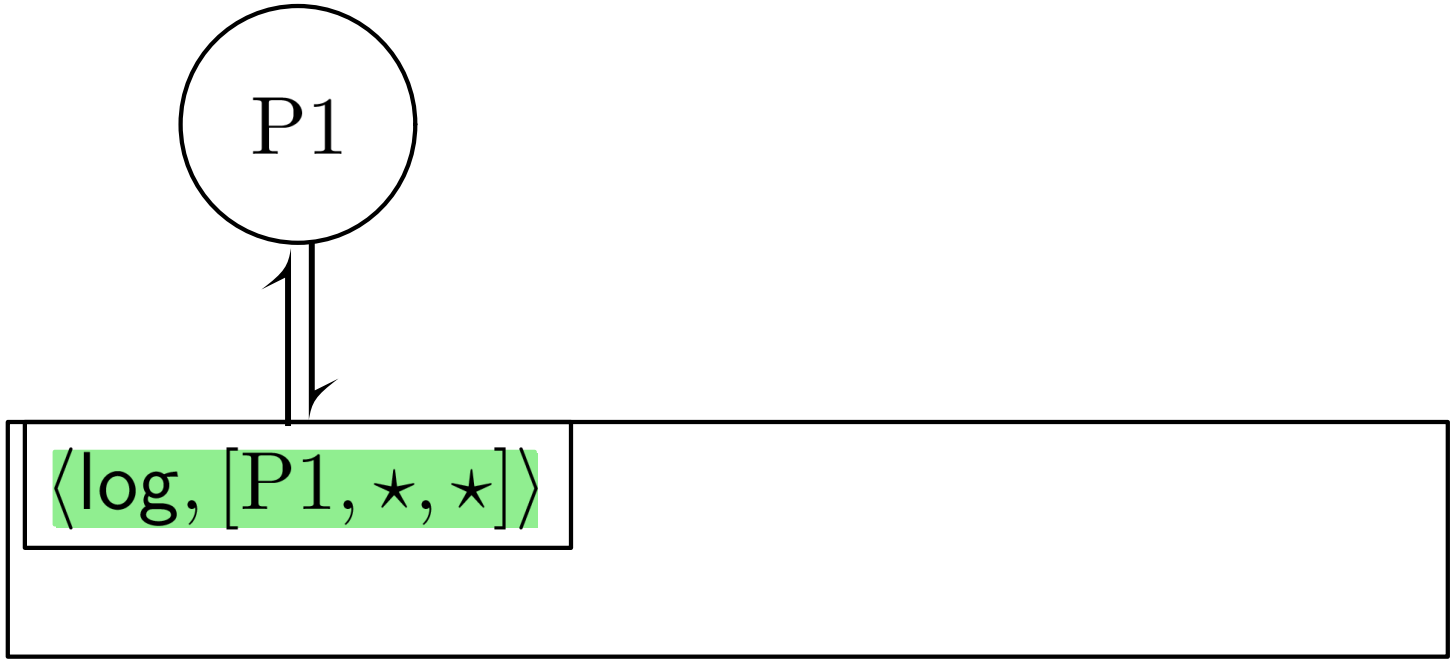
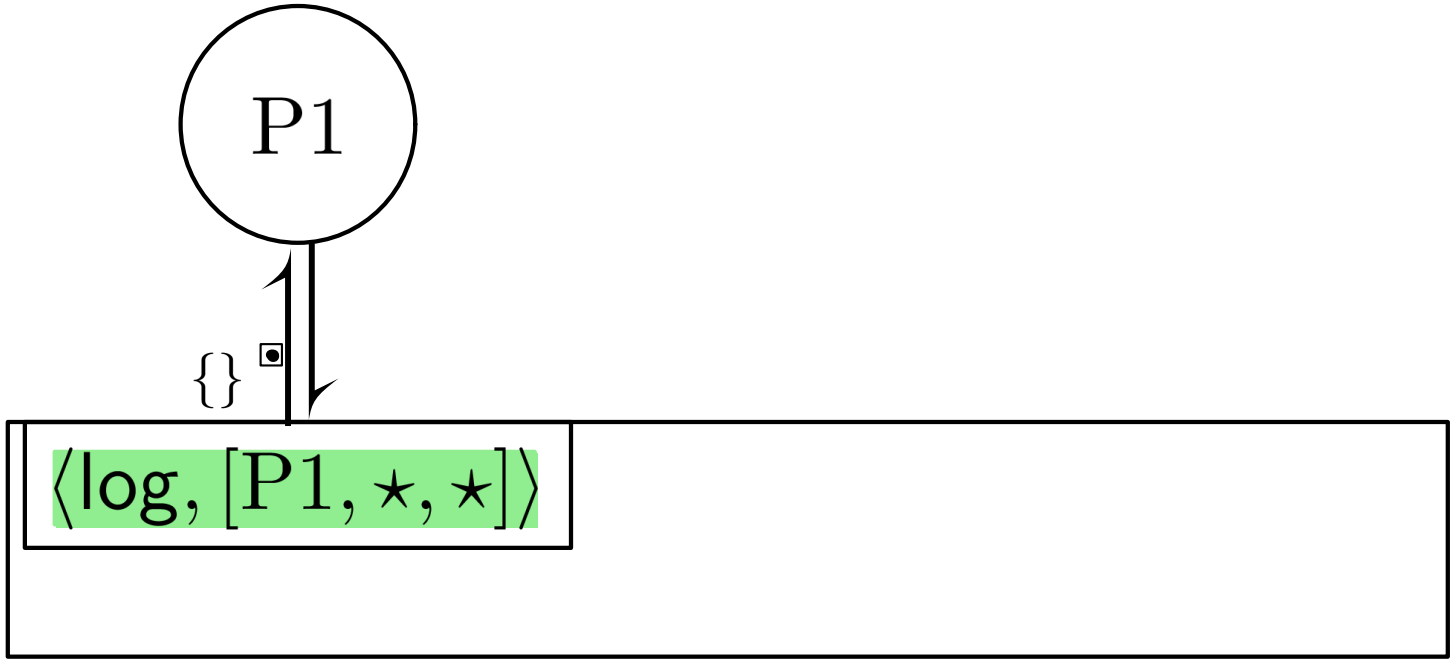


Routing Events for Presence Detection



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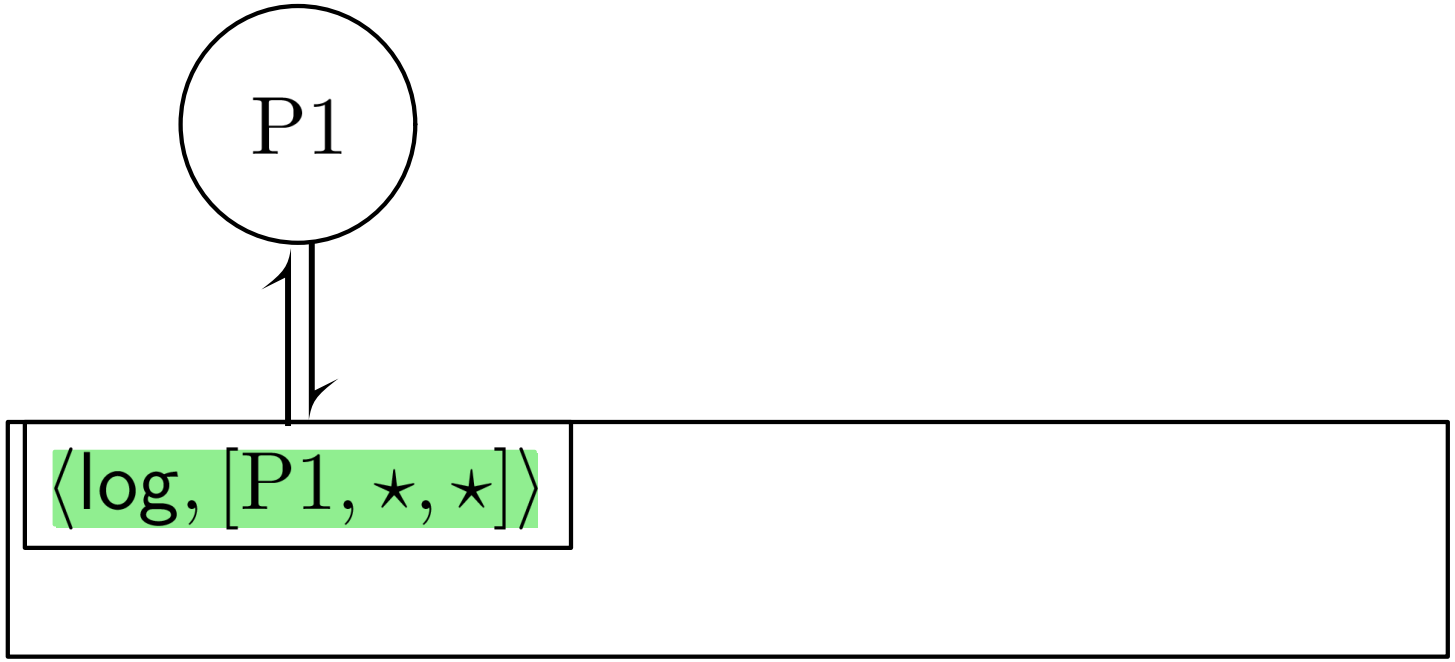

Routing Events for Crash Detection

cf. Erlang's links/monitors [Armstrong 2003]

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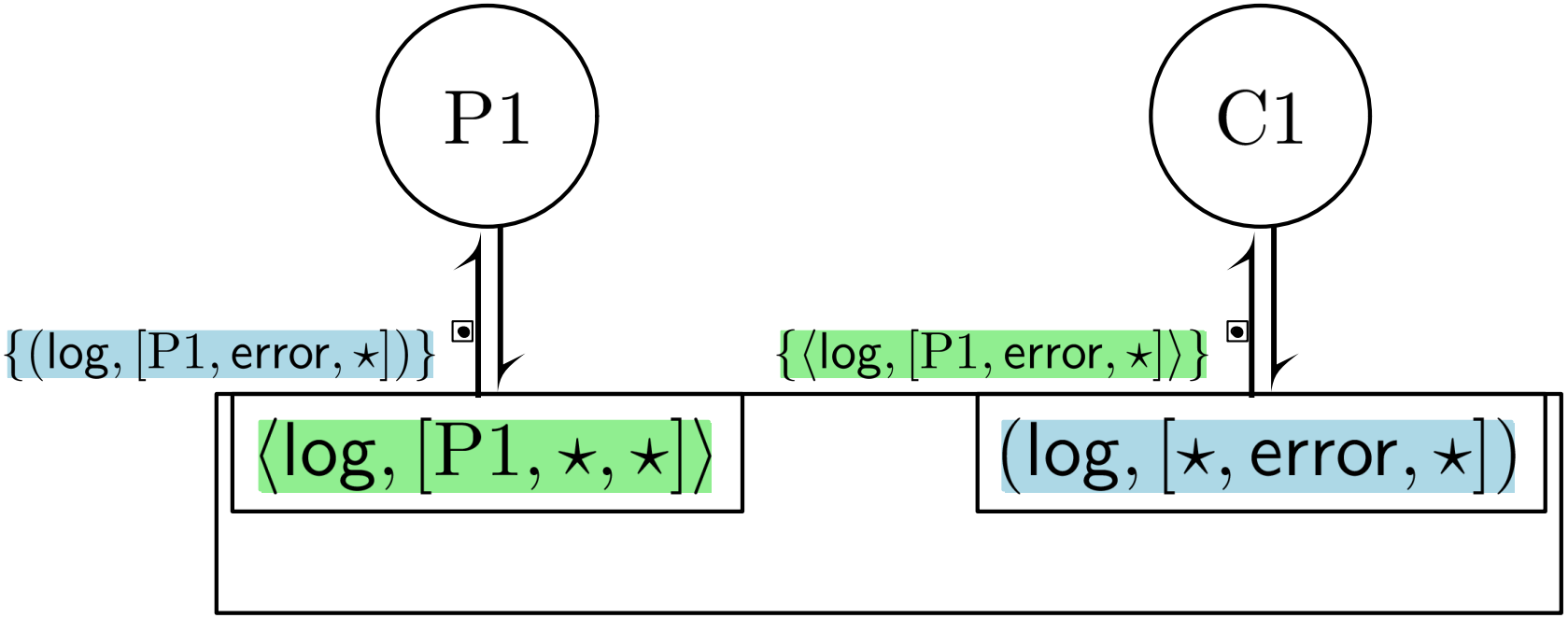

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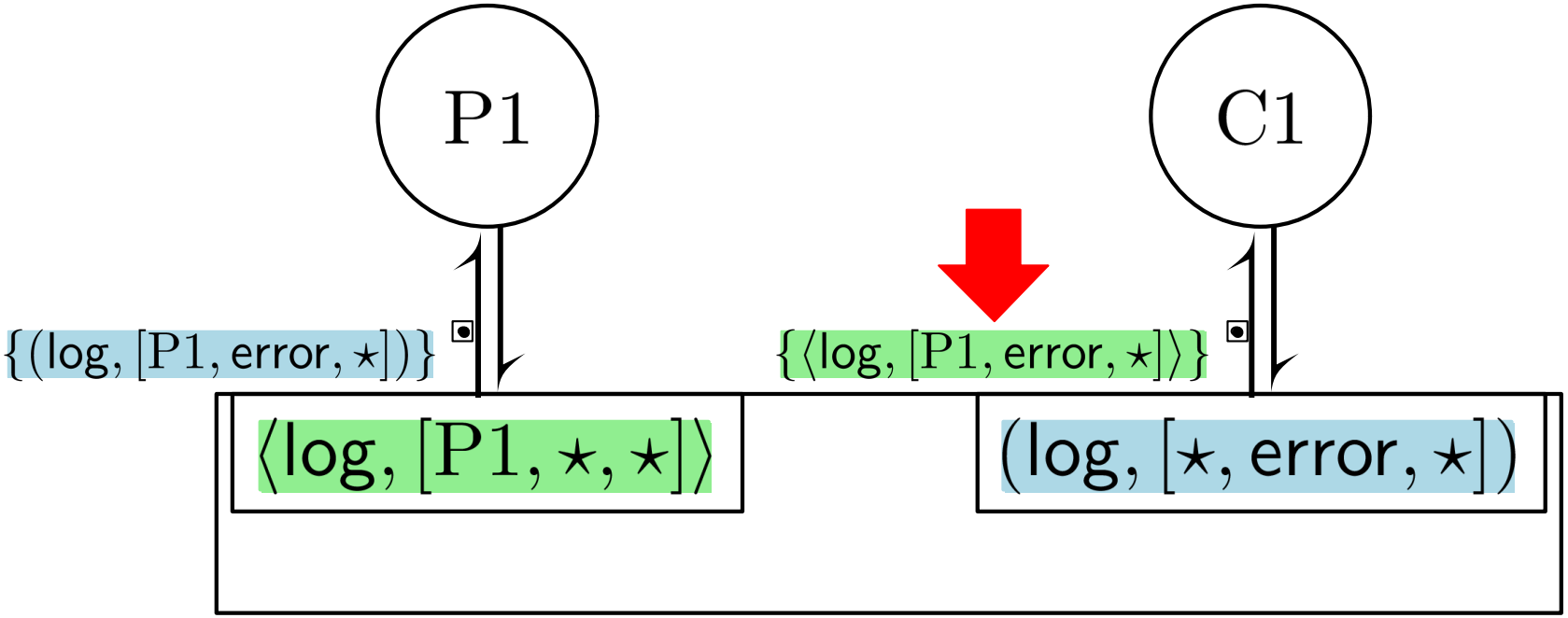

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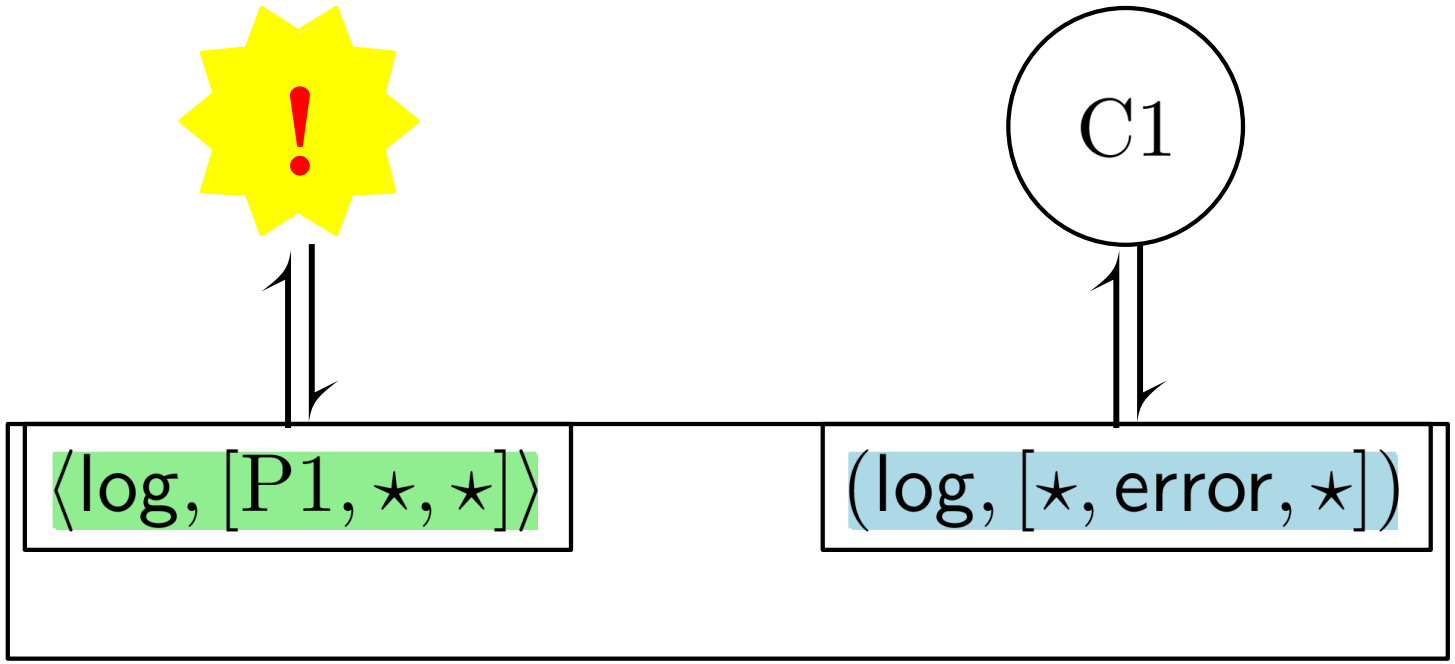

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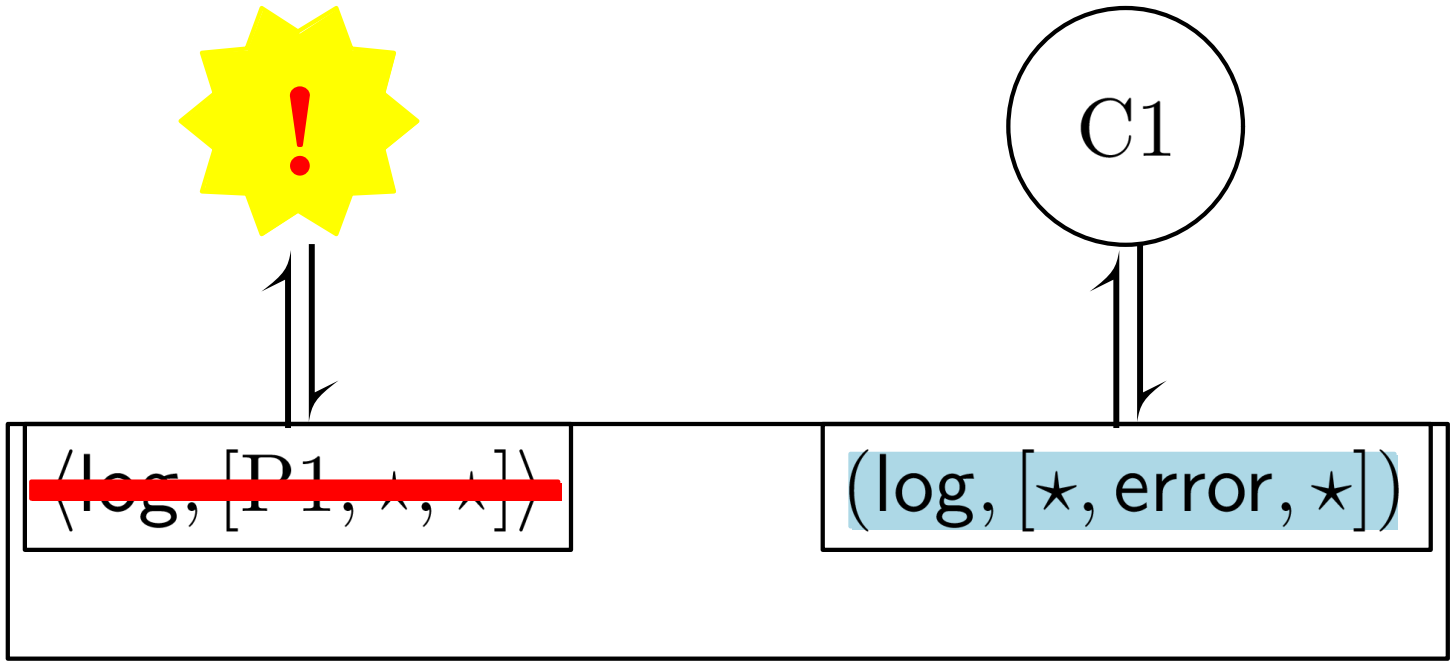

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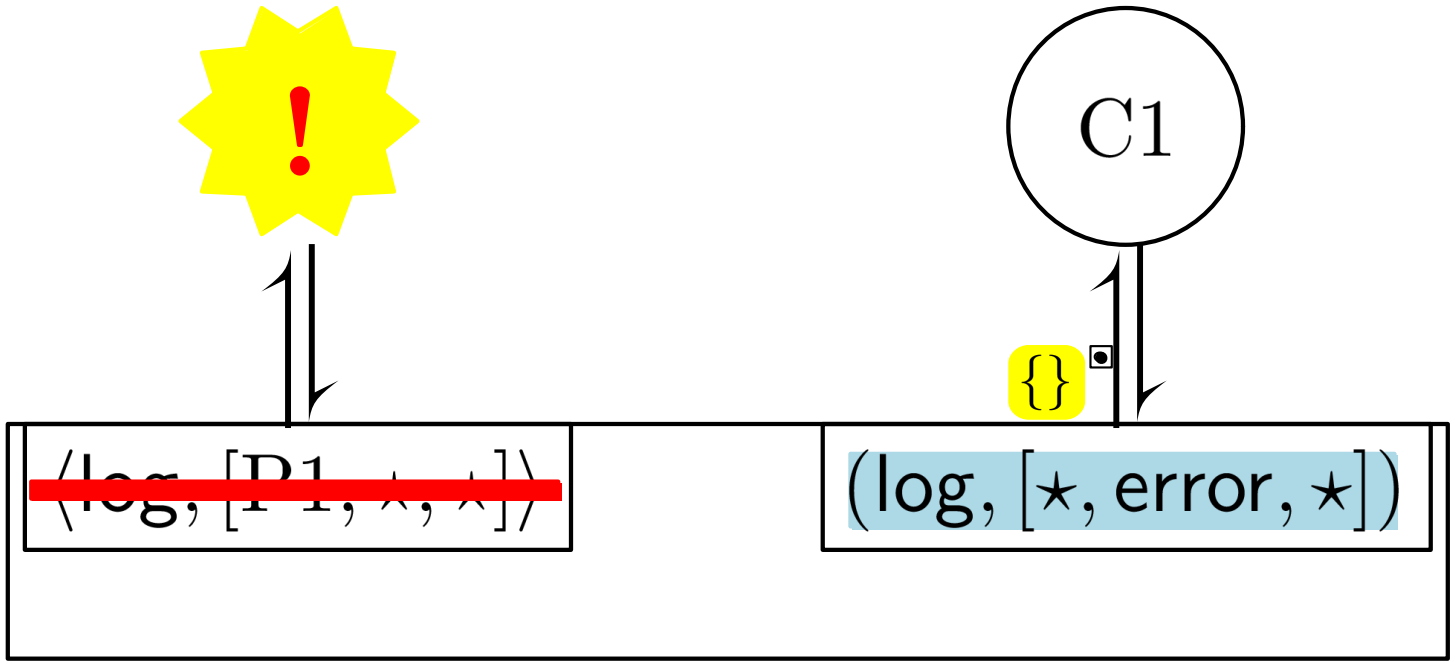

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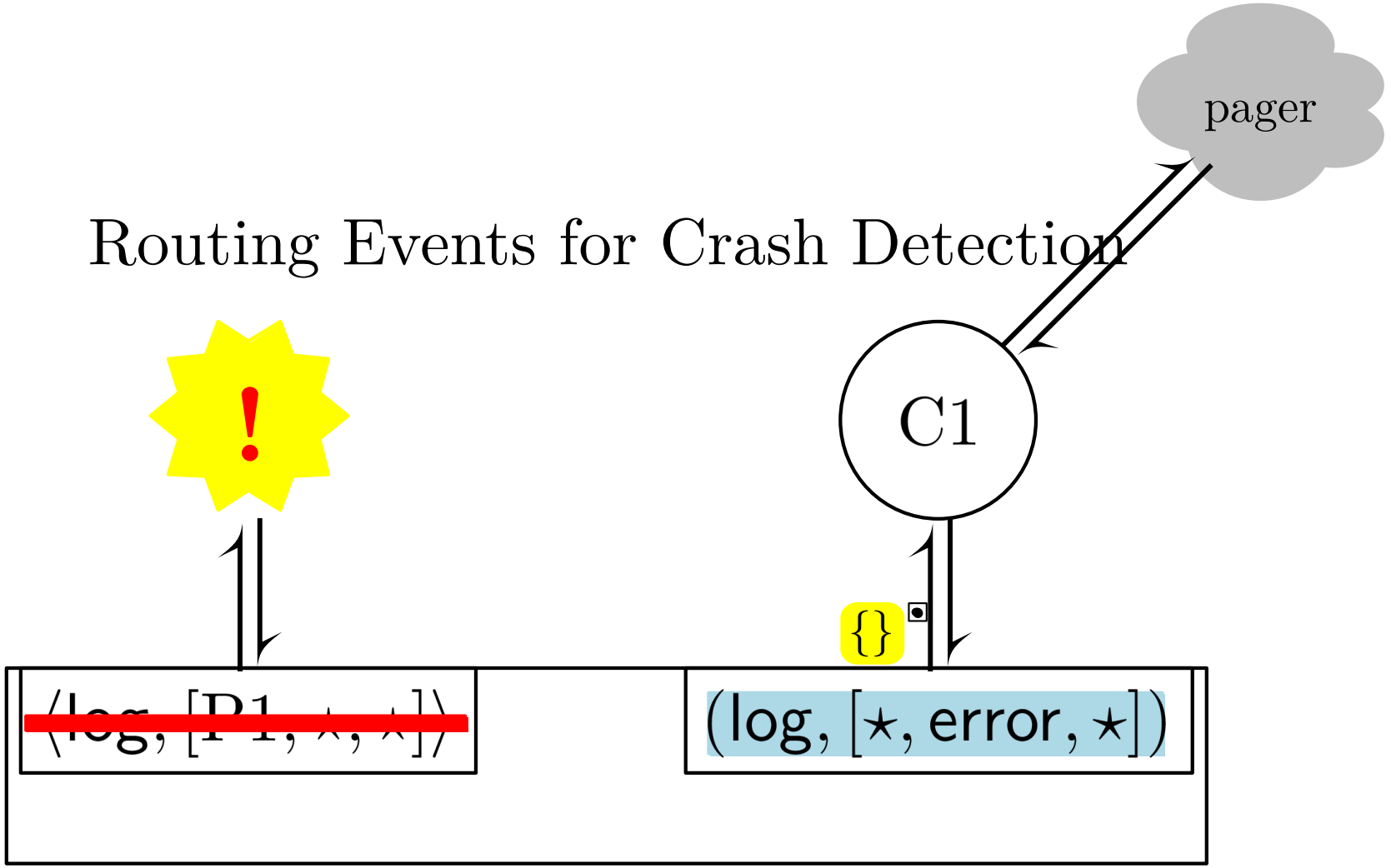

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Logging: Requirements Scorecard

Route log entries from producers to consumers	☑ pub/sub
Consumers filter log messages	☑ pub/sub
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Alert when a producer crashes/exits	☑ routing events
Uniform treatment of I/O	☑ pub/sub

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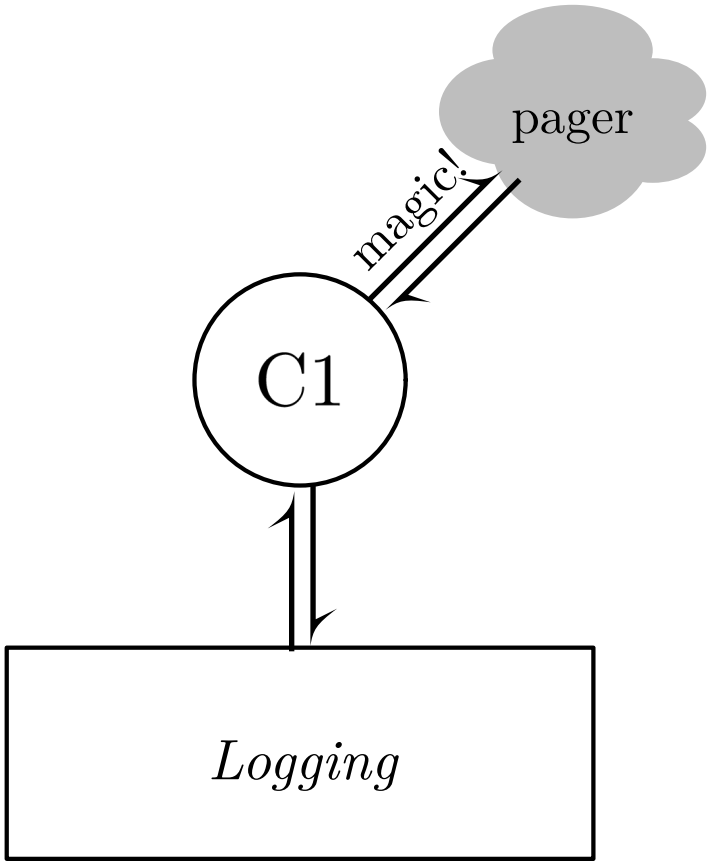
Alert when a producer crashes/exits	☑ routing events
Uniform treatment of I/O	⛀ not finished!

PART IV: Why Hierarchical Layering? How?

Logging: Requirements Scorecard

Route log entries from producers to consumers	☑
Consumers filter log messages	☑
Decouple producers from consumers	☑
Avoid shared-state explosion	☑
Discovery of logging service	☑
Only produce if someone's listening	☑
Alert when a producer crashes/exits	☑
Uniform treatment of I/O	☐ not finished!

Layers make I/O Uniform



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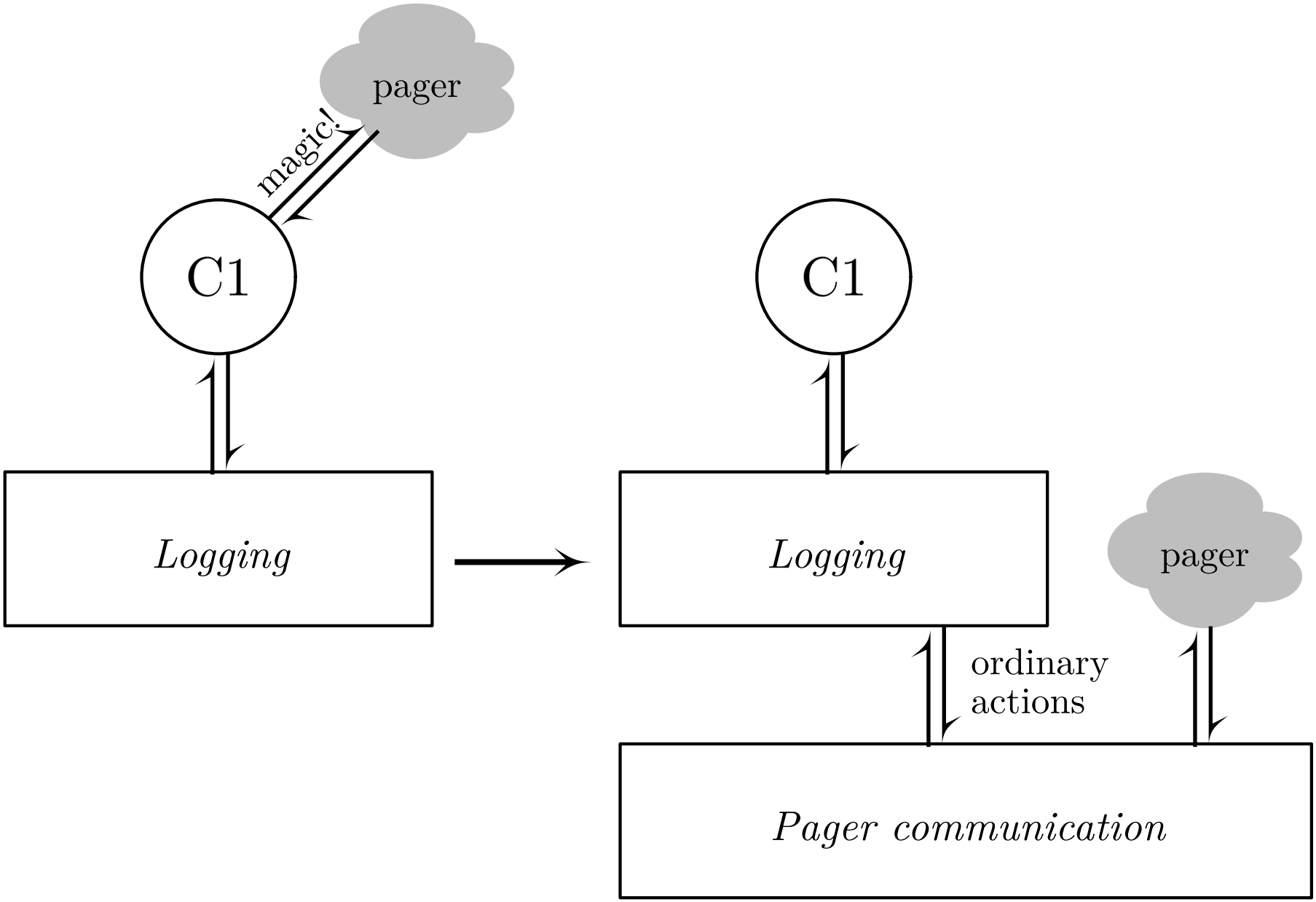

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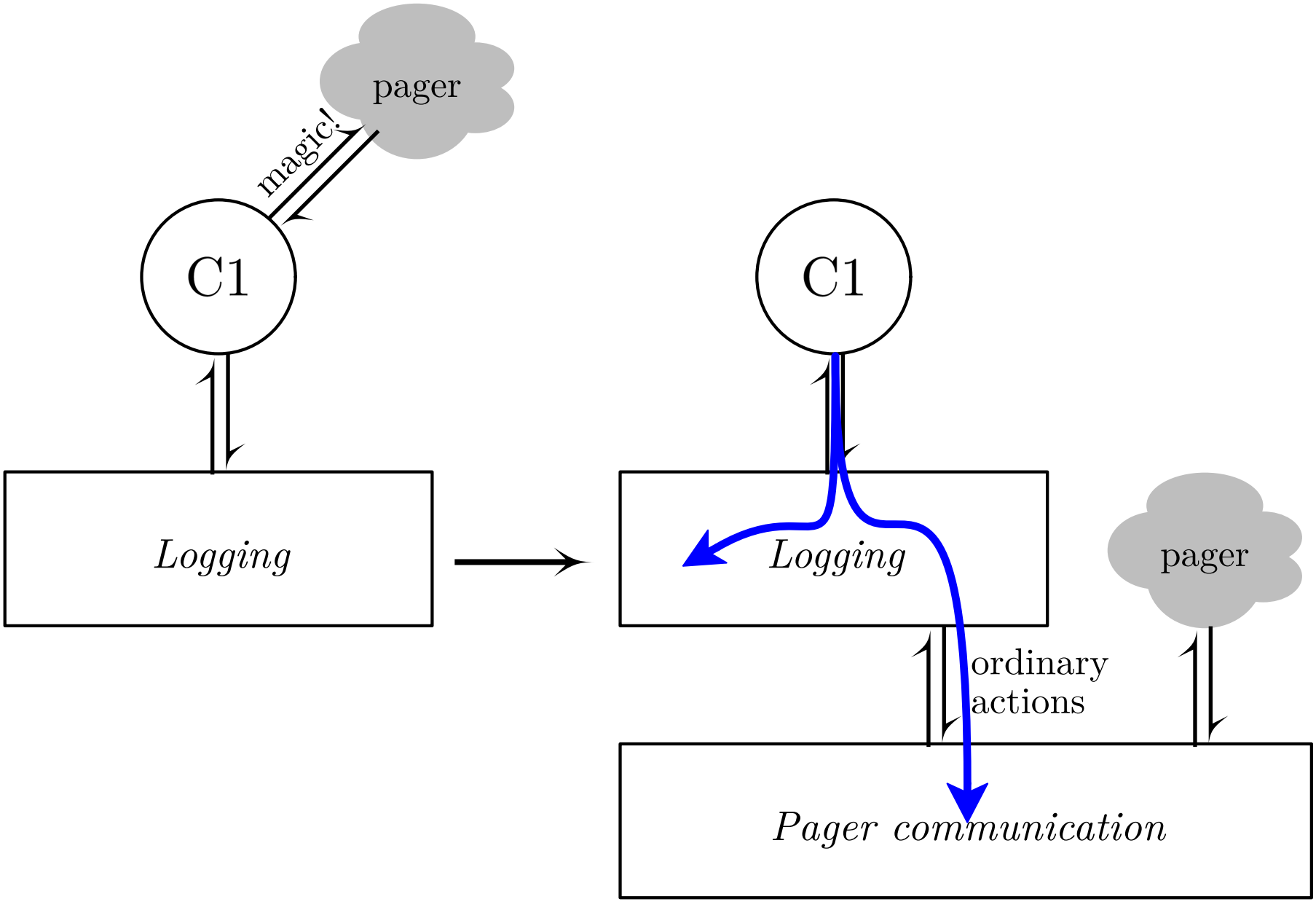
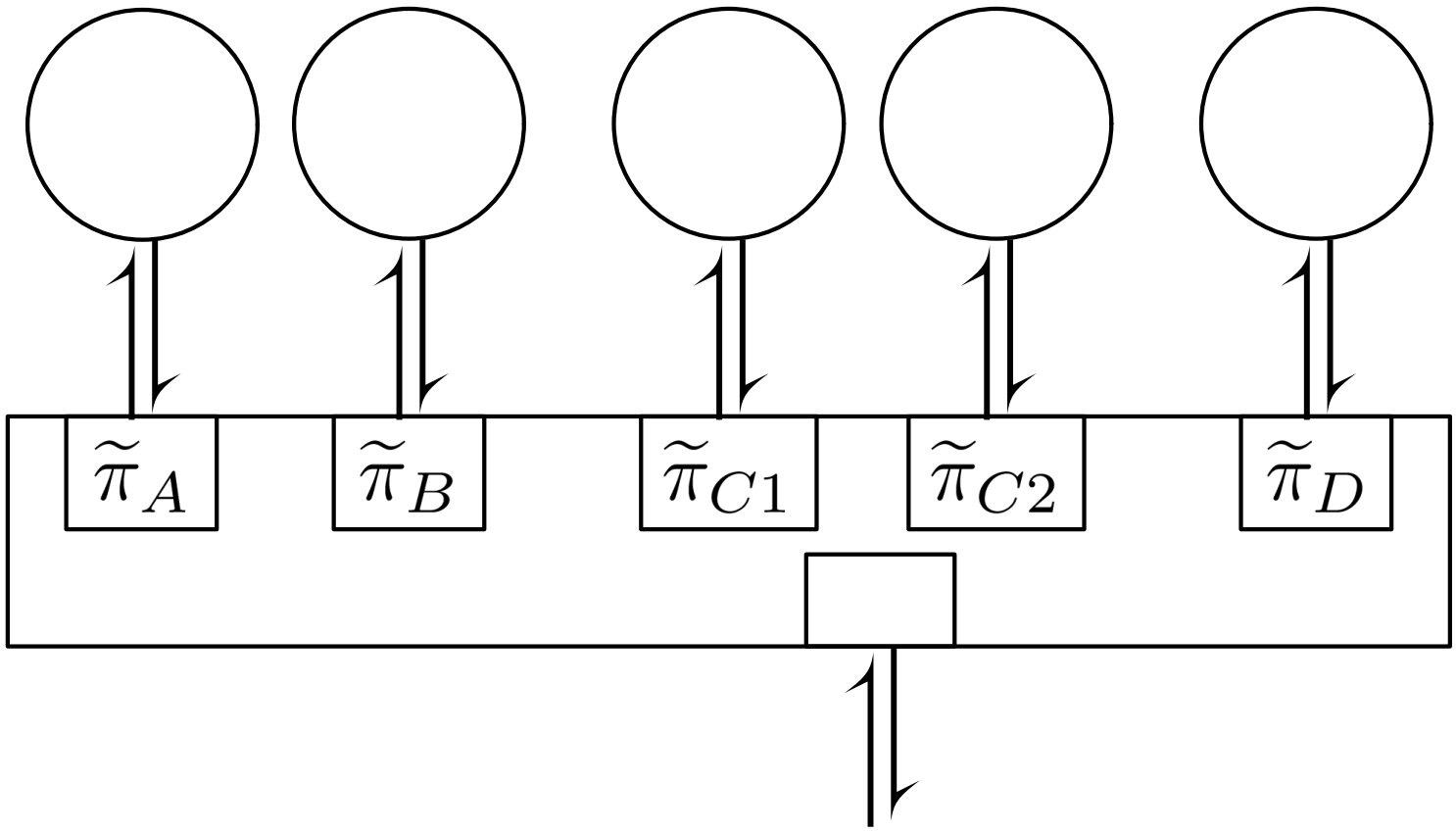
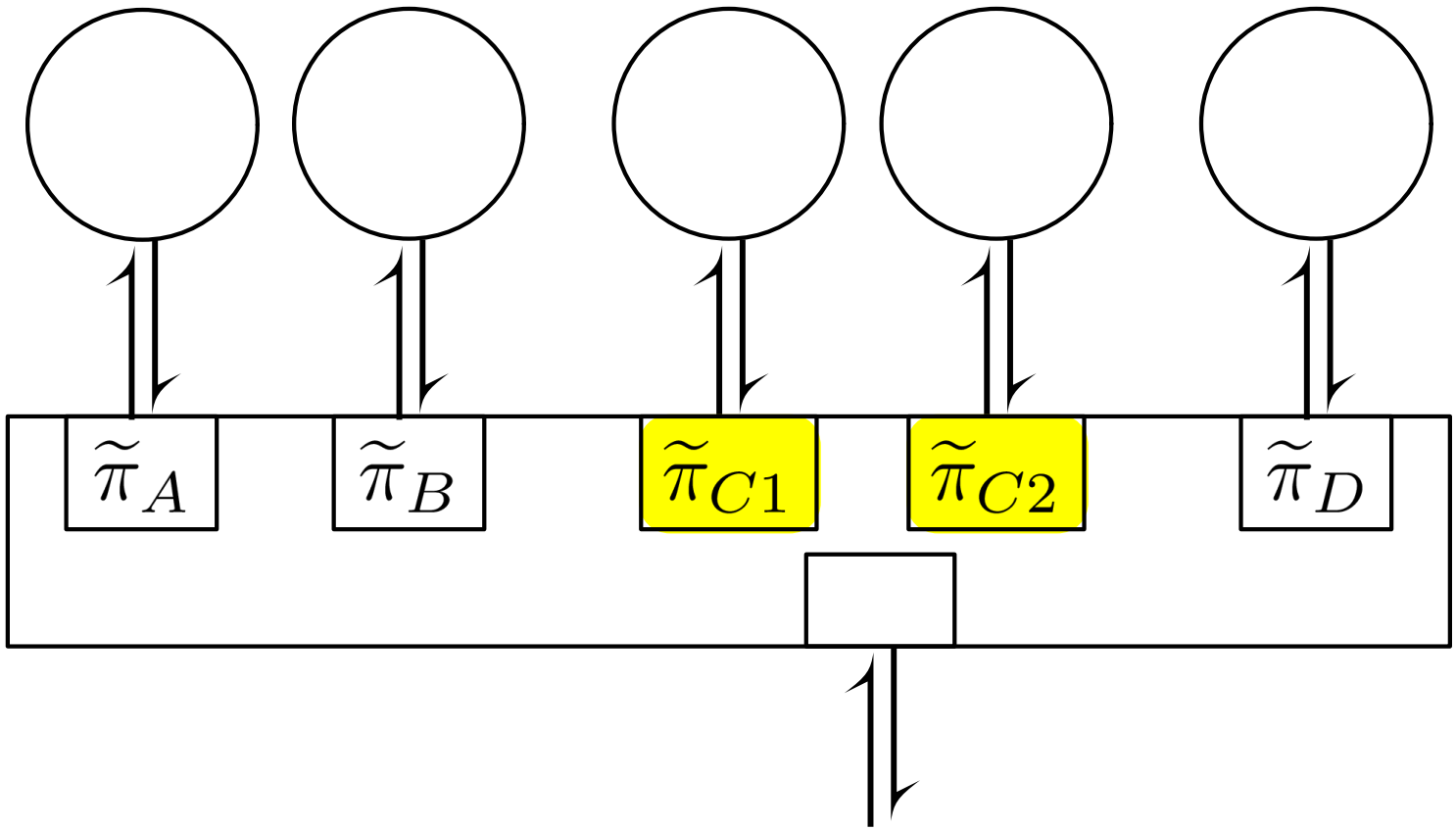


Layers Scope Conversations



Layers Scope Conversations



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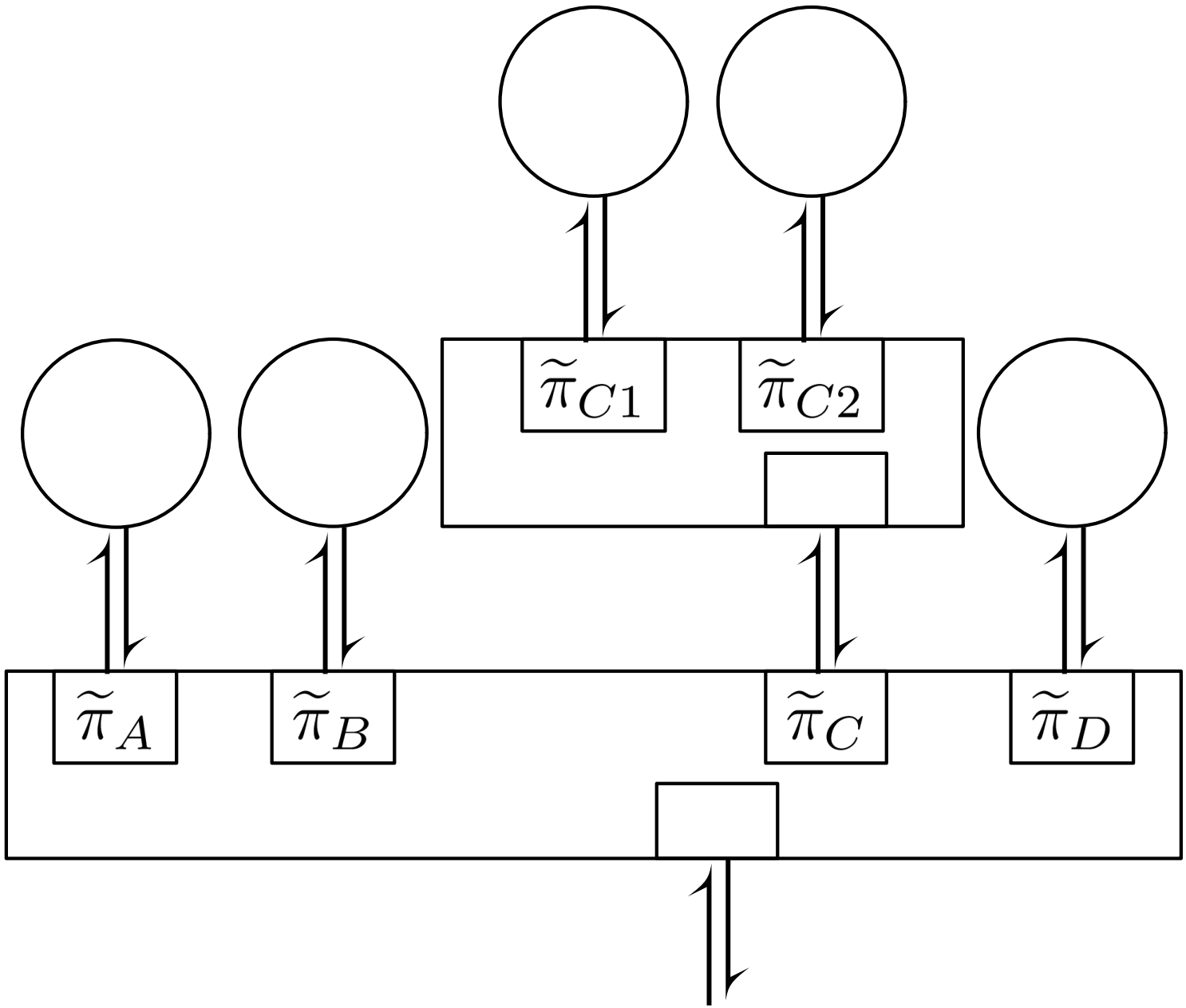

Layers Compose

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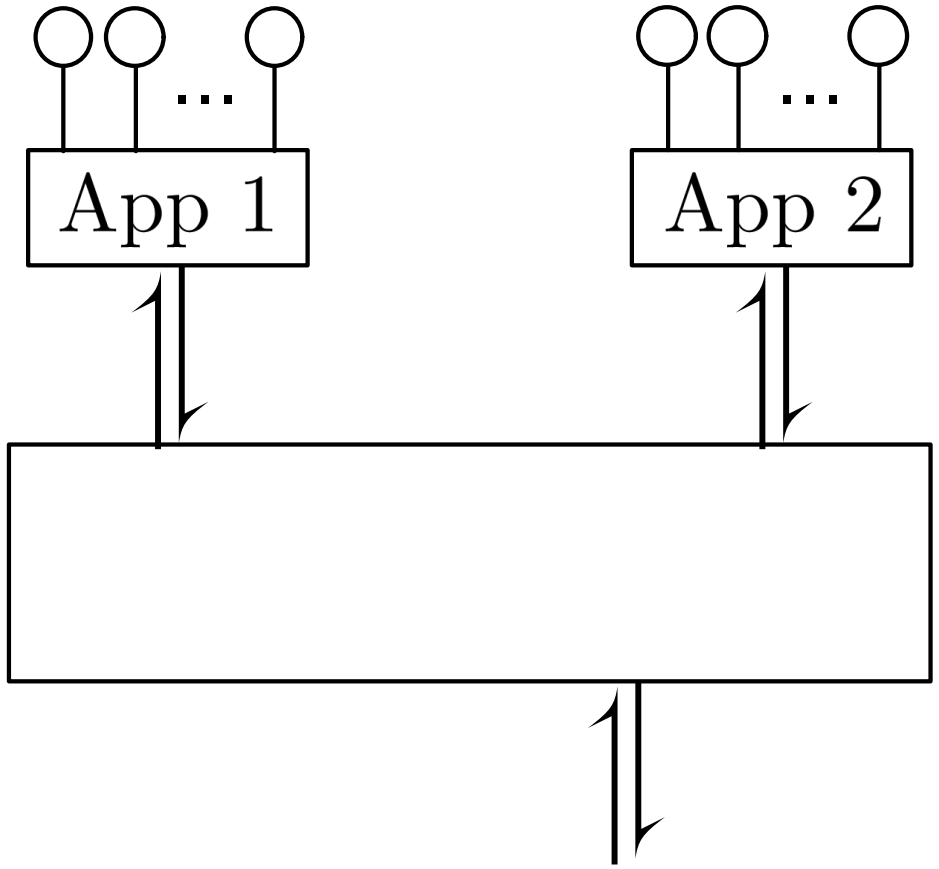
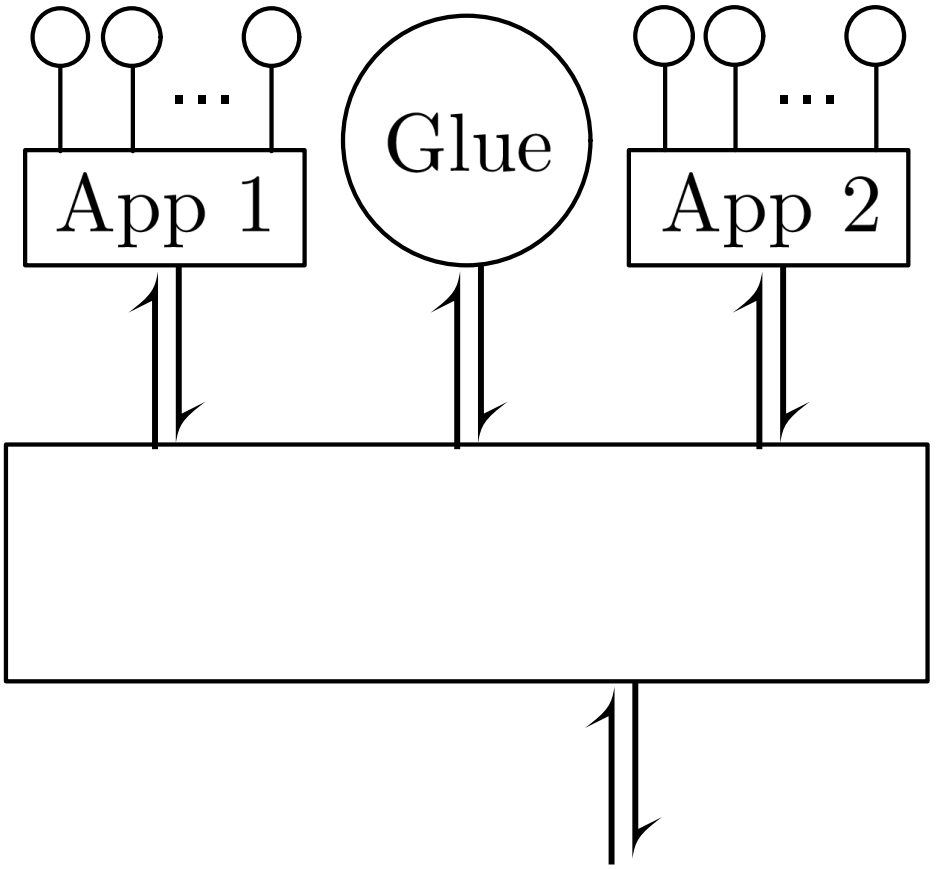
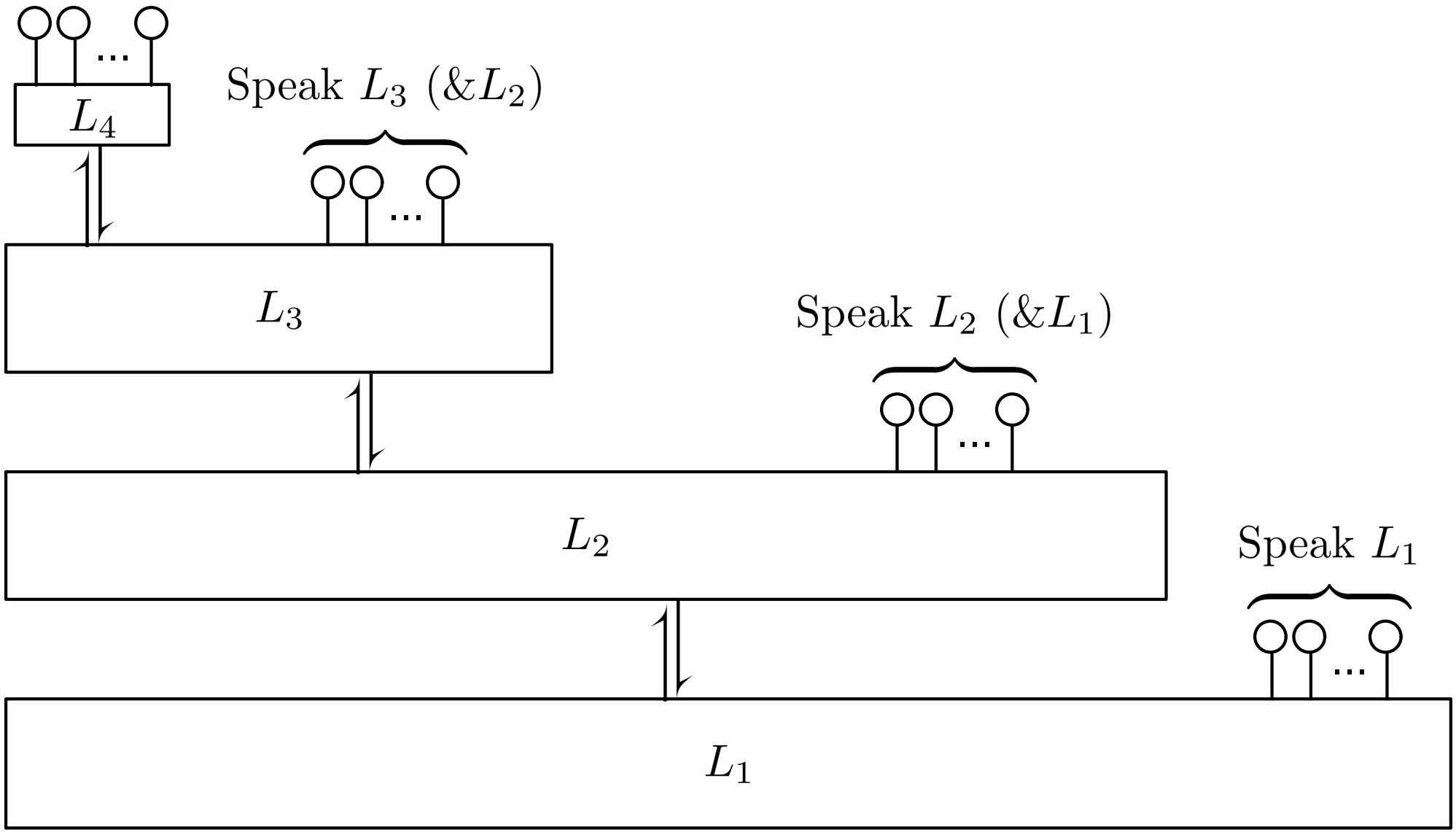


Layers Compose



One Layer = One Protocol



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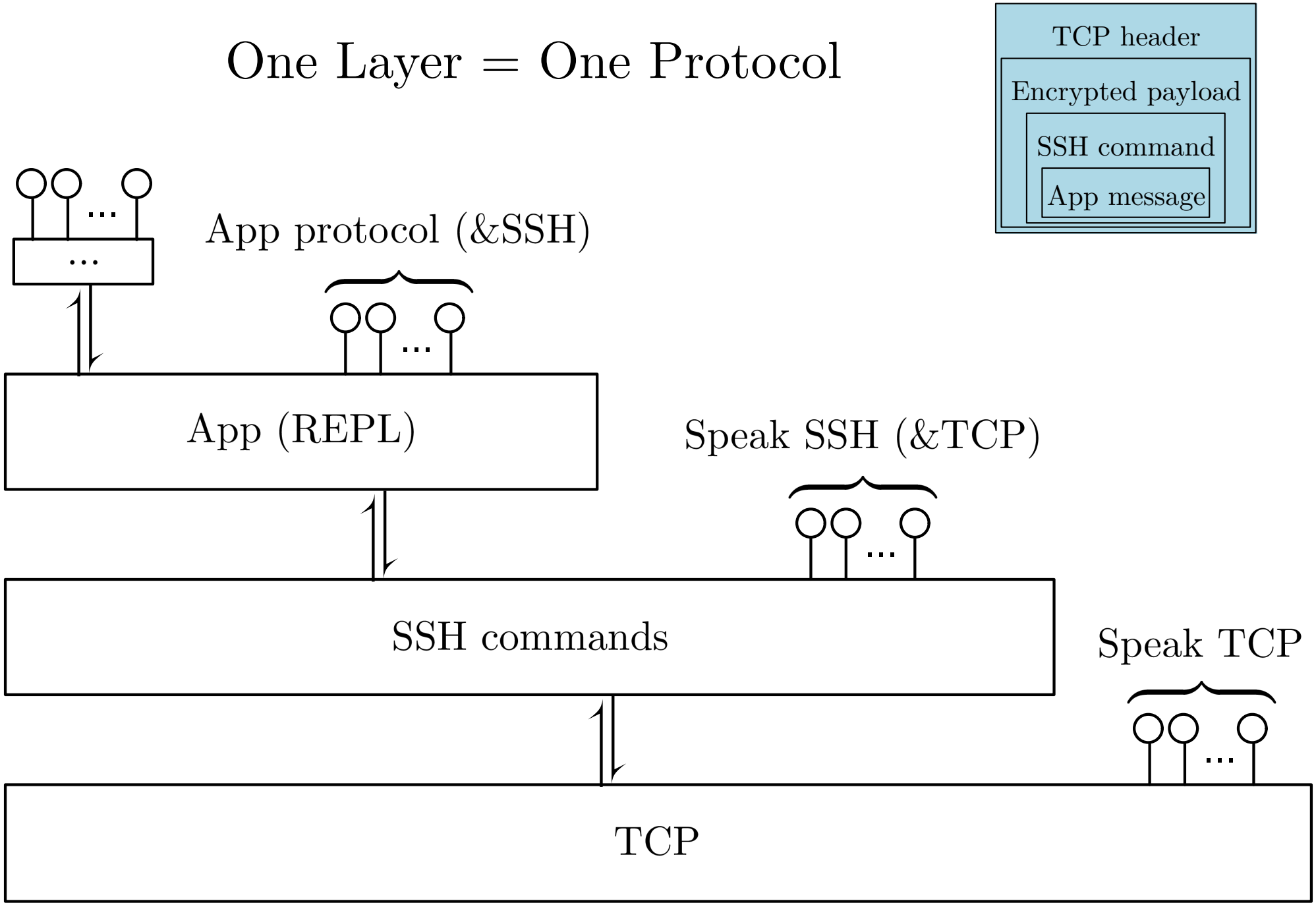

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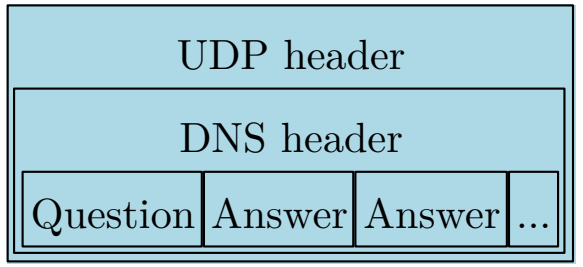

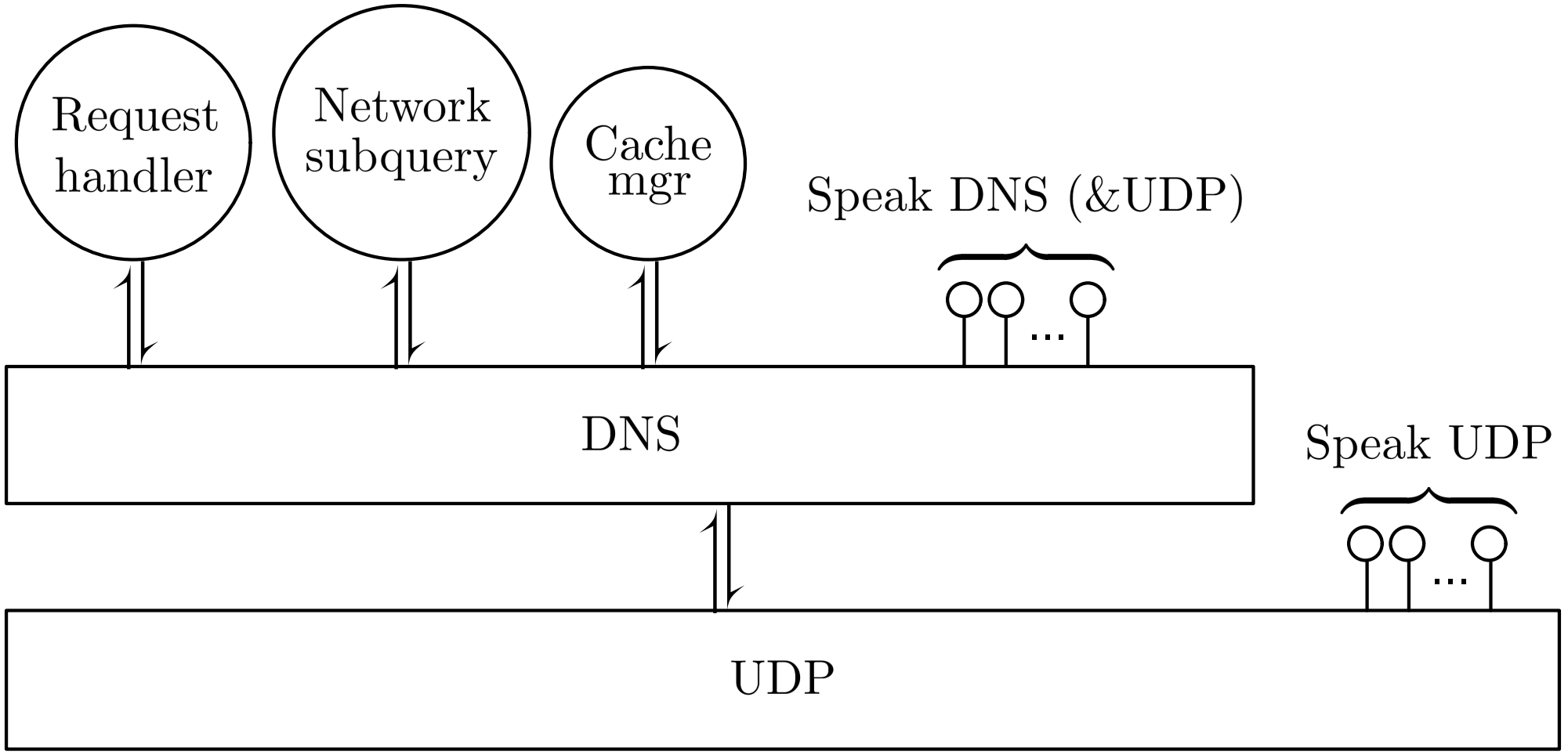

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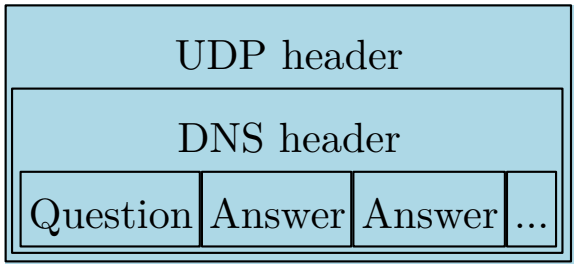
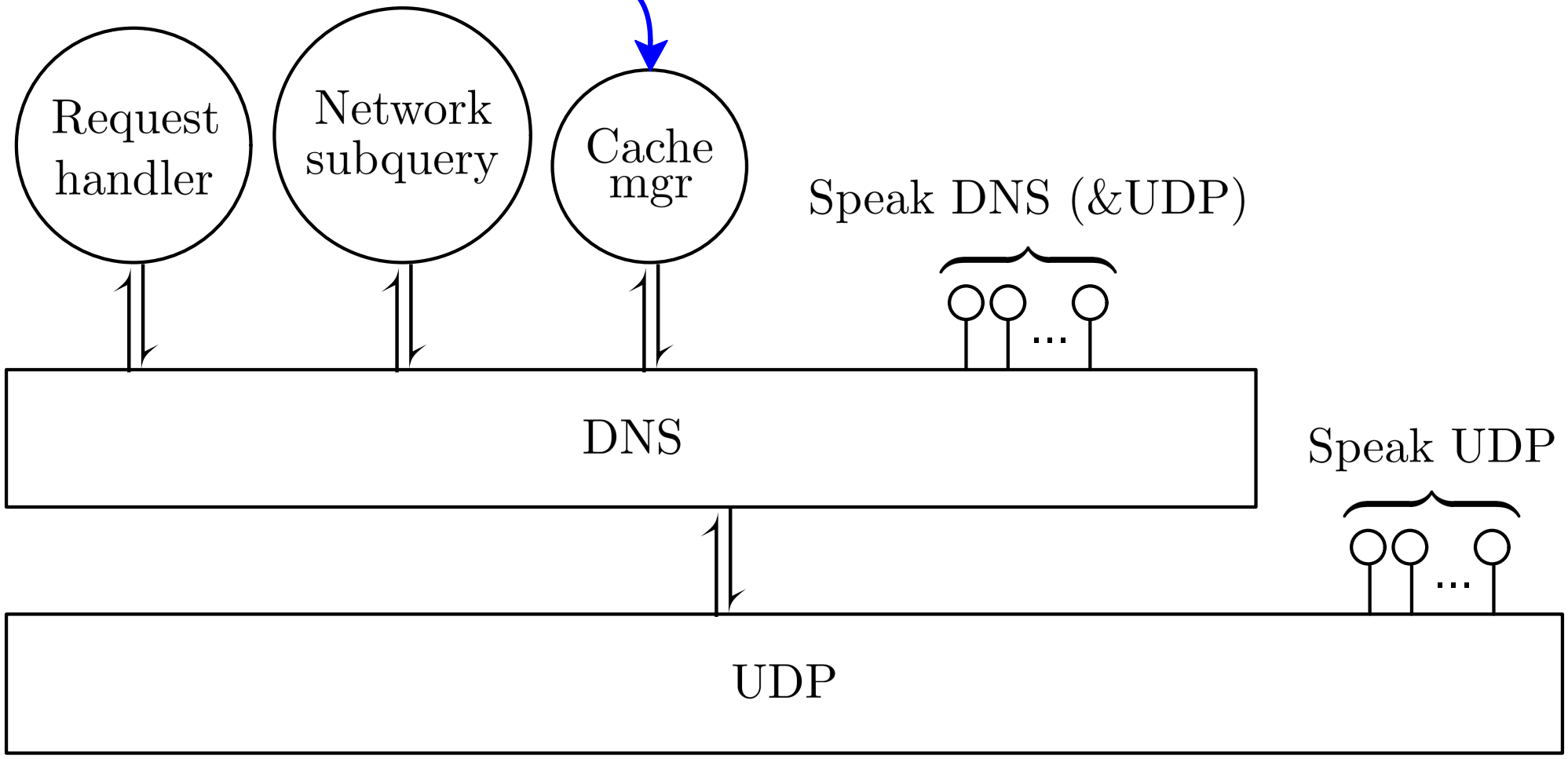


Snoops via pub/sub to populate cache!



Interests — Local sub — Local adv

$$\pi \quad = \quad (p) \quad | \quad \langle p \rangle$$

Messages — Send *locally*

$$m \quad = \quad \langle v \rangle$$

Interests

Local sub

Local adv

Outside interest

$$\pi \quad = \quad (p) \quad | \quad \langle p \rangle \quad | \quad \lfloor \pi$$

Messages

Send *locally*

Send *outside*

$$m \quad = \quad \langle v \rangle \quad | \quad \lfloor m$$

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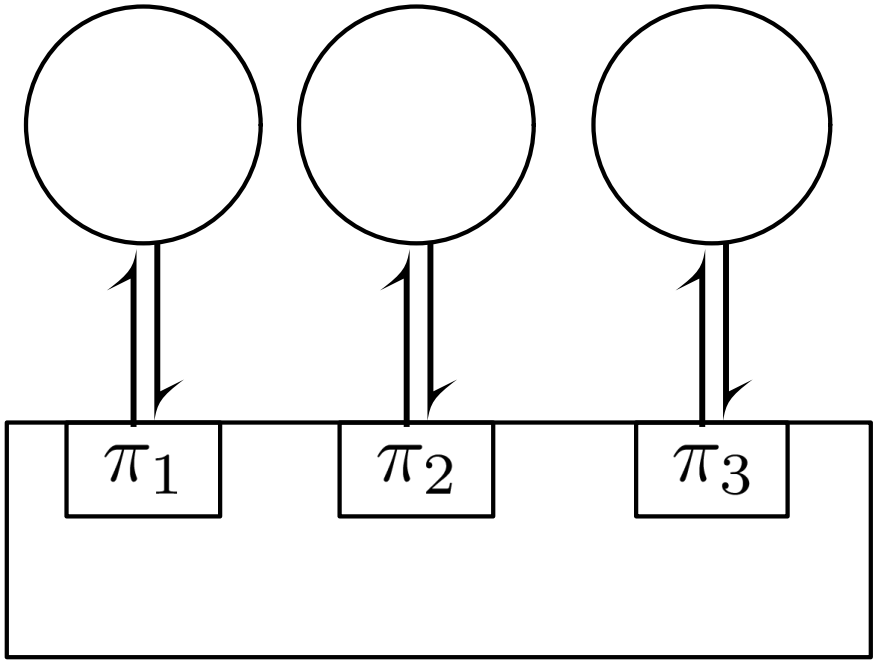

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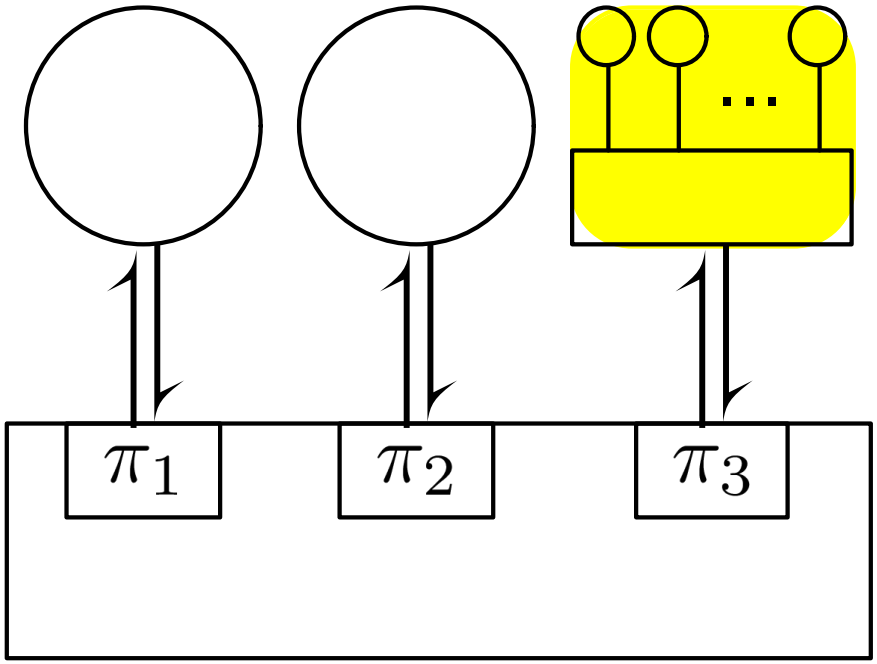
Messages — Send *locally* — Send *outside*

$$m \quad = \quad \langle v \rangle \quad | \quad \lfloor m$$



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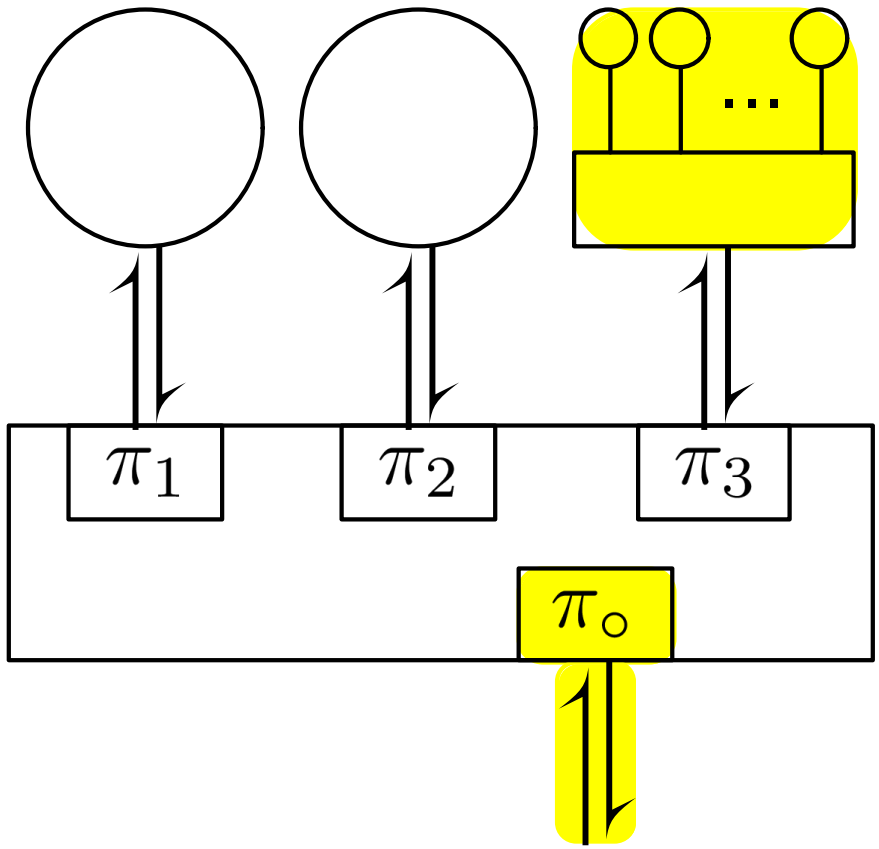

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Alert when a producer crashes/exits	☑ routing events
Uniform treatment of I/O	☑ layering
+ great additional benefits from layering	☑

PART V: Conclusions

Marketplace

Typed Racket

Minimart

Racket

JS-Marketplace

Javascript

Marketplace

Typed Racket

DNS server (UDP)

SSH server (TCP)

Chat server

Echo server

Minimart

Racket

Websocket driver

Generic msg broker

JS-Marketplace

Javascript

Websocket driver

DOM driver

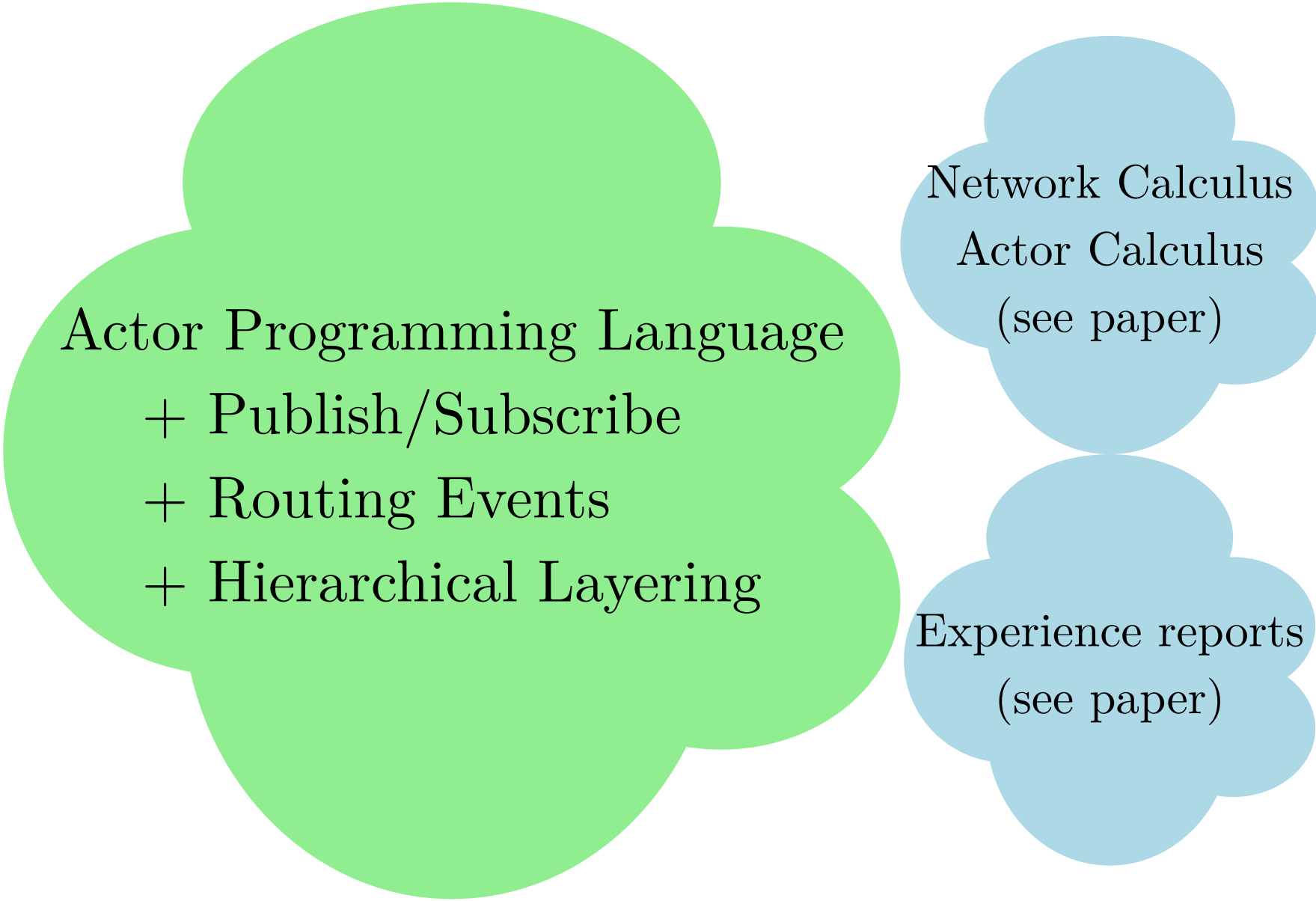
jQuery driver

Chat + roster

GUI composition

Marketplace	Minimart	JS-Marketplace
Typed Racket	Racket	Javascript
DNS server (UDP)	Websocket driver	Websocket driver
SSH server (TCP)	Generic msg broker	DOM driver
Chat server		jQuery driver
Echo server		Chat + roster
		GUI composition

Details and experience report in the paper!


Actor Programming Language
+ Publish/Subscribe
+ Routing Events
+ Hierarchical Layering
Network Calculus
Actor Calculus
(see paper)
Experience reports
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Thank you!

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http://www.ccs.neu.edu/home/tonyg/marketplace/