Safe Composition of Systems of Communicating Finite State Machines

Franco Barbanera[1], *Rolf Hennicker* [2],

[1]University of Catania (IT) [2]LMU Munich (D)

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OVERVIEW

- Introduction: the need for system composability
- The "participants-as-interfaces" (PaI) approach to (binary) system composition
- ICE'24: PaI for multicomposition (for CFSM systems).

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The need of systems composability

- Concurrent/Distributed systems are

  not STAND-ALONE ENTITIES

- (expecially nowadays) they are parts of

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Good composition methods

They should be

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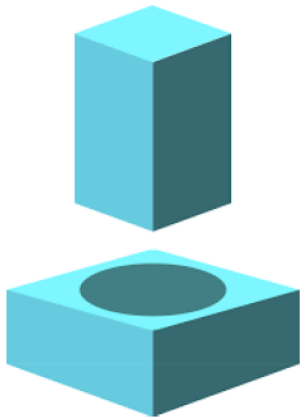
- CONSERVATIVE

  Altering as less as possible the single systems



Good composition methods

They should be

- CONSERVATIVE
- FLEXIBLE

i.e. "system independent": the composition mechanism
- is not part of the system
-allows to consider **any** system as potentially **open**

Good composition methods

They should be

- CONSERVATIVE
- FLEXIBLE
- SAFE

  Guaranteeing not to “break” relevant properties of the single systems we compose.

Good composition methods are **safe** when...

If one starts from systems like this....

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...one does not end up with something like that

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The "participants-as-interfaces" (PaI) approach

For systems with message-passing interactions

Introduced (as far as we know) in

Franco Barbanera, Ugo de'Liguoro, Rolf Hennicker:
Global Types for Open Systems. **ICE 2018**

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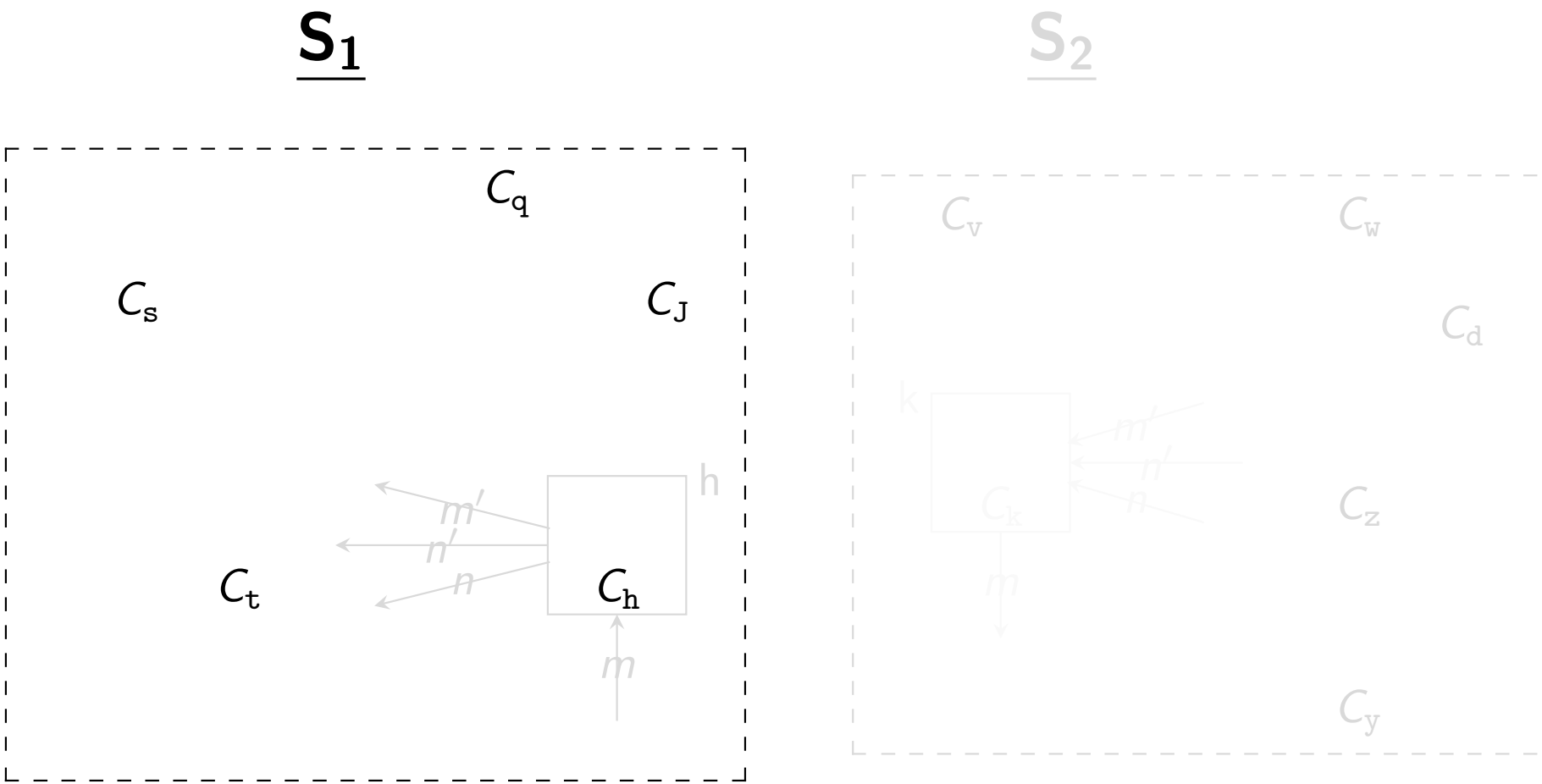

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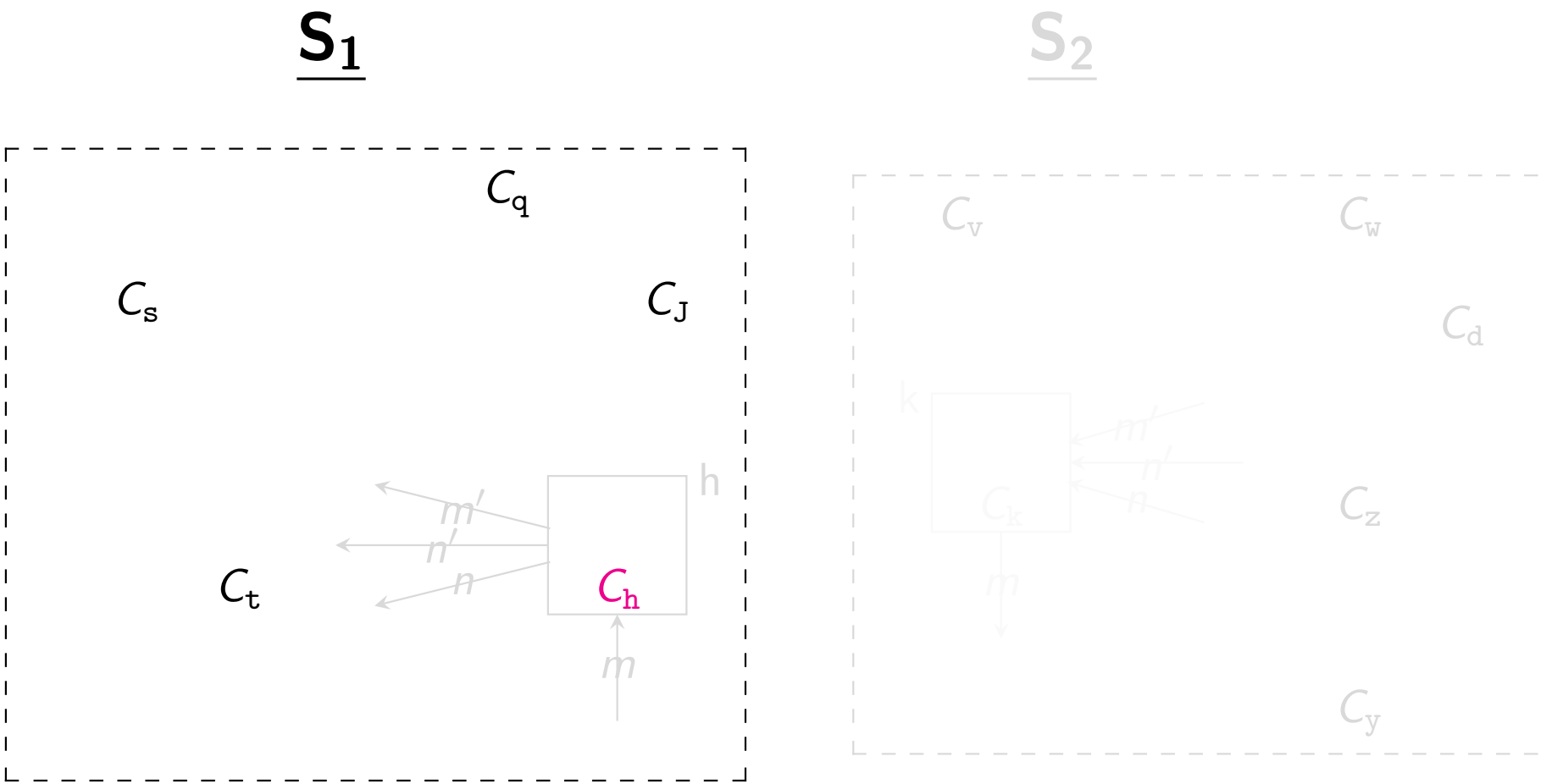
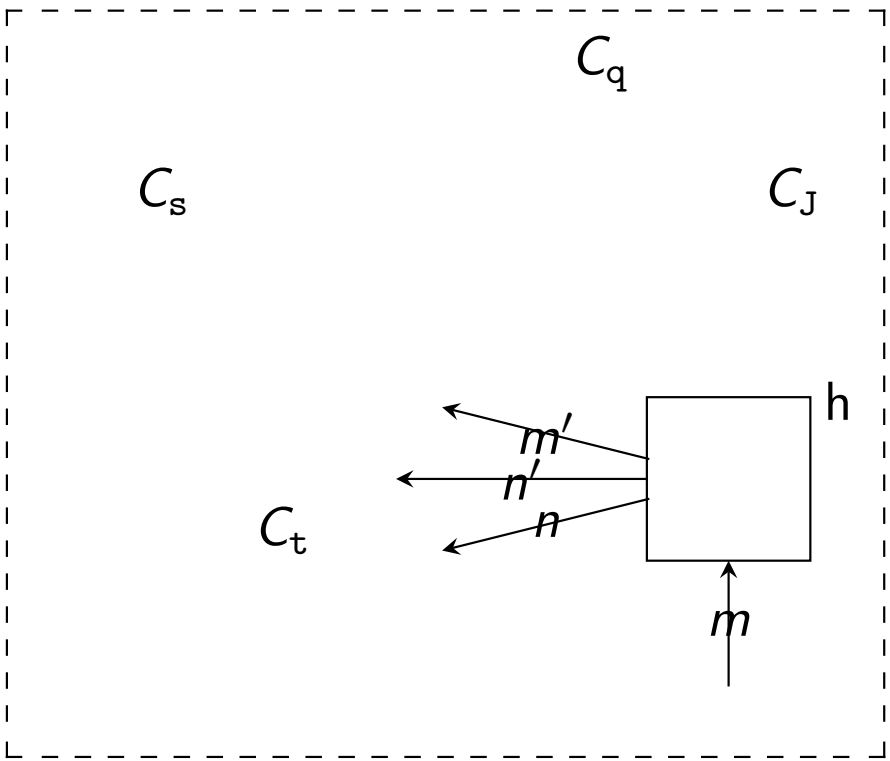


The "participants-as-interfaces" (PaI) approach

S_1



S_2

The "participants-as-interfaces" (PaI) approach

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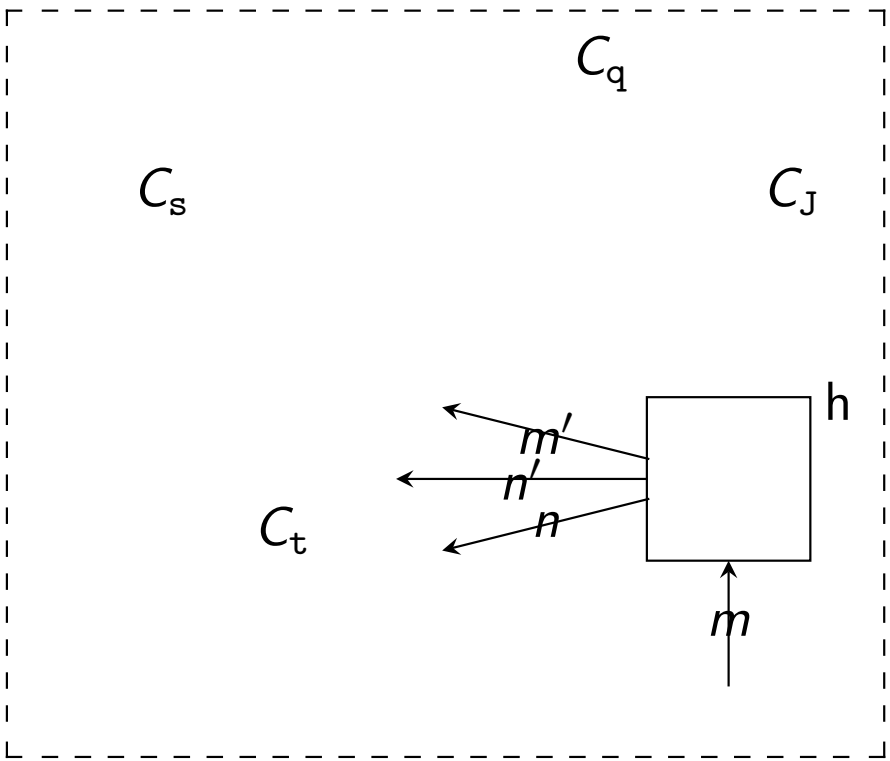

S_2

We abstract here from the way communications are performed and from the logical order of the exchanged messages.

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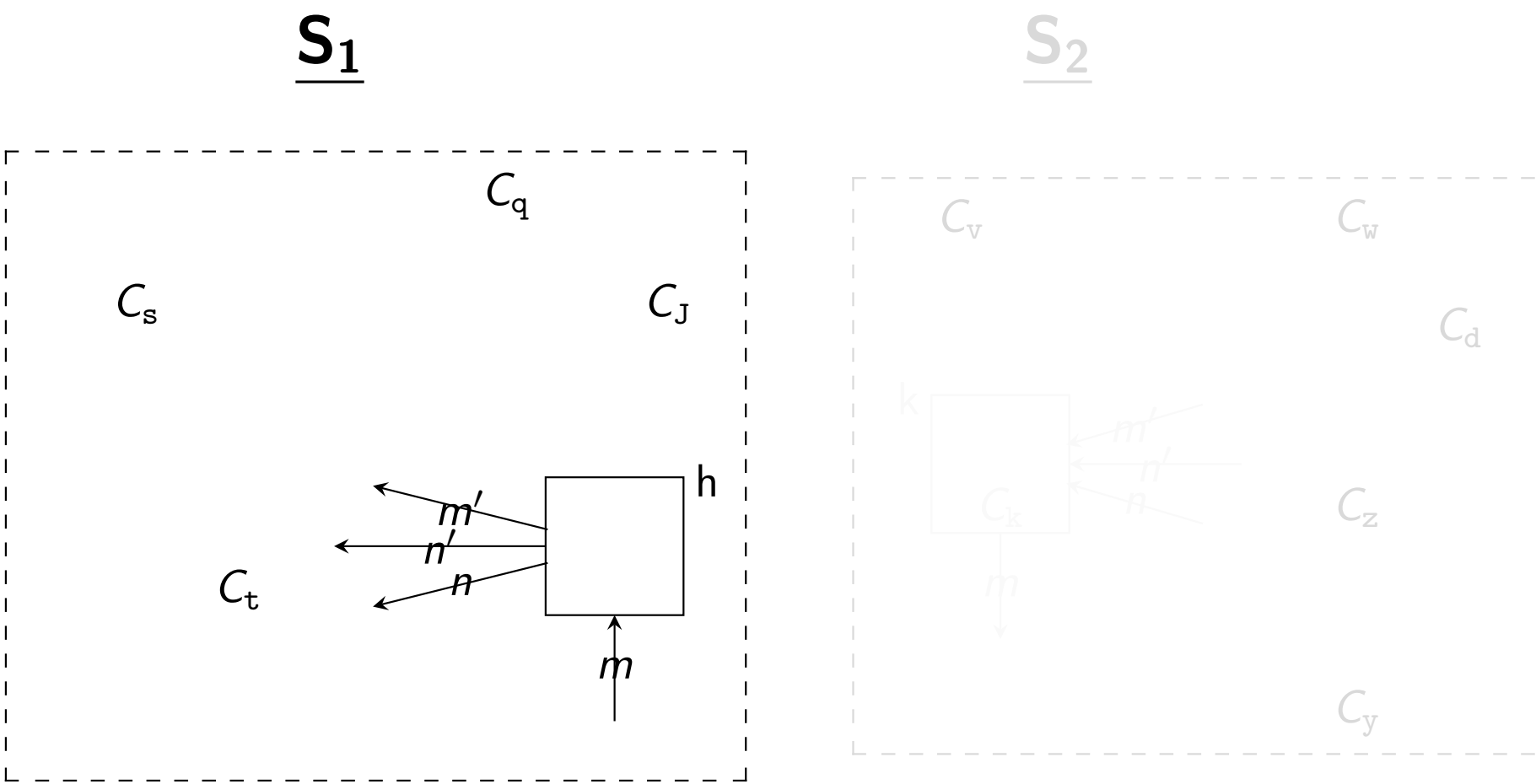

C_h's behaviour can be looked at as an interface (i.e. a description of what can be offered by an outer system)

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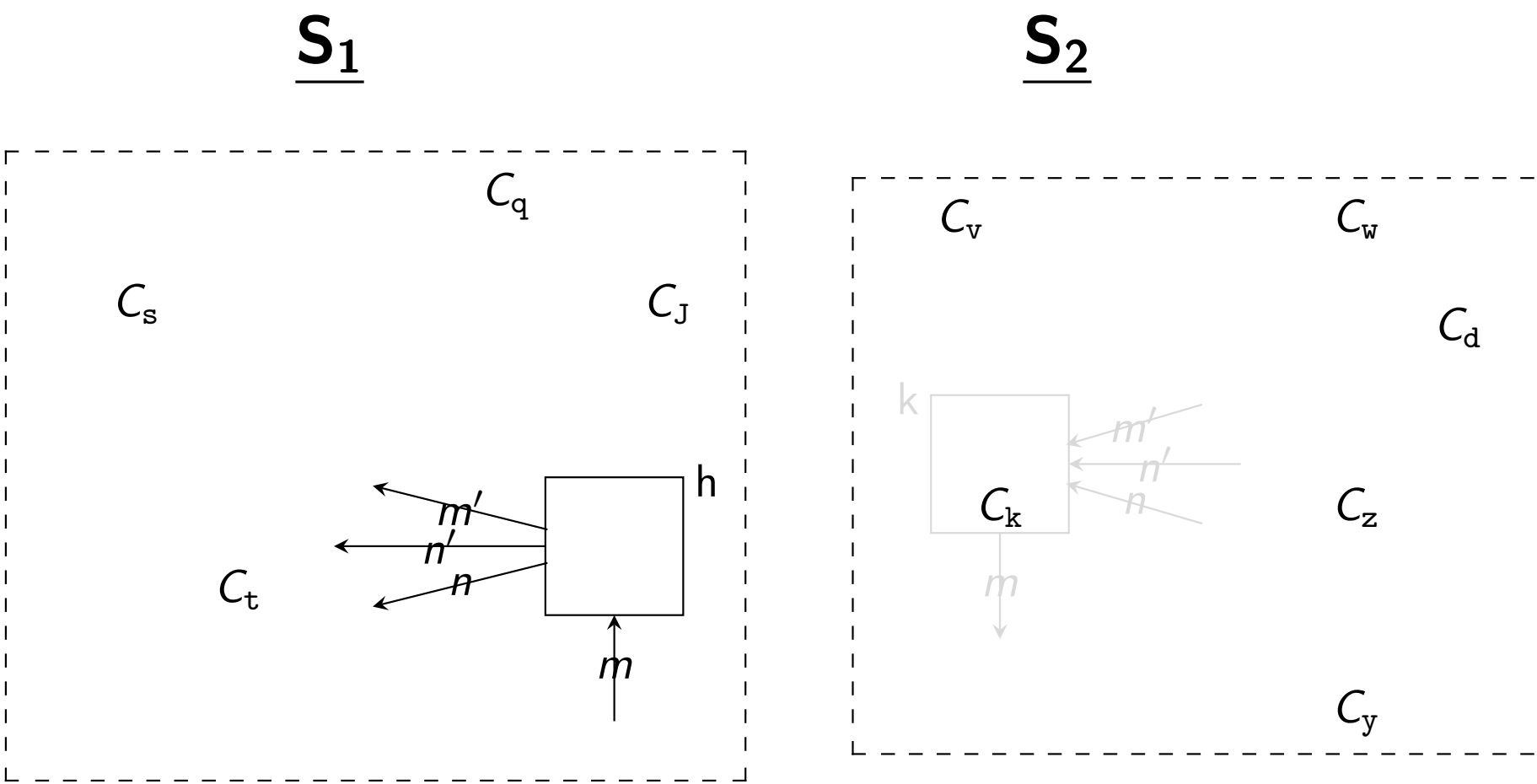

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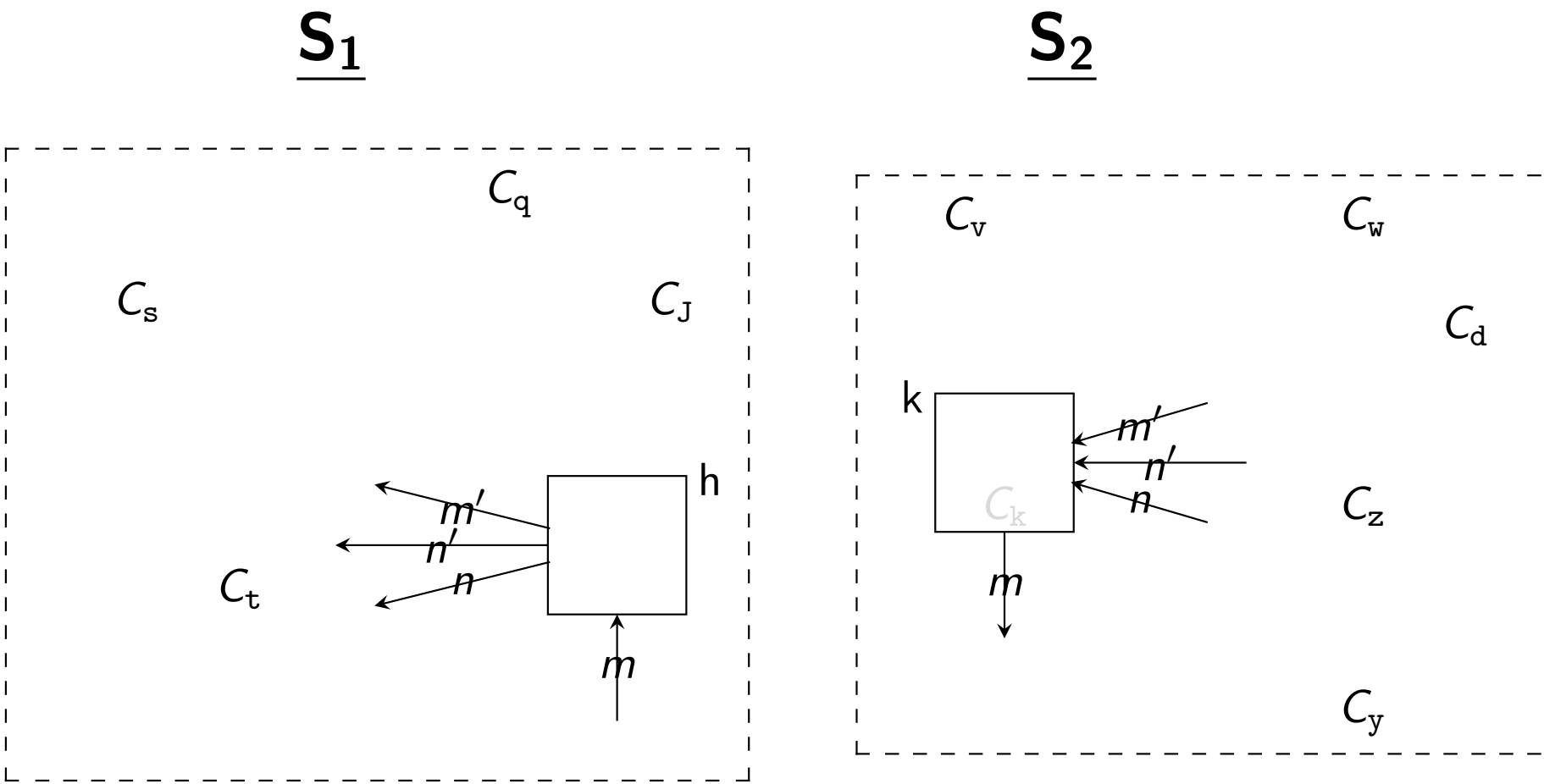

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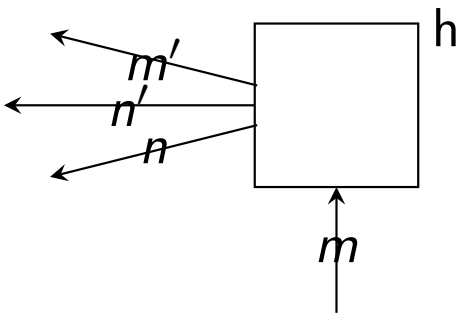

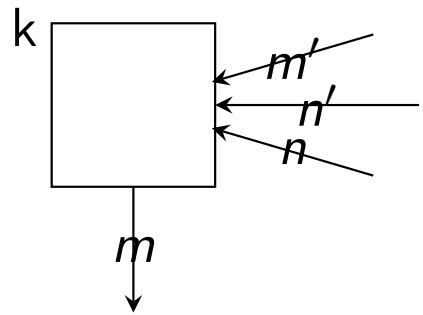

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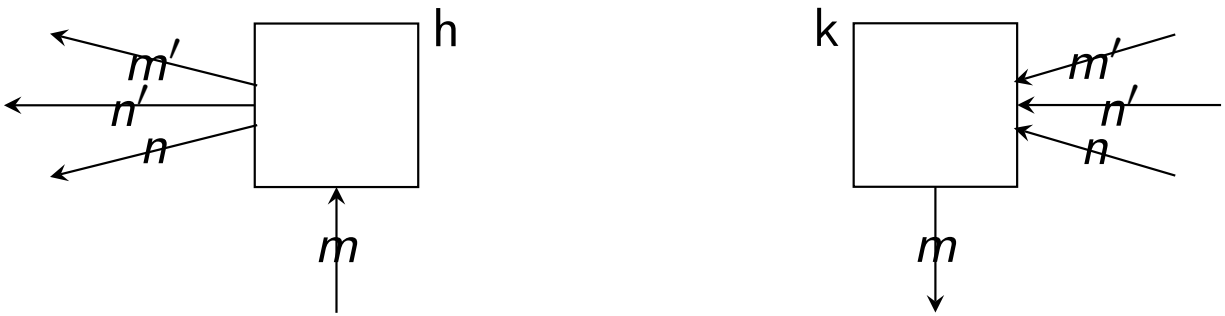

COMPATIBLE: an h's input is a k's output, and vice versa

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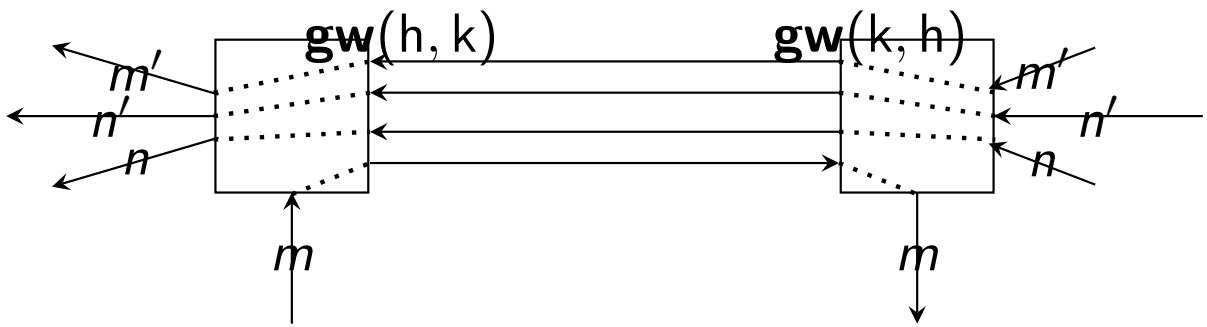
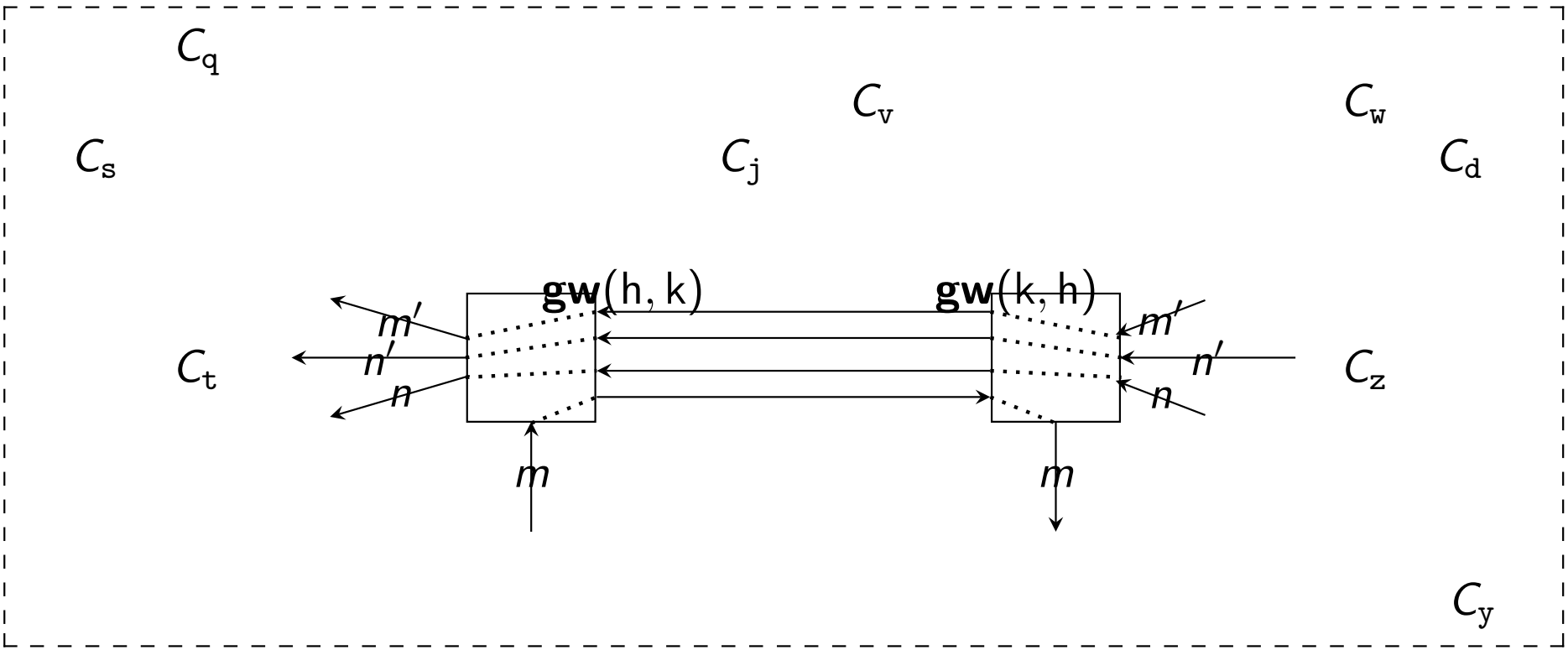


Composition via gateways (forwarders)

The "participants-as-interfaces" (PaI) approach

$$\underline{\mathbf{S_1}}^{\mathsf{h}\leftrightarrow\mathsf{k}}\underline{\mathbf{S_2}}$$



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The "participants-as-interfaces" (PaI) approach

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Which formalism for concurrent system description?

Which communication model?

The "participants-as-interfaces" (PaI) approach

- SAFE ✓

A number of results for PaI binary composition
(see paper's References)

for MPST - MultiParty Session Types - (synchronous)

for CFSM - Communicating Finite State Machines - (synchronous and asynchronous).

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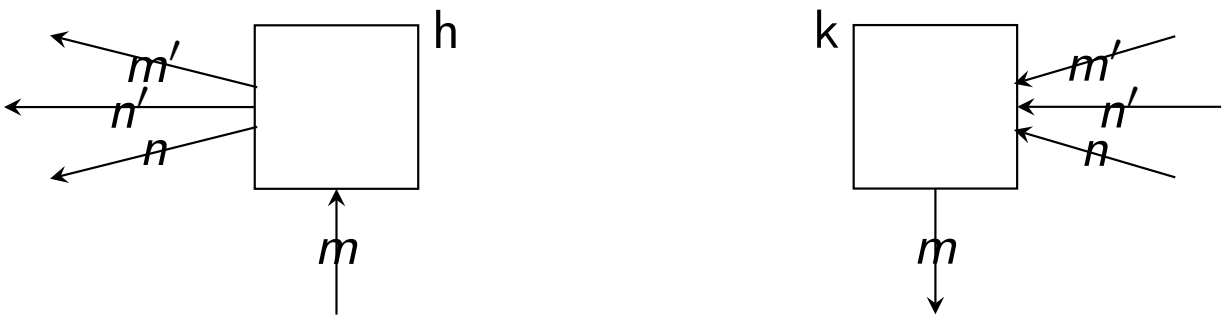
Strict conditions to get safeness in synchronous CFSM systems

F. Barbanera, Ivan Lanese, Emilio Tuosto:
Composition of synchronous communicating systems. JLAMP (2023)

The "participants-as-interfaces" (PaI) approach

SAFENESS guaranteed by
Compatibility of Interfaces



COMPATIBILITY $=_{\textbf{roughly}}$ Bisimulation

The "participants-as-interfaces" (PaI) approach

Drawback of binary composition:

By connecting systems two-by-two we get only tree-topologies.

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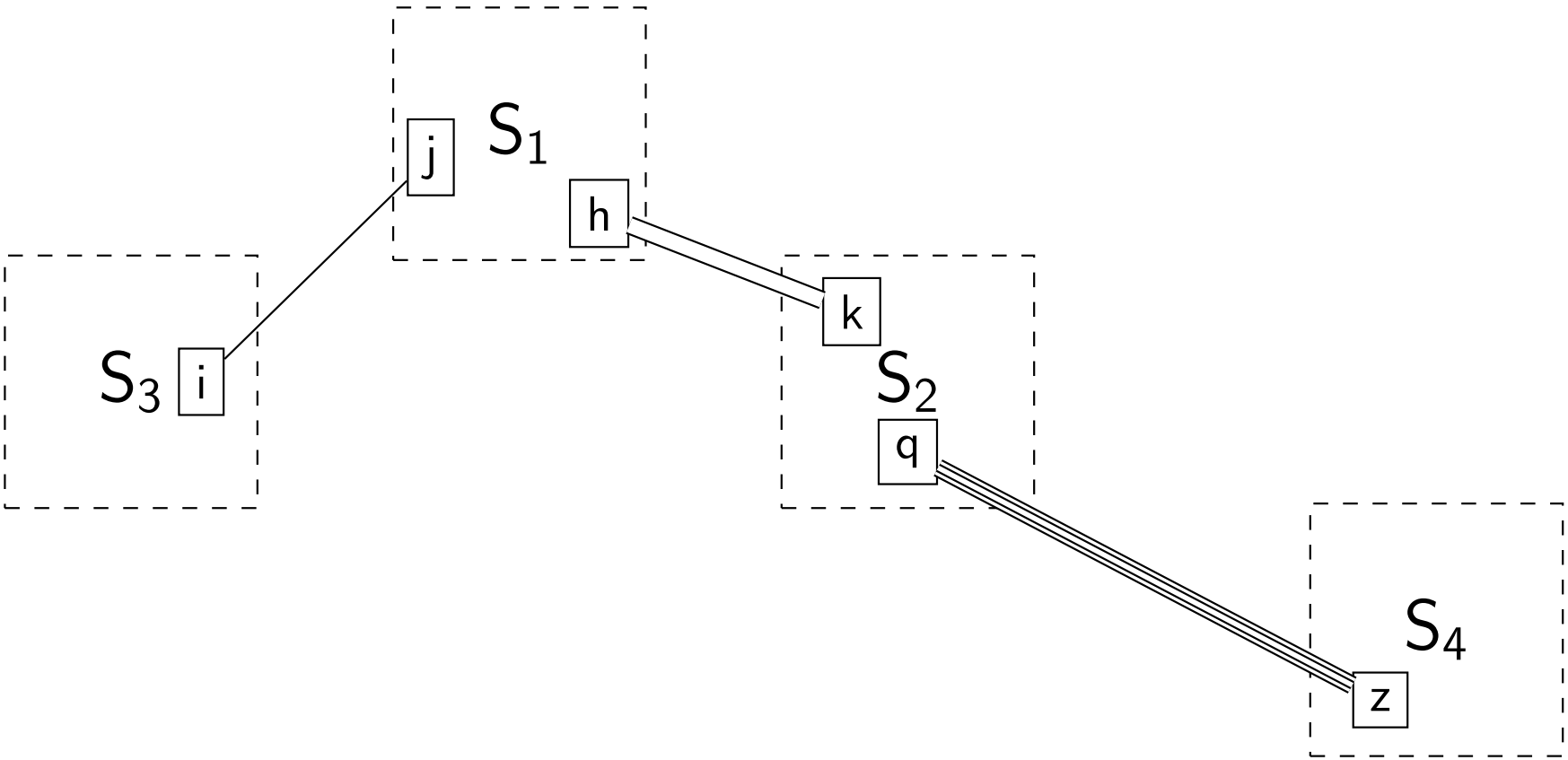

PaI Multicomposition

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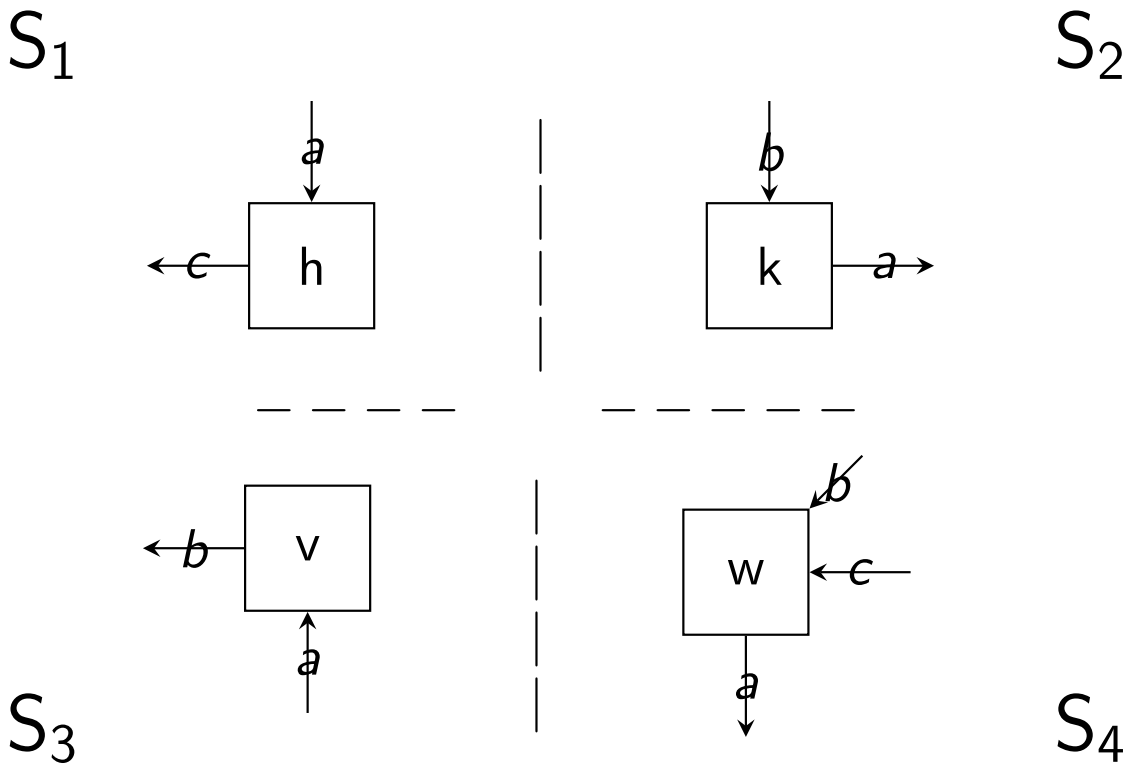

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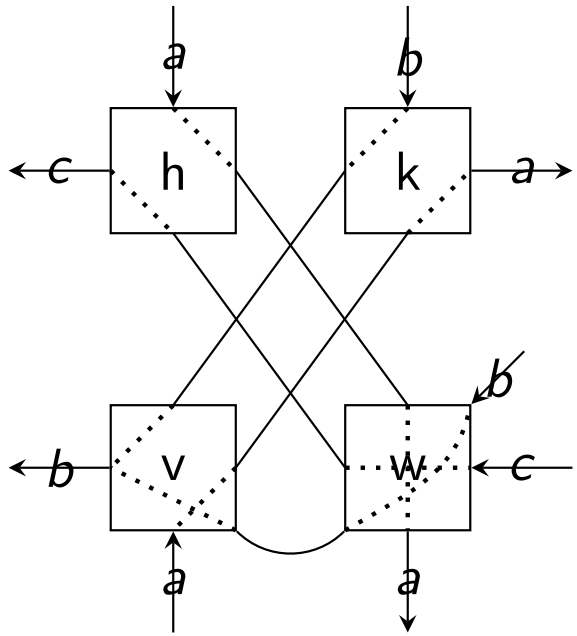

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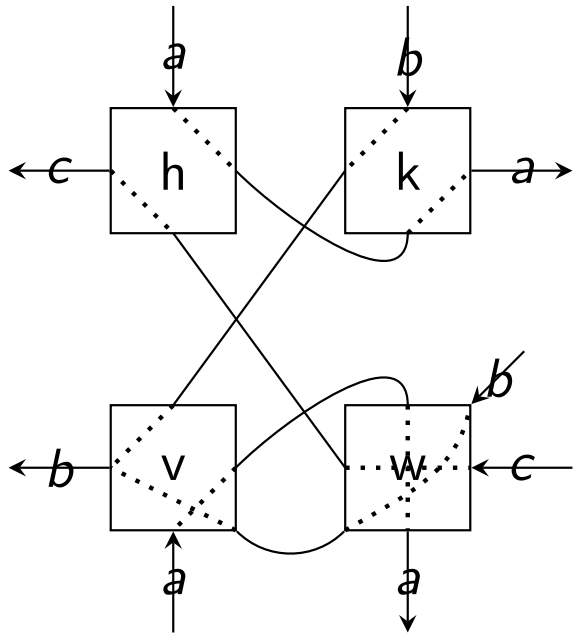

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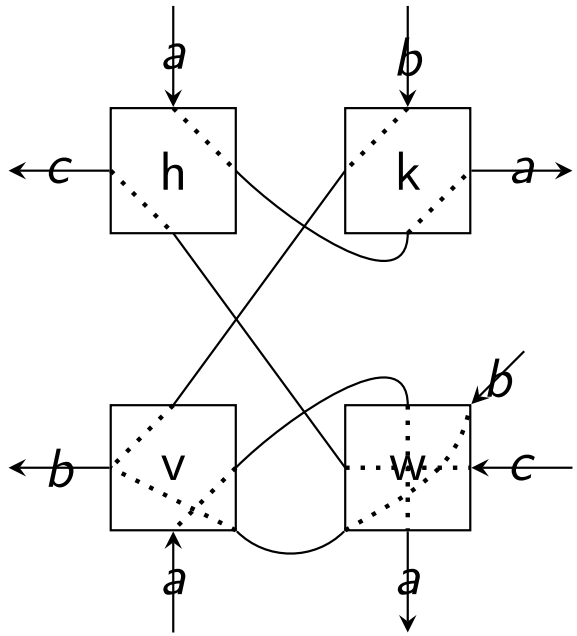

Issues: • Many different "connection policies" (all safe?).

Exploiting PaI multicomposition for (synchronous) MPST

F. Barbanera, M. Dezani-Ciancaglini, L. Gheri, N. Yoshida: Multicompatibility for Multiparty-Session Composition. **PPDP 2023**

Exploiting PaI multicomposition for systems of (asynchronous) CFSMs

Communicating Finite State Machines (CFSMs)

A formalism for the description and the analysis of distributed systems.

A machine M_A

- M_A can send msg1 to machine M_B;
  asynchronously; *through the directed buffered FIFO channel* AB
- Then, either msg2 or msg3 can be received from M_B or M_C;
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- and so on....

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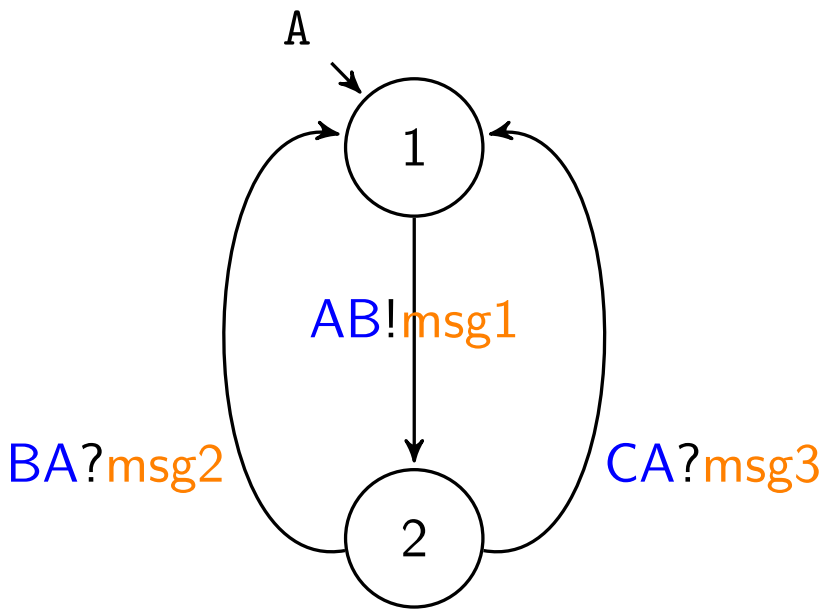

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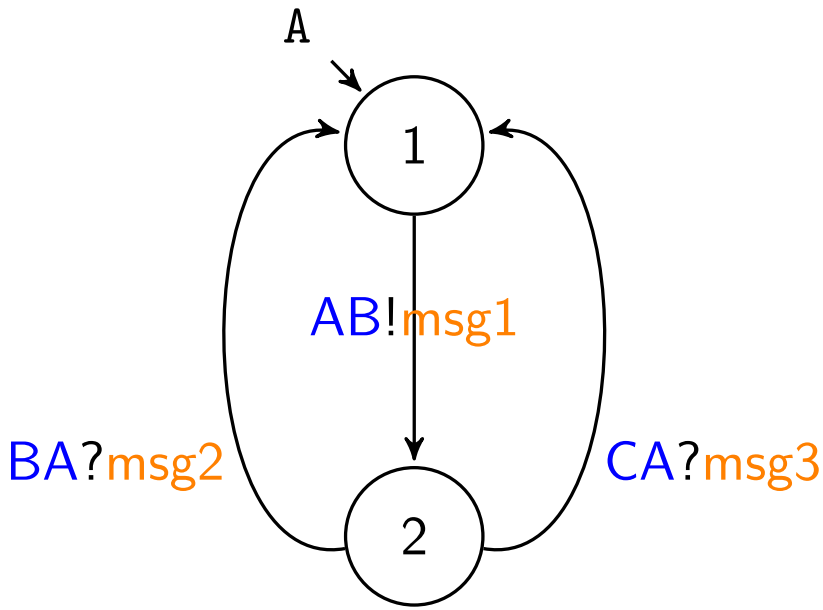

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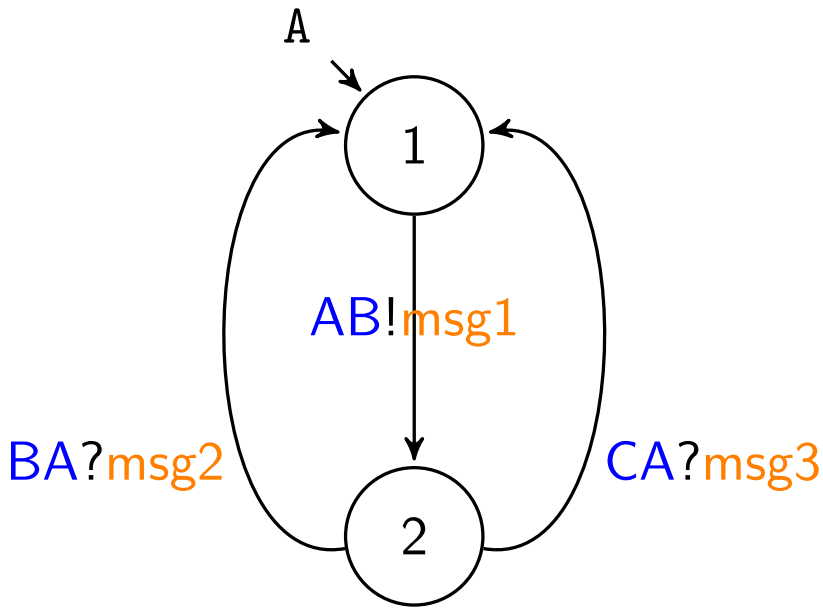

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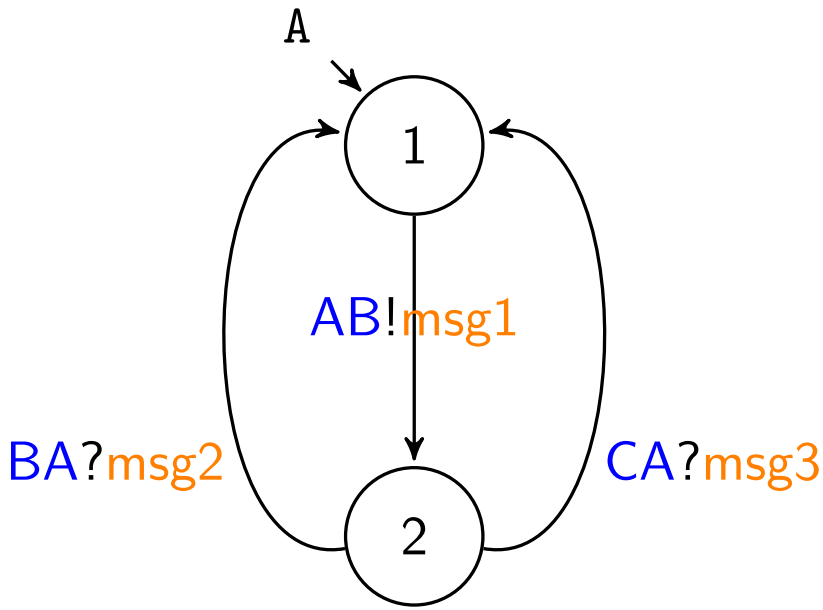

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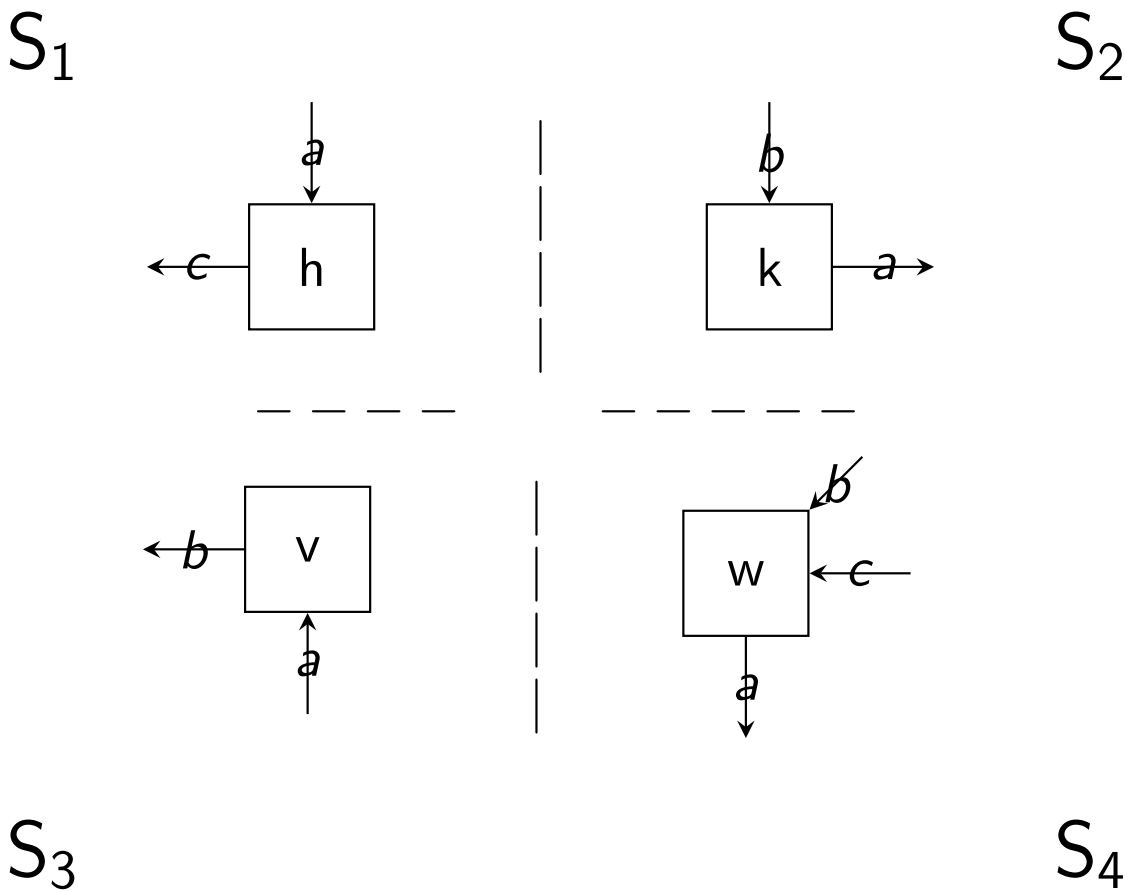

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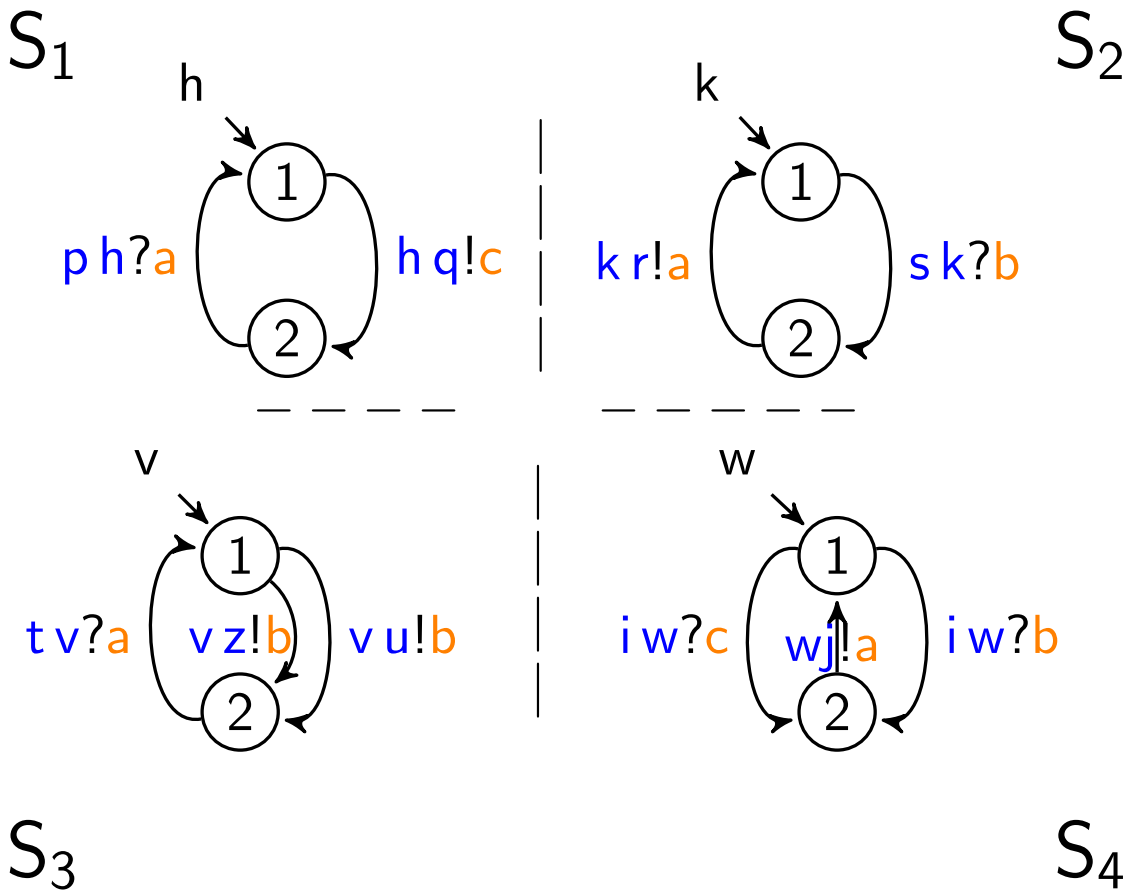

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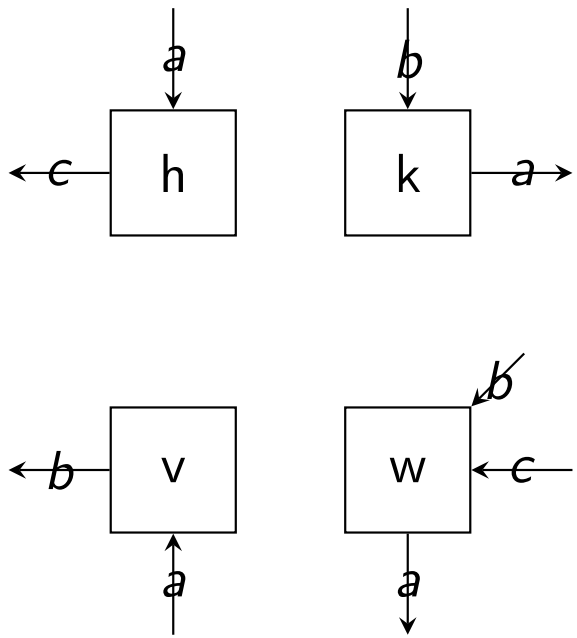

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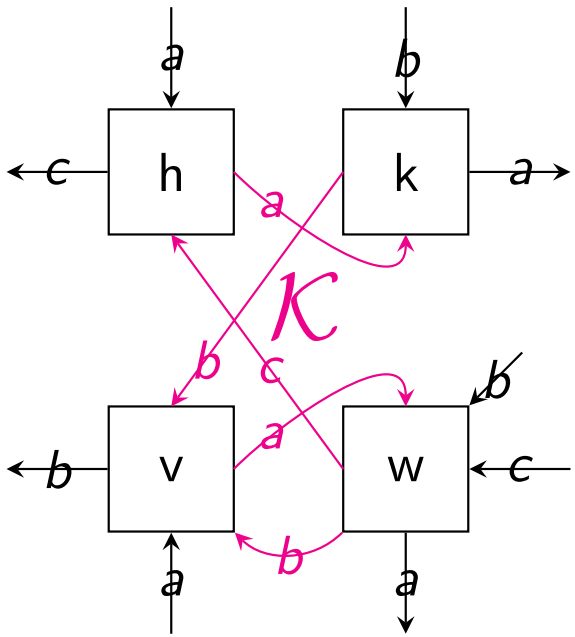
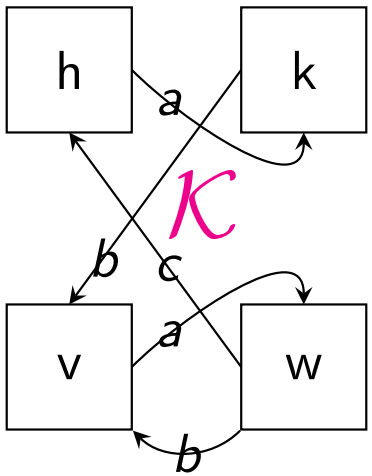


Connection Policies as CFSM systems



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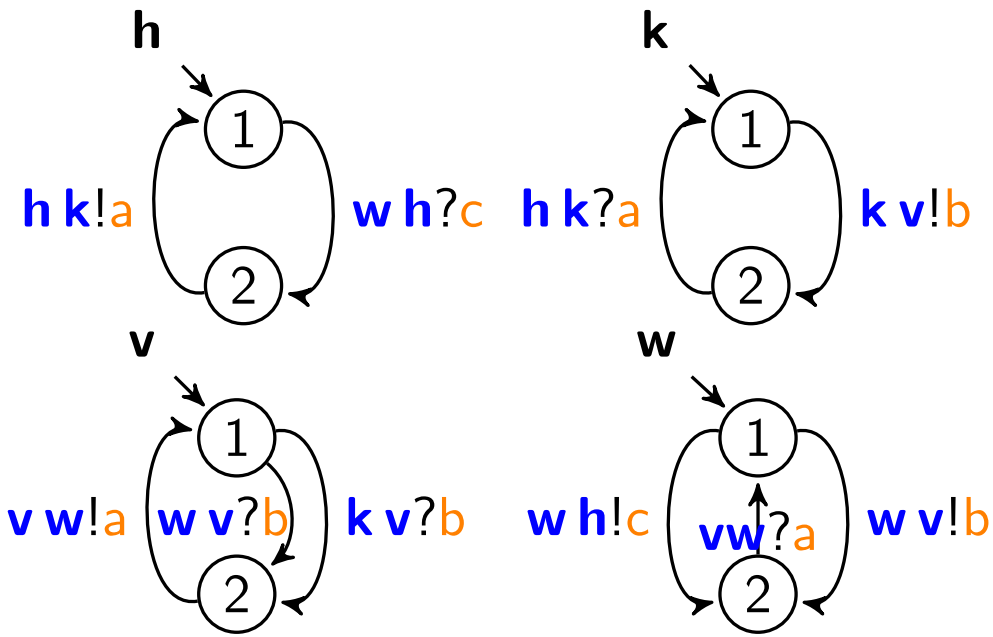
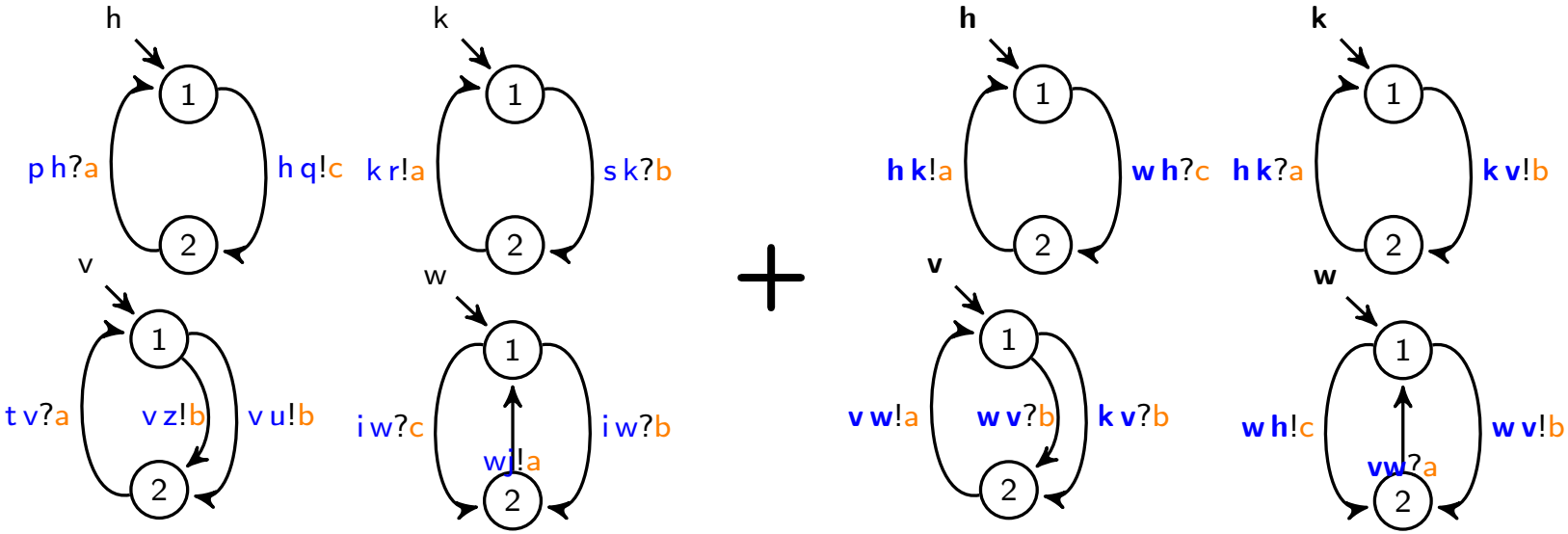


Interfaces + Connection Policy = Gateways



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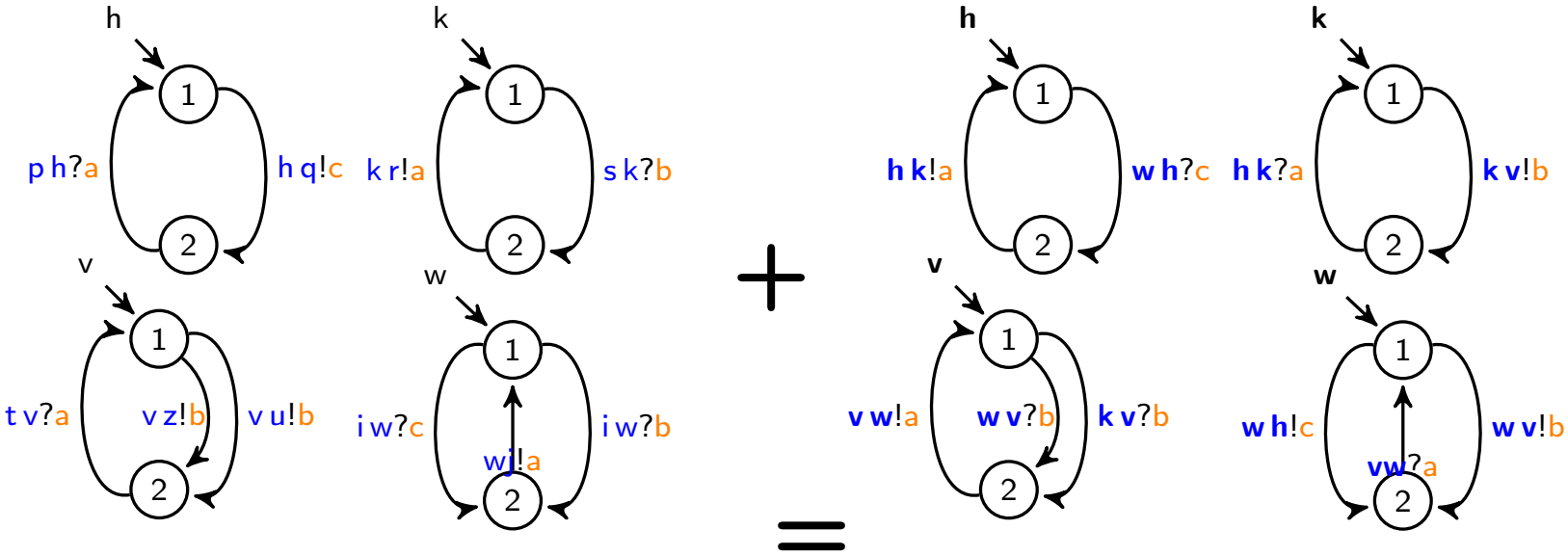

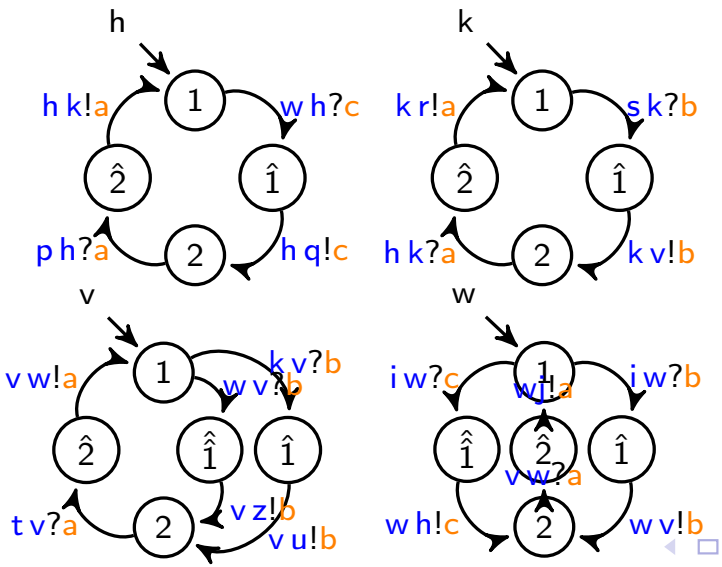

Safeness for PaI Multicomposition

Let
- $\{S_i\}_{i \in I}$ be a set of CFSM systems
- $\mathbb{K}$ a communication policy for choosen interfaces
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- Lock-freeness ✗

In the future

- Multicompatibility.
  In the binary composition:
  Compatibility of interfaces ($\sim$ bisimilarity) entails communication properties for the unique connection policy (if any).
- Multiconnection via "interfacing infrastructure".
- "Partial" gateways
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Thanks for your attention