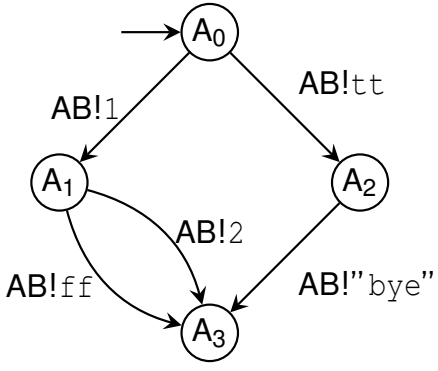
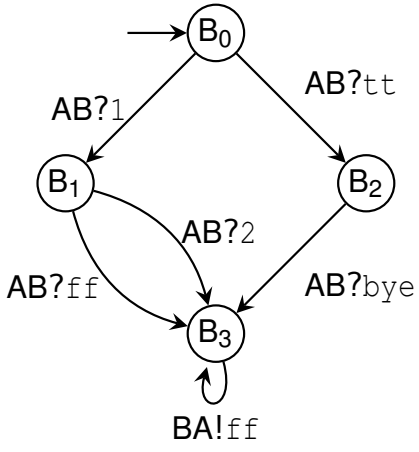
Communicating finite state machines



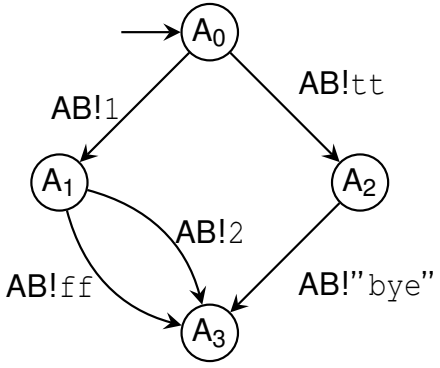
A



B

cf. Brand & Zafiropulo 1983

Communicating finite state machines



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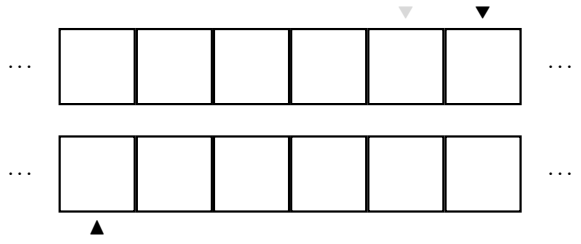

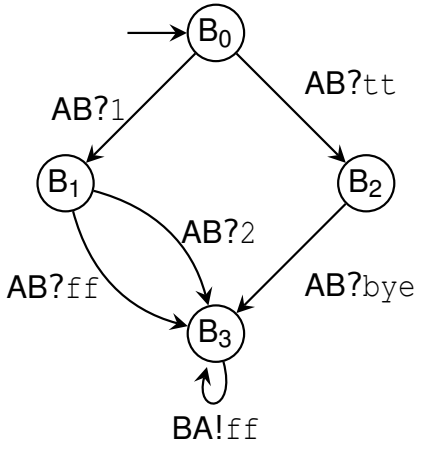

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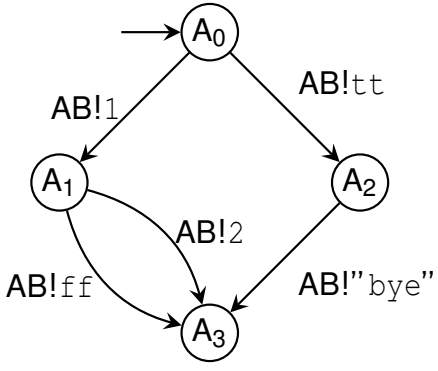

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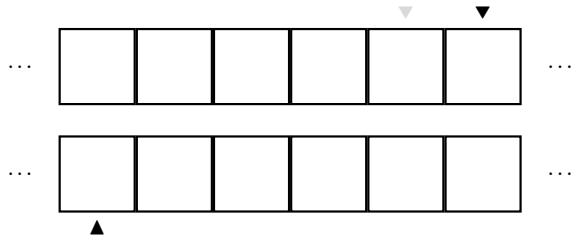

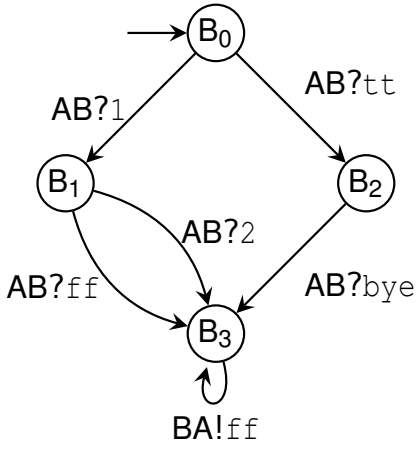

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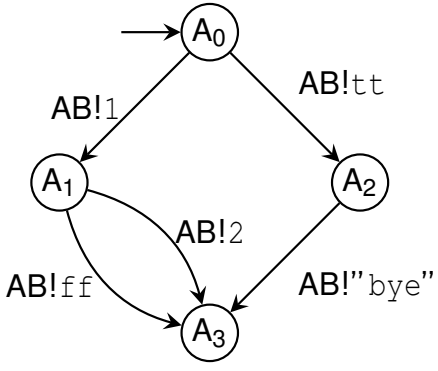

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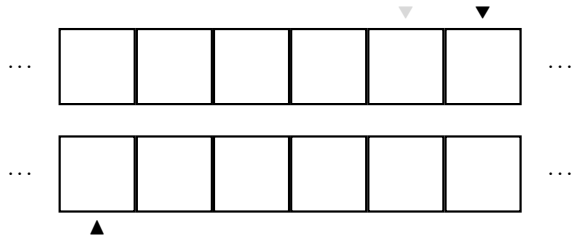

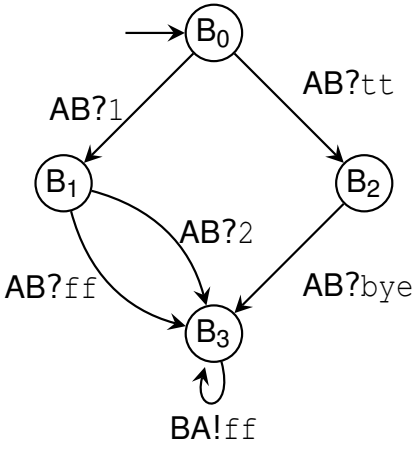

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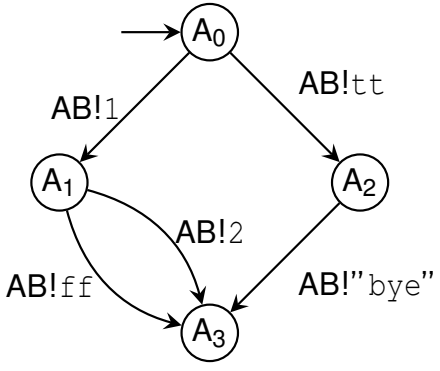
Communicating finite state machines



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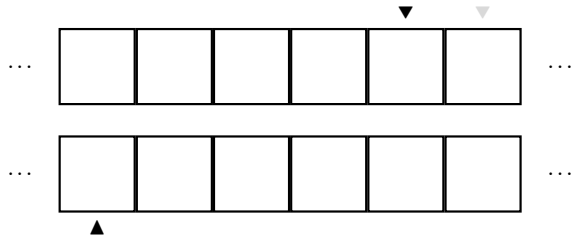

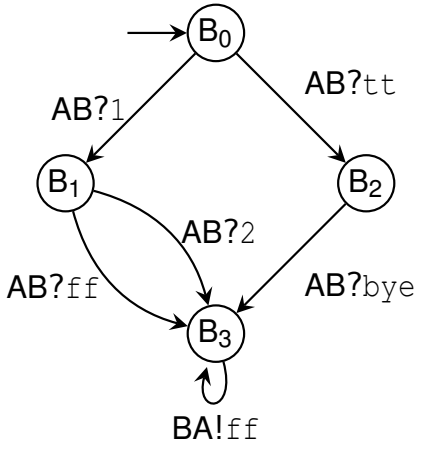

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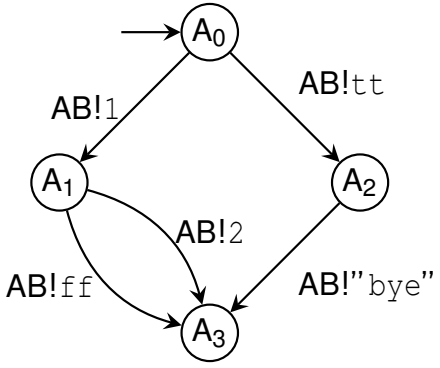

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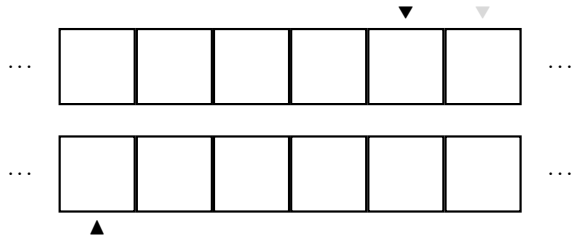

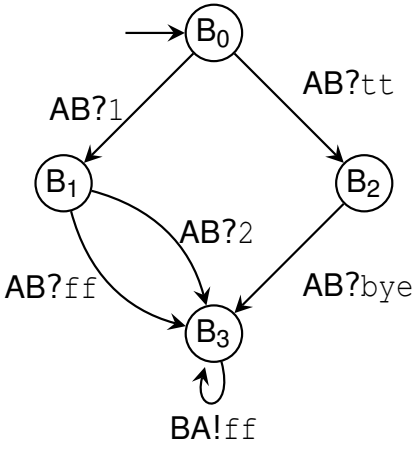

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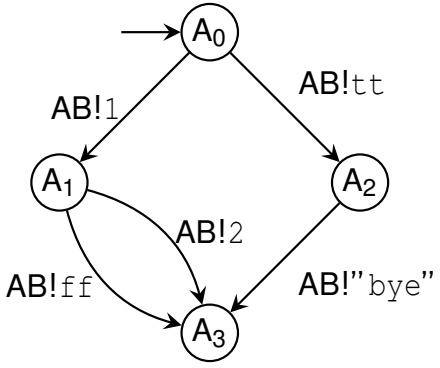

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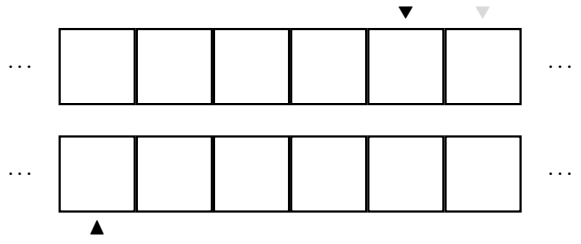

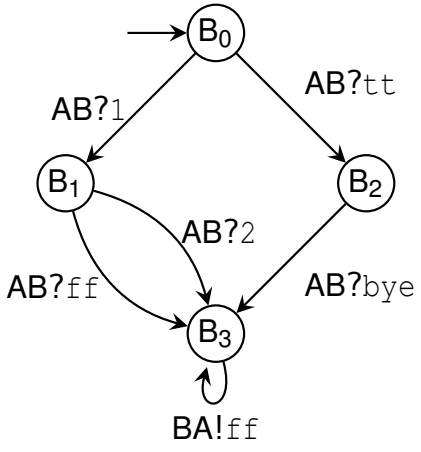

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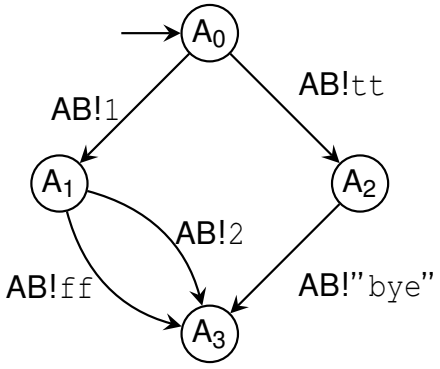

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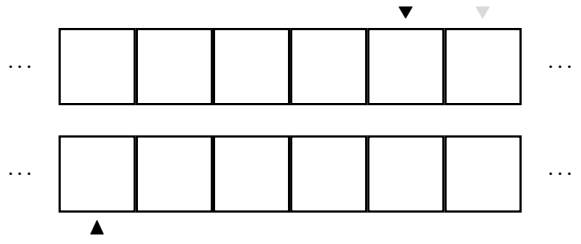

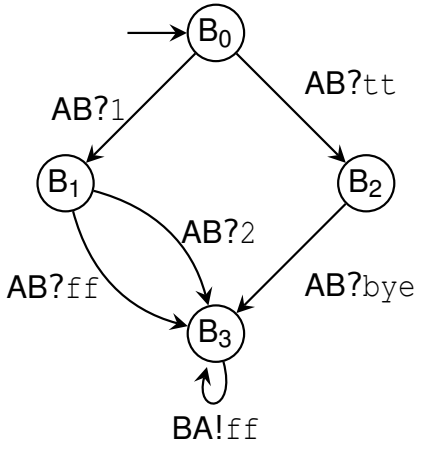

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Choreographies uʍop-əpᴉsdn (finale)

A glimpse of Erlang

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Semantics

- Message passing
- FIFO buffers [[mailboxes in Erlang]]
- Spawn of threads

Asynchrony by design

Erlang is an incarnation of the well-known actor model of Hewitt and Agha...dates back to '73!

Exercise:

What does this program do?

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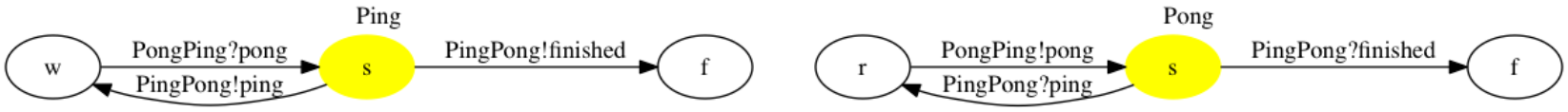
Friendlier representations

Local behaviour: communicating machines

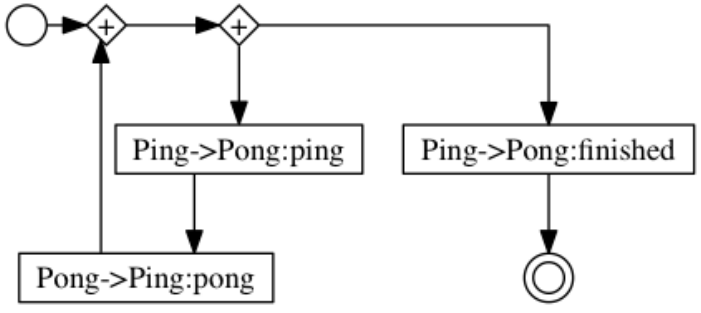


ChoSyn

...this is also amenable to tool supported analysis...:

`https://bitbucket.org/emlio_tuosto/gmc-synthesis-v0.2`

Choregraphy: global graph



..."synchronous" distributed workflow (Deniélou and Yoshida 2012)

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Is there anyone not familiar with Erlang?

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Is this program correct?

A:

No!

Exercise:

What does this program do? Does it work?

Exercise:

find the bug

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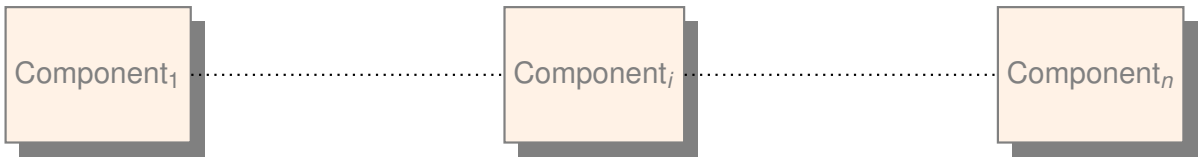
Tools help...

go to shell!

From programs to designs



[Lange, Tuosto: CONCUR 2012]

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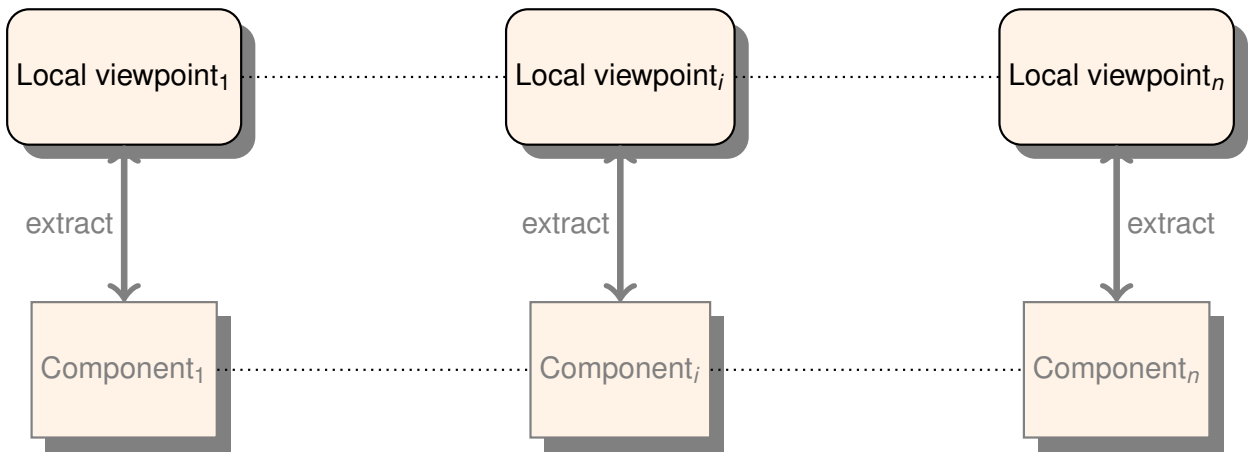

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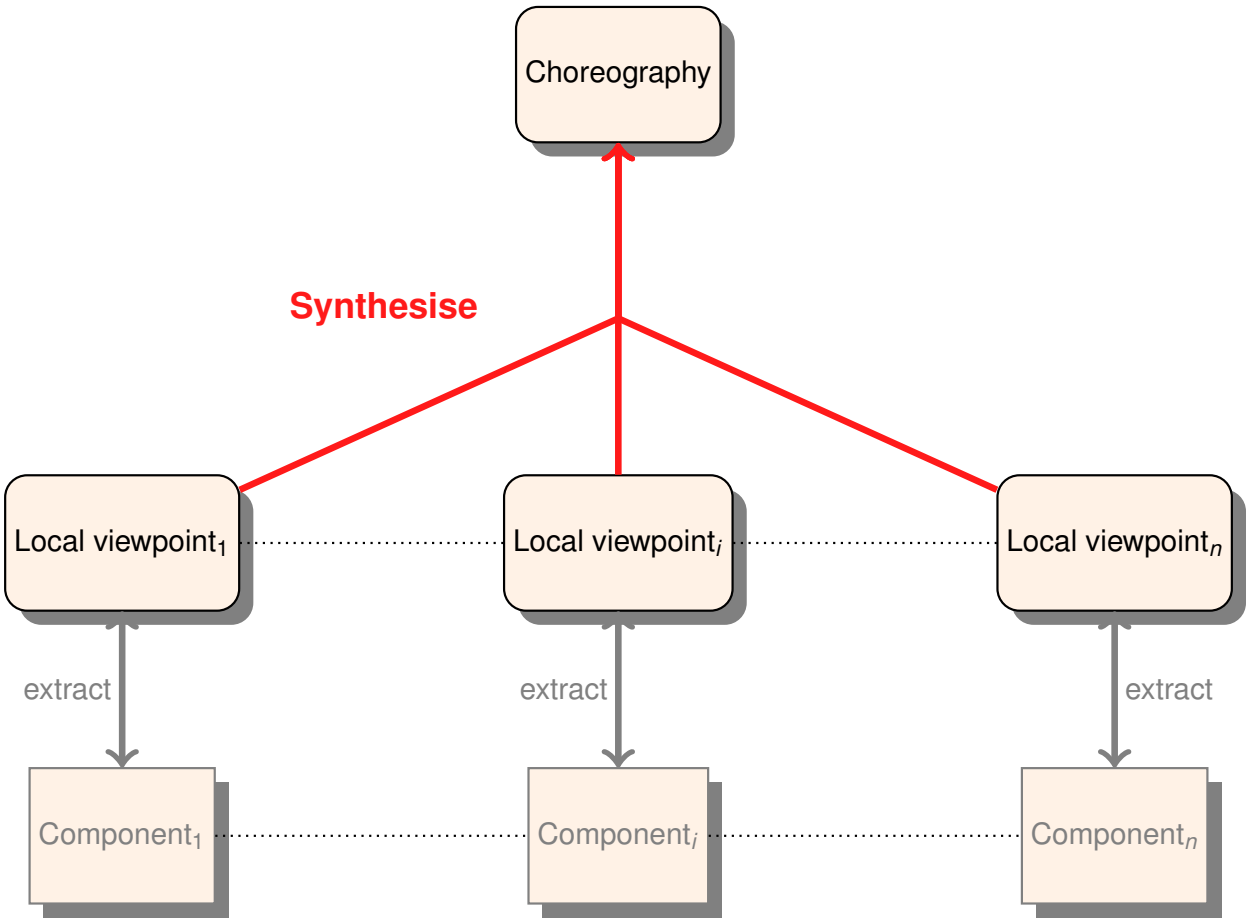
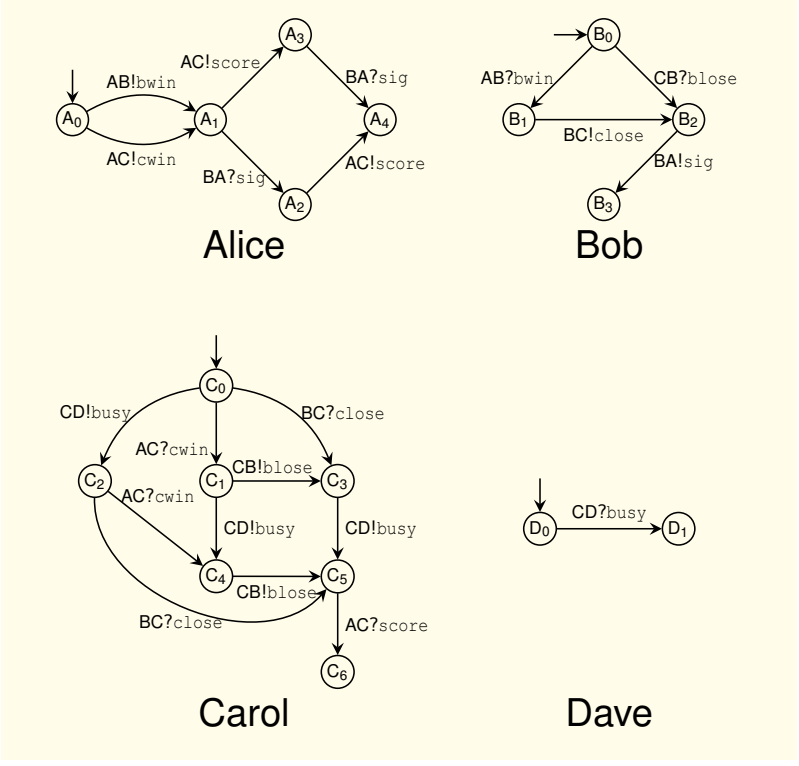


[Lange, Tuosto: CONCUR 2012]

Synthesis: problem statement

Q: Given a set of CFSMs, do they “form a good” choreography?



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Q: Is there a class of (finite subsets of) CFSMs that “form” choreographies?

[Lange, Tuosto, Yoshida: POPL 2015]

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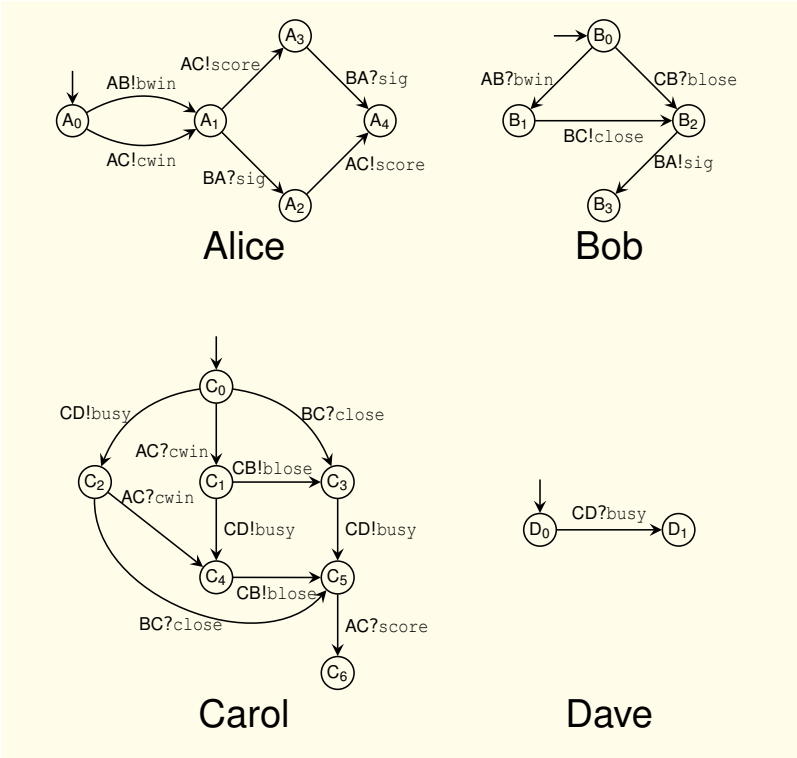

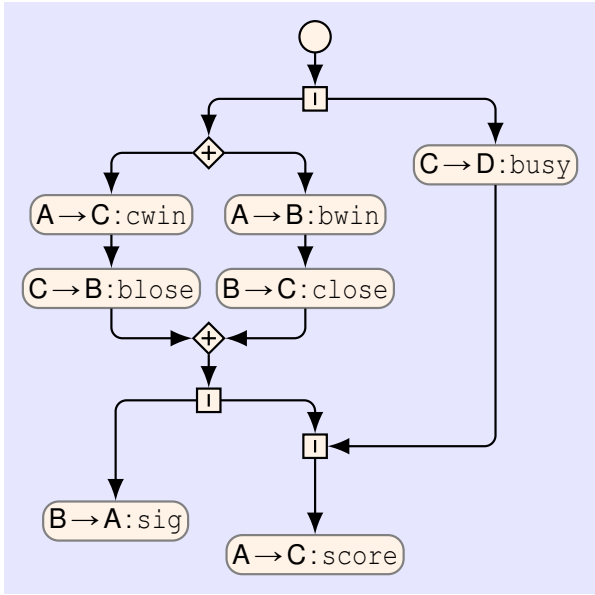

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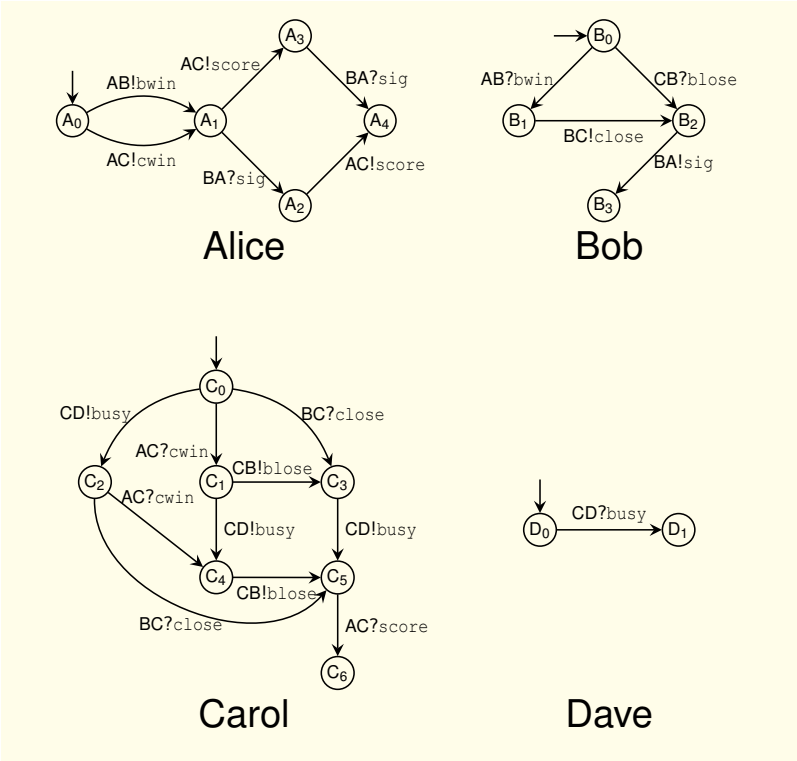

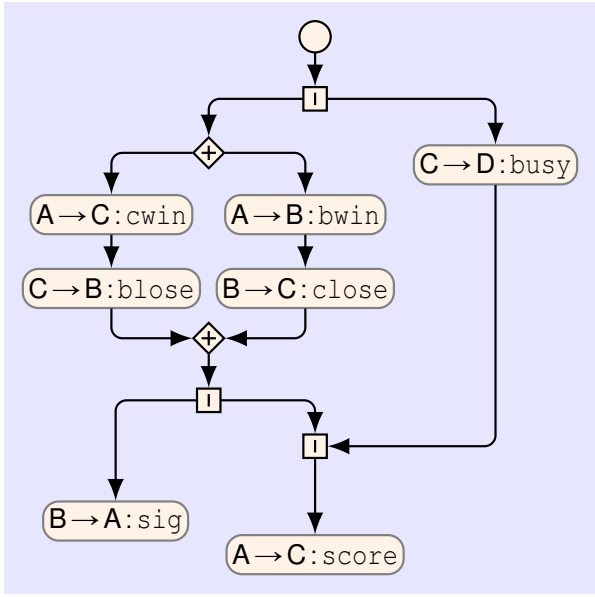

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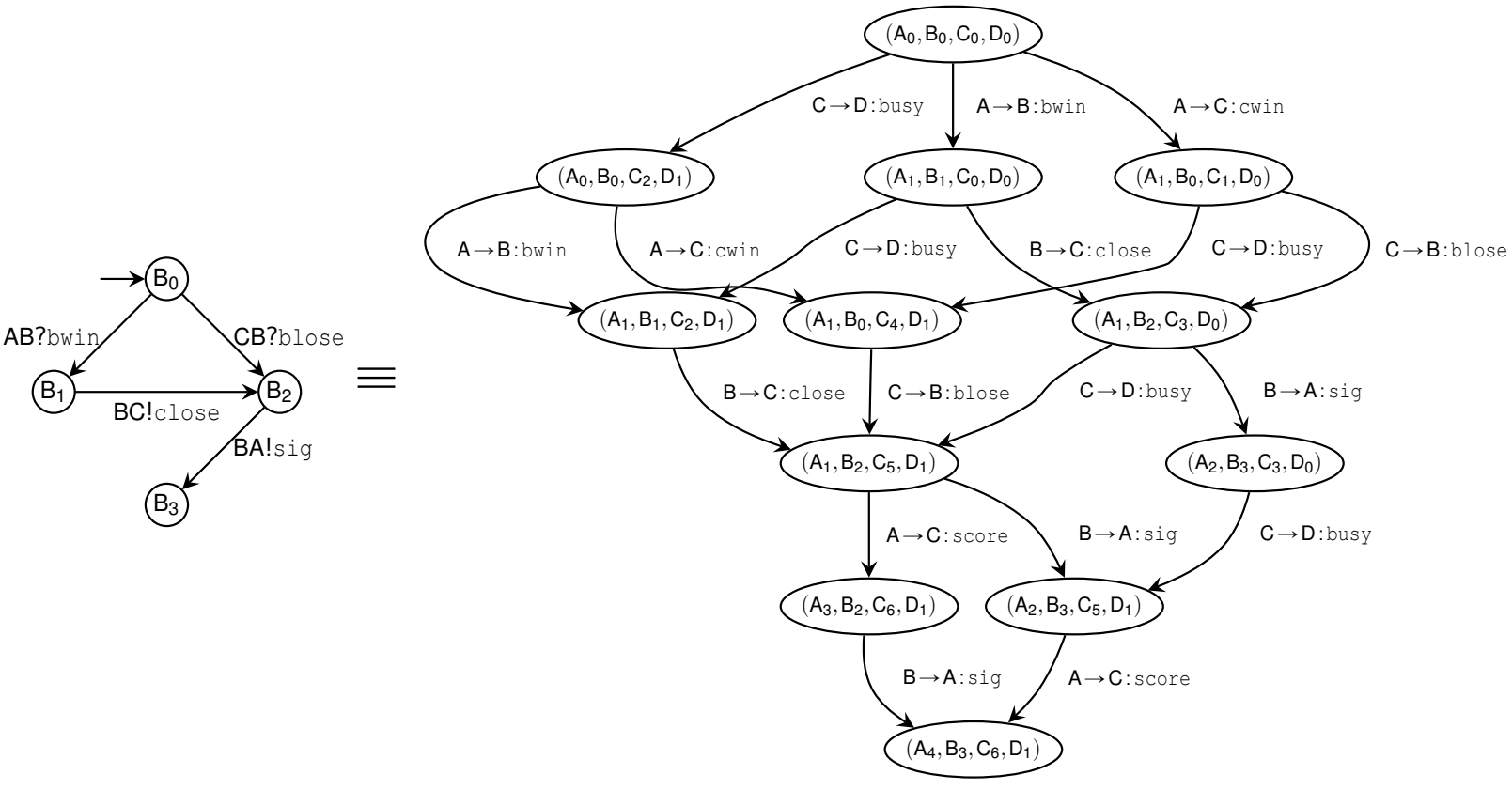
[Lange, Tuosto, Yoshida: POPL 2015]

Checking Compatibility: Representability

Representability

- The projected TS ≡ original machine
- Each branching in each machine must be represented in TS



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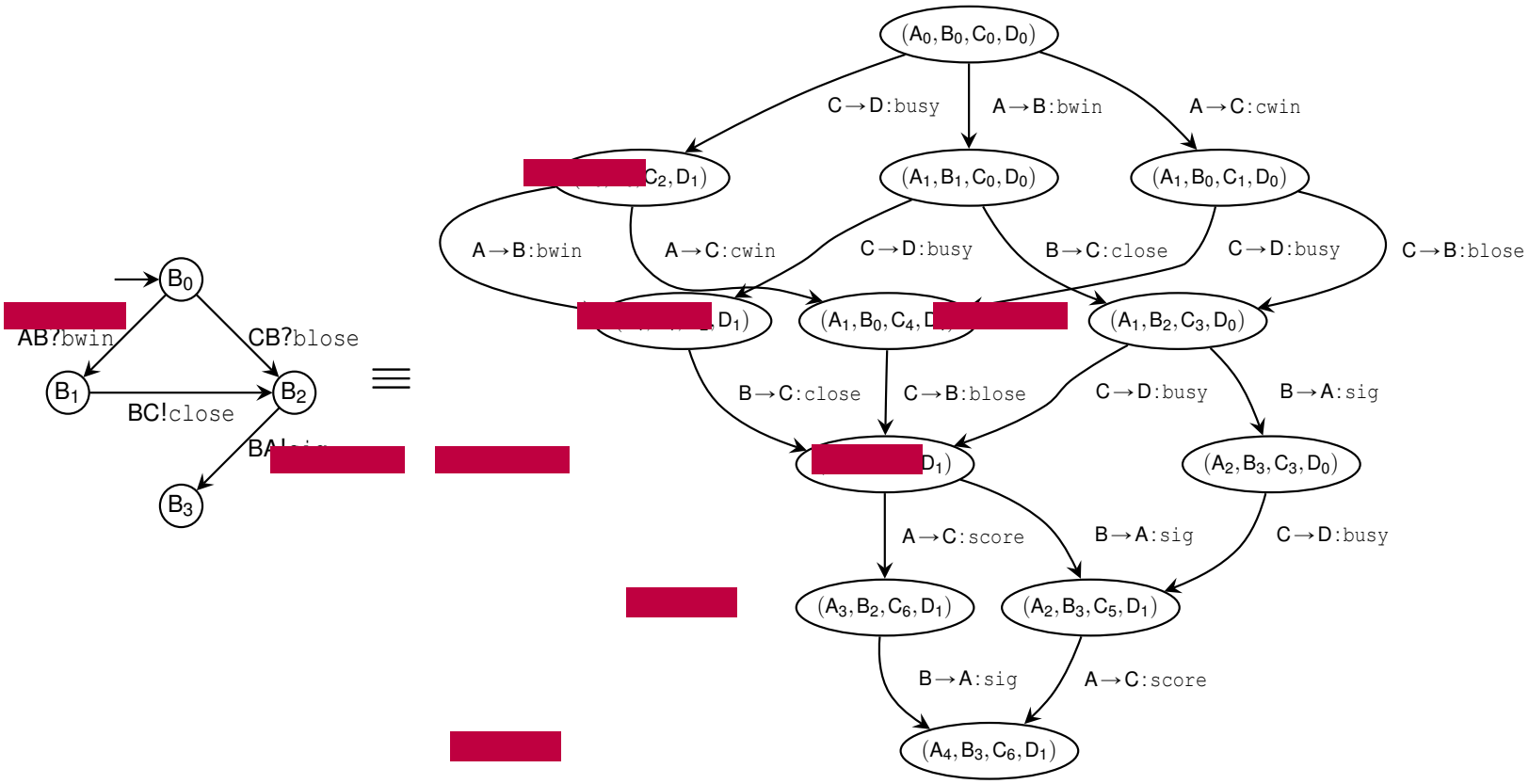
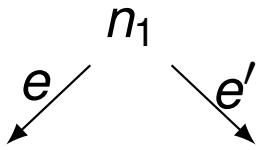


Checking Compatibility: Branching Property

Branching Property:

each branching 

in TS must be either

- commuting:

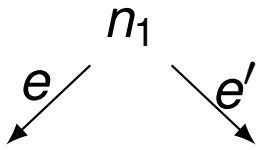
- or, each *last node* n_k

must be a “well-formed” choice, i.e.,

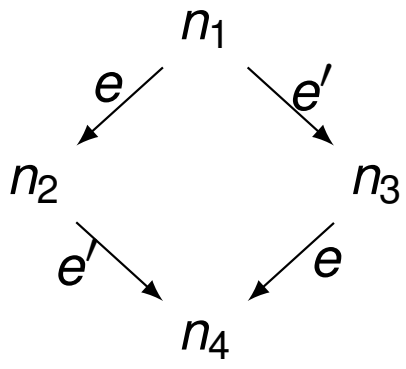
- each participant
  - receives a different message in each branch, or
  - is not involved in the choice
- there is a unique sender

Checking Compatibility: Branching Property

Branching Property:

each branching 

in TS must be either

- commuting: 

- or, each *last node* n_k

must be a "well-formed" choice, i.e.,

- each participant
  - receives a different message in each branch, or
  - is not involved in the choice
- there is a unique sender

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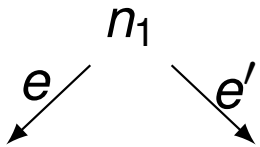
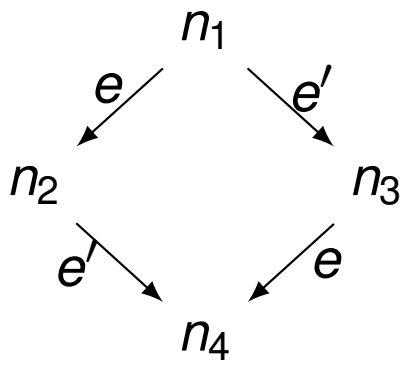
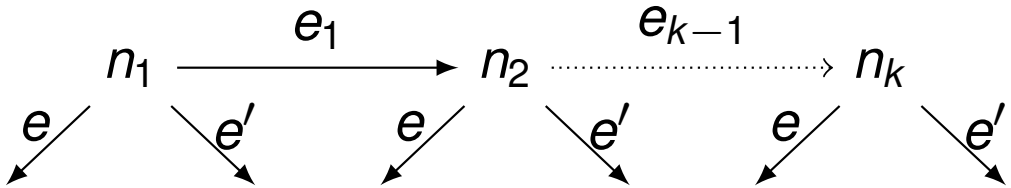
each branching 

in TS must be either

- commuting: 

- or, each *last node* n_k



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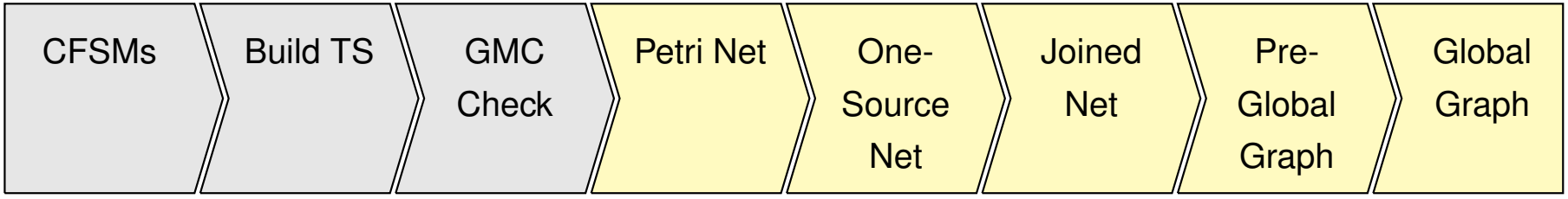
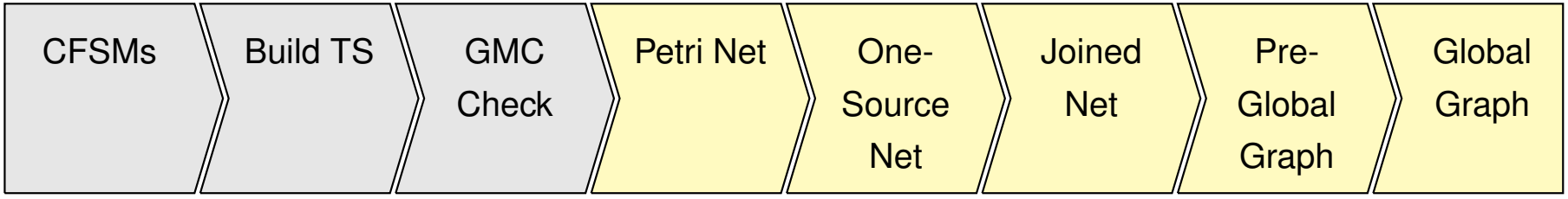
Last node reachable

Transformation Workflow



We use the work of Cortadella et al. (IEEE TC'98), based on the theory of regions, to synthesise a **safe** and **extended free-choice** Petri net from the Synchronous Transition System.

Transformation Workflow



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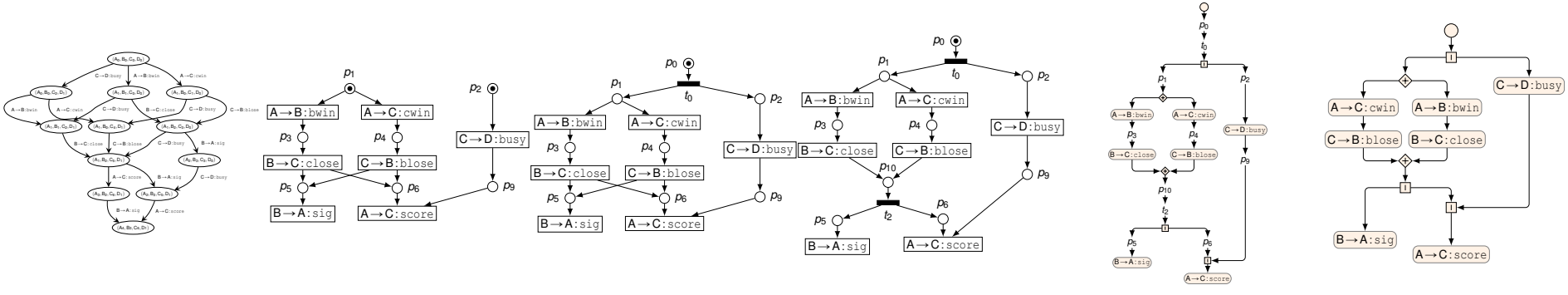
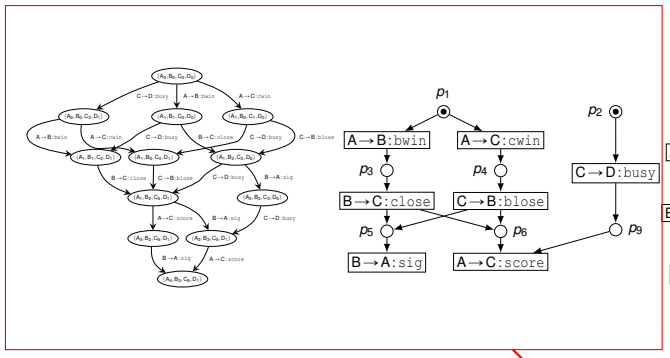
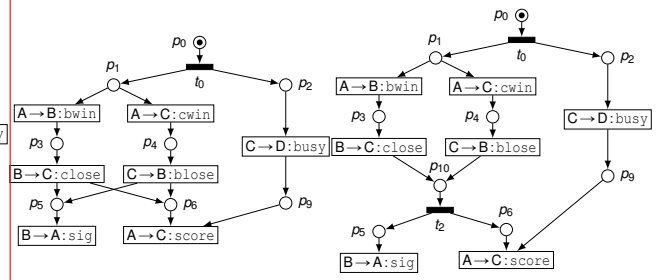
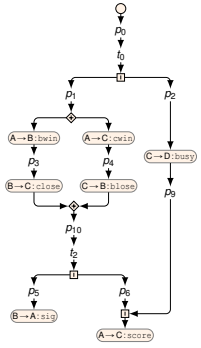
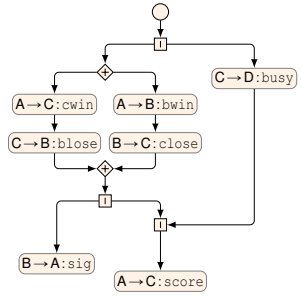


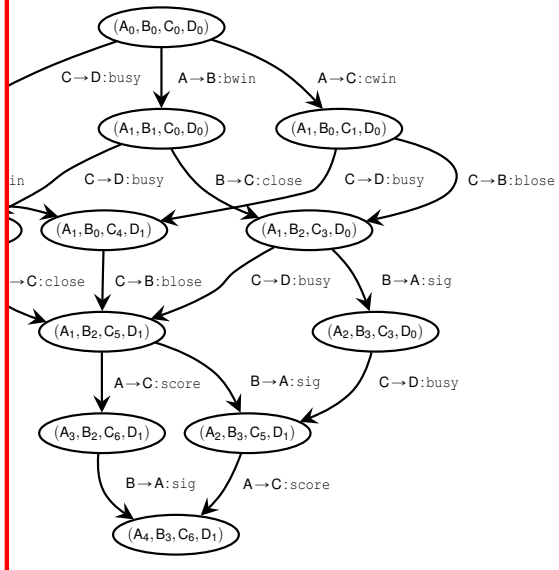
Step 1: TS ⇝ PN

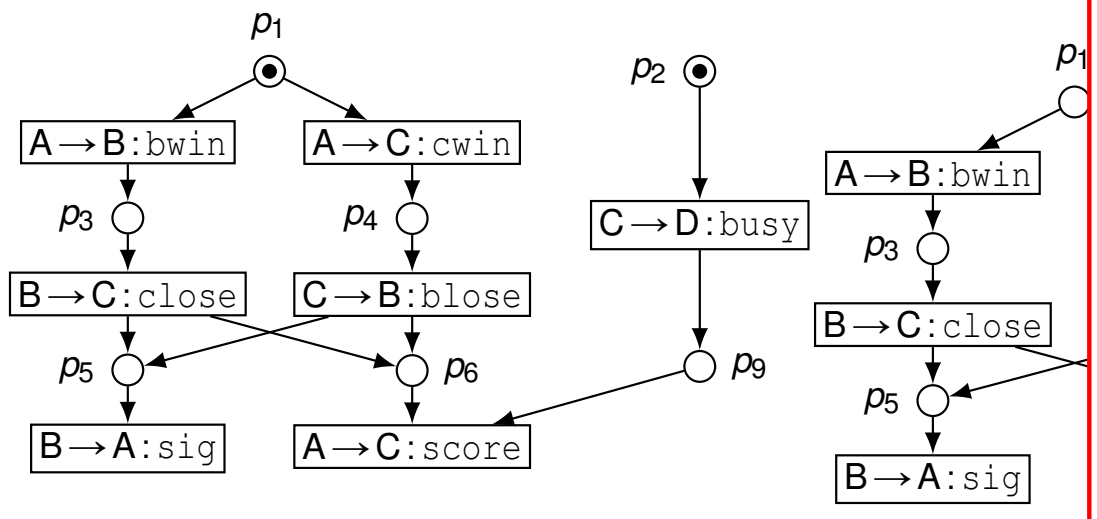






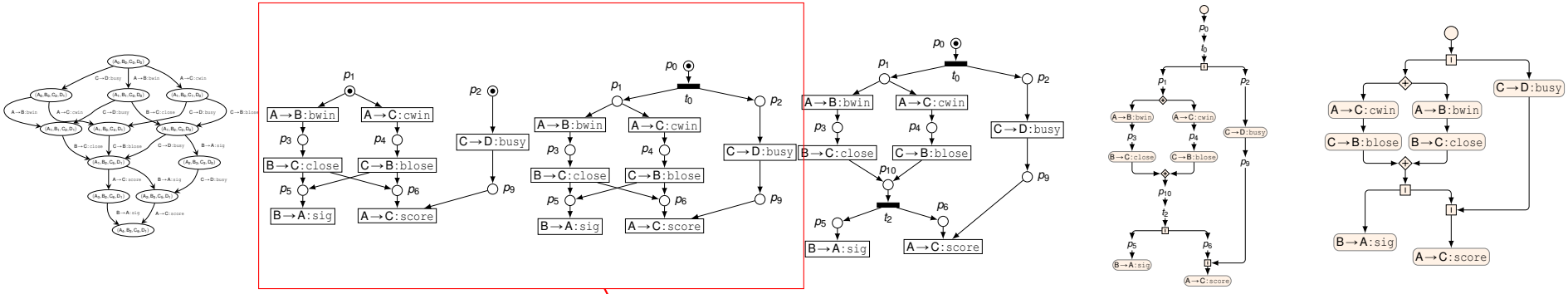


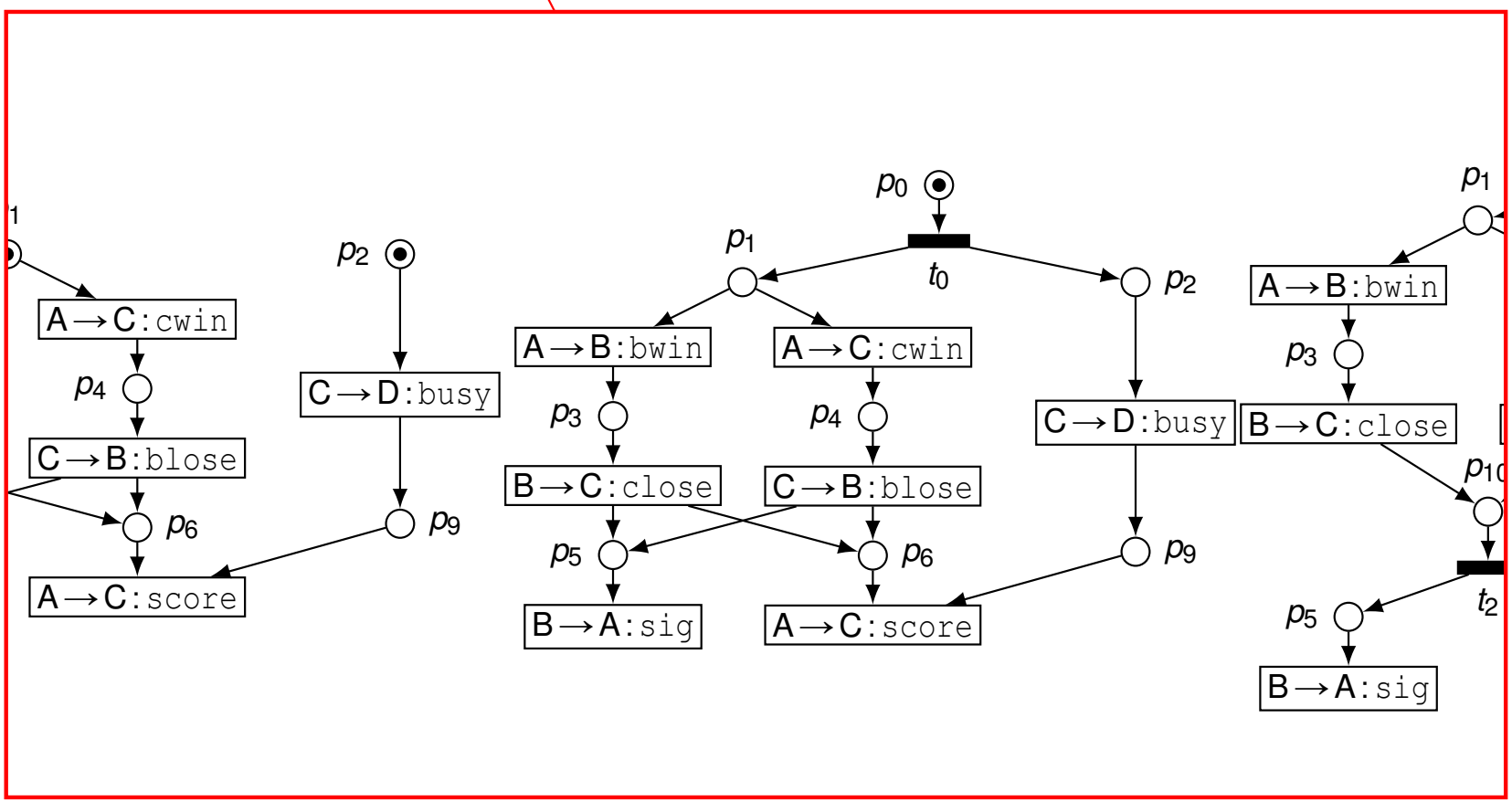




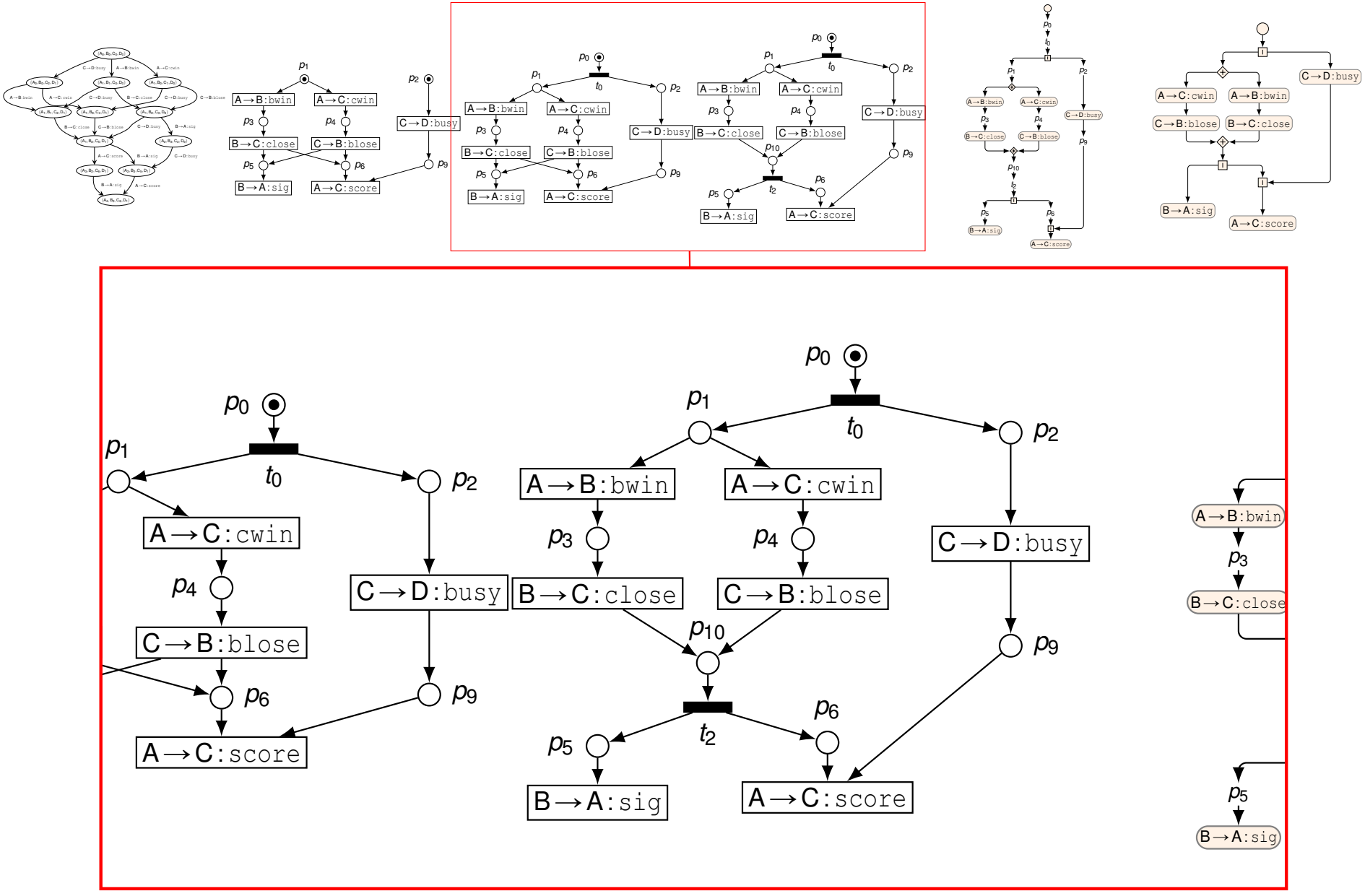
(cf. Algorithm of Cortadella et al.)

Step 2: PN ⇝ 1-source PN

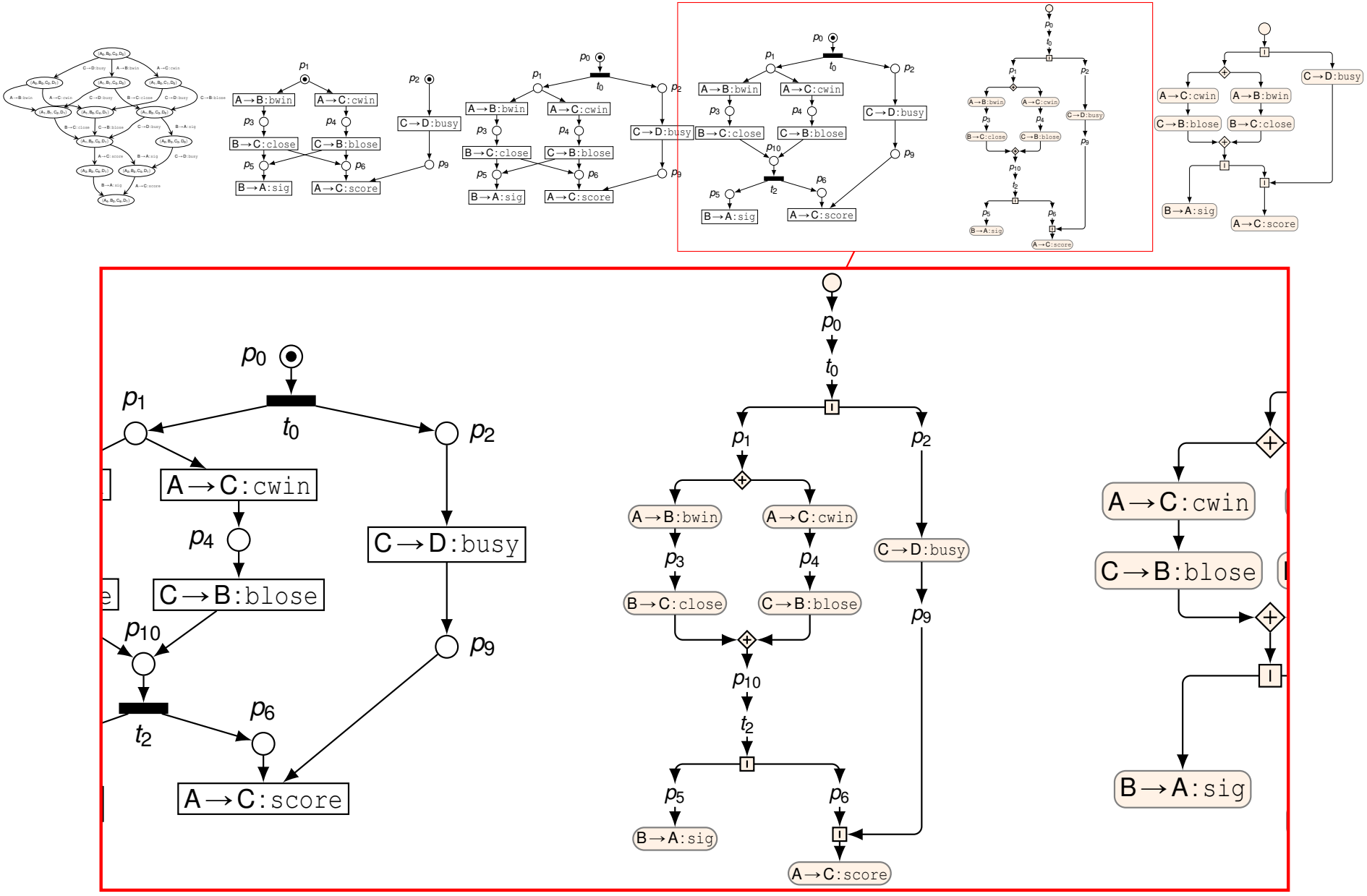




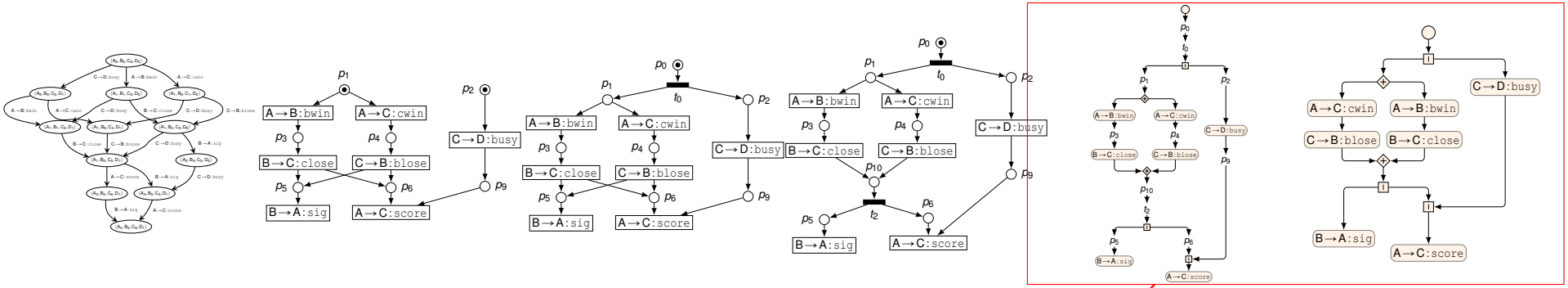
Step 3: 1-source PN ⇝ Joined PN

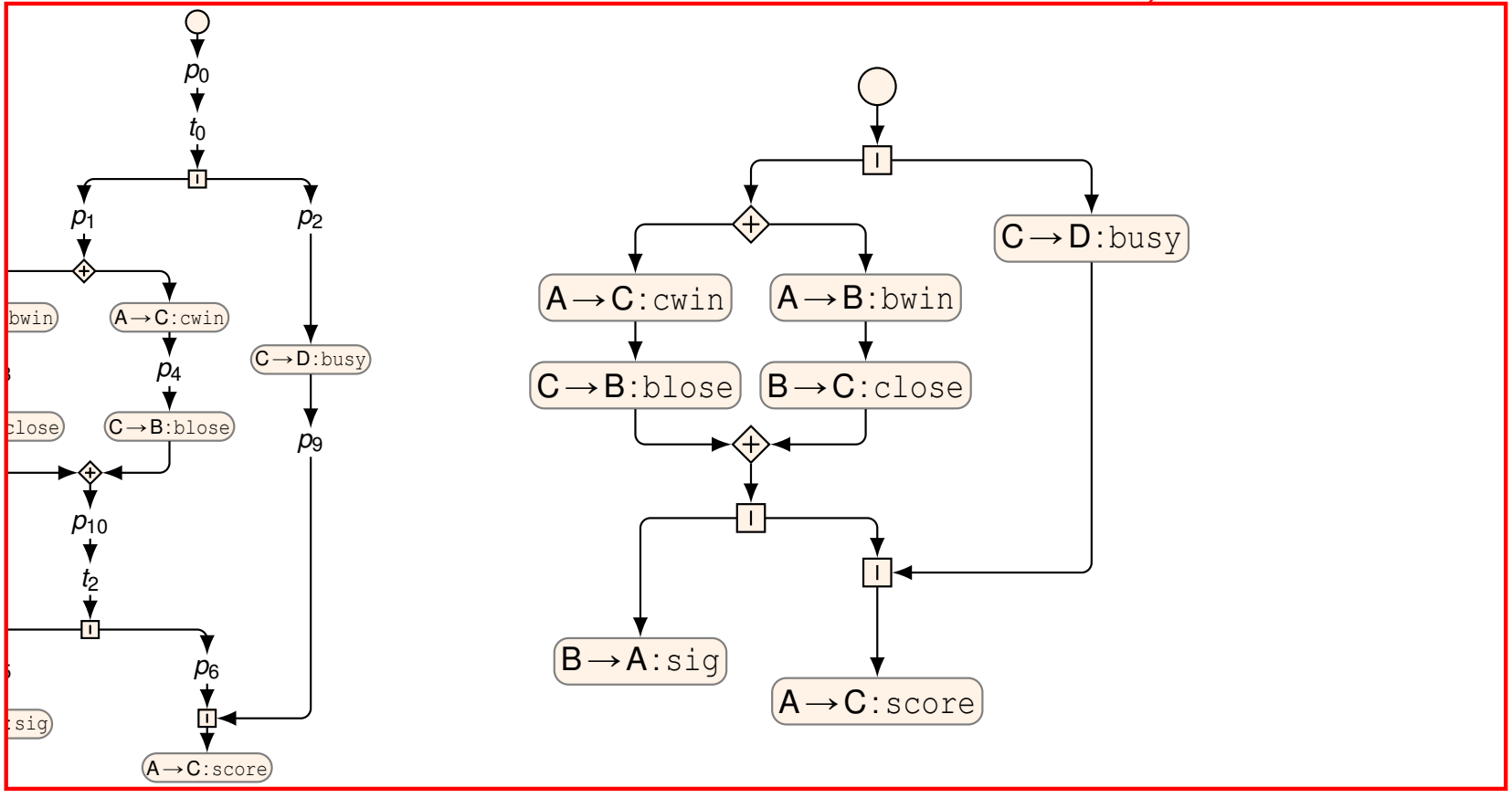


Step 4: Joined PN ⇝ Pre-Interaction Graph



Step 5: Pre-Interaction Graph ⇝ Interaction Graph





Distilling models

/emtalks/images/flow.png \protect \unhbox \voidb@x \penalty \@M

Why is this not so simple?

Decisions have to be taken for good abstractions:

on granularity

- every atomic thread is a participant: “too refined”...perhaps
- what about a participant when one of its threads “hiddenly” forks?
- 1 participant = several threads, usually

⊢ but a too coarse model could be not so good either

on state transitions

- state transition of machines depend on which are the participants
- states are determined by the invocations they make
- but some invocations are “internal”

⊢ care is necessary about what is observable

An application: the gen_server

From www.erlang.org

/emtalks/images/gen$_s$*erver*$_m$*an.png* \let =\let =\beamer@thcuse@ \bea

$\geqslant$11k Erlang's repos with $\geqslant$31k use of gen_server on github only

Step 1: Identifying participants on gen_server

For ping-pong

this step is trivial

The obvious

- let: Participants = Client (C) + Server (S)
  - $\perp$: From docs: C does not interact directly with S
- $\vdash$: Something from the API must be exposed...so
- let: Particants = C + Library (L)
  - $\perp$: This also fails: too coarse we tried
- $\vdash$ Participants = C + L + S
  (... may be; but let's use this working hypothesis)

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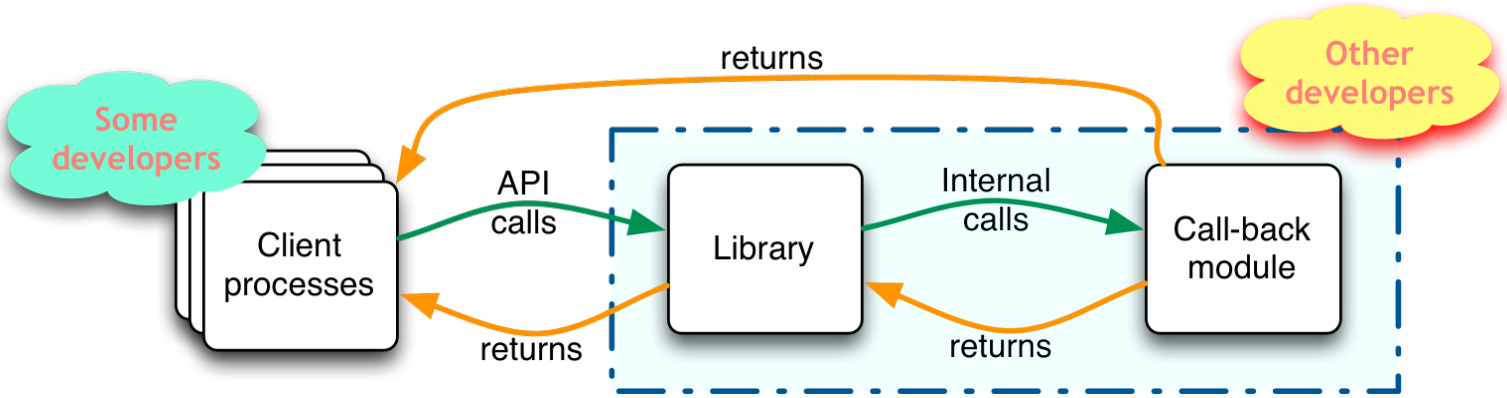
Step 2: Identifying events on gen_server

From gen_server API

Clients can

- start new instances of gen_server
- stop a gen_server
- request to handle C's calls

gen_server communication events



Step 3: extracting CFSMs on gen_server

Aren't they cute?

/emtalks/images/gen$_s$*erver*$_m$*achines.png* \let =\let =\beamer@thcuse@