An Operational Semantics of BPMN Collaboration

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Learn PAd

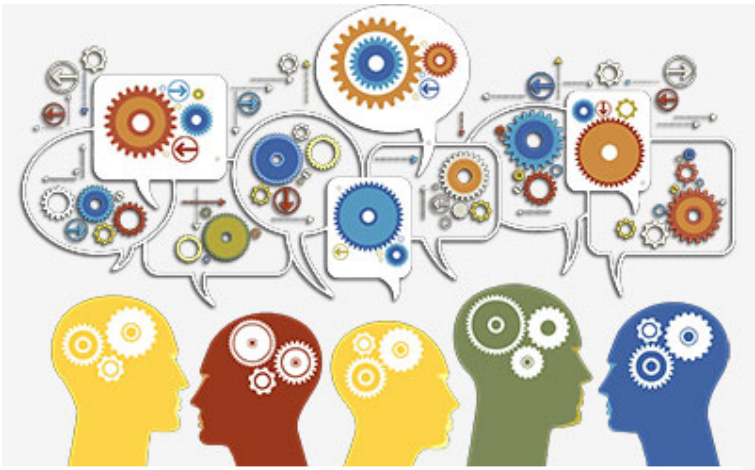
Learn PAd

FP7 EU project in the area of Technology Enhanced Learning aiming at exploiting the usage of models in the organization of learning contents for civil servants.

http://www.learnpad.eu

Definition of modelling languages and tools to represent and reason on different perspectives of a complex organisation

Process improvement, alignment of IT systems and business objectives, resources allocation, ...



Business Process Modeling

*A Business Process is a **collection of related and structured activities undertaken by one or more organisations in order to pursue some particular goal**...*

Motivations

Learn PAd

- demonstrators from public administrations. SUAP (Sportello Unico Attività Produttive) a quite complex BP that foresees the cooperation of several PAs
- No Magic (MagicDraw), one of the project partners, is also an OMG partner

Before starting

We did not consider all the BPMN elements and in particular the OR-join

Motivations

LEARN PAD

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BPMN 2.0

Many different notations have been proposed to represent Business Process models with differences both in the possibility to express perspectives related to the organizations, and in the level of formality used to define the elements composing the notation

BPMN 2.0 is currently acquiring a clear predominance

- OMG standard (v.2.0.2 - Sept. 2013)
- intuitive graphical notation
- wide acceptance by industry and academia
- supported by a wide spectrum of modelling tools

It permits to model collaborations of different organisations that exchange messages and cooperate to reach a shared business objective

Our Contribution

OMG did not provide a rigorous semantics for BPMN 2.0

We provide a precise characterisation of BPMN elements:

- Direct formalisation in terms of LTS
- Special emphasis on communication within collaboration diagrams

In the last years, many proposal have been defined by the research community to provide a formal semantics to the BPMN 2.0 notation, but ...

- generally based on the definition of mappings to formal notations
- do not specifically target collaborations
- assumptions on structural properties are generally made

Major Benefits

- It is a native semantics, rather than a mapping to a formal notation (equipped with its own semantics) like most of the proposals in the literature
- It provides a compositional approach based on LTS, which paves the way for the use of consolidated analysis techniques and related software tools
- It is suitable to model business processes with arbitrary topology, without imposing syntactical restrictions to the modeler, such as *well-structuredness* (which, e.g., imposes gateways in a process to form single-entry-single-exit fragments)
- Besides core elements such as tasks, gateways, sequence flow, etc., it takes into account collaborations and message exchange, which are often overlooked by other formalisations

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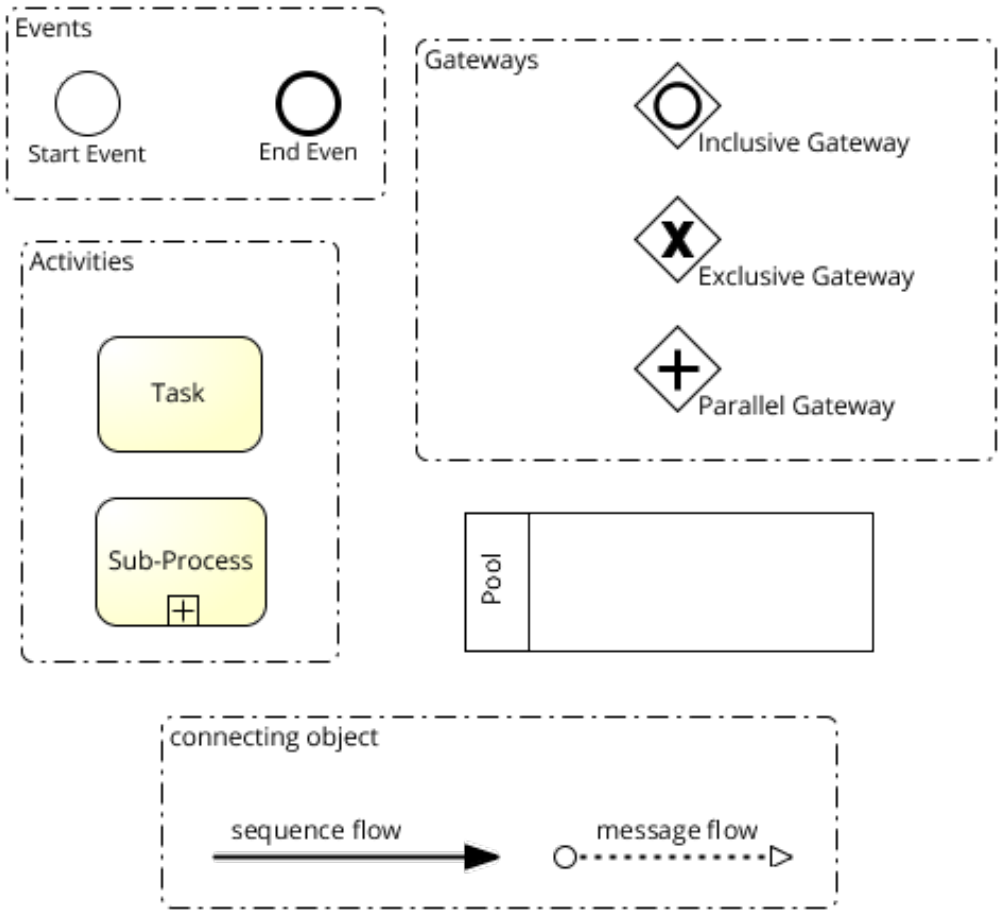
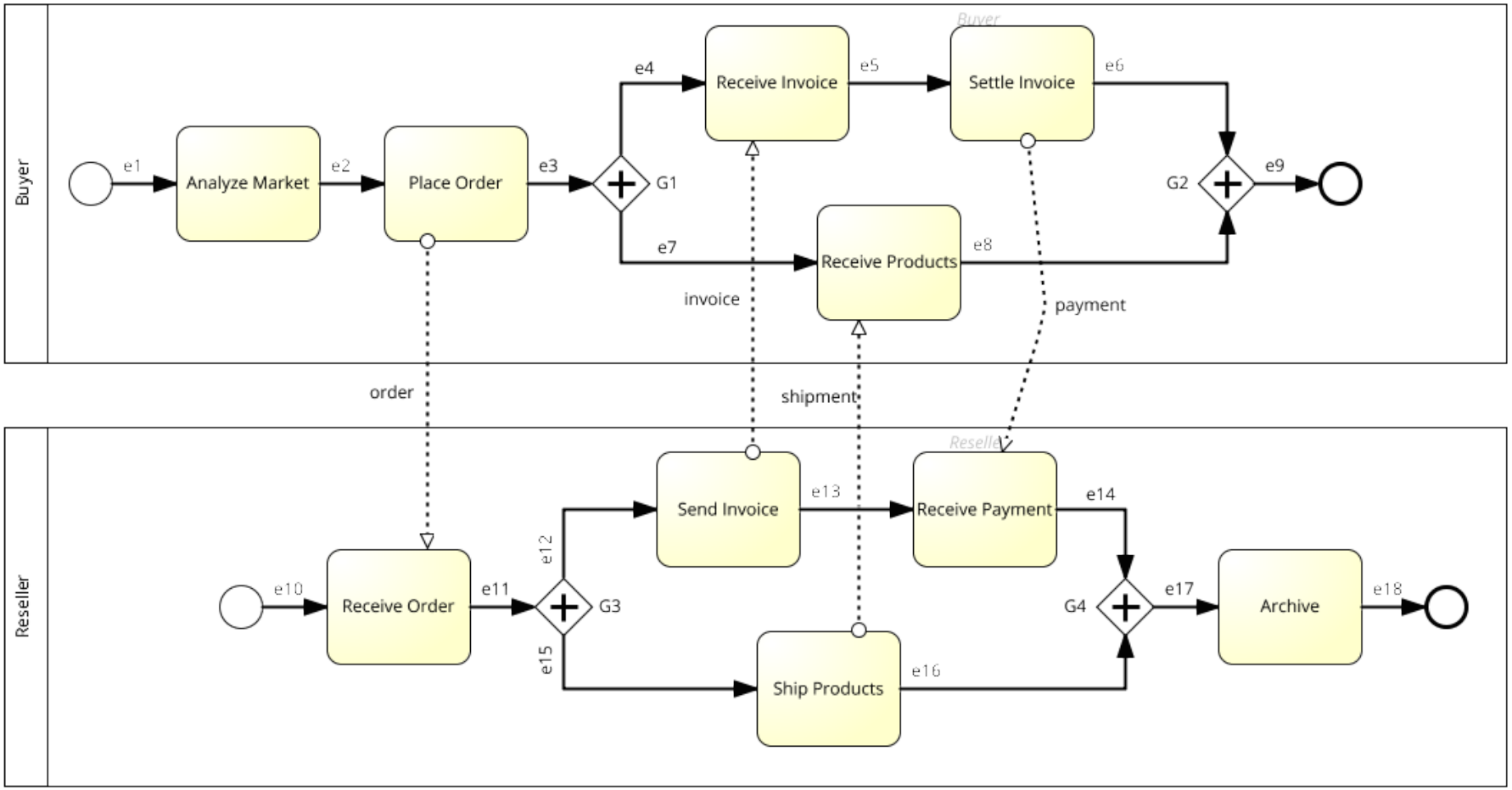
Background Notions on BPMN 2.0

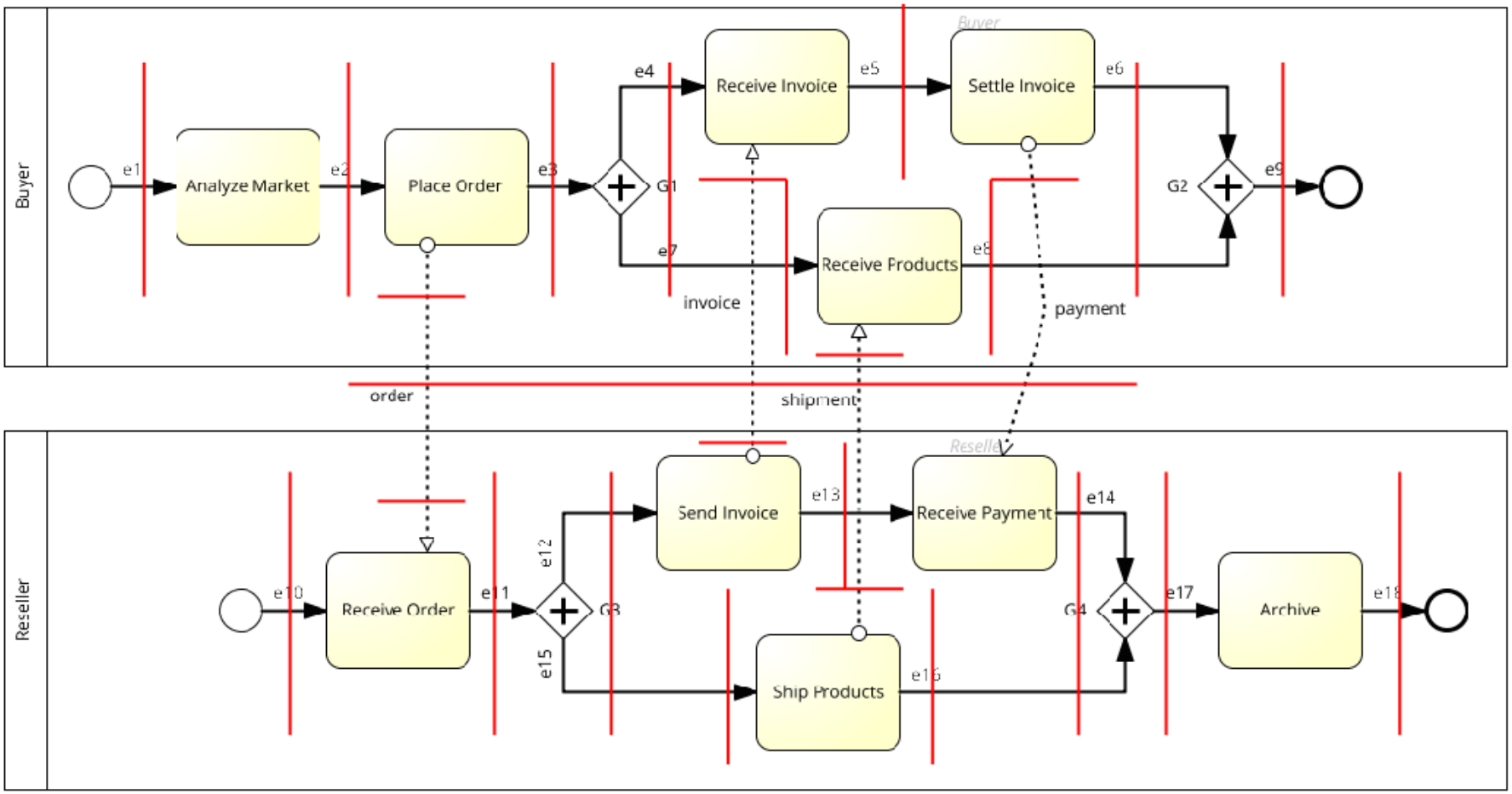
BPMN basic elements



Buyer-Reseller Example

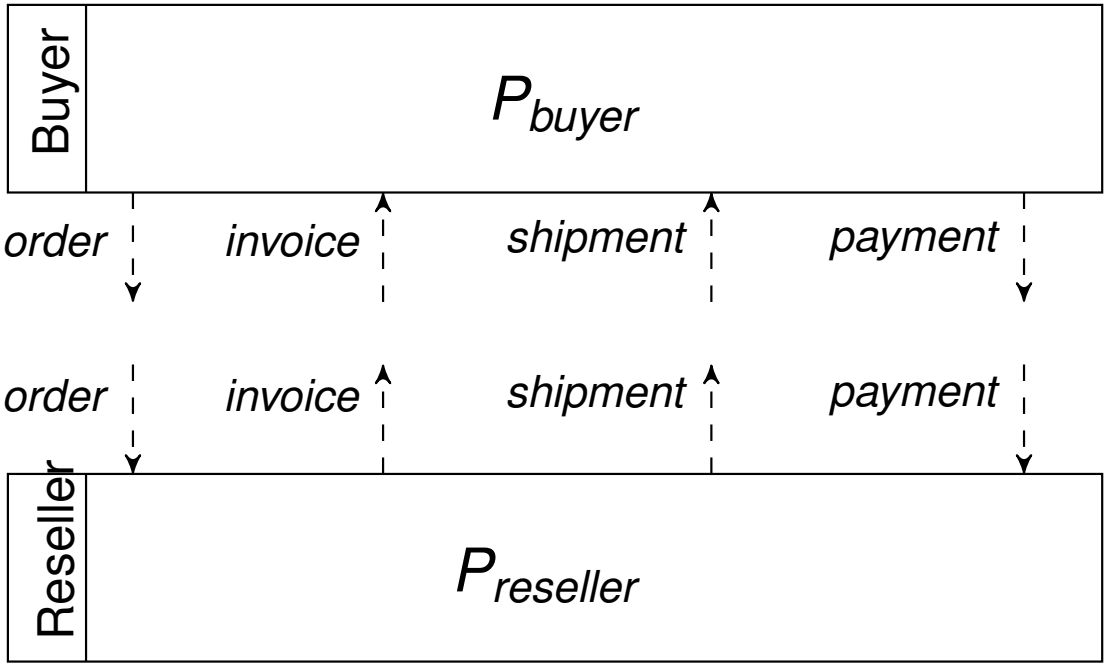


Buyer-Reseller “cuts”

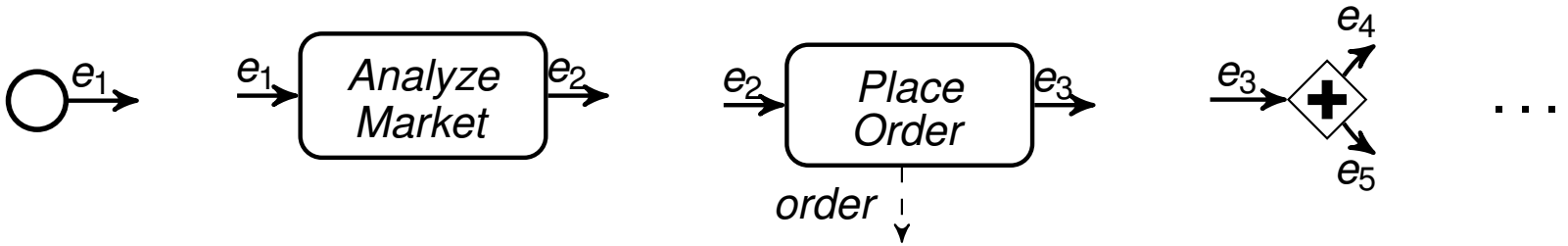


Buyer-Reseller layers

Collaboration layer



BNF Syntax - Process layer (P_{buyer})



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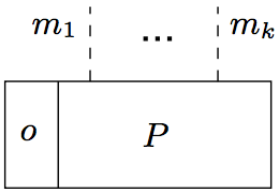
BNF Syntax

(Collaborations) C ::=

(Pool, $k \geqslant 0$)



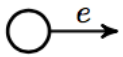
(Pool collection) | C_1 C_2

(Gateways) G ::=

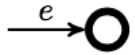
(XOR/AND/OR)

(Processes) P ::=

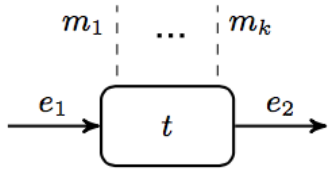
(Start event)



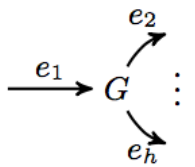
(End event) |



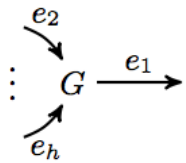
(Task, $k \geqslant 0$) |



(Split gateway, $h > 2$) |



(Join gateway, $h > 2$) |



(Node collection) | P_1 P_2

Operational Semantics

The Operational semantics is based on a set of inference rules defined at different layers:

- Collaboration Layer
- Process Layer
  - Control Flow Constructs
  - Task Constucts
  - Node Collections

Marking

the semantics is given in terms of *marked collaborations*, i.e. collections of pools equipped with a marking.
A *marking* is a distribution of tokens over pool message edges and process elements that indicate message arrivals and the process nodes that are active or not in a given step of the execution.

Operational Semantics – Collaboration

We write $C \overset{l}{\longmapsto} C'$ to mean that "collaboration C can perform a transition labeled by l and become C' in doing so". Transition labels are generated by the following production rule:

$$(\mathit{Labels}) \qquad l \ ::= \ o : \alpha \ \mid \ o_1 \rightarrow o_2 : m$$

where:

- $o : \alpha$ denotes an action α peformed by the process instance of organisation o
- $o_1 \rightarrow o_2 : m$ denotes the exchange of a message m from organisation o_1 to o_2.

Operational Semantics – Process

We write $P \overset{\alpha}{\longmapsto} P'$ to mean that "process P can perform a transition labeled by α and become P' in doing so". The labels used by this auxiliary transition relation are generated by the following production rules:

(Actions) $\alpha ::= \tau \mid !m \mid ?m$

(Internal actions) $\tau ::= \mathit{enabled}\ t \mid \mathit{completed}\ t \mid (-\tilde{e}_1, +\tilde{e}_2)$

where notation $\tilde{e}$ indicates a set of edges. The meaning of labels is as follows:

- τ denotes an action internal to the process
- $!m$ and $?m$ denote send and receive actions, respectively.

The meaning of internal actions is as follows:

- *enabled t* and *completed t* denote the start and completion of the execution of task *t*, respectively;
- the pair $(-\tilde{e}_1, +\tilde{e}_2)$ denotes movement of workflow tokens in the process graph, in particular one token is removed from each edge in the $\tilde{e}_1$ set and one is added to each edge in the $\tilde{e}_2$ set

Collaboration Layer

Internal Action:

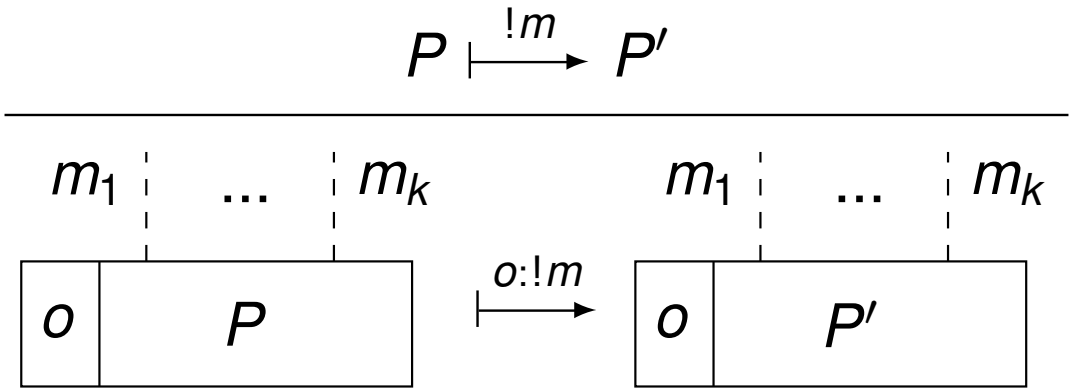
$$\frac{P \overset{\tau}{\longmapsto} P'}{m_1 \;\ldots\; m_k \;\; o \;\; P \;\xrightarrow{o:\tau}\; m_1 \;\ldots\; m_k \;\; o \;\; P'}$$

Receive action:

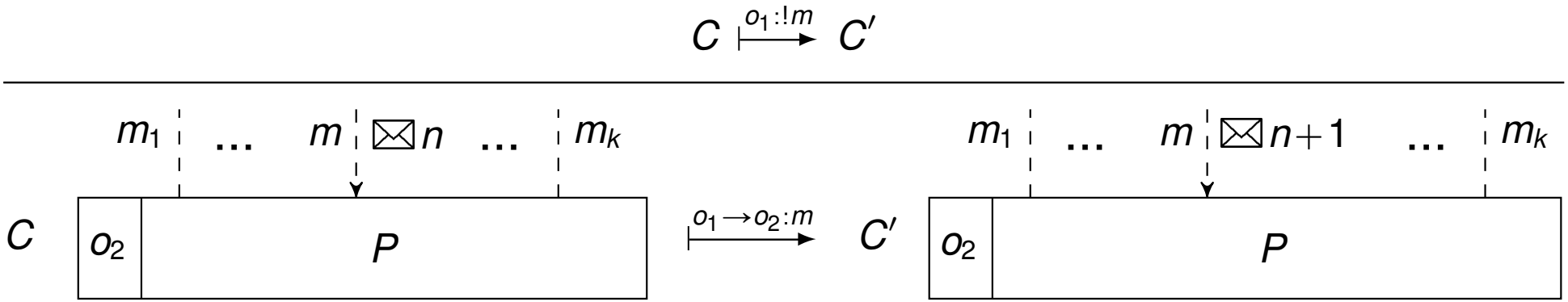
$$\frac{P \overset{?m}{\longmapsto} P' \qquad n > 0}{m_1 \;\ldots\; m \boxtimes n \;\ldots\; m_k \;\; o \;\; P \;\xrightarrow{o:?m}\; m_1 \;\ldots\; m \boxtimes n-1 \;\ldots\; m_k \;\; o \;\; P'}$$

Collaboration Layer

Send Action:

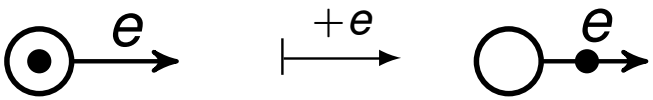


Delivery Action:

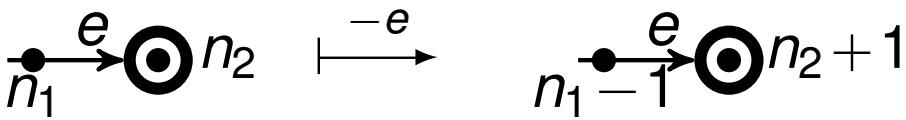


Process Layer – Control Flow Constucts 1/3

Start event:

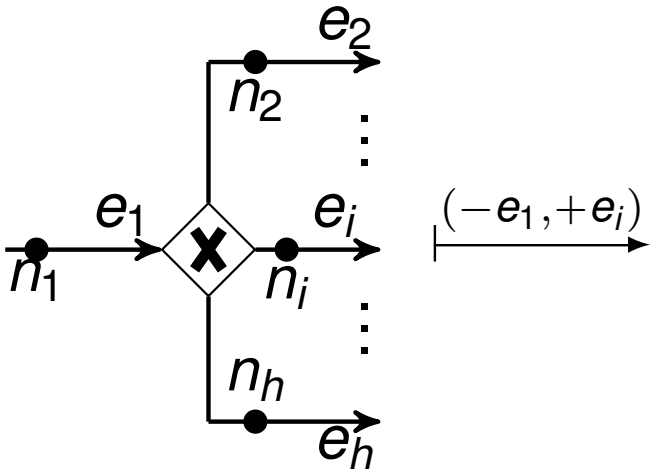


End event:

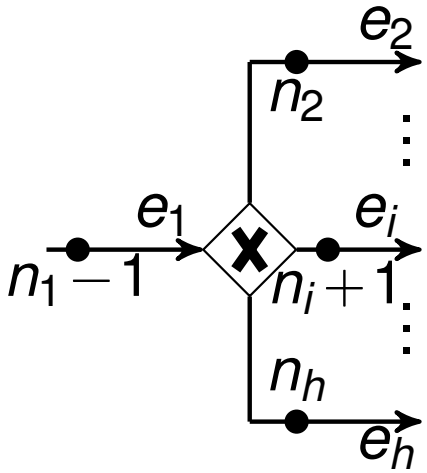


$n_1 > 0$

XOR Split:



$(-e_1, +e_i)$

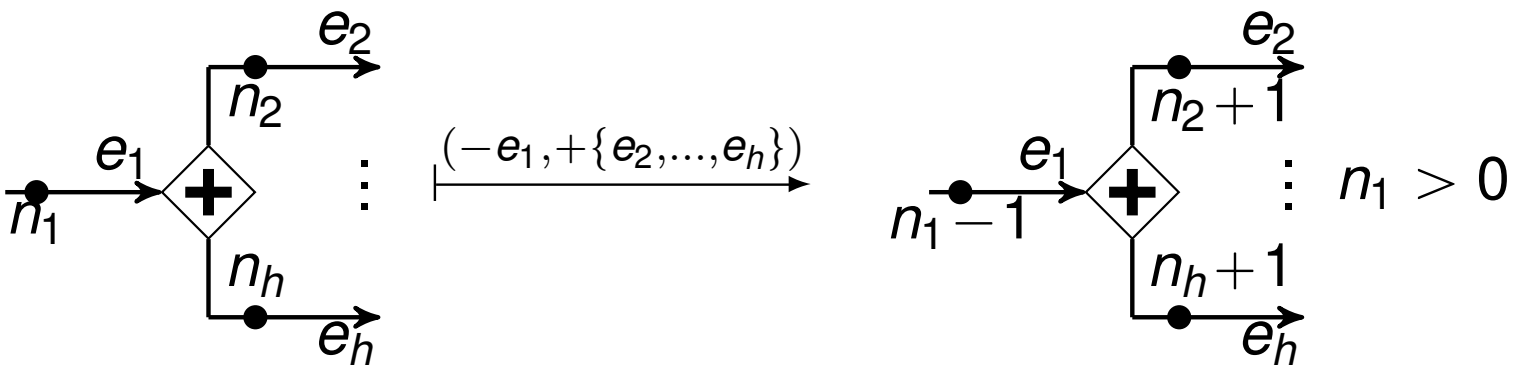


$n_1 > 0$

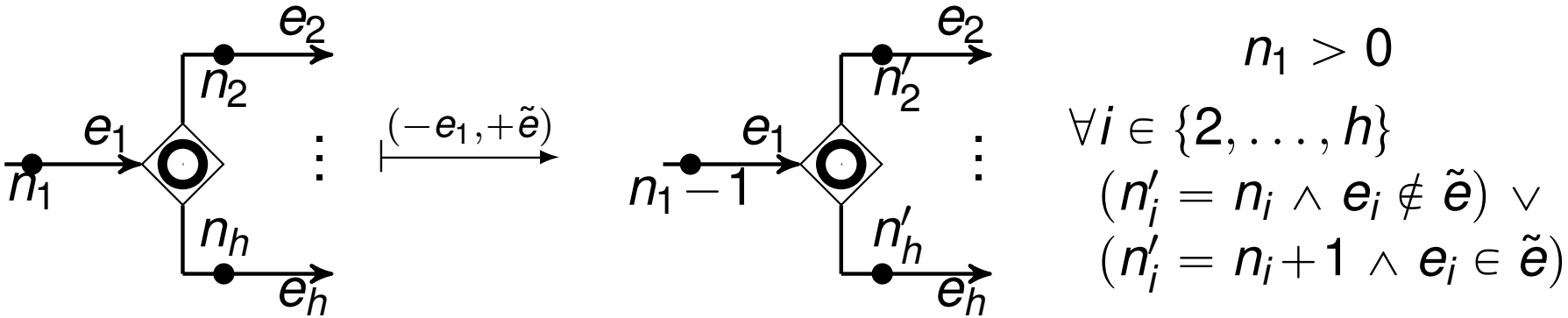
$2 \leqslant i \leqslant h$

Process Layer – Control Flow Constucts 2/3

AND Split:

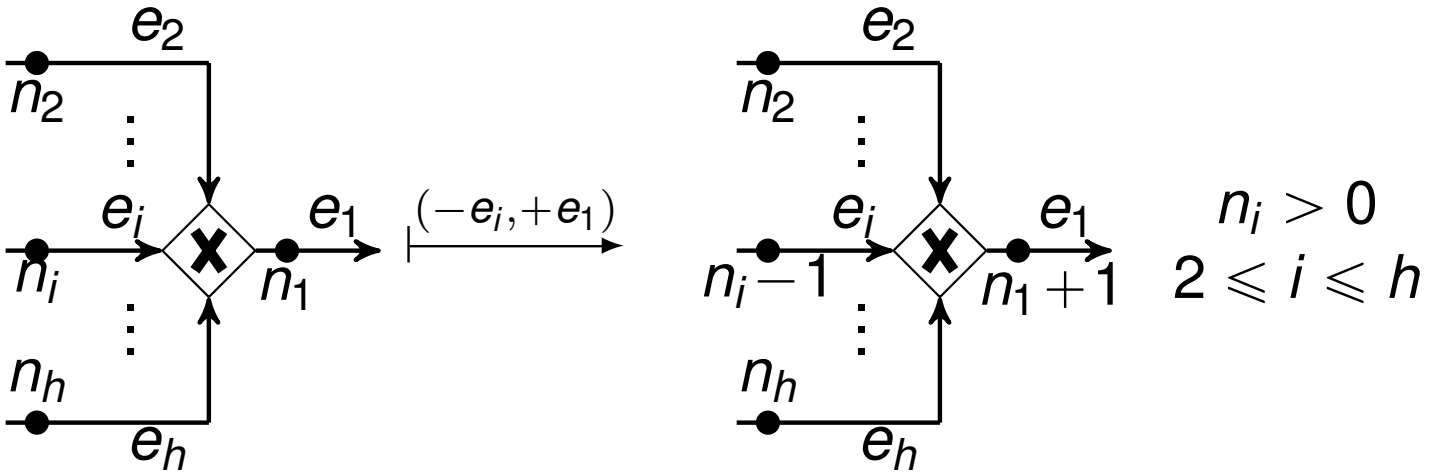


OR Split:

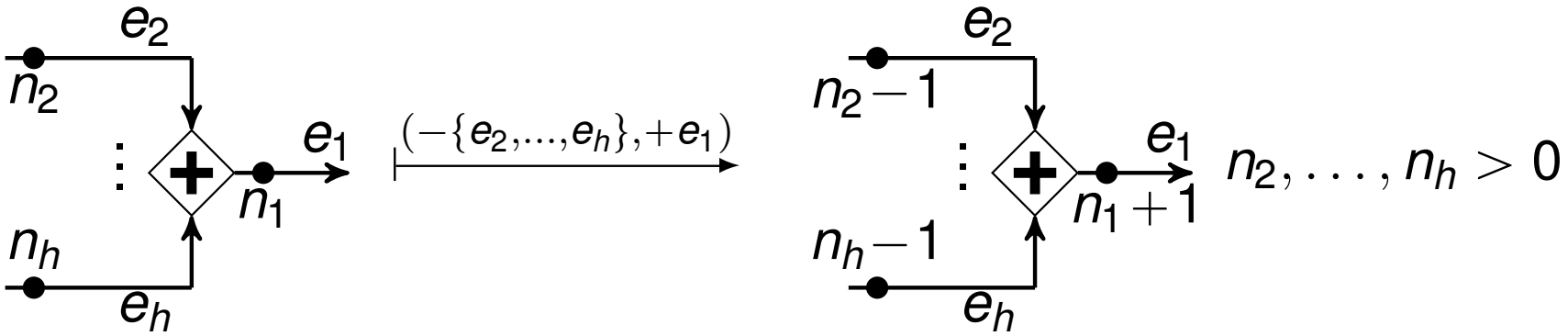


Process Layer – Control Flow Constucts 3/3

XOR Join:

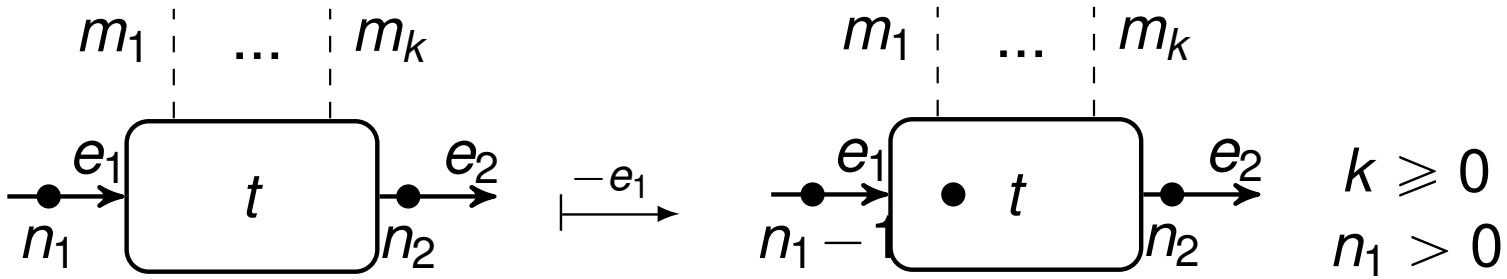


AND Join:



Process Layer – Task Constructs 1/2

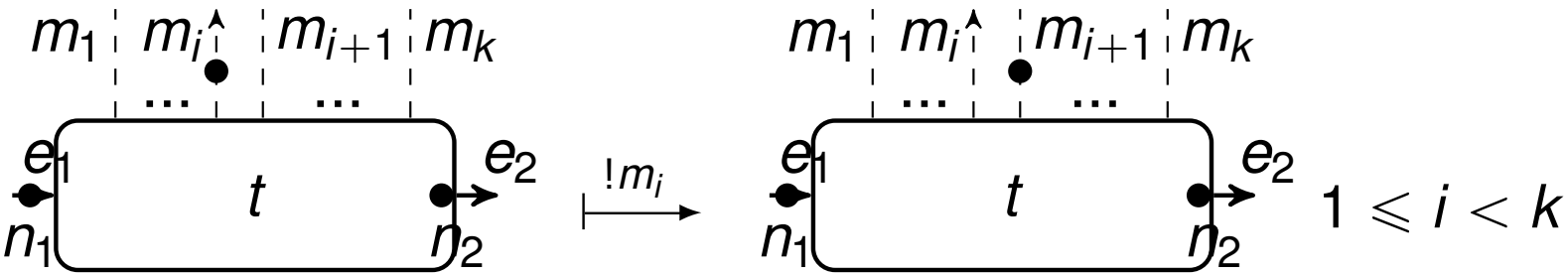
Enable Task (1):



$k \geqslant 0$

$n_1 > 0$

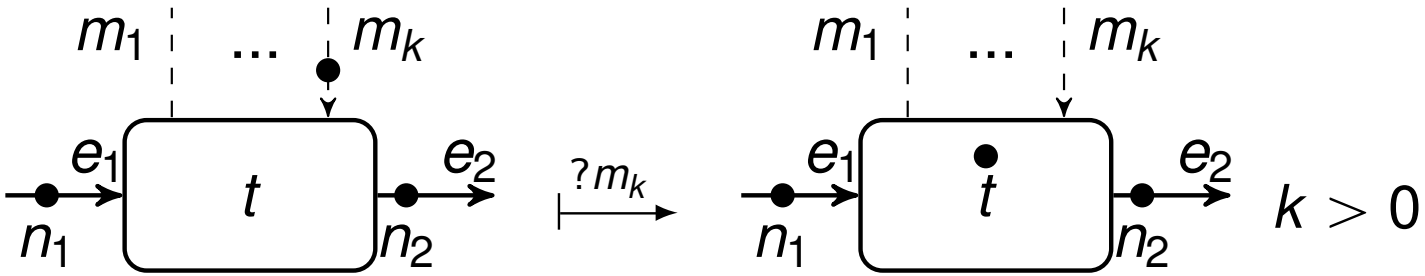
Send Task (1):



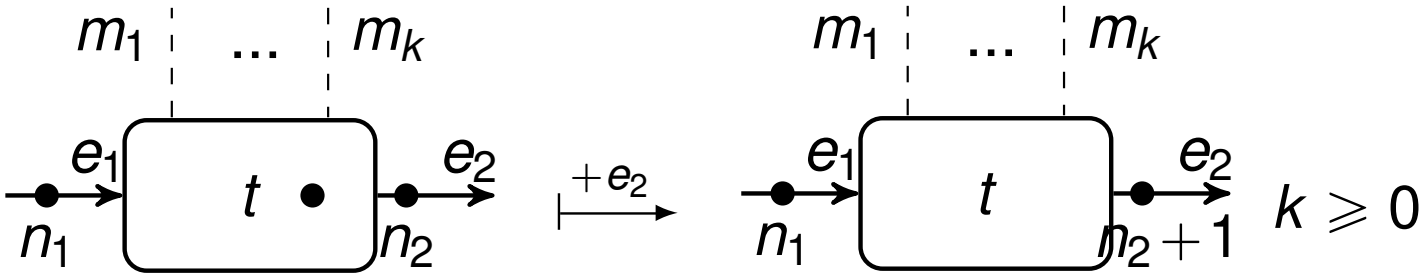
$1 \leqslant i < k$

Process Layer – Task Constructs 2/2

Receive Task (2):



Complete Task (2):



Process Layer - Node Collection

Connected processes:

$$\frac{P_1 \overset{(-\tilde{e}_1,+\tilde{e}_2)}{\longmapsto} P_1'}{P_1 \quad P_2 \overset{(-\tilde{e}_1,+\tilde{e}_2)}{\longmapsto} P_1' \quad P_2 \pm_{\tilde{e}_1,\tilde{e}_2}}$$

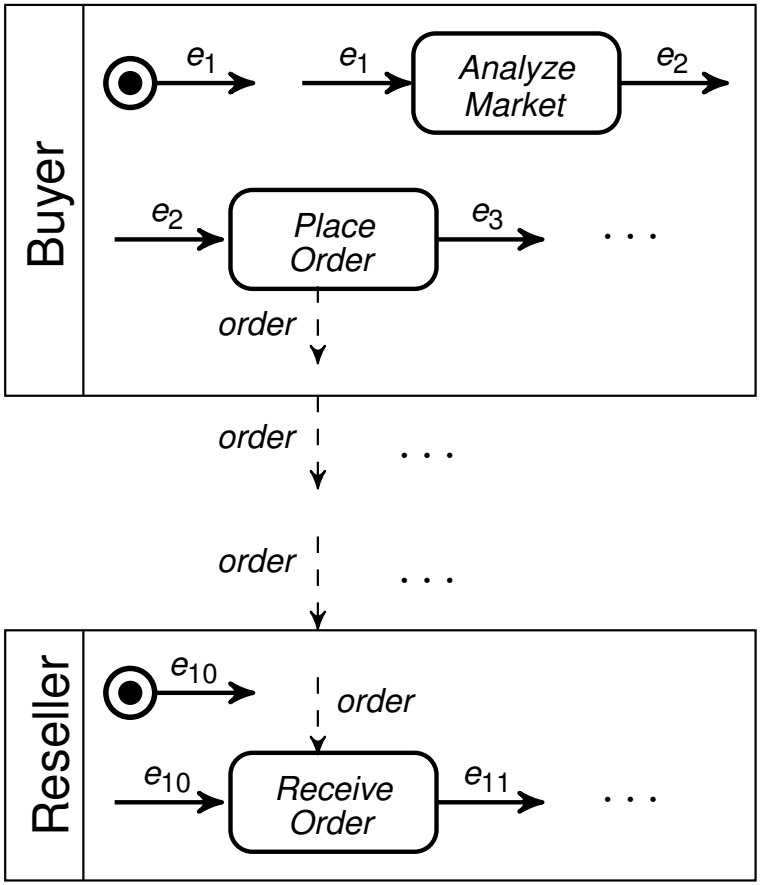
$$\frac{P_2 \overset{(-\tilde{e}_1,+\tilde{e}_2)}{\longmapsto} P_2'}{P_1 \quad P_2 \overset{(-\tilde{e}_1,+\tilde{e}_2)}{\longmapsto} P_1 \pm_{\tilde{e}_1,\tilde{e}_2} \quad P_2'}$$

Independent processes:

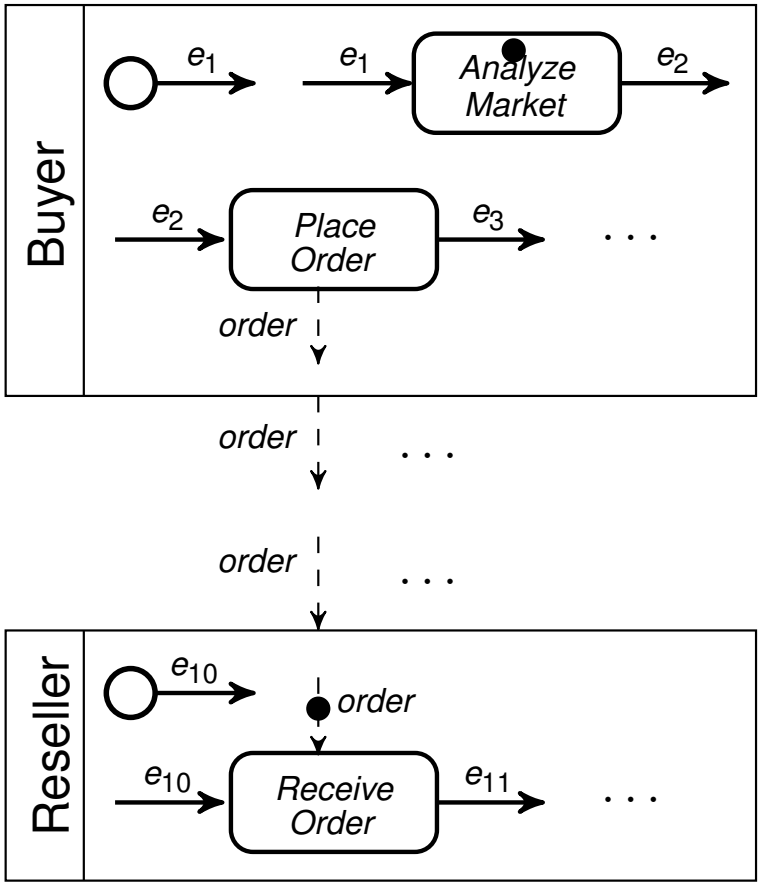
$$\frac{P_1 \overset{\alpha}{\longmapsto} P_1' \qquad \alpha \neq (-\tilde{e}_1, +\tilde{e}_2)}{P_1 \quad P_2 \overset{\alpha}{\longmapsto} P_1' \quad P_2}$$

$$\frac{P_2 \overset{\alpha}{\longmapsto} P_2' \qquad \alpha \neq (-\tilde{e}_1, +\tilde{e}_2)}{P_1 \quad P_2 \overset{\alpha}{\longmapsto} P_1 \quad P_2'}$$

Semantics of the running example - Part I

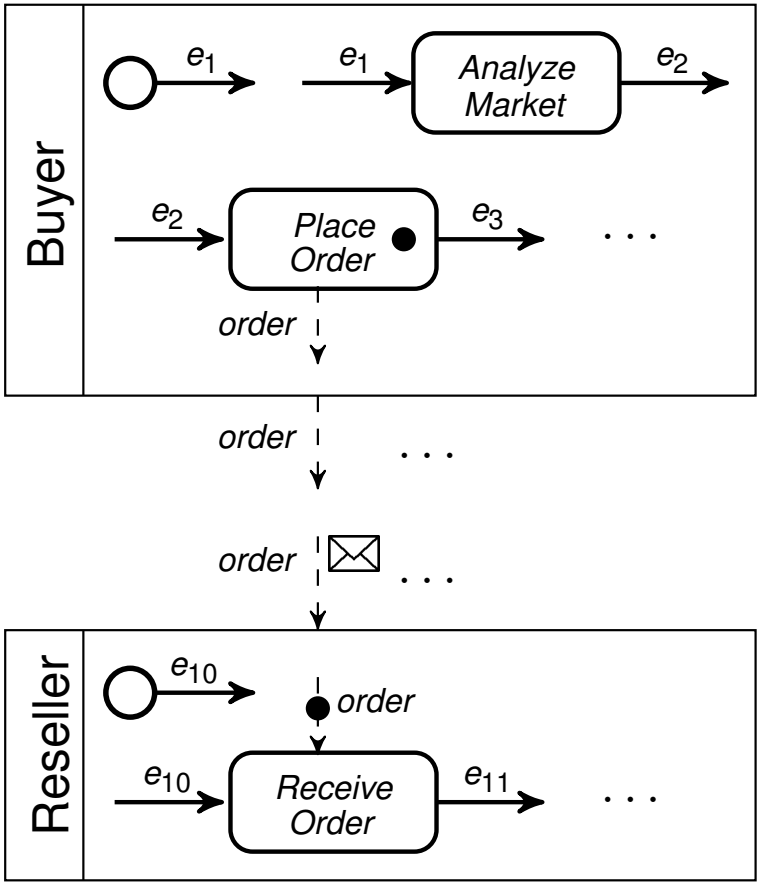


1 - Initial configuration

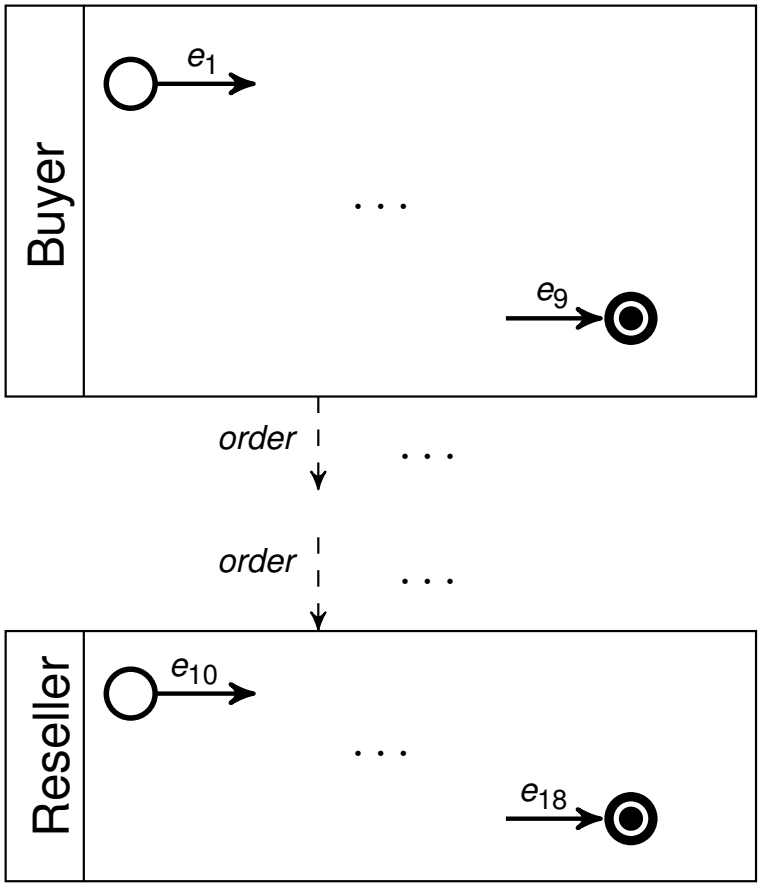


2 - Reseller ready to receive the order

Semantics of the running example - Part II



3 - Order sent not read yet by the reseller



4 - Collaboration Terminated

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Concluding Remarks

The lack of a shared, well-established, comprehensive formal semantics for BPMN was the main driver of the work considering the wide adoption of the language both from industry and research communities

We provide a novel formalisation that provides an operational semantics to BPMN in the SOS style by relying on the notion of LTS

- It focuses on the business process collaboration capability supported by message exchange
- It enables designers to freely specify their processes with an arbitrary topology supporting the adherence to the standard, without the requirement of defining well-structured models
- It allows one to verify properties on the model using consolidated formal reasoning techniques based on LTS

Future Works

Extend the formalisation to model more BPMN elements, such as data objects, sub-processing, error handling, multiple instances of the same process and OR join gateway

Investigate verification of properties in the model by expressing such properties by means of temporal logic after the implementation of the language (by means of Maude)

- We can check, e.g., if *after* the enabling of a given task it can be *eventually* completed or not
- We can verify, e.g., if *for all* possible executions all processes involved in a collaboration successfully terminates

Proof some properties suitable to check the internal consistency of the system of rules in some way, i.e. to check that the syntax restrictions are preserved along the transitions

Develop a tool chain integrating this verification environment with a BPMN modelling environment, such as Eclipse BPMN Modeller

Thank you!

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  `http://www.learnpad.eu`
- MIUR PRIN CINA (2010LHT4KM)
  `http://sysma.imtlucca.it/cina/doku.php`