Business Processes Modelling

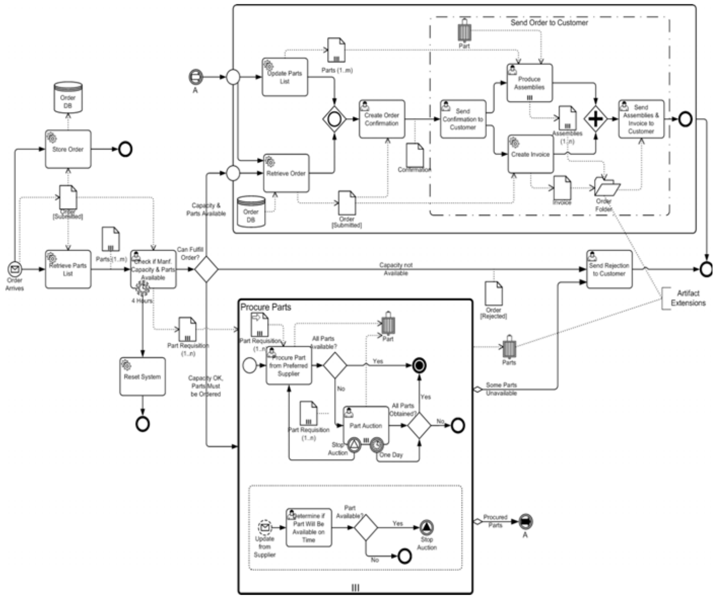
MPB (6 cfu, 295AA)

Roberto Bruni

http://www.di.unipi.it/~bruni

22 - Business process modelling notation

Object



We overview BPMN and their analysis based on Petri nets

Ch.4.7, 5.7 of Business Process Management: Concepts, Languages, Architectures
Ch.3, 4 of Fundamental of Business Process Management. M. Dumas et al.

Standardisation

The development of BMPN is an important step in

reducing the fragmentation that existed
with myriad of process modelling tools and notations

exploiting experiences with many divergent proposals to
consolidate the best ideas

supporting the adoption of **inter-operable**
business process management systems

Business Process Management Initiative

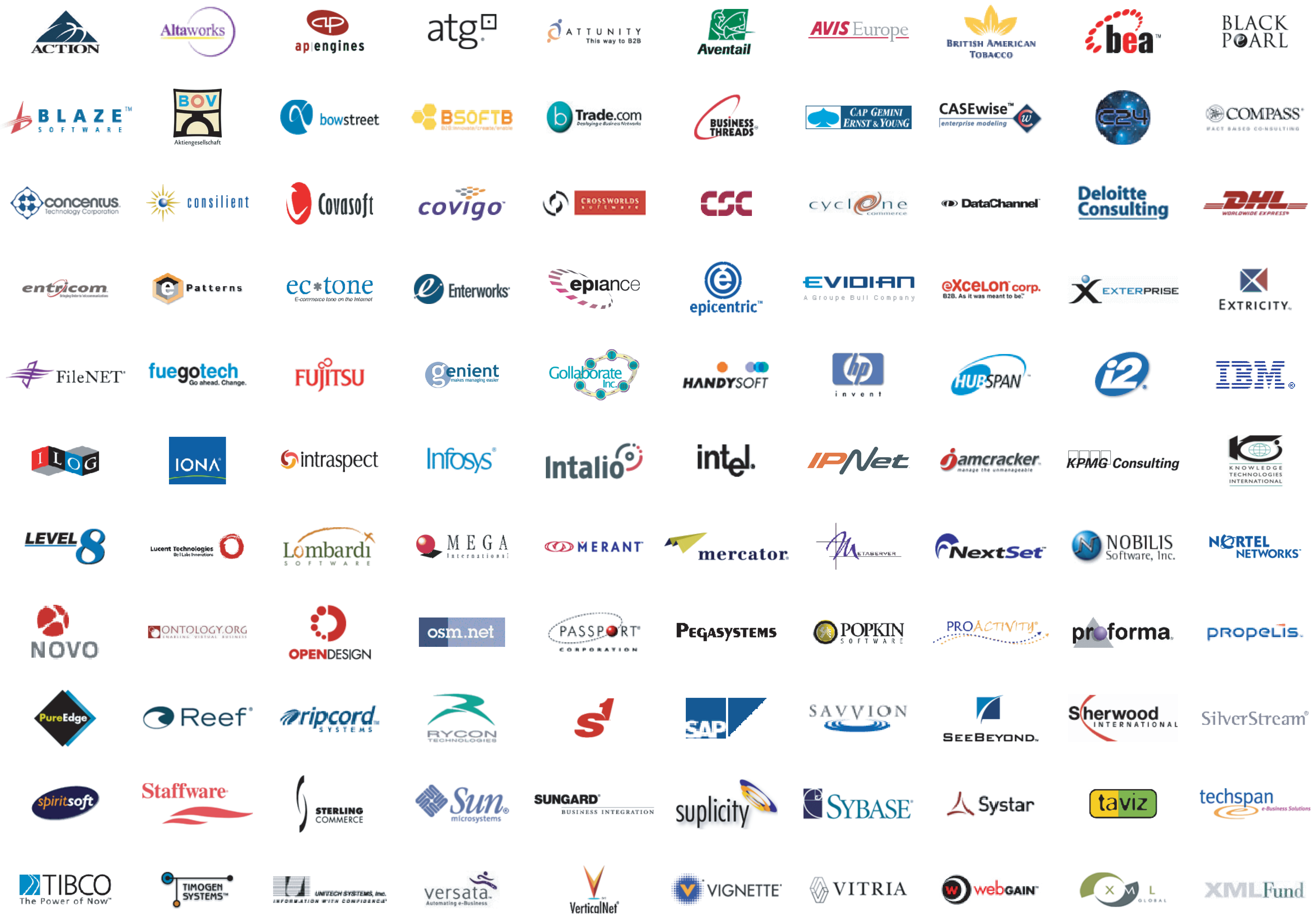
August 2000

The **Business Process Management Initiative**
was an **independent organization** devoted to

the development of **open specifications**

for the management of **e-Business processes**
that span multiple applications, corporate departments, and
business partners, behind the firewall and over the Internet

The membership of the BPMI Notation Working Group represents a large segment of the BP modelling community



BMI-DTF

June 2005

The Business Process Management Initiative (BPMI.org)
and the Object Management Group™ (OMG™)
decided to merge their activities on
Business Process Management (BPM)
to provide thought leadership and industry standards for this vital and growing industry.

The combined group has named itself the
Business Modeling & Integration Domain Task Force
(**BMI -DTF**)

Business process diagram

BPMN defines a standard for
Business Process Diagrams (**BPD**)

based on **flowcharting technique**
tailored to graphical models of business process operations

Four basic categories of elements:
Swimlanes
Flow objects
Artefacts
Connecting objects

BPMN 1.0 (2004/06)

Main goal:

provide a **notation** that is **readily understandable by all** business users

from the **business analysts** who create initial drafts of the processes

to the **technical developers** responsible for implementing the technology that will perform those processes

to the **business people** who will manage those processes

BPMN Versioning

BPMN 1.0 approved 2006
BPMN 1.1 approved 2007
BPMN 1.2 approved 2009

BPMN 2.0 Beta 1 proposed 2009
BPMN 2.0 Beta 2 proposed 2010
BPMN 2.0 Final delivered 2011

Disclaim

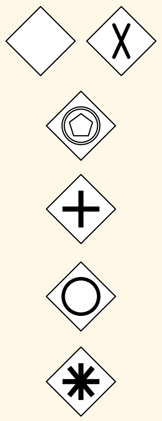
Formal rigor and conciseness are not primary concerns
(over 100 symbols,
shorthands and alternative constructs are often available)

The large number of object types
and their continuous evolution
makes it hard to define mappings
and to prove their consistency under all contexts

Inconsistencies and ambiguities in BPMN standard
are **present but hard to detect**

BPMN - Business Process Modeling Notation

Gateways



Data-based Exclusive Gateway
When splitting, it routes the sequence flow to exactly one of the outgoing branches based on conditions. When merging, it awaits one incoming branch to complete before triggering the outgoing flow.

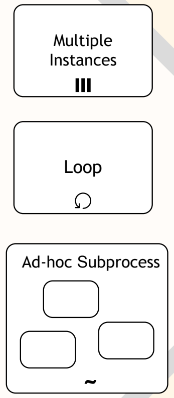
Event-based Exclusive Gateway
Is always followed by catching events or receive tasks. Sequence flow is routed to the subsequent event/task which happens first.

Parallel Gateway
When used to split the sequence flow, all outgoing branches are activated simultaneously. When merging parallel branches it waits for all incoming branches to complete before triggering the outgoing flow.

Inclusive Gateway
When splitting, one or more branches are activated based on branching conditions. When merging, it awaits all active incoming branches to complete.

Complex Gateway
It triggers one or more branches based on complex conditions or verbal descriptions. Use it sparingly as the semantics might not be clear.

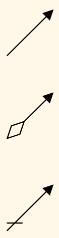
Activities



Multiple Instances of the same activity are started in parallel or sequentially, e.g. for each line item in an order.

Loop Activity is iterated if a loop condition is true. The condition is either tested before or after the activity execution.

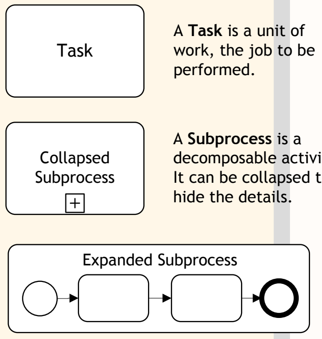
Ad-hoc Subprocesses contain tasks only. Each task can be executed arbitrarily often until a completion condition is fulfilled.



Sequence Flow defines the execution order of activities.

Conditional Flow has a condition assigned that defines whether or not the flow is used.

Default Flow is the default branch to be chosen if all other conditions evaluate to false.

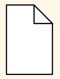


A **Task** is a unit of work, the job to be performed.

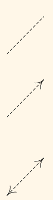
A **Subprocess** is a decomposable activity. It can be collapsed to hide the details.

An **Expanded Subprocess** contains a valid BPMN diagram.

Data



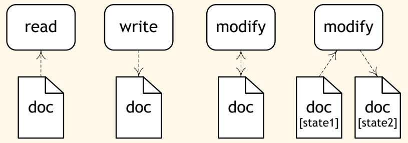
A **Data Object** represents information flowing through the process, such as business documents, e-mails or letters.

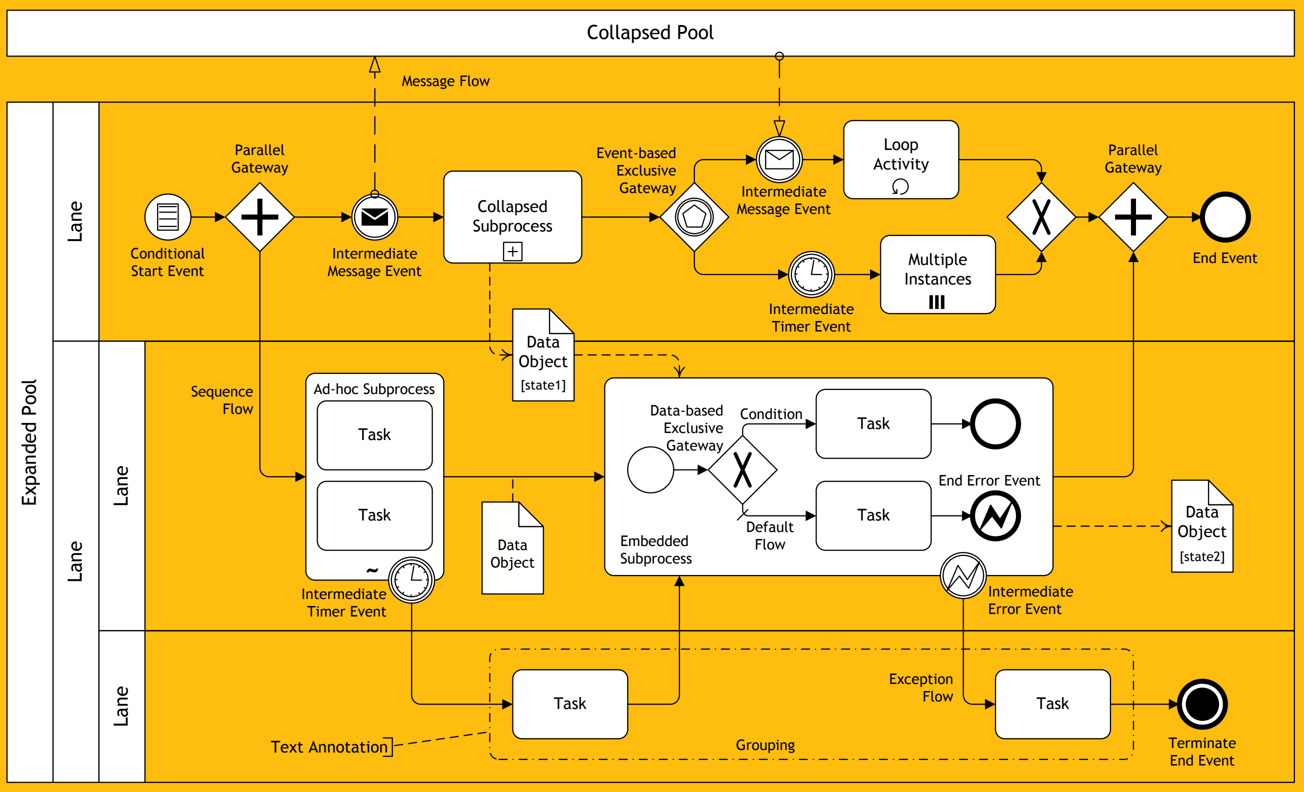


Attaching a data object with an **Undirected Association** to a sequence flow indicates hand-over of information between the activities involved.

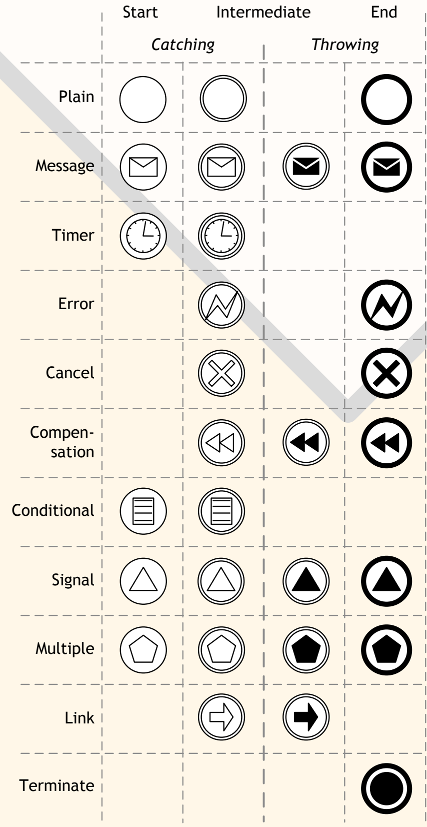
A **Directed Association** indicates information flow. A data object can be read at the start of an activity or written upon completion.

A **Bidirected Association** indicates that the data object is modified, i.e. read and written during the execution of an actvity.



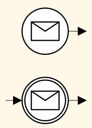


Events



Event	Description
Plain	Untyped events, typically showing where the process starts or ends.
Message	Receiving and sending messages.
Timer	Cyclic timer events, points in time, time spans or timeouts.
Error	Catching or throwing named errors.
Cancel	Reacting to cancelled transactions or triggering cancellation.
Compen-sation	Compensation handling or triggering compensation.
Conditional	Reacting to changed business conditions or integrating business rules.
Signal	Signalling across different processes. One signal thrown can be caught multiple times.
Multiple	Catching or throwing one out of a set of events.
Link	Off-page connectors. Two corresponding link events equal a sequence flow.
Terminate	Triggering the immediate termination of a process.

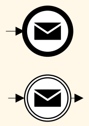
Catching



Start Event: Catching an event starts a new process instance.

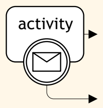
Intermediate Event (catching): The process can only continue once an event has been caught.

Throwing



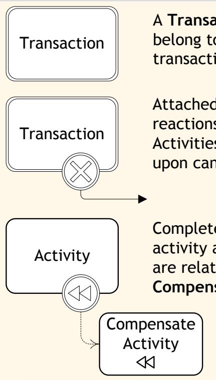
End Event: An event is thrown when the end of the process is reached.

Intermediate Event (throwing): An event is thrown and the process continues.



Attached Intermediate Event: The activity is aborted once an event is caught.

Transactions

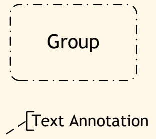


A **Transaction** is a set of activities that logically belong together; it might follow a specified transaction protocol.

Attached **Intermediate Cancel Events** indicate reactions to the cancellation of a transaction. Activities inside the transaction are compensated upon cancellation.

Completed activities can be compensated. An activity and the corresponding **Compensate Activity** are related using an attached **Intermediate Compensation Event**.

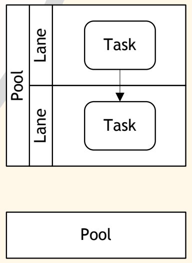
Documentation



An arbitrary set of objects can be defined as a **Group** to show that they logically belong together.

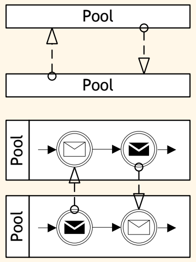
Any object can be associated with a **Text Annotation** to provide additional documentation.

Swimlanes



Pools and **Lanes** represent responsibilities for activities in a process. A pool or a lane can be an organization, a role, or a system. Lanes sub-divide pools or other lanes hierarchically.

Collapsed Pools hide all internals of the contained processes.



Message Flow symbolizes information flow across organizational boundaries. Message flow can be attached to pools, activities, or message events.

The order of message exchanges can be specified by combining message flow and sequence flow.

Business **P**rocess **T**echnology
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BPMN Version 1.2

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ORYX

BPMN 1.0 poster

BPMN 2.0 vs 1.0

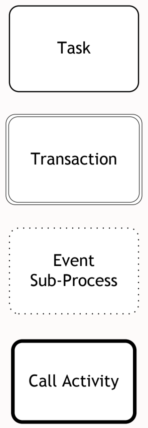
Updated (new markers):
Tasks/SubProcesses
Events
Gateways
Artefacts

Added:
Choreographies
Full metamodel
XML Serialization
Diagram Interchange
BPMN Execution Semantics (verbal)

BPMN 2.0 - Business Process Model and Notation

http://bpmb.de/poster

Activities



A **Task** is a unit of work, the job to be performed. When marked with a ⊞ symbol it indicates a **Sub-Process,** an activity that can be refined.

A **Transaction** is a set of activities that logically belong together; it might follow a specified transaction protocol.

An **Event Sub-Process** is placed into a Process or Sub-Process. It is activated when its start event gets triggered and can interrupt the higher level process context or run in parallel (non-interrupting) depending on the start event.

A **Call Activity** is a wrapper for a globally defined Sub-Process or Task that is reused in the current process.

Activity Markers

Markers indicate execution behavior of activities:

- ⊞ Sub-Process Marker
- Loop Marker
- III Parallel MI Marker
- ☰ Sequential MI Marker
- ~ Ad Hoc Marker
- ⏪ Compensation Marker

Task Types

Types specify the nature of the action to be performed:

- ✉ Send Task
- ✉ Receive Task
- User Task
- Manual Task
- Business Rule Task
- Service Task
- Script Task

Sequence Flow

defines the execution order of activities.

Default Flow

is the default branch to be chosen if all other conditions evaluate to false.

Conditional Flow

has a condition assigned that defines whether or not the flow is used.

Gateways

Exclusive Gateway

When splitting, it routes the sequence flow to exactly one of the outgoing branches. When merging, it awaits one incoming branch to complete before triggering the outgoing flow.

Event-based Gateway

Is always followed by catching events or receive tasks. Sequence flow is routed to the subsequent event/task which happens first.

Parallel Gateway

When used to split the sequence flow, all outgoing branches are activated simultaneously. When merging parallel branches it waits for all incoming branches to complete before triggering the outgoing flow.

Inclusive Gateway

When splitting, one or more branches are activated. All active incoming branches must complete before merging.

Complex Gateway

Complex merging and branching behavior that is not captured by other gateways.

Exclusive Event-based Gateway (instantiate)

Each occurrence of a subsequent event starts a new process instance.

Parallel Event-based Gateway (instantiate)

The occurrence of all subsequent events starts a new process instance.

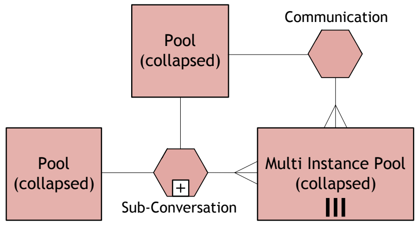
Conversations

A **Communication** defines a set of logically related message exchanges. When marked with a ⊞ symbol it indicates a Sub-Conversation, a compound conversation element.

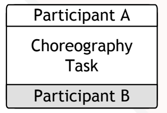
A **Conversation Link** connects Communications and Participants.

A **Forked Conversation Link** connects Communications and multiple Participants.

Conversation Diagram

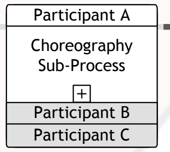


Choreographies



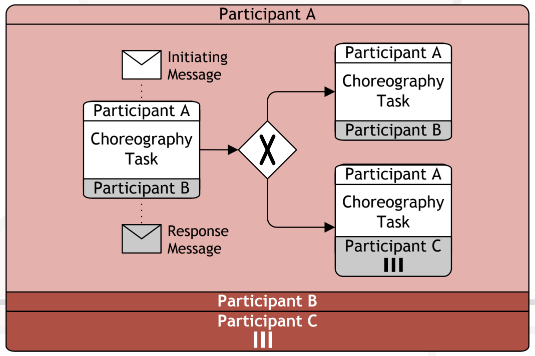
A **Choreography Task** represents an Interaction (Message Exchange) between two Participants.

Multiple Participants Marker denotes a set of Participants of the same kind.

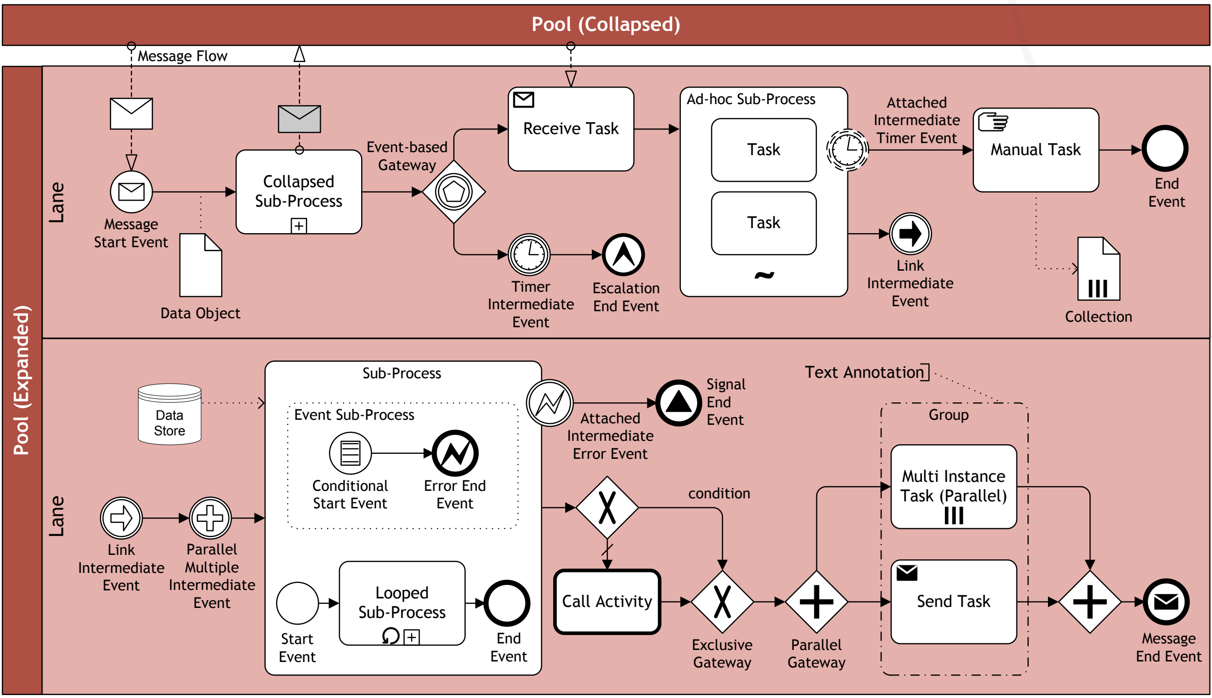


A **Choreography Sub-Process** contains a refined choreography with several Interactions.

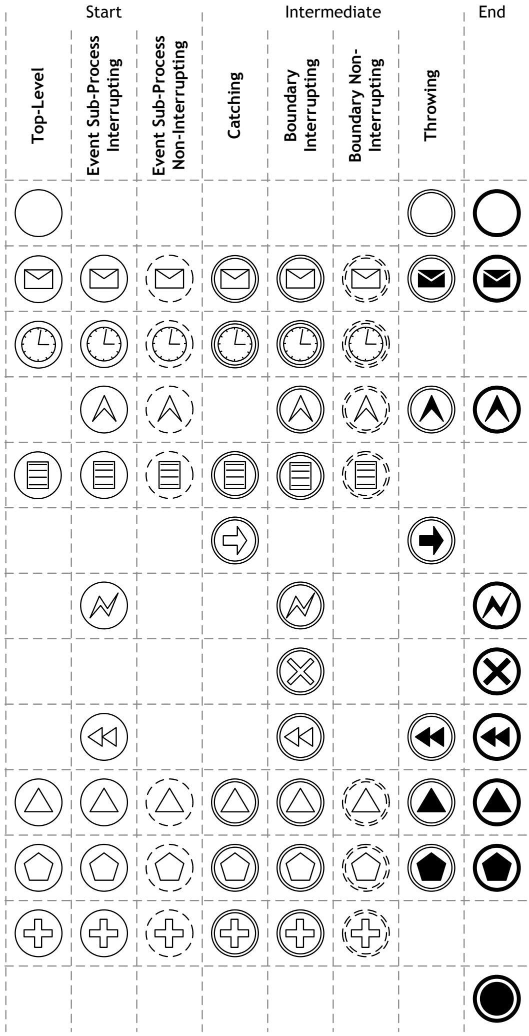
Choreography Diagram



Collaboration Diagram



Events


Start
Intermediate
End
Top-Level
Event Sub-Process Interrupting
Event Sub-Process Non-Interrupting
Catching
Boundary Interrupting
Boundary Non-Interrupting
Throwing

None: Untyped events, indicate start point, state changes or final states.

Message: Receiving and sending messages.

Timer: Cyclic timer events, points in time, time spans or timeouts.

Escalation: Escalating to an higher level of responsibility.

Conditional: Reacting to changed business conditions or integrating business rules.

Link: Off-page connectors. Two corresponding link events equal a sequence flow.

Error: Catching or throwing named errors.

Cancel: Reacting to cancelled transactions or triggering cancellation.

Compensation: Handling or triggering compensation.

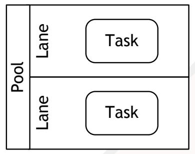
Signal: Signalling across different processes. A signal thrown can be caught multiple times.

Multiple: Catching one out of a set of events. Throwing all events defined

Parallel Multiple: Catching all out of a set of parallel events.

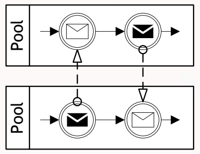
Terminate: Triggering the immediate termination of a process.

Swimlanes



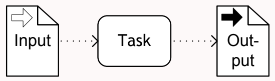
Pools (Participants) and **Lanes** represent responsibilities for activities in a process. A pool or a lane can be an organization, a role, or a system. Lanes subdivide pools or other lanes hierarchically.

Message Flow symbolizes information flow across organizational boundaries. Message flow can be attached to pools, activities, or message events.



The order of message exchanges can be specified by combining message flow and sequence flow.

Data



A **Data Input** is an external input for the entire process. It can be read by an activity.

A **Data Output** is a variable available as result of the entire process.

A **Data Object** represents information flowing through the process, such as business documents, e-mails, or letters.

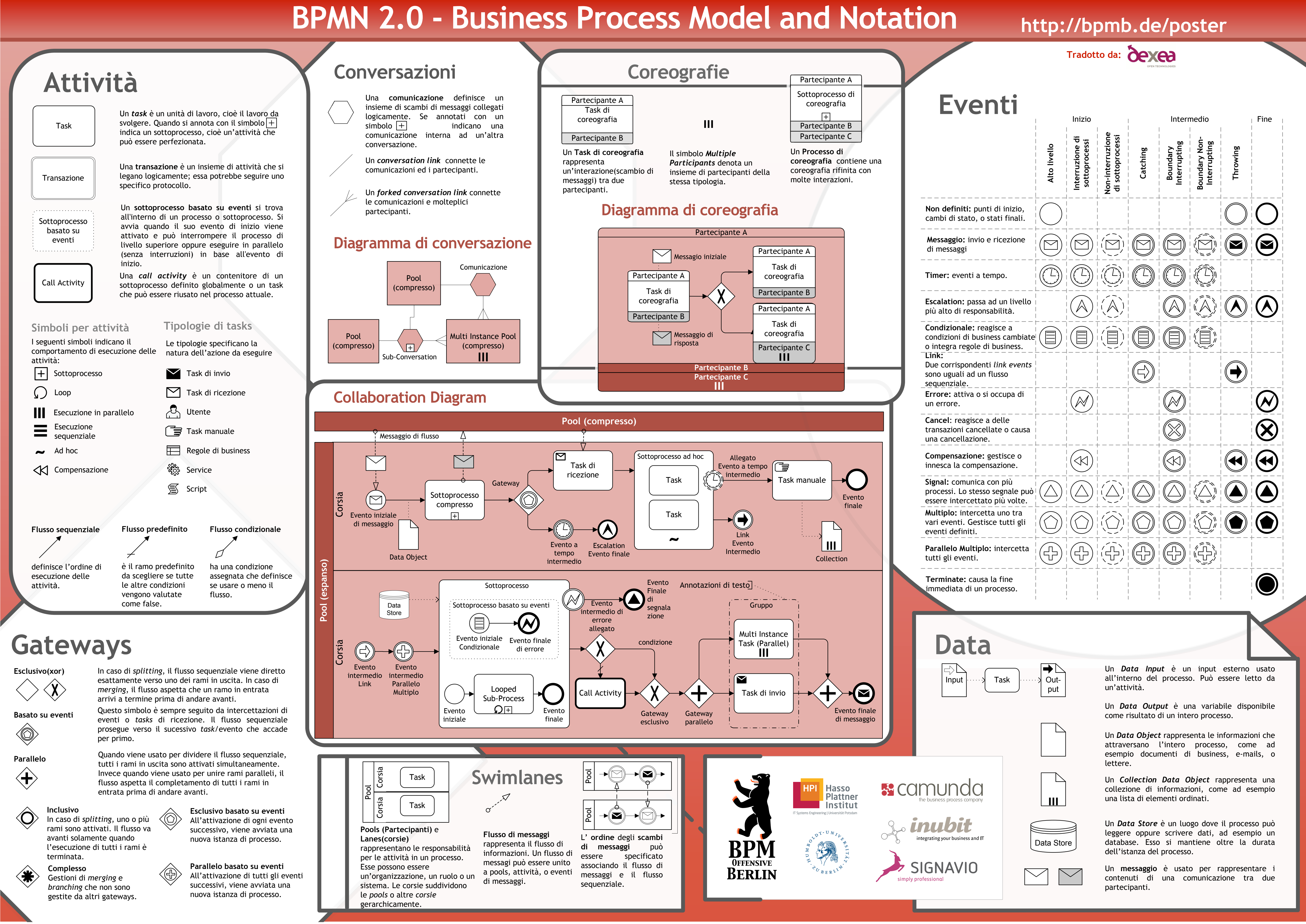
A **Collection Data Object** represents a collection of information, e.g., a list of order items.

Data Store

A **Data Store** is a place where the process can read or write data, e.g., a database or a filing cabinet. It persists beyond the lifetime of the process instance.

A **Message** is used to depict the contents of a communication between two Participants.

BPMN 2.0 poster



BPMN 2.0 - Business Process Model and Notation

http://bpmb.de/poster

Tradotto da: dexea OPEN TECHNOLOGIES

Attività

Un ***task*** è un unità di lavoro, cioè il lavoro da svolgere. Quando si annota con il simbolo ⊞ indica un sottoprocesso, cioè un'attività che può essere perfezionata.

Una **transazione** è un insieme di attività che si legano logicamente; essa potrebbe seguire uno specifico protocollo.

Un **sottoprocesso basato su eventi** si trova all'interno di un processo o sottoprocesso. Si avvia quando il suo evento di inizio viene attivato e può interrompere il processo di livello superiore oppure eseguire in parallelo (senza interruzioni) in base all'evento di inizio.

Una ***call activity*** è un contenitore di un sottoprocesso definito globalmente o un task che può essere riusato nel processo attuale.

Simboli per attività

I seguenti simboli indicano il comportamento di esecuzione delle attività:

- ⊞ Sottoprocesso
- ⟲ Loop
- ||| Esecuzione in parallelo
- ☰ Esecuzione sequenziale
- ~ Ad hoc
- ⏪ Compensazione

Tipologie di tasks

Le tipologie specificano la natura dell'azione da eseguire

- ✉ Task di invio
- ✉ Task di ricezione
- 👤 Utente
- ☞ Task manuale
- ▦ Regole di business
- ⚙ Service
- 📜 Script

Flusso sequenziale

definisce l'ordine di esecuzione delle attività.

Flusso predefinito

è il ramo predefinito da scegliere se tutte le altre condizioni vengono valutate come false.

Flusso condizionale

ha una condizione assegnata che definisce se usare o meno il flusso.

Conversazioni

Una **comunicazione** definisce un insieme di scambi di messaggi collegati logicamente. Se annotati con un simbolo ⊞ indicano una comunicazione interna ad un'altra conversazione.

Un ***conversation link*** connette le comunicazioni ed i partecipanti.

Un ***forked conversation link*** connette le comunicazioni e molteplici partecipanti.

Diagramma di conversazione

Coreografie

Un **Task di coreografia** rappresenta un'interazione(scambio di messaggi) tra due partecipanti.

Il simbolo ***Multiple Participants*** denota un insieme di partecipanti della stessa tipologia.

Un **Processo di coreografia** contiene una coreografia rifinita con molte interazioni.

Diagramma di coreografia

Collaboration Diagram

Eventi

	Inizio			Intermedio				Fine
	Alto livello	Interruzione di sottoprocessi	Non-interruzione di sottoprocessi	Catching	Boundary Interrupting	Boundary Non-Interrupting	Throwing	
Non definiti: punti di inizio, cambi di stato, o stati finali.	○						○	○
Messaggio: invio e ricezione di messaggi	✉	✉	✉	✉	✉	✉	✉	✉
Timer: eventi a tempo.	◷	◷	◷	◷	◷	◷		
Escalation: passa ad un livello più alto di responsabilità.		⌃	⌃		⌃	⌃	⌃	⌃
Condizionale: reagisce a condizioni di business cambiate o integra regole di business.	☰	☰	☰	☰	☰	☰		
Link: Due corrispondenti *link events* sono uguali ad un flusso sequenziale.				⇨			➡	
Errore: attiva o si occupa di un errore.		ϟ			ϟ			ϟ
Cancel: reagisce a delle transazioni cancellate o causa una cancellazione.					⊗			⊗
Compensazione: gestisce o innesca la compensazione.		⏪			⏪		⏪	⏪
Signal: comunica con più processi. Lo stesso segnale può essere intercettato più volte.	△	△	△	△	△	△	▲	▲
Multiplo: intercetta uno tra vari eventi. Gestisce tutti gli eventi definiti.	⬠	⬠	⬠	⬠	⬠	⬠	⬟	⬟
Parallelo Multiplo: intercetta tutti gli eventi.	✚	✚	✚	✚	✚	✚		
Terminate: causa la fine immediata di un processo.								●

Gateways

Esclusivo(xor)

In caso di *splitting*, il flusso sequenziale viene diretto esattamente verso uno dei rami in uscita. In caso di *merging*, il flusso aspetta che un ramo in entrata arrivi a termine prima di andare avanti.

Basato su eventi

Questo simbolo è sempre seguito da intercettazioni di eventi o *tasks* di ricezione. Il flusso sequenziale prosegue verso il sucessivo *task*/evento che accade per primo.

Parallelo

Quando viene usato per dividere il flusso sequenziale, tutti i rami in uscita sono attivati simultaneamente. Invece quando viene usato per unire rami paralleli, il flusso aspetta il completamento di tutti i rami in entrata prima di andare avanti.

Inclusivo
In caso di *splitting*, uno o più rami sono attivati. Il flusso va avanti solamente quando l'esecuzione di tutti i rami è terminata.

Complesso
Gestioni di *merging* e *branching* che non sono gestite da altri gateways.

Esclusivo basato su eventi
All'attivazione di ogni evento successivo, viene avviata una nuova istanza di processo.

Parallelo basato su eventi
All'attivazione di tutti gli eventi successivi, viene avviata una nuova istanza di processo.

Swimlanes

Pools (Partecipanti) e **Lanes(corsie)** rappresentano le responsabilità per le attività in un processo. Esse possono essere un'organizzazione, un ruolo o un sistema. Le corsie suddividono le *pools* o altre *corsie* gerarchicamente.

Flusso di messaggi rappresenta il flusso di informazioni. Un flusso di messagi può essere unito a pools, attività, o eventi di messaggi.

L' **ordine** degli **scambi di messaggi** può essere specificato associando il flusso di messaggi e il flusso sequenziale.

BPM OFFENSIVE BERLIN

HPI Hasso Plattner Institut
IT Systems Engineering | Universität Potsdam

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the business process company

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Data

Un ***Data Input*** è un input esterno usato all'interno del processo. Può essere letto da un'attività.

Un ***Data Output*** è una variabile disponibile come risultato di un intero processo.

Un ***Data Object*** rappresenta le informazioni che attraversano l'intero processo, come ad esempio documenti di business, e-mails, o lettere.

Un ***Collection Data Object*** rappresenta una collezione di informazioni, come ad esempio una lista di elementi ordinati.

Un ***Data Store*** è un luogo dove il processo può leggere oppure scrivere dati, ad esempio un database. Esso si mantiene oltre la durata dell'istanza del processo.

Un **messaggio** è usato per rappresentare i contenuti di una comunicazione tra due partecipanti.

BPMN 2.0 poster (in Italian)

BPMN 2.0 (2009/11)
FAQ

What is BPMN?

BPMN is a graphical notation that depicts the steps (end to end flow) in a business process.

The notation has been specifically designed
to coordinate the sequence of processes and
the messages that flow
between different participants
in a related set of activities.

BPMN 2.0 (2009/11) FAQ

Why is BPMN important?

The world of business processes has changed dramatically over the past few years.
Processes can be coordinated from behind, within and over organizations boundaries.
A business process now spans multiple participants and coordination can be complex.

Until BPMN, there has not been a standard modelling technique developed that addresses these issues.
BPMN provides users with a **royalty free notation**.

This will benefit users in a similar manner in which UML standardised the world of software engineering.
There will be training courses, books and a body of knowledge that users can access in order to better implement a business process.

BPMN 2.0 (2009/11)
FAQ

Who is BPMN targeted at?

BPMN is targeted at a **high level for business users** and at a **lower level for process implementers**.

The former should be able to easily read and understand a BPMN diagram.
The latter should be able to adorn a BPMN diagram with further details in order to represent the process in a physical implementation.

BPMN is targeted at users, vendors and service providers that need to communicate business processes in a standard manner.

BPMN 2.0 (2009/11) FAQ

Will there be a major rewrite?

Not for 2 or 3 years…

(still no revision is planned)

Strong points of BPMN

Simplicity: A small set of basic symbols

Extensibility: many decorations available
(new ones can be added in the future)

Graphical design: **intuitive**

Generality: **orchestration** + **choreography**

Tool availability: **exchange format**

Weaknesses of BPMN

over 100 graphical elements

verbose description (500 pages)

difficult to learn comprehensively:
different reading of the same diagram are possible

different BPMN vendors implement the execution of
BPMN diagrams in different ways (and for different subsets)

BPMN basics: Swimlanes (pools, lanes)

Swimlanes

Many process modelling methodologies utilise the concept of a **swimlane** as a mechanism to **organise activities into separate visual categories** in order to illustrate different capabilities or responsibilities

BPMN supports two main swimlane objects:

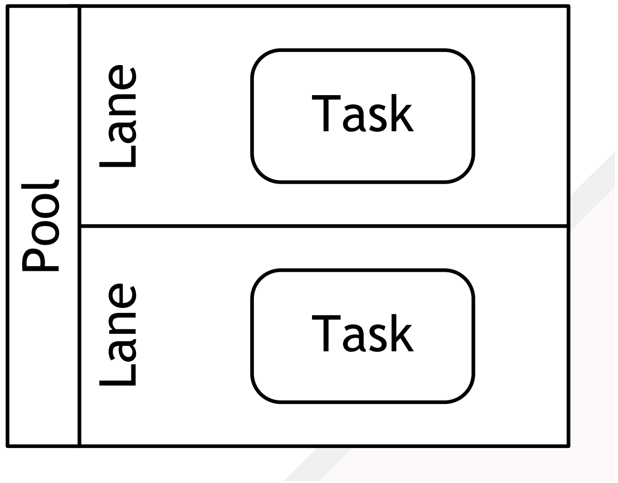
Pool

Lane

Pools and Lanes

A **pool** represents a participant (or role) in a process
A pool is represented as a rectangle with a name

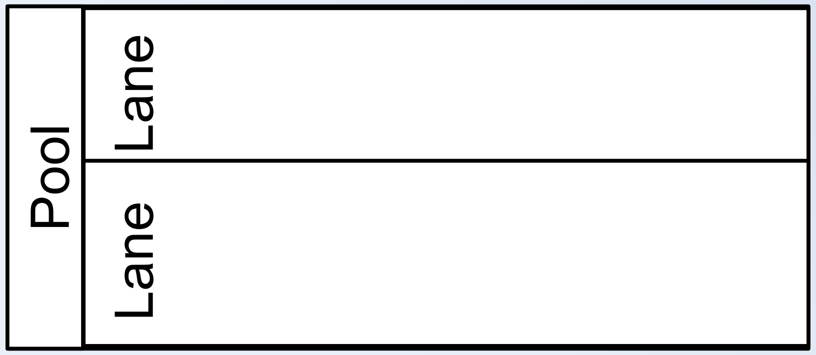
A **lane** is a hierarchical sub-partition within a pool
that is used to organise and categorise activities



A lane is an inner rectangle to the pool
that extends to the entire length of the pool

Swimlanes

Pools and lanes are used to represent organizations, roles, systems and responsibilities. Examples: 'University', 'Sales division', 'Warehouse', 'ERP system',...



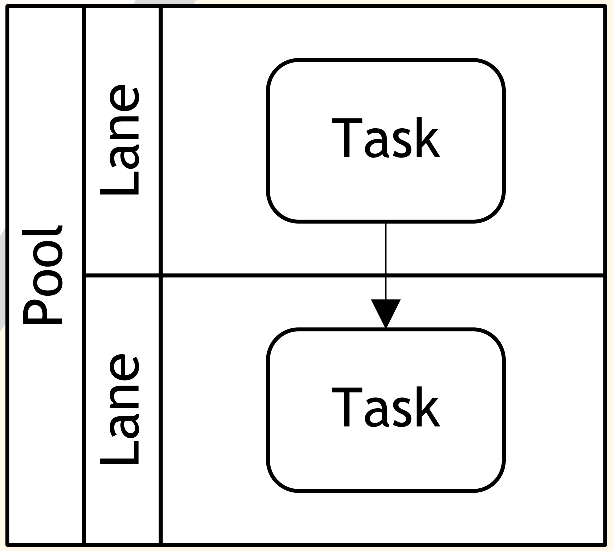
A Pool MUST contain 0 or 1 business process.

A Pool can contain 0 or more lanes.

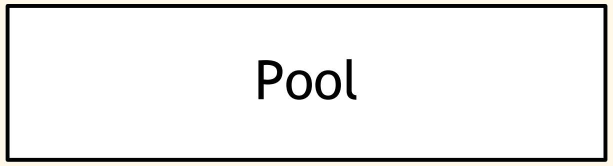
Two pools can only be connected with message flows.

A **Pool** represents a participant in a process. It contains a business process and is used in B2B situations.

A **Lane** is a sub-partition within a pool used to organize and categorize activities.



Pools and **Lanes** represent responsibilities for activities in a process. A pool or a lane can be an organization, a role, or a system. Lanes sub-divide pools or other lanes hierarchically.



Collapsed Pools hide all internals of the contained processes.

Naming conventions

Process models:
a noun possibly preceded by an adjective

the label is often obtained by ``nominalizing'' the verb that describe the main action in the process (e.g., claim handling, order fulfillment)

Avoid long labels
Articles are often omitted

BPMN basics: Flow Objects (events, activities, gateways)

Flow objects

Theory:
fix a small set of core elements
so that modellers do not have to learn and recognise
a large number of different shapes:

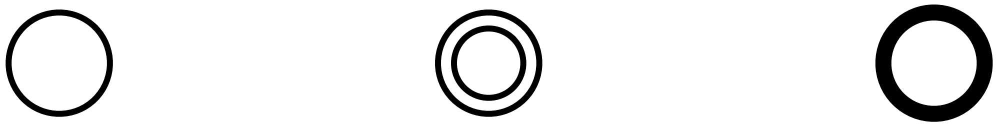
Events
Activities
Gateways

Practice:
use different border styles and internal markers
to add many more information
(this way the notation is **extensible**)

Events

An **event** is something that “happens” during the course of a business process

The type of an event is one among:
start, **intermediate**, **end**



An event is represented as a circle
its type depends on the style of the border
(thin, double, thick)

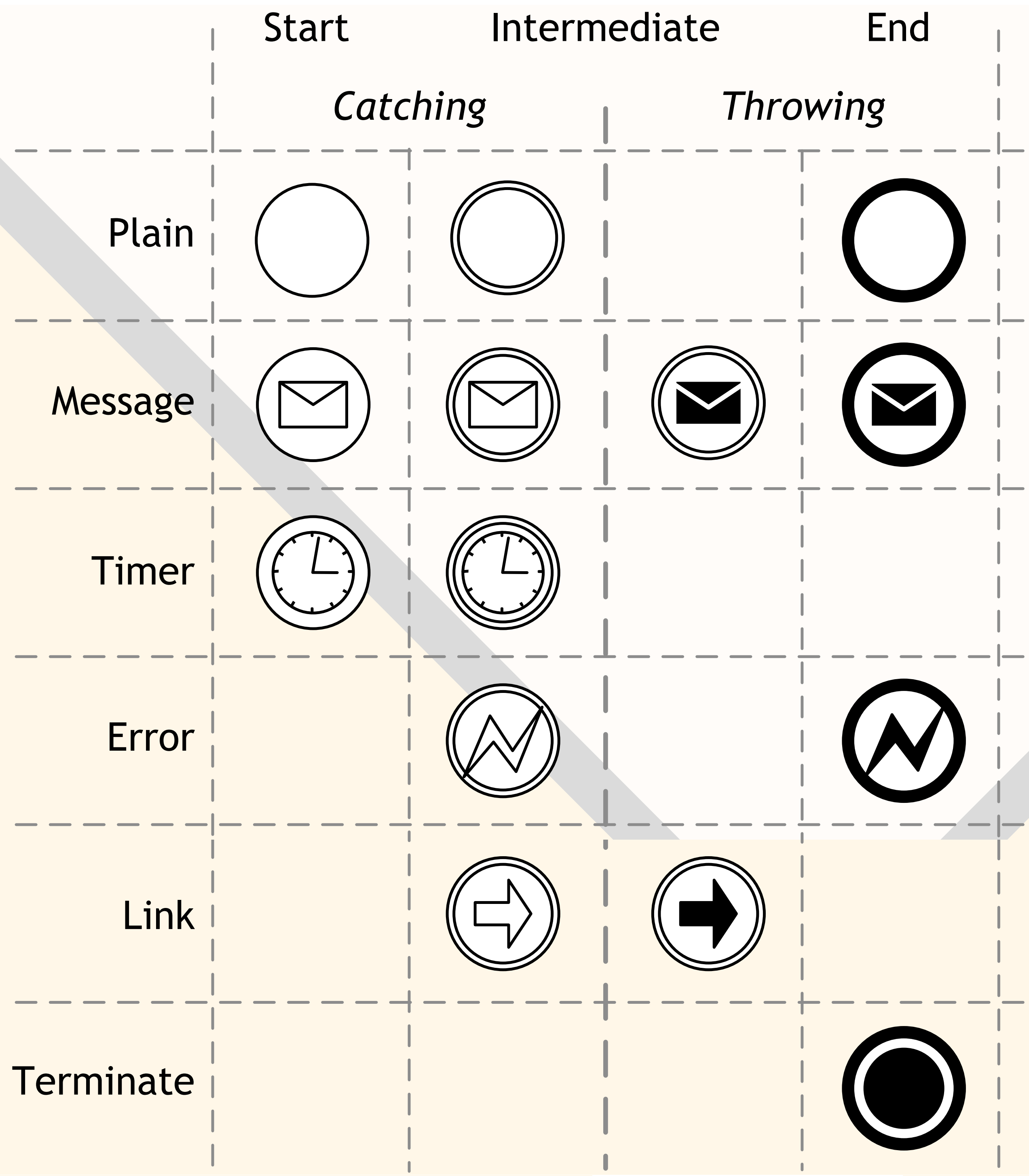
An event can have a cause (**trigger**) or an impact (**result**)
Internal markers denote the trigger or result

Naming conventions

Events:
the label should begin with a noun and
end with a verb in past participle form
to indicate something that just happened
(e.g., Invoice emitted)

the noun can be preceded by an adjective
(e.g., Urgent order sent)

Avoid long labels
Articles are often omitted



Untyped events, typically showing where the process starts or ends.

Receiving and sending messages.

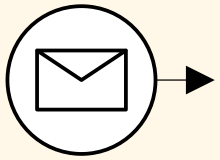
Cyclic timer events, points in time, time spans or timeouts.

Catching or throwing named errors.

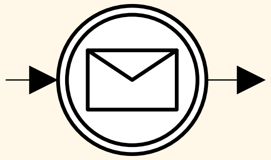
Off-page connectors. Two corresponding link events equal a sequence flow.

Triggering the immediate termination of a process.

Catching

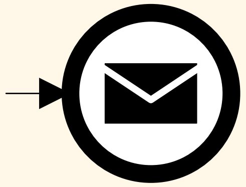


Start Event: Catching an event starts a new process instance.

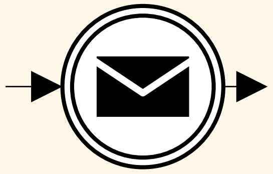


Intermediate Event (catching): The process can only continue once an event has been caught.

Throwing



End Event: An event is thrown when the end of the process is reached.

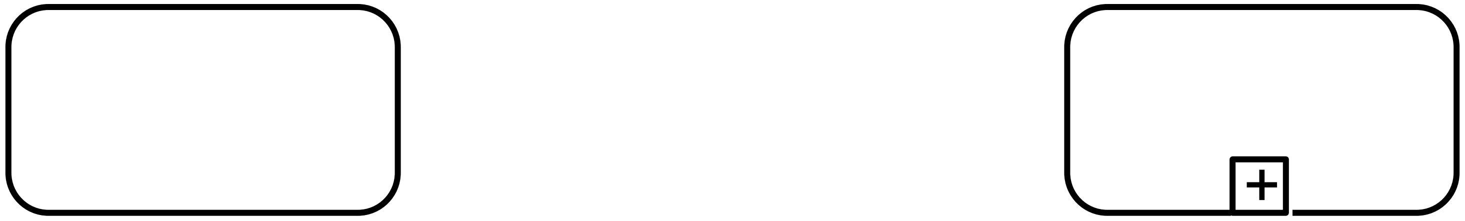


Intermediate Event (throwing): An event is thrown and the process continues.

Activities

An **activity** is some “unit of work” (job) to be done during the course of a business process

An activity can be
atomic (**task**) or compound (**sub-process**)



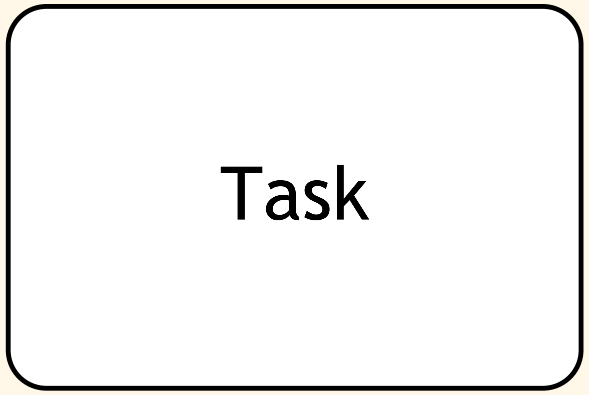
An activity is represented as a rounded box,
Suitable markers are used to indicate
the nature of the action to be performed (**task type**)
and the execution behaviour (**activity marker**)

Sub-processes

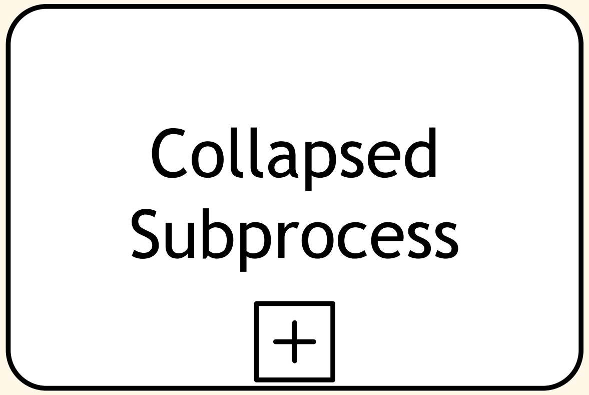
Process models tend to be too large
to be understood at once

Hiding certain parts within sub-processes
we improve readability

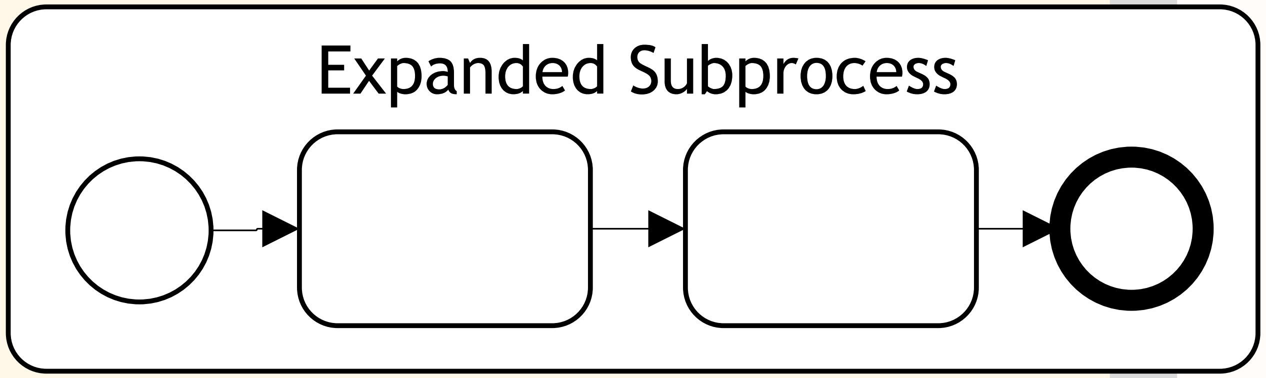
A **sub-process** is a self-contained, composite activity
that can be broken into smaller units of work


Task

A **Task** is a unit of work, the job to be performed.


Collapsed Subprocess

A **Subprocess** is a decomposable activity. It can be collapsed to hide the details.


Expanded Subprocess

An **Expanded Subprocess** contains a valid BPMN diagram.

Activity types and markers

Activity Markers

Markers indicate execution behavior of activities:

- ⊞ Sub-Process Marker
- ⟲ Loop Marker
- ||| Parallel MI Marker
- ≡ Sequential MI Marker
- ~ Ad Hoc Marker
- ⏪ Compensation Marker

Task Types

Types specify the nature of the action to be performed:

- ✉ Send Task
- ✉ Receive Task
- 👤 User Task
- ☞ Manual Task
- ▦ Business Rule Task
- ⚙ Service Task
- 📜 Script Task

Naming conventions

Activities:

verb in the imperative form followed by a noun
(e.g., Approve order)

the noun can be preceded by an adjective
(e.g., Issue driver license)

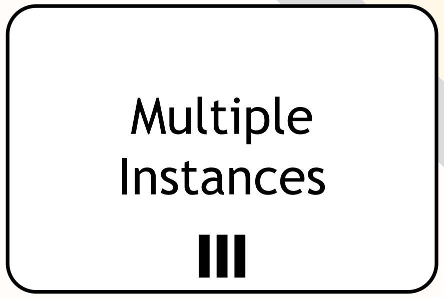
the verb may be followed by a complement
(e.g., Renew driver license via offline agencies)

Avoid long labels
Articles are often omitted

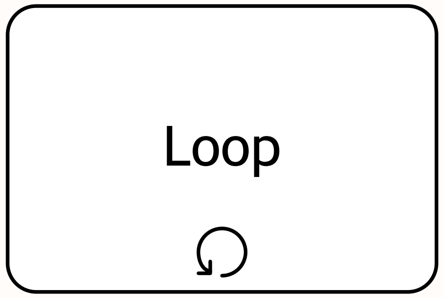
Events vs Activities

Events are instantaneous

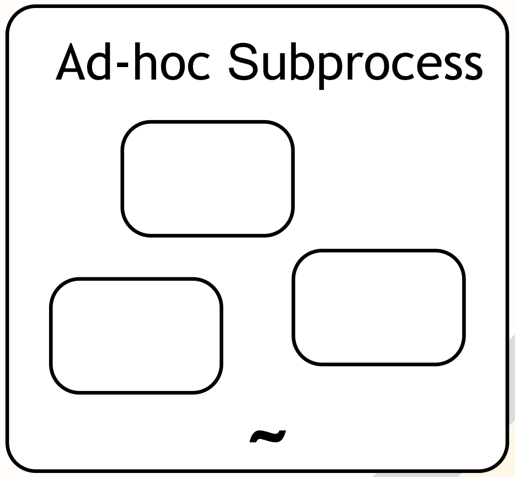
Activities take time (have a duration)



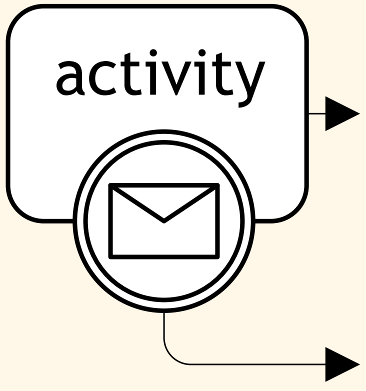
Multiple Instances of the same activity are started in parallel or sequentially, e.g. for each line item in an order.



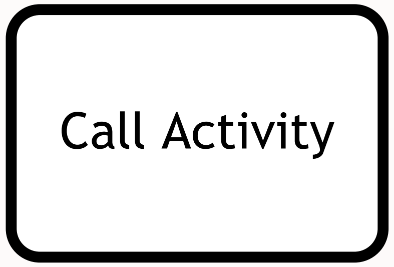
Loop Activity is iterated if a loop condition is true. The condition is either tested before or after the activity execution.



Ad-hoc Subprocesses contain tasks only. Each task can be executed arbitrarily often until a completion condition is fulfilled.



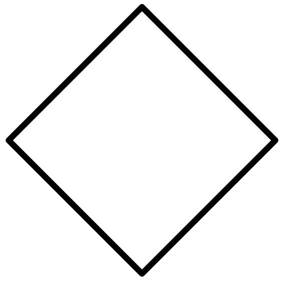
Attached Intermediate Event: The activity is aborted once an event is caught.



A **Call Activity** is a wrapper for a globally defined Sub-Process or Task that is reused in the current process.

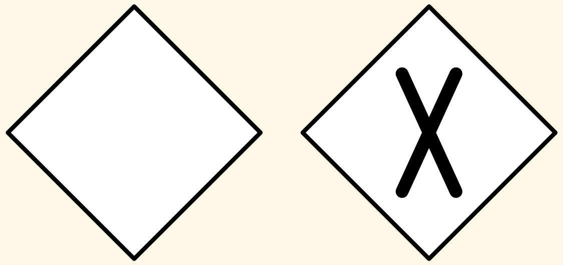
Gateways

A **gateway** is used to control the splitting and joining of paths in the sequence flow (conditional, fork, wait)

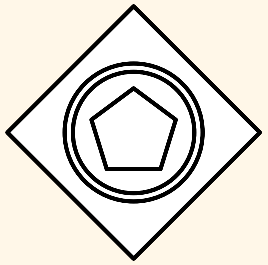


A gateway is represented as a diamond shape
Suitable markers are used to indicate
the nature of behaviour control

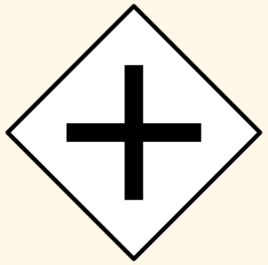
Gateway markers



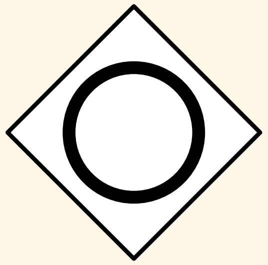
Data-based Exclusive Gateway
When splitting, it routes the sequence flow to exactly one of the outgoing branches based on conditions. When merging, it awaits one incoming branch to complete before triggering the outgoing flow.



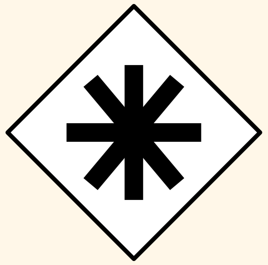
Event-based Exclusive Gateway
Is always followed by catching events or receive tasks. Sequence flow is routed to the subsequent event/task which happens first.



Parallel Gateway
When used to split the sequence flow, all outgoing branches are activated simultaneously. When merging parallel branches it waits for all incoming branches to complete before triggering the outgoing flow.



Inclusive Gateway
When splitting, one or more branches are activated based on branching conditions. When merging, it awaits all active incoming branches to complete.



Complex Gateway
It triggers one or more branches based on complex conditions or verbal descriptions. Use it sparingly as the semantics might not be clear.

BPMN basics:
Artefacts
(data-objects, groups, text annotations)

Artefacts

BPMN is designed to allow modellers and modelling tools some flexibility in extending the basic notation

Any number of artefacts can be added to a diagram as appropriate for the specific context of the business process being modelled

BPMN includes three pre-defined types of artefacts:

Data object

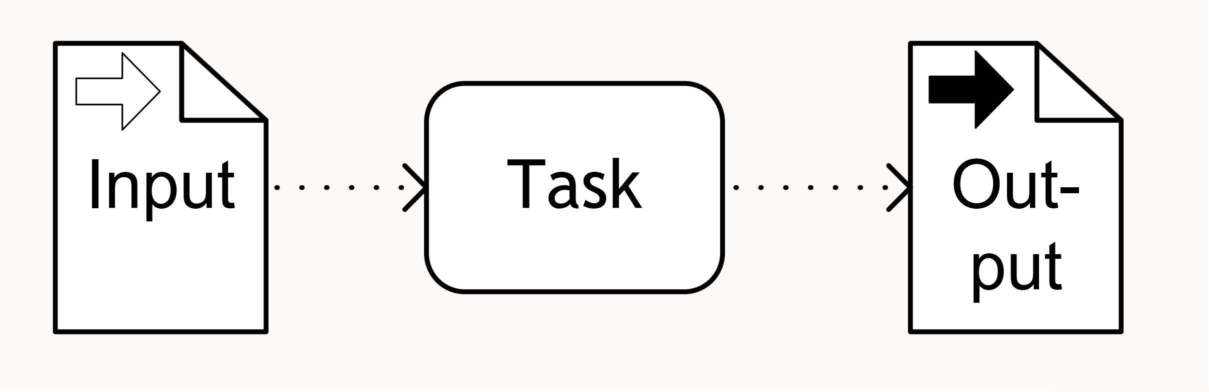
Group

Text annotation

Data object

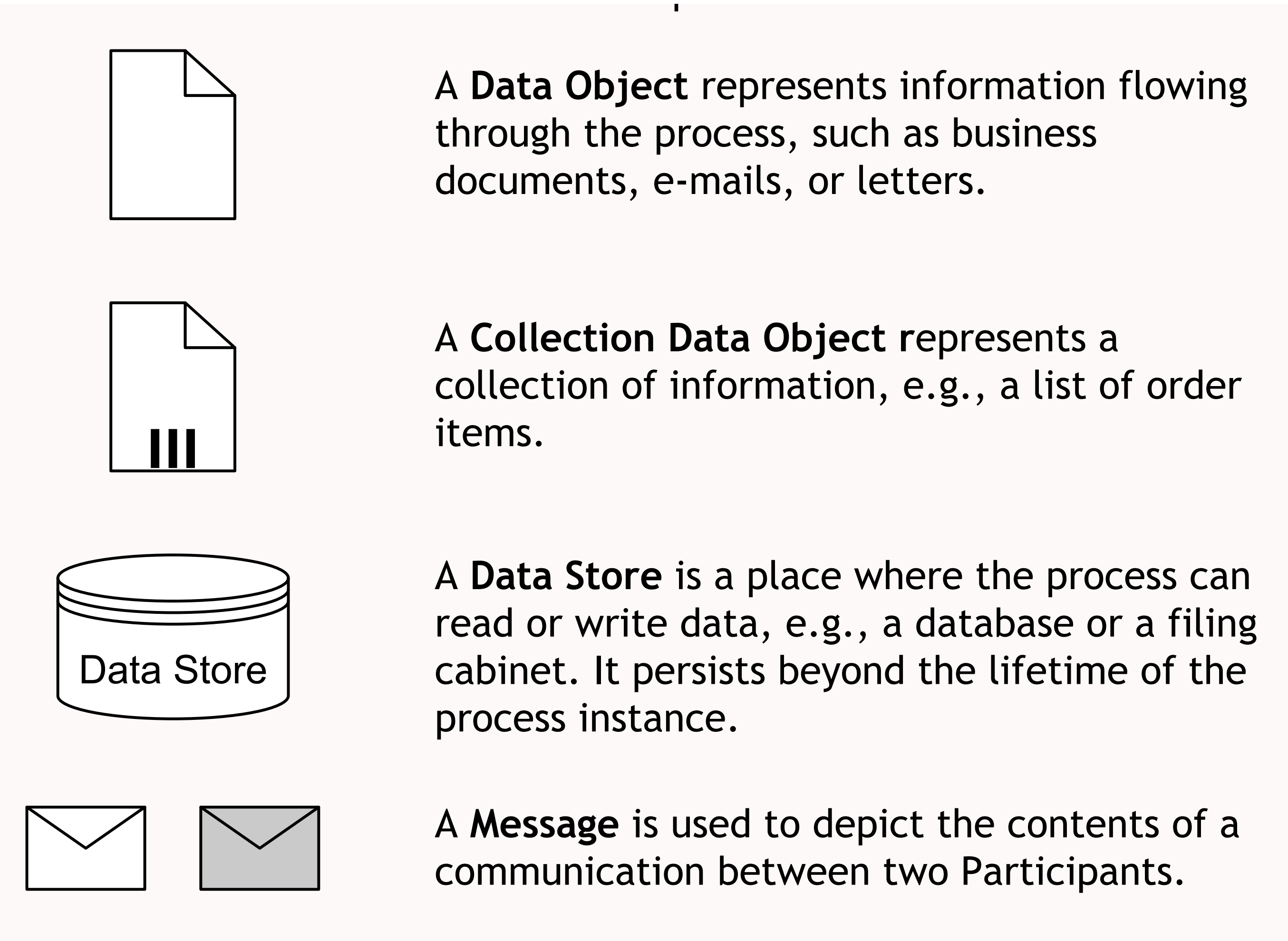
A **data object** specifies the data that are required or produced by an activity

A data object is often represented by the usual file icon



A **Data Input** is an external input for the entire process. It can be read by an activity.

A **Data Output** is a variable available as result of the entire process.



A **Data Object** represents information flowing through the process, such as business documents, e-mails, or letters.

A **Collection Data Object** represents a collection of information, e.g., a list of order items.

A **Data Store** is a place where the process can read or write data, e.g., a database or a filing cabinet. It persists beyond the lifetime of the process instance.

A **Message** is used to depict the contents of a communication between two Participants.

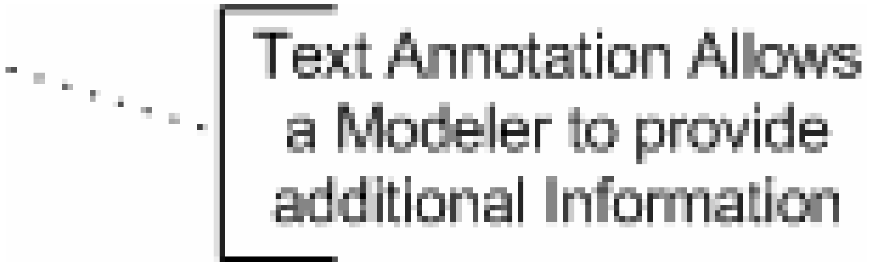
Group

An arbitrary set of objects can be defined as a **group** to show that they logically belong together

A group is represented by rounded corner rectangles with dashed lines

Annotation

Any object can be associated with a **text annotation** to provide any additional information and documentation that can be needed



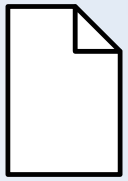
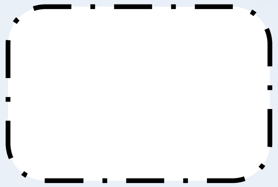
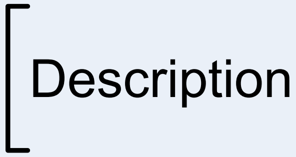
Text Annotation Allows a Modeler to provide additional Information

A text annotation is represented as a dotted-line call-out

Artefacts

Artefacts are used to provide additional information about the process. If required, modellers and modelling tools are free to add new artefacts.

Examples of data objects: 'A letter', 'Email message', 'XML document', 'Confirmation',...

Set of standardized artefacts		
Data object	 [state]	Data objects provide information about what activities are required to be triggered and/or what they produce. They are considered as Artefacts because they do not have any direct effect on the Sequence Flow or Message Flow of the Process. The state of the data object should also be set.
Group		Grouping can be used for documentation or analysis purposes. Groups can also be used to identify the activities of a distributed transaction that is shown across Pools. Grouping of activities does not affect the Sequence or Message Flow.
Annotation		Text Annotations are a mechanism for a modeller to provide additional information for the reader of a BPMN Diagram.

BPMN basics: Connecting objects (sequence flow, message flow, association)

Connecting objects

The Flow objects are connected together in a diagram to create the basic skeletal structure of a business process

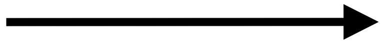
Three connecting objects can be used:

Sequence flow
Message flow
Association

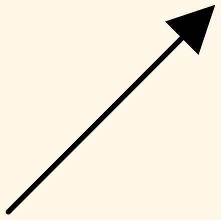
Sequence flow

A **sequence flow** is used to show the order in which activities are to be performed

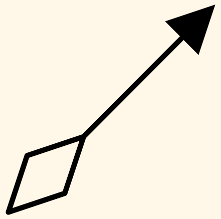
Note: connected objects must **reside in the same pool** (but they can be in different lanes)
the term “control flow” is generally avoided in BPMN



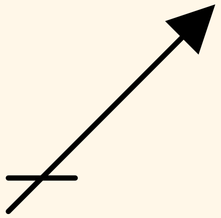
A sequence flow is represented by a solid line with a solid arrowhead



Sequence Flow defines the execution order of activities.



Conditional Flow has a condition assigned that defines whether or not the flow is used.



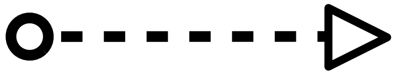
read as ``otherwise''

Default Flow is the default branch to be chosen if all other conditions evaluate to false.

Message flow

A **message flow** is used to show the flow
of messages between two separate process participants
(business entities or business roles)
that send and receive them

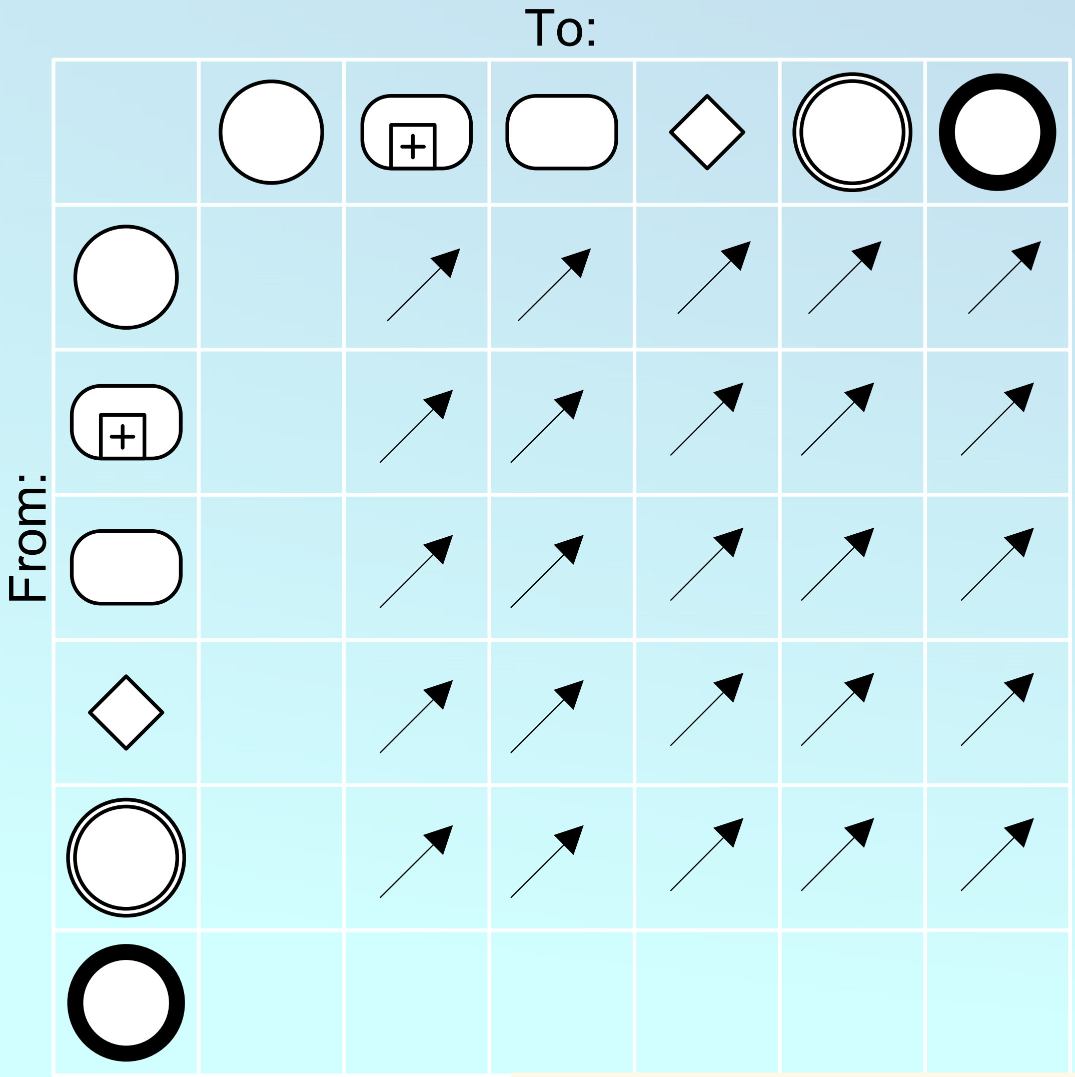
Note: the participants **reside in separate pools**

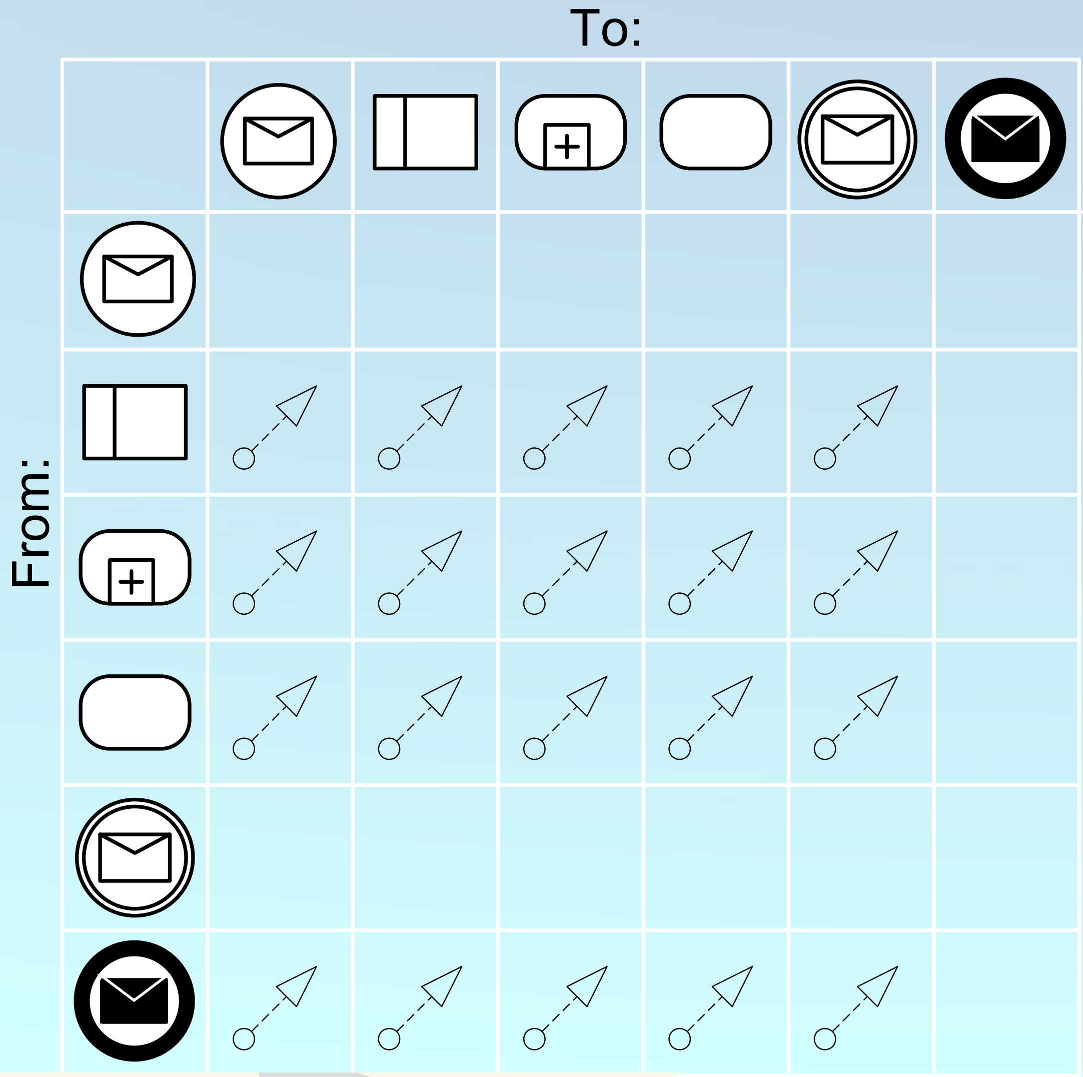


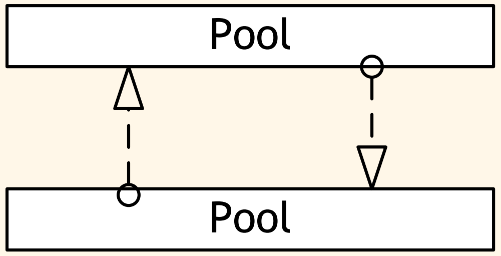
A message flow is represented by
a dashed line with a open arrowheads (see above)

Sequence Flow and Message Flow rules

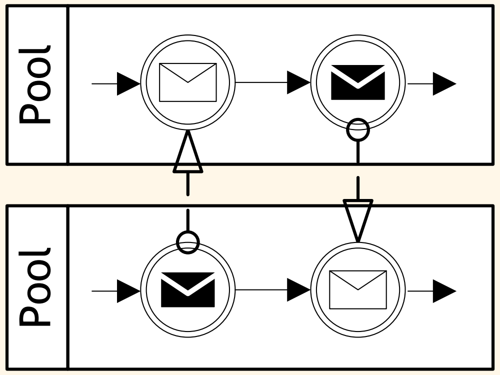
Only objects that can have an incoming and/or outgoing Sequence Flow / Message Flow are shown in the Tables Below.







Message Flow symbolizes information flow across organizational boundaries. Message flow can be attached to pools, activities, or message events.

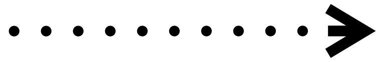


The order of message exchanges can be specified by combining message flow and sequence flow.

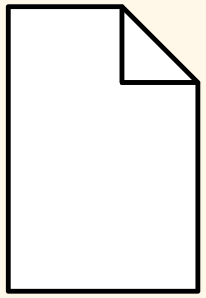
Association

An **association** is used to associate data, text, and other artefacts with flow objects

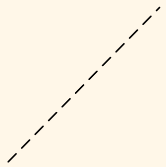
Note: in particular, input and output of activities



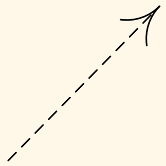
An association is represented by
a dotted line with a line arrowhead



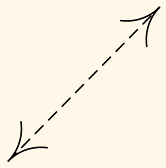
A **Data Object** represents information flowing through the process, such as business documents, e-mails or letters.



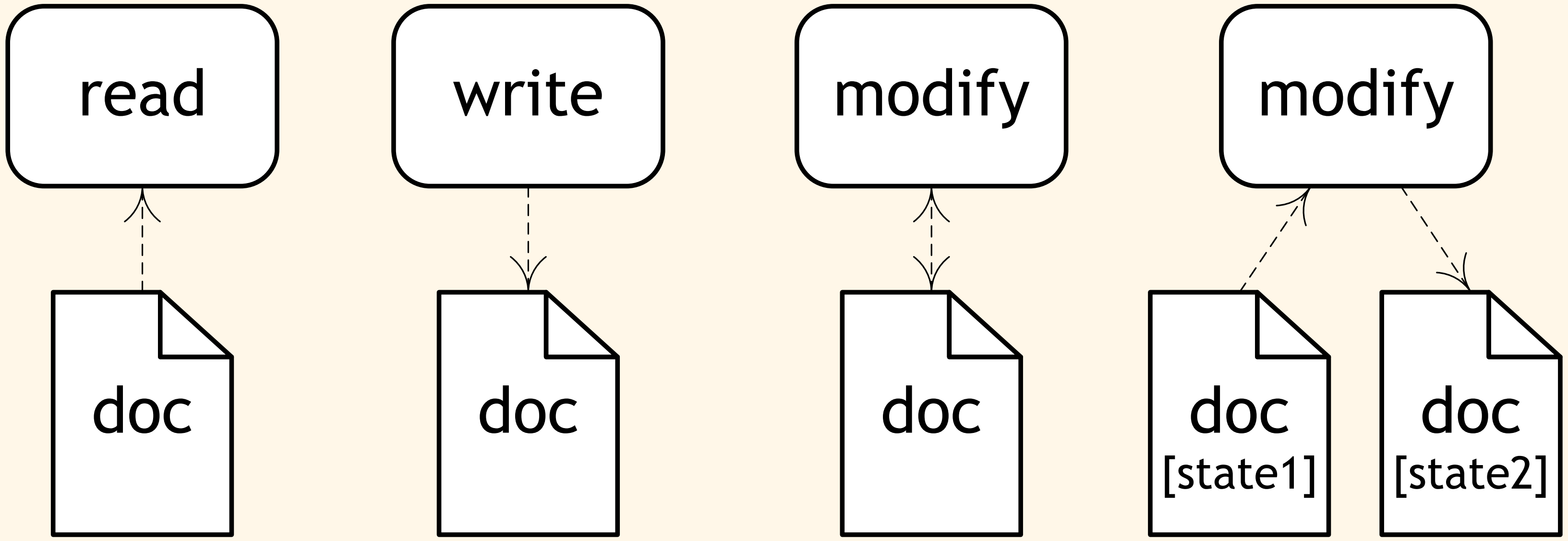
Attaching a data object with an **Undirected Association** to a sequence flow indicates hand-over of information between the activities involved.



A **Directed Association** indicates information flow. A data object can be read at the start of an activity or written upon completion.

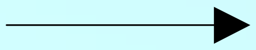
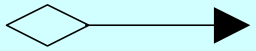
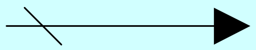
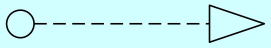
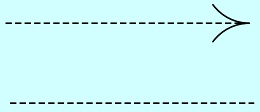


A **Bidirected Association** indicates that the data object is modified, i.e. read and written during the execution of an actvity.



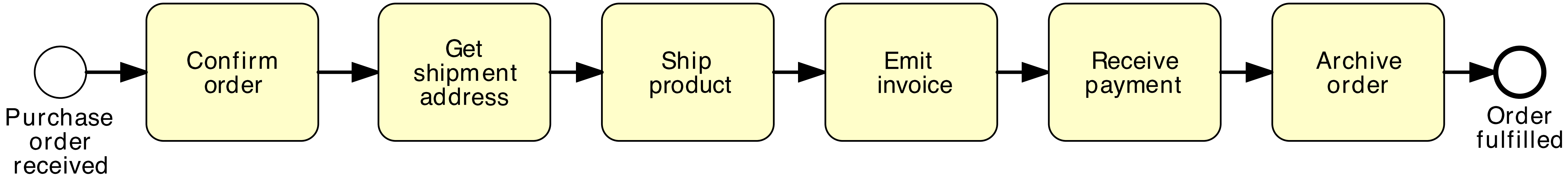
Graphical connecting objects

There are three ways of connecting **Flow objects (Events, Activities, Gateways)** with each other or with other information – using sequence flows, message flows or associations.

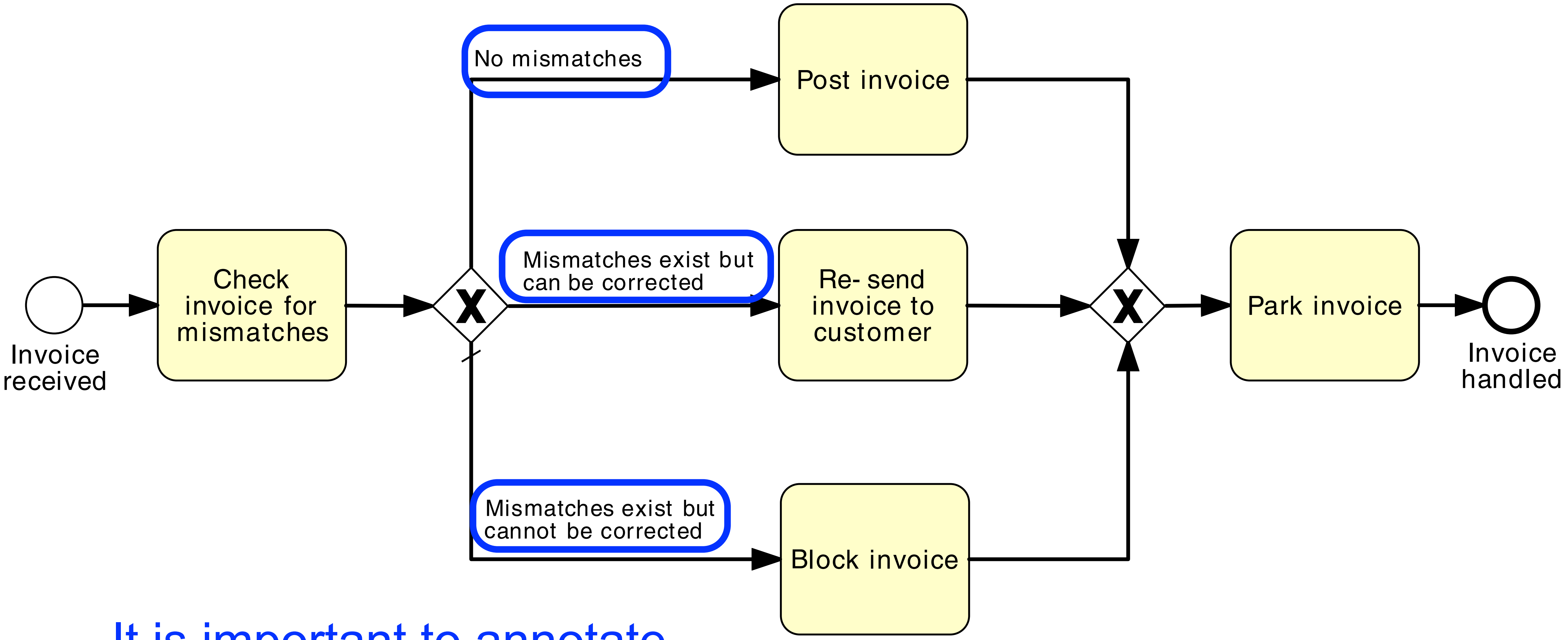
Graphical connecting objects		
Normal sequence flow		A Sequence Flow is used to show the order In which the activities in a process will be performed.
Conditional sequence flow		A Sequence Flow can have condition expressions which are evaluated at runtime to determine whether or not the flow will be used.
Default sequence flow		For Data-Based Exclusive Decisions or Inclusive Decisions, one type of flow is the Default condition flow. This flow will be used only if all other outgoing conditional flows are NOT true at runtime.
Message flow		A Message Flow is used to show the flow of messages between two participants that are prepared to send and receive them. In BPMN, two separate Pools in a Diagram can represent the two participants.
Association		An Association (directed, non-directed) is used to associate information with Flow Objects. Text and graphical non-Flow Objects can be associated with Flow objects.

A few patterns

Sequence: order fulfillment

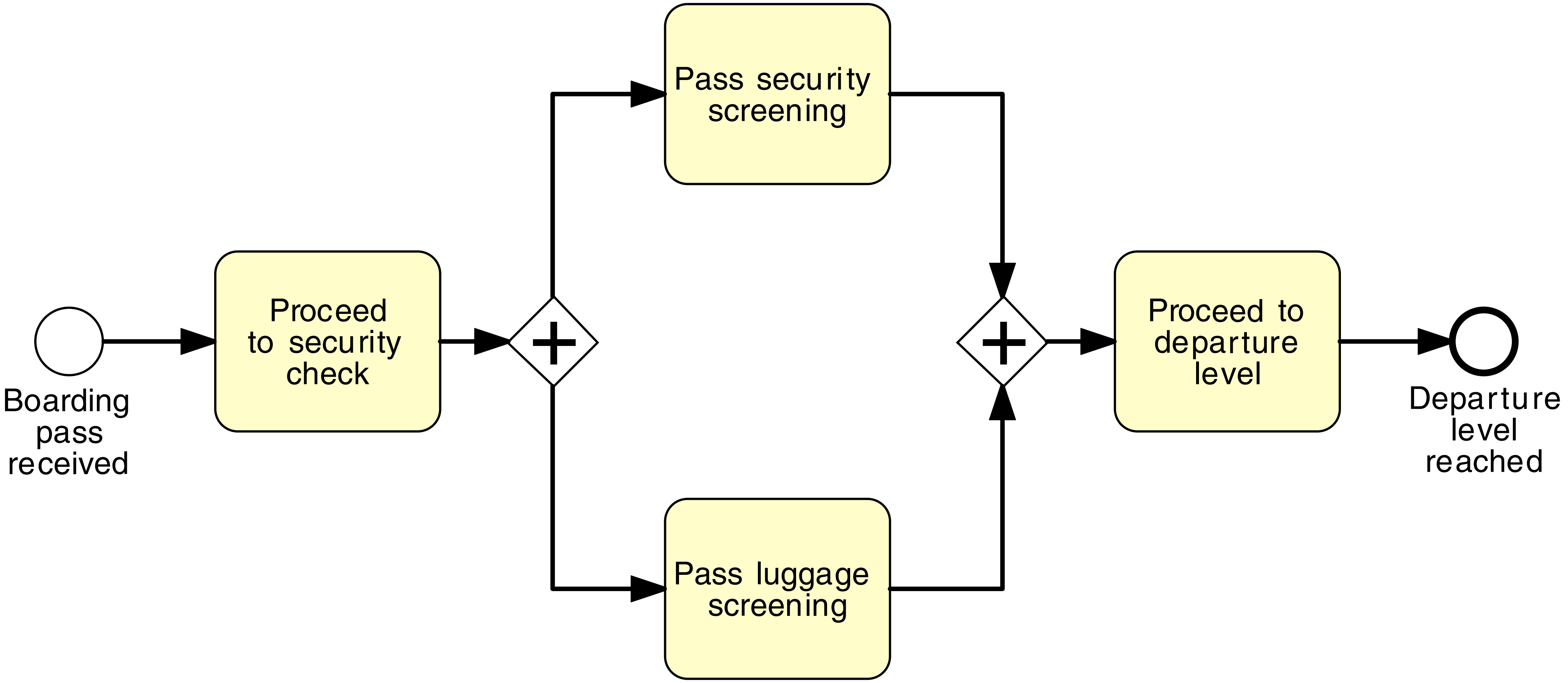


Exclusive decisions: invoice checking process

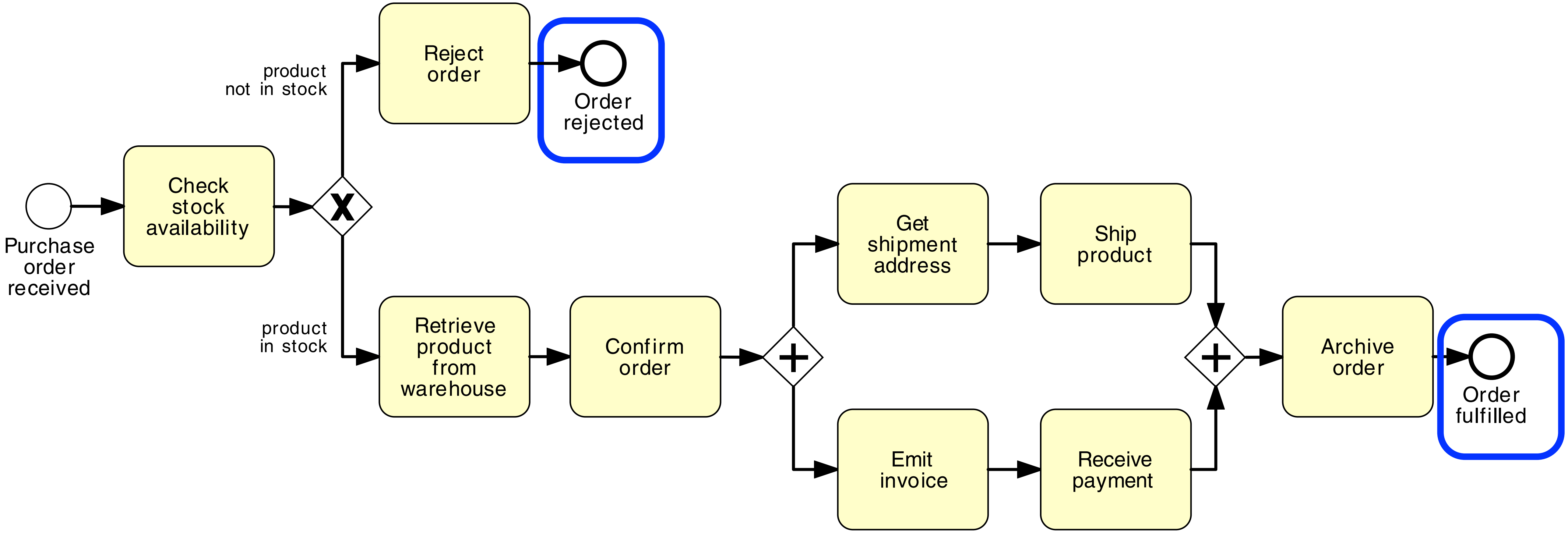

Invoice received
Check invoice for mismatches
No mismatches
Mismatches exist but can be corrected
Mismatches exist but cannot be corrected
Post invoice
Re-send invoice to customer
Block invoice
Park invoice
Invoice handled

It is important to annotate branches with the conditions under which they are taken

Parallel activities: airport security check



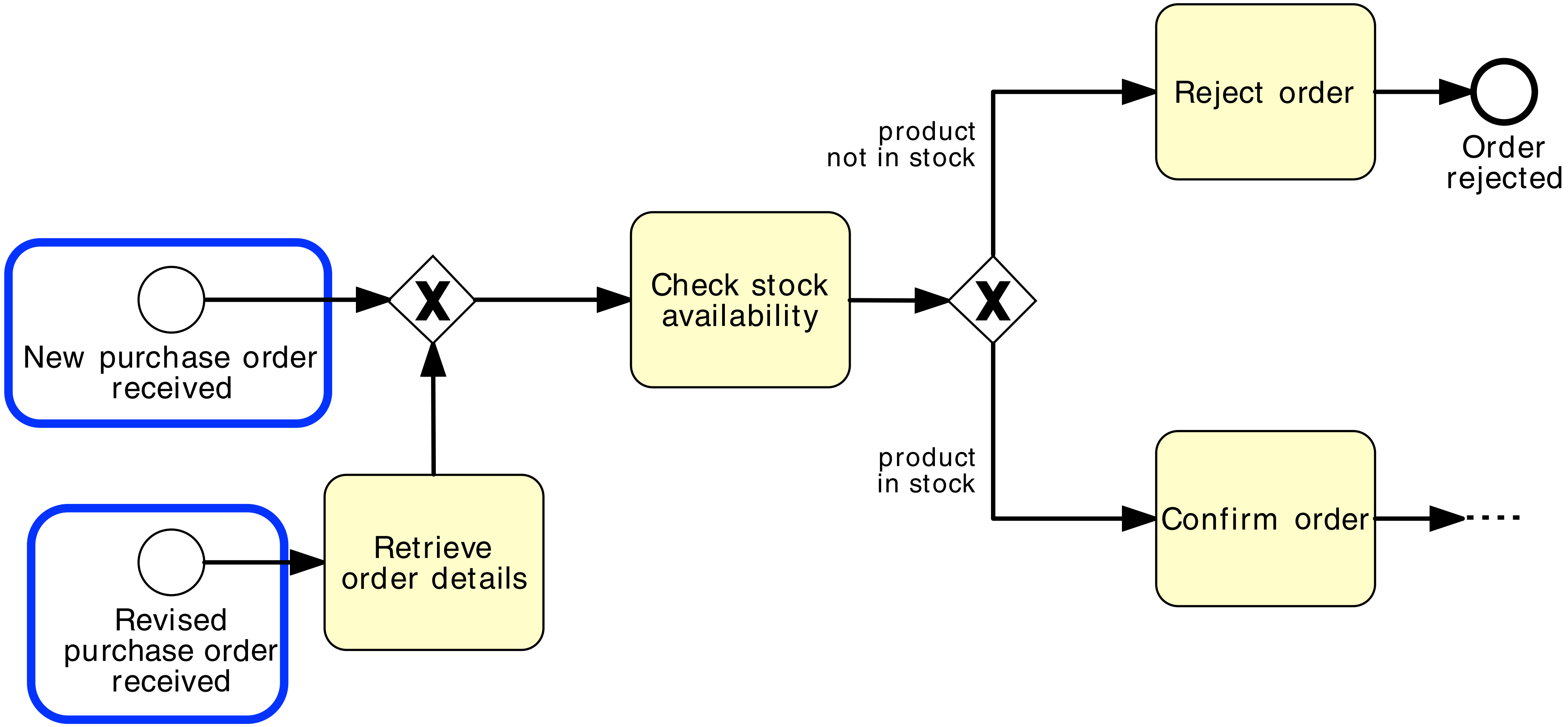
XOR + AND: order fulfillment



Multiple end events are often considered as a convenient notation (they are mutually exclusive in the example)

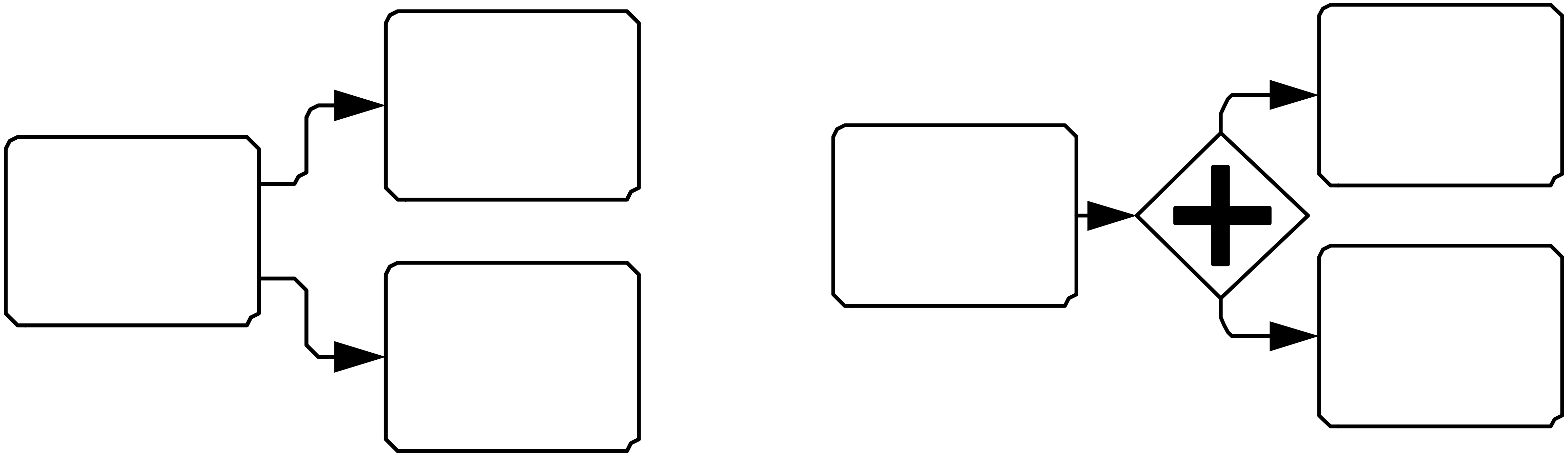
BPMN adopts **implicit termination** semantics:
a case ends only when each ``token” reaches the end

Multiple start events: order fulfillment



Multiple start events are often considered as a convenient notation (they capture mutually exclusive triggers to start a process instance)

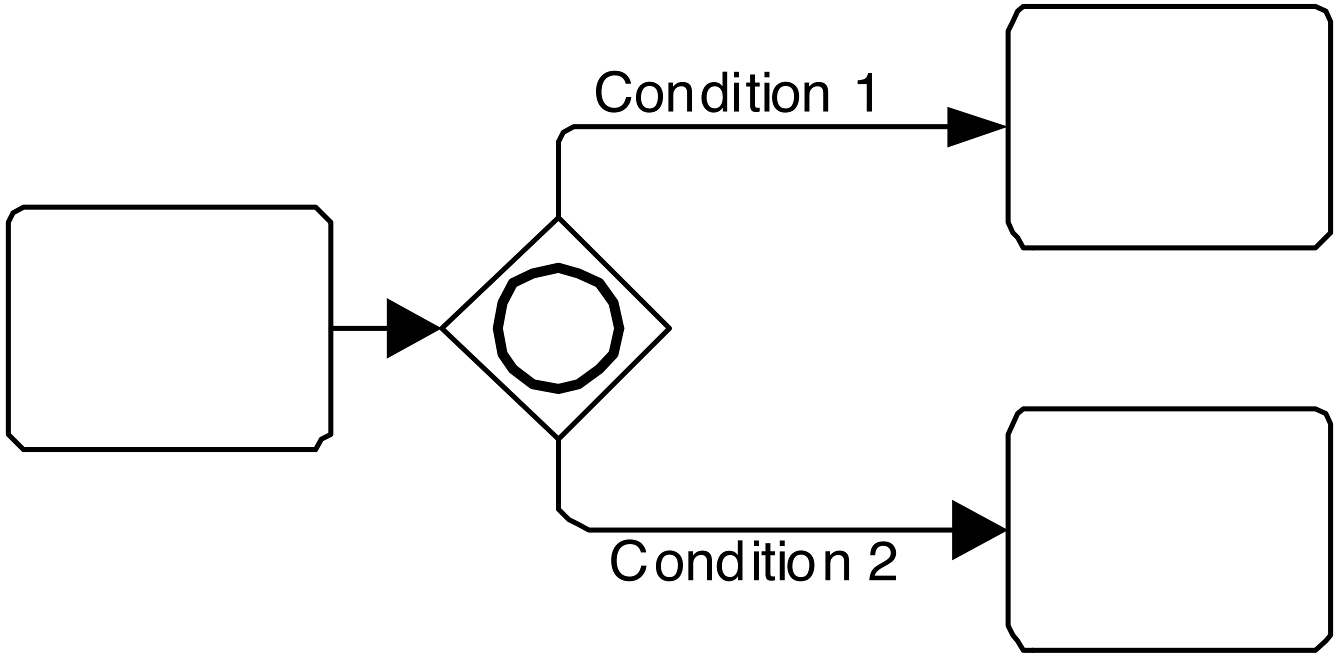
Omitting gateways



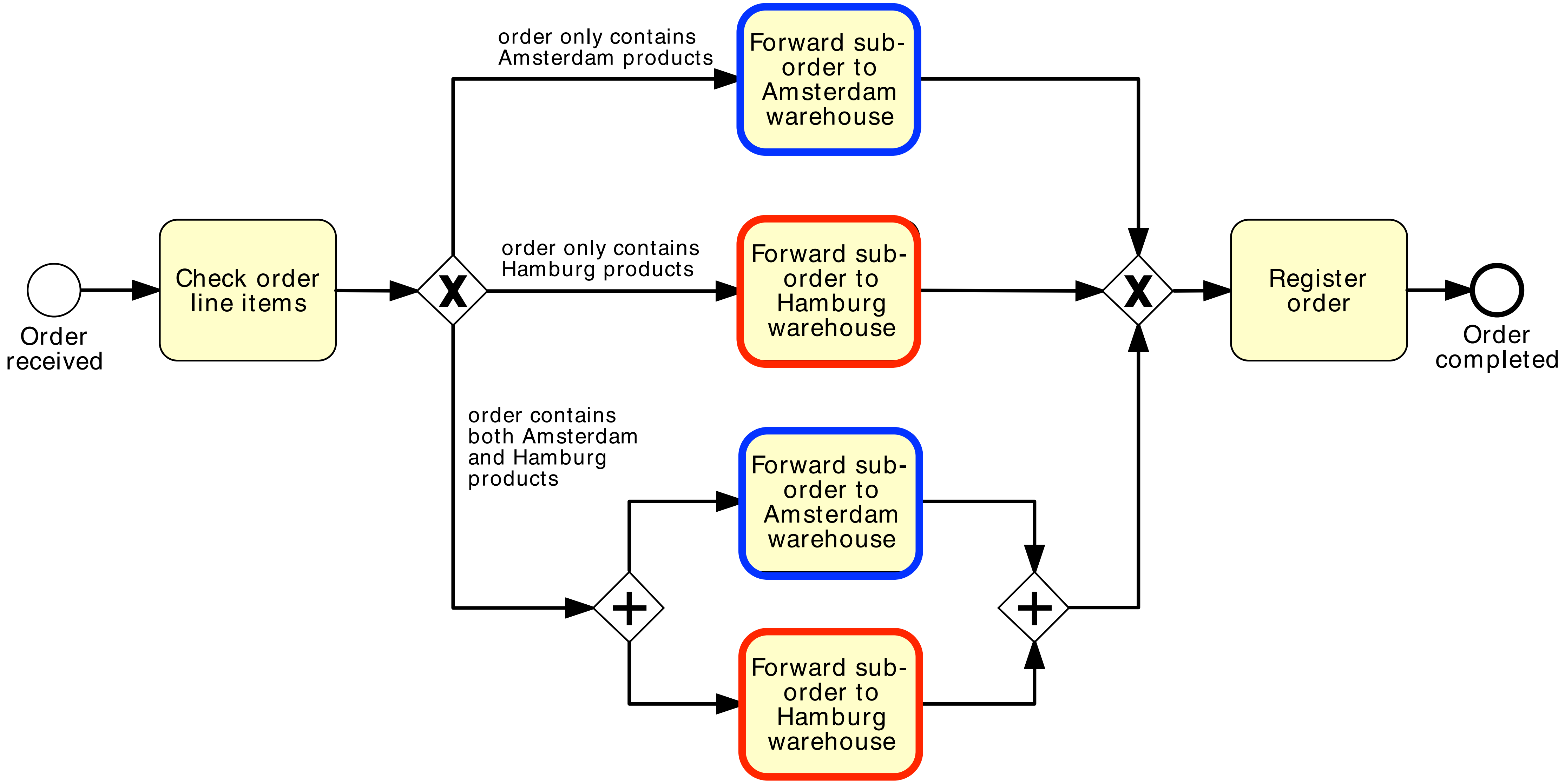
An **AND-gateway** can be omitted when it **follows** an activity or event

Similarly, a **XOR-gateway before** an activity or event can be omitted

Inclusive decisions (one, many)

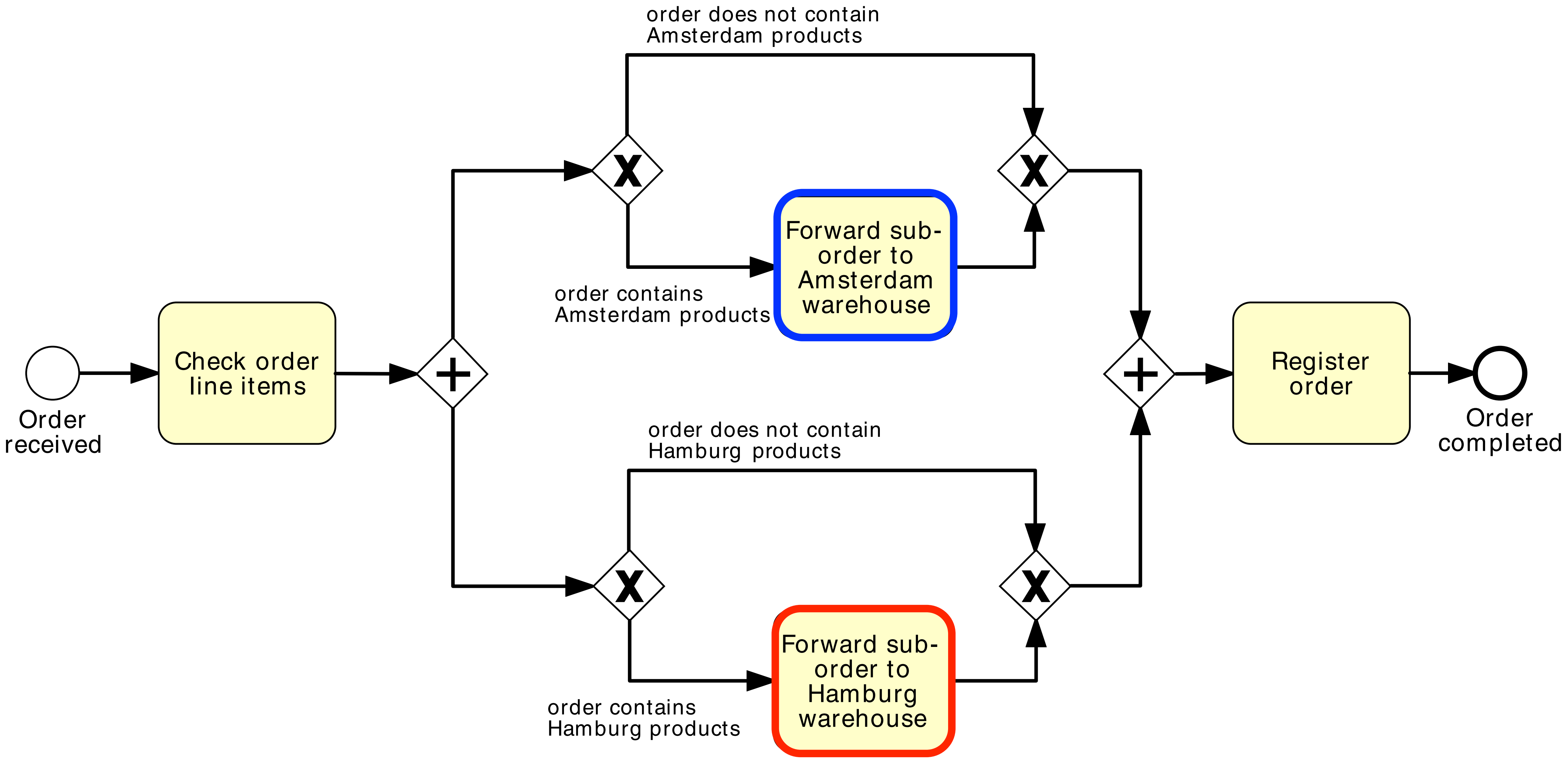


Inclusive decisions: order distribution


order only contains Amsterdam products
Forward sub-order to Amsterdam warehouse
order only contains Hamburg products
Forward sub-order to Hamburg warehouse
Order received
Check order line items
X
X
Register order
Order completed
order contains both Amsterdam and Hamburg products
Forward sub-order to Amsterdam warehouse
+
+
Forward sub-order to Hamburg warehouse

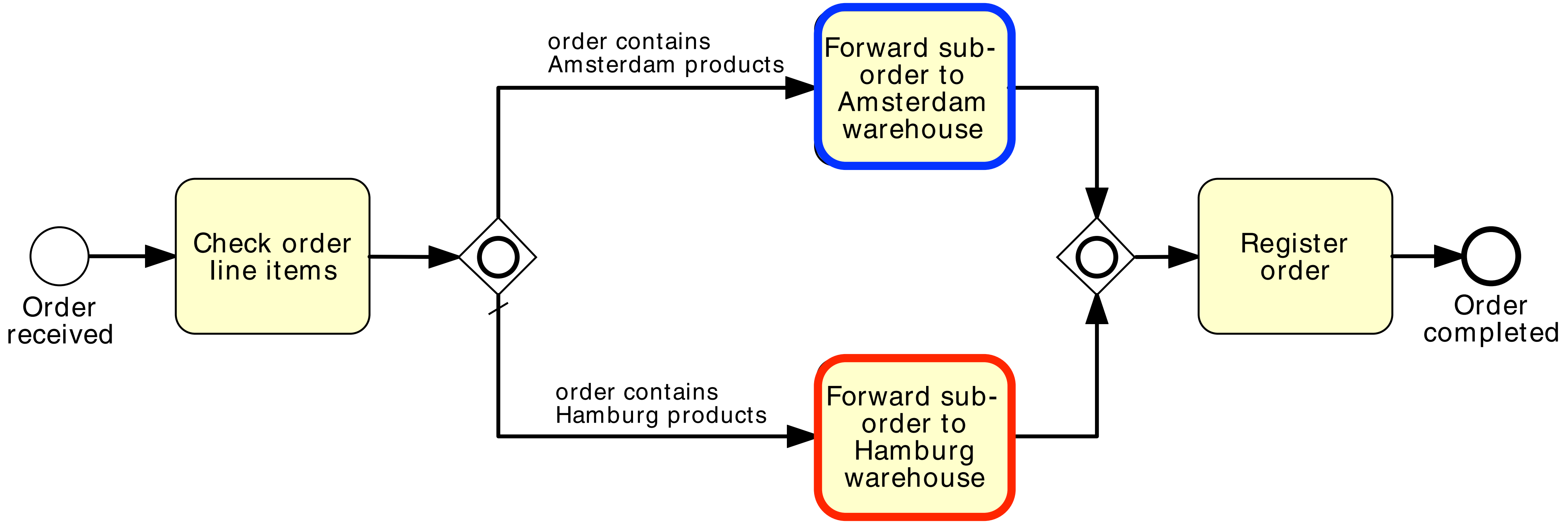
Only XOR / AND gateways, but the diagram is convoluted!
What if we had three or more warehouses? (does not scale)

Inclusive decisions: order distribution


order does not contain Amsterdam products
Forward sub-order to Amsterdam warehouse
order contains Amsterdam products
Order received
Check order line items
Register order
Order completed
order does not contain Hamburg products
Forward sub-order to Hamburg warehouse
order contains Hamburg products

Only XOR / AND gateways, the diagram can ``scale”, but is it correct? (also the case no-warehouse is now possible)

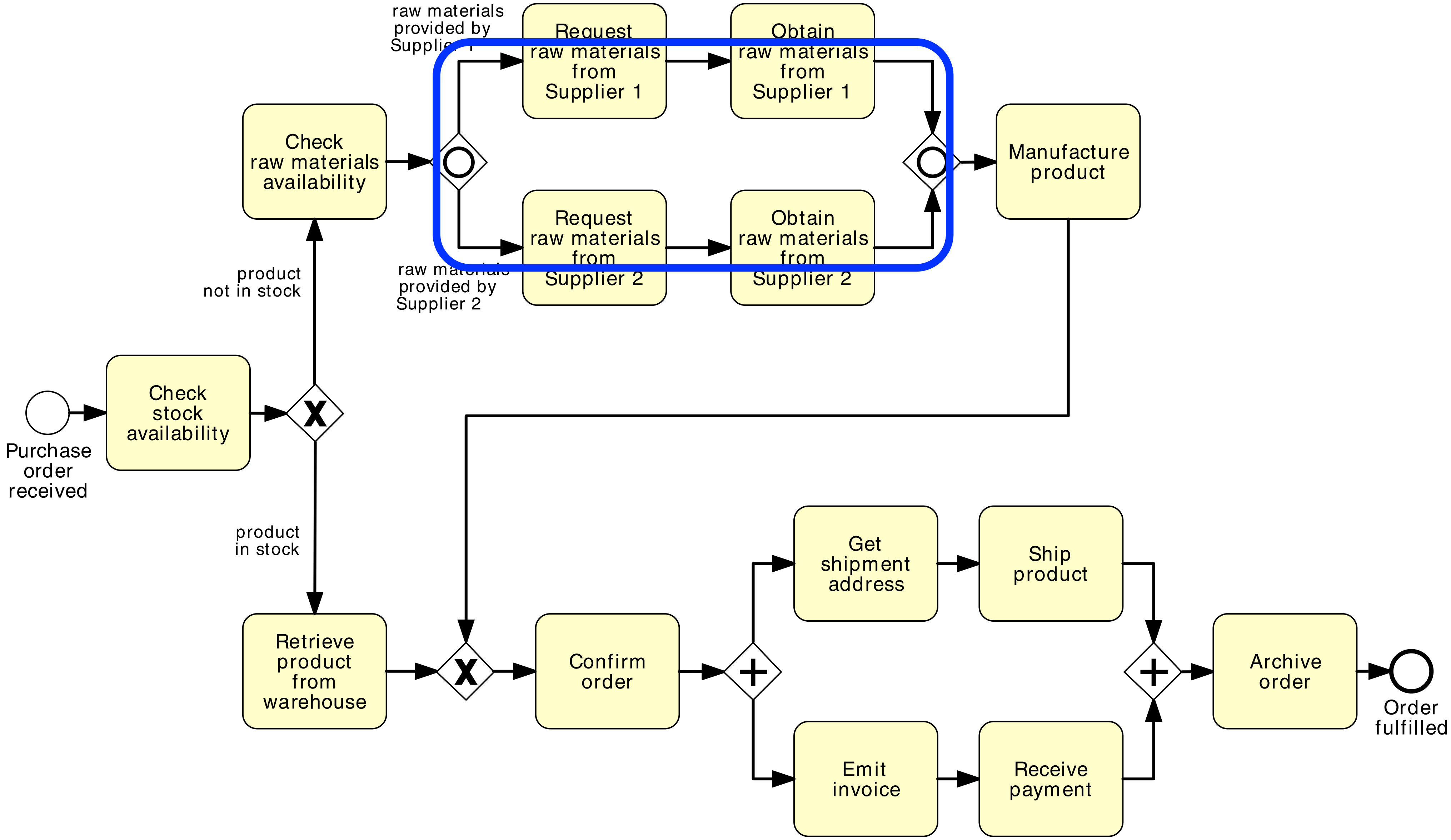
Inclusive decisions: order distribution


Order received
Check order line items
order contains Amsterdam products
Forward sub-order to Amsterdam warehouse
order contains Hamburg products
Forward sub-order to Hamburg warehouse
Register order
Order completed

OR gateways, the diagram can ``scale'',
but remember all the **issues with unmatched OR-joins**: they are still valid!

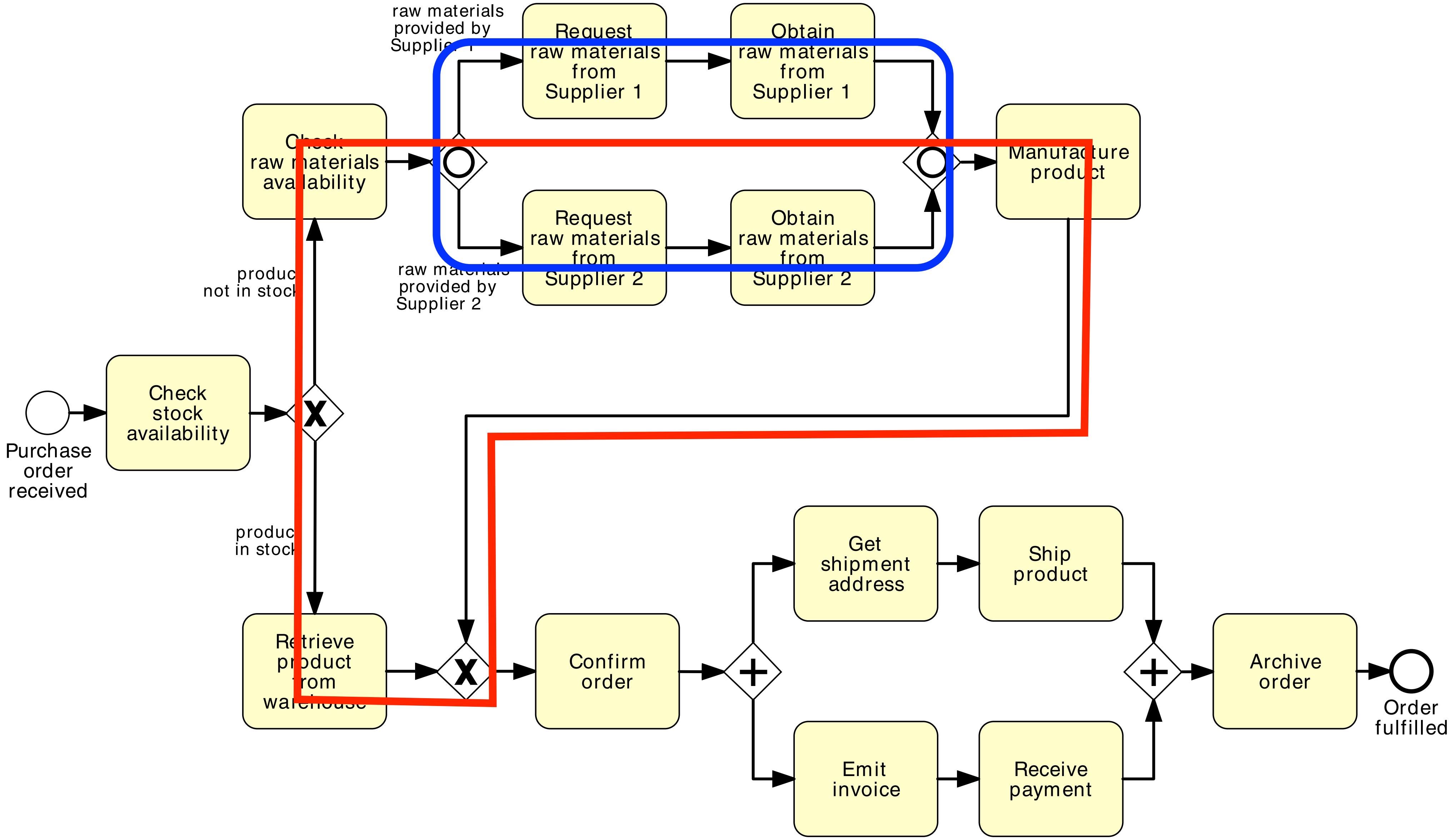
Use OR-gateways only when strictly necessary

XOR + AND + OR: order fulfillment


raw materials provided by Supplier 1
Request raw materials from Supplier 1
Obtain raw materials from Supplier 1
Check raw materials availability
Manufacture product
Request raw materials from Supplier 2
Obtain raw materials from Supplier 2
raw materials provided by Supplier 2
product not in stock
Purchase order received
Check stock availability
product in stock
Retrieve product from warehouse
Confirm order
Get shipment address
Ship product
Emit invoice
Receive payment
Archive order
Order fulfilled

Better if gateways are balanced

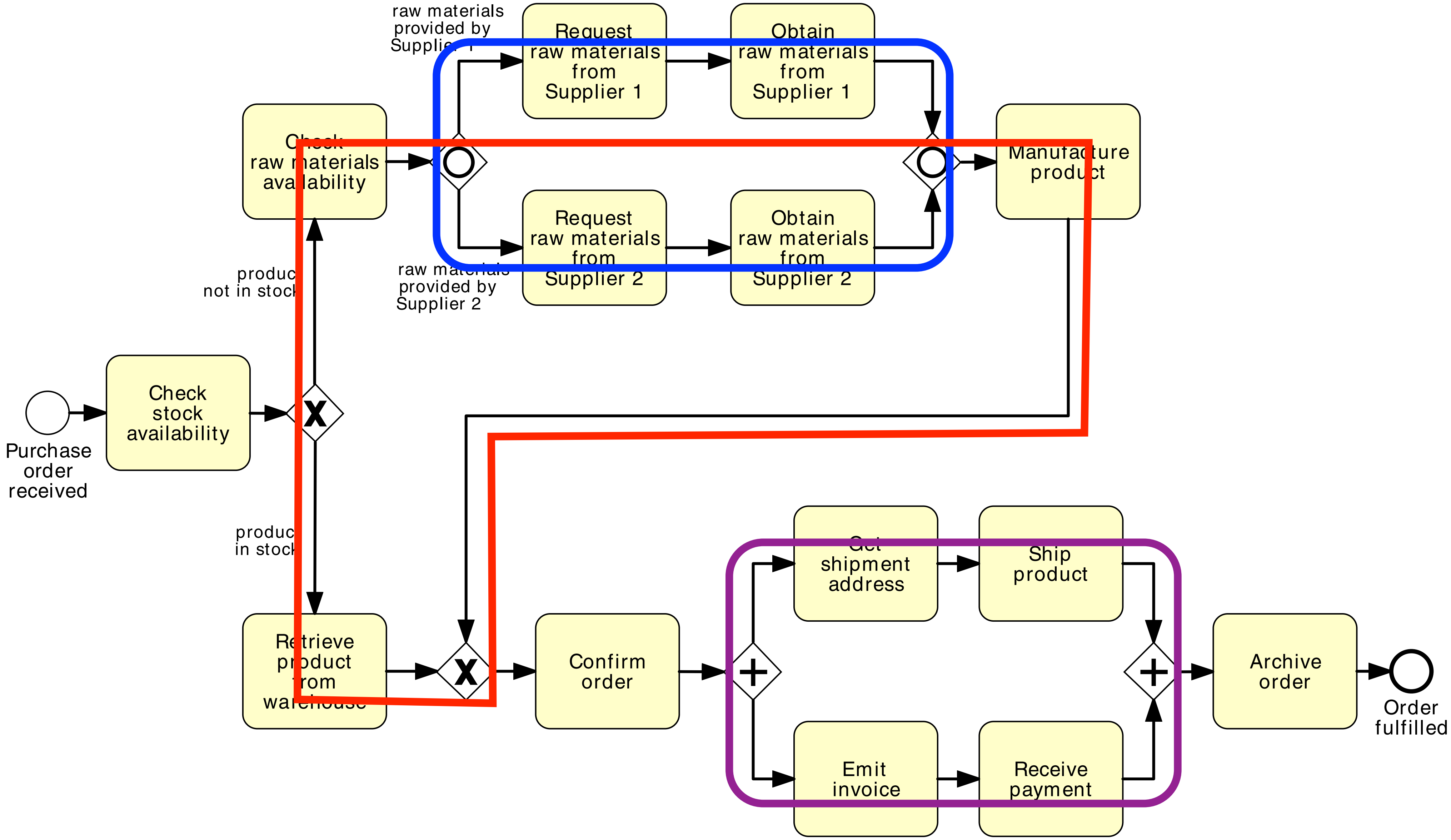
XOR + AND + OR: order fulfillment



Purchase order received
Check stock availability
X
product not in stock
product in stock
Check raw materials availability
raw materials provided by Supplier 1
raw materials provided by Supplier 2
Request raw materials from Supplier 1
Obtain raw materials from Supplier 1
Request raw materials from Supplier 2
Obtain raw materials from Supplier 2
Manufacture product
Retrieve product from warehouse
X
Confirm order
+
Get shipment address
Ship product
Emit invoice
Receive payment
+
Archive order
Order fulfilled

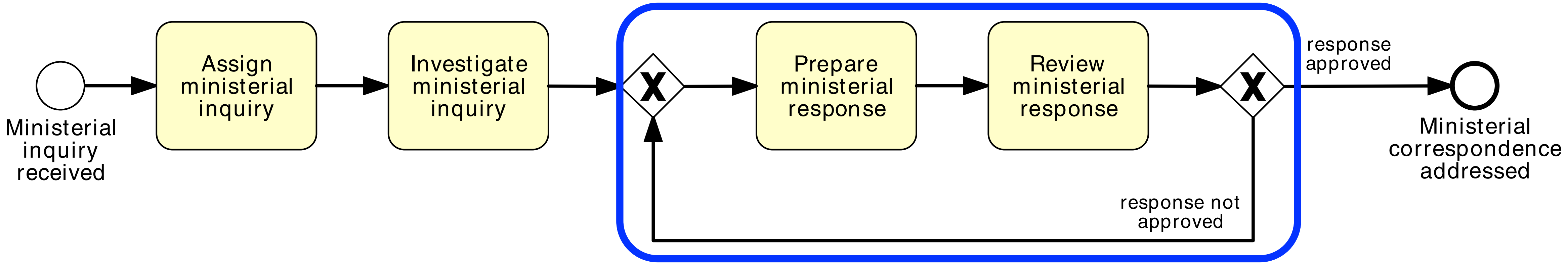
Better if gateways are balanced

XOR + AND + OR: order fulfillment


raw materials provided by Supplier 1
Request raw materials from Supplier 1
Obtain raw materials from Supplier 1
Check raw materials availability
Manufacture product
Request raw materials from Supplier 2
Obtain raw materials from Supplier 2
product not in stock
raw materials provided by Supplier 2
Purchase order received
Check stock availability
product in stock
Get shipment address
Ship product
Retrieve product from warehouse
Confirm order
Archive order
Order fulfilled
Emit invoice
Receive payment

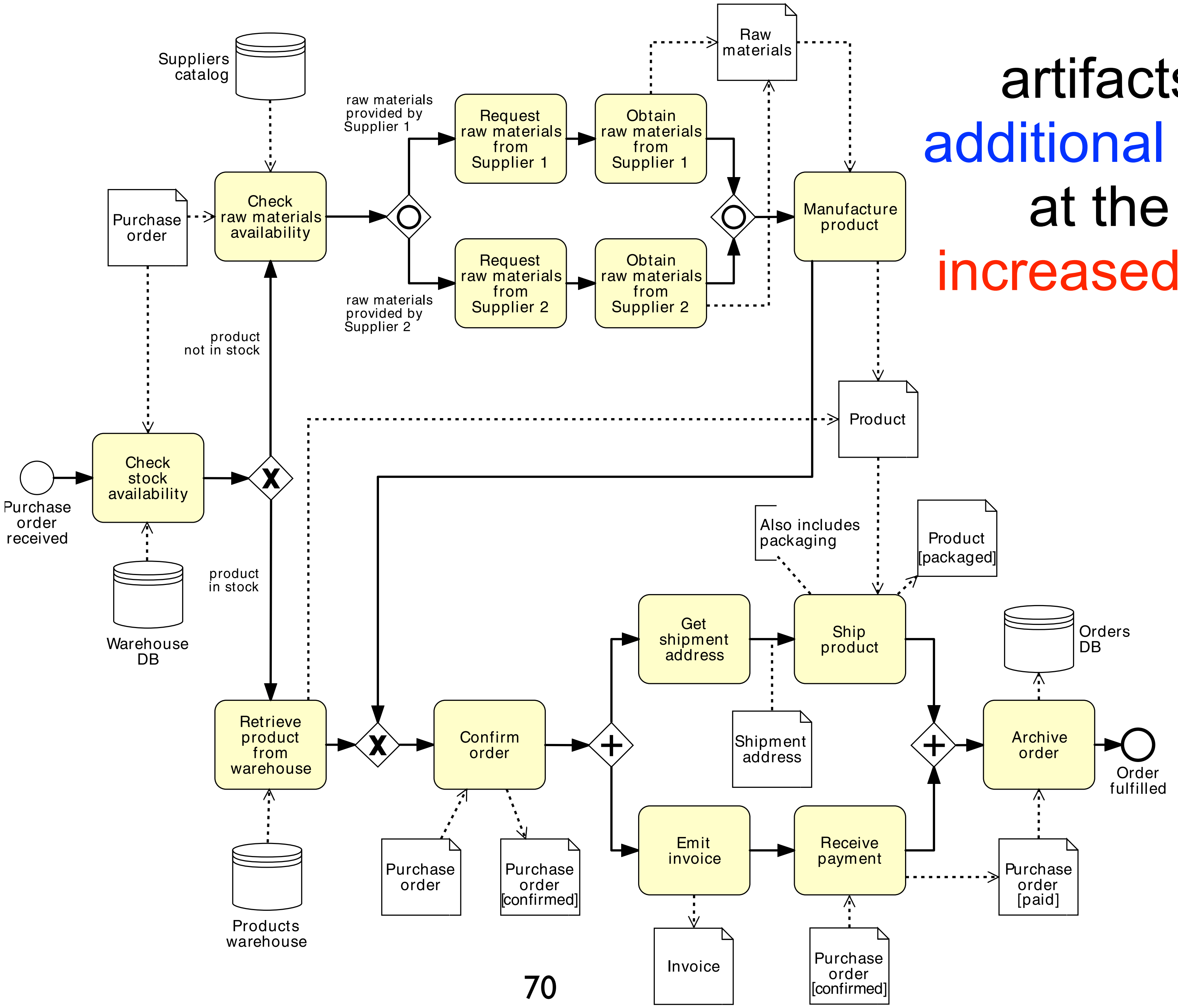
Better if gateways are balanced

Rework and repetition: ministerial correspondence


Ministerial inquiry received
Assign ministerial inquiry
Investigate ministerial inquiry
Prepare ministerial response
Review ministerial response
response approved
response not approved
Ministerial correspondence addressed

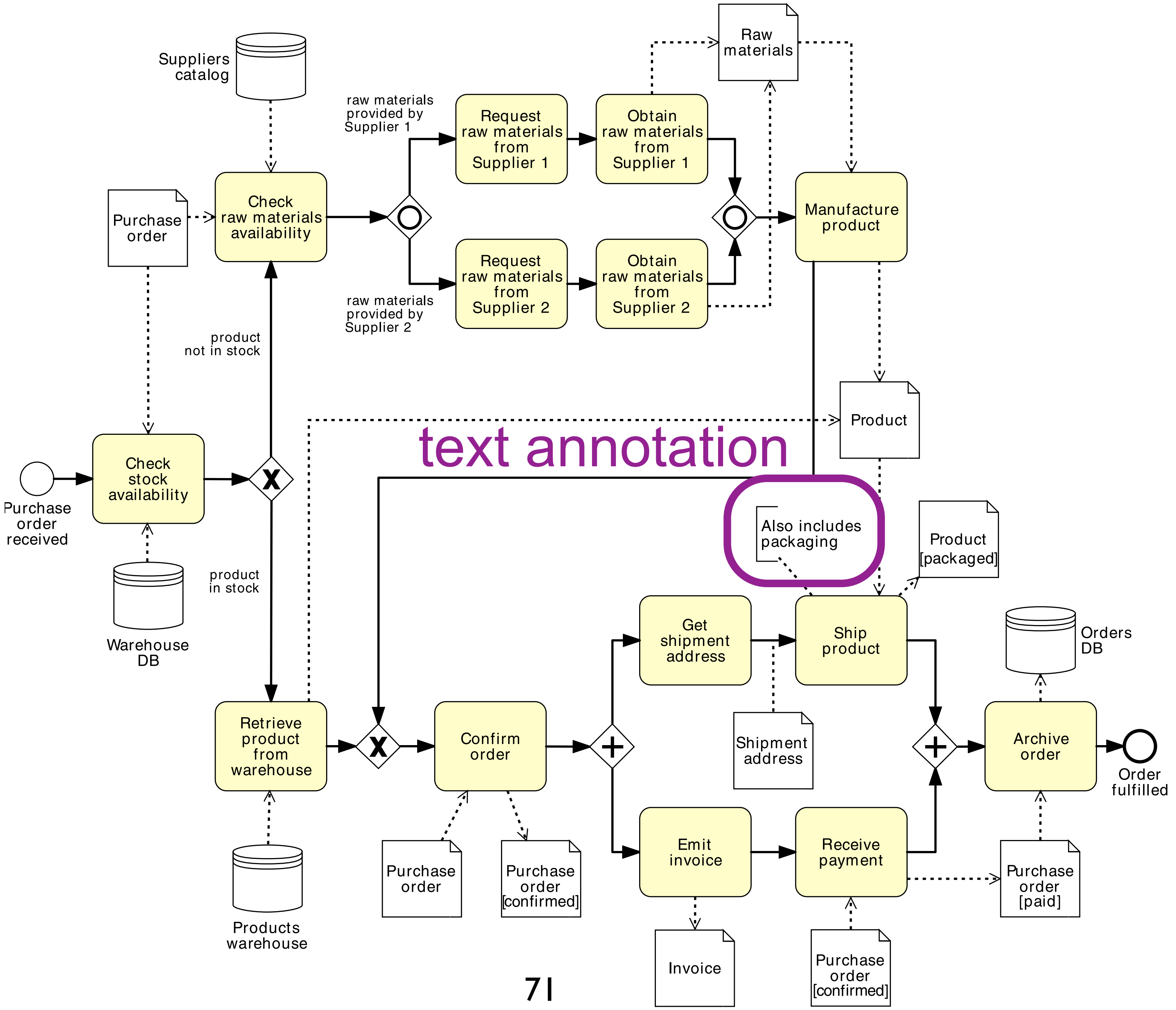
A repetition block starts with a XOR-join
and ends with a decision gateway (XOR-split)

Information artifacts: order fulfillment

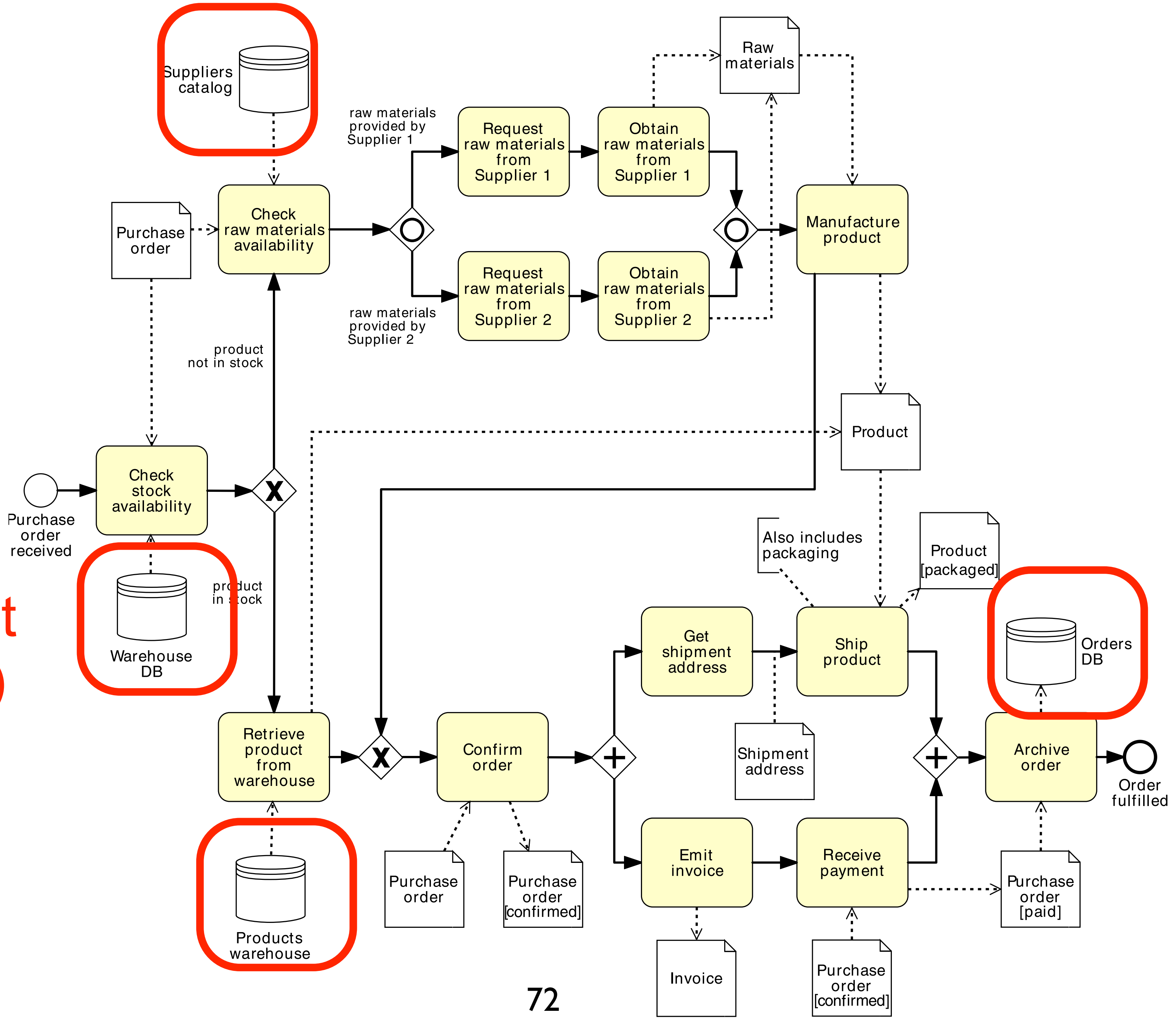


artifacts provide
additional information,
at the price of
increased complexity

Information artifacts: order fulfillment



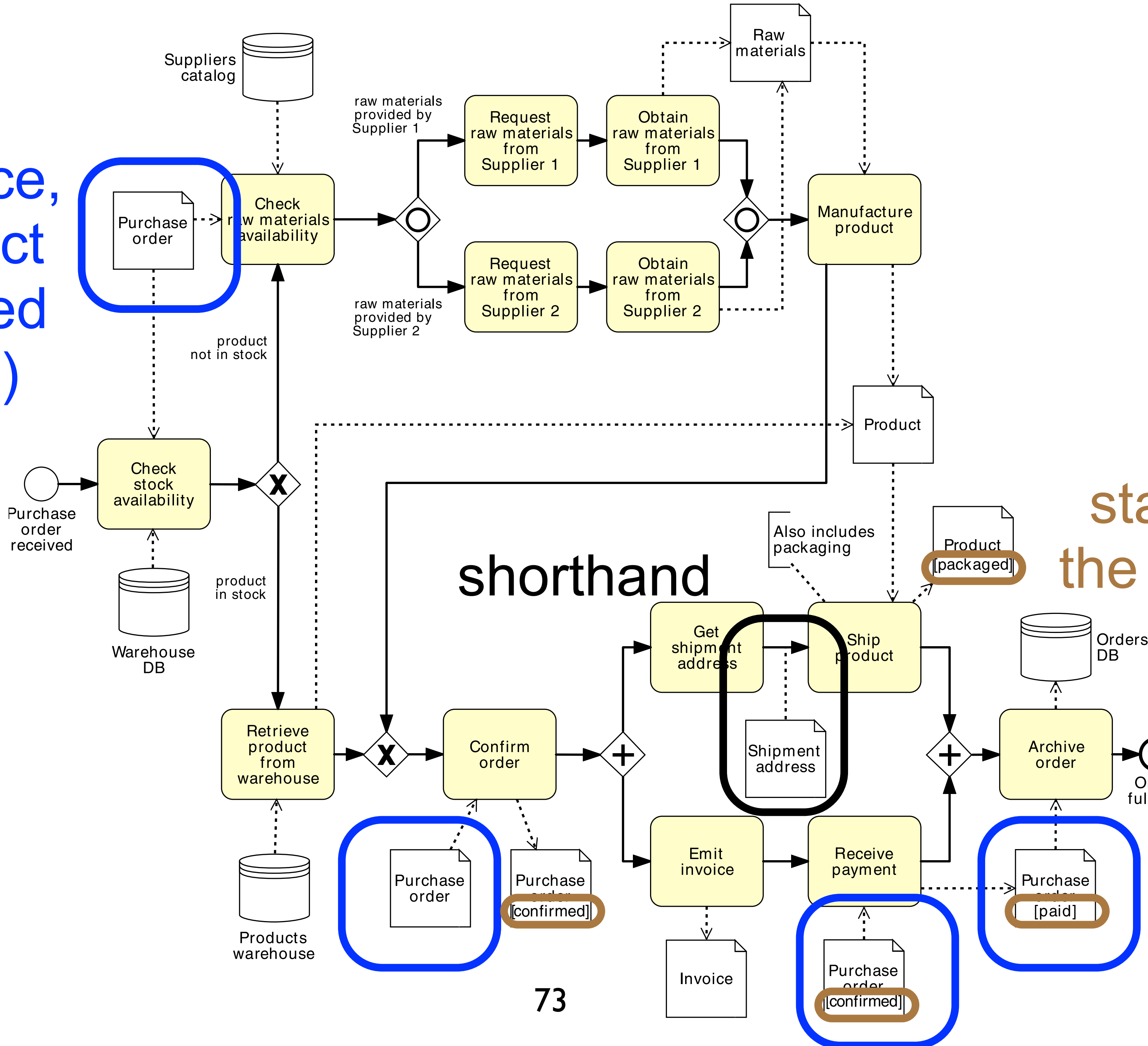
Information artifacts: order fulfillment



data stores (for persistent data objects)

Information artifacts: order fulfillment

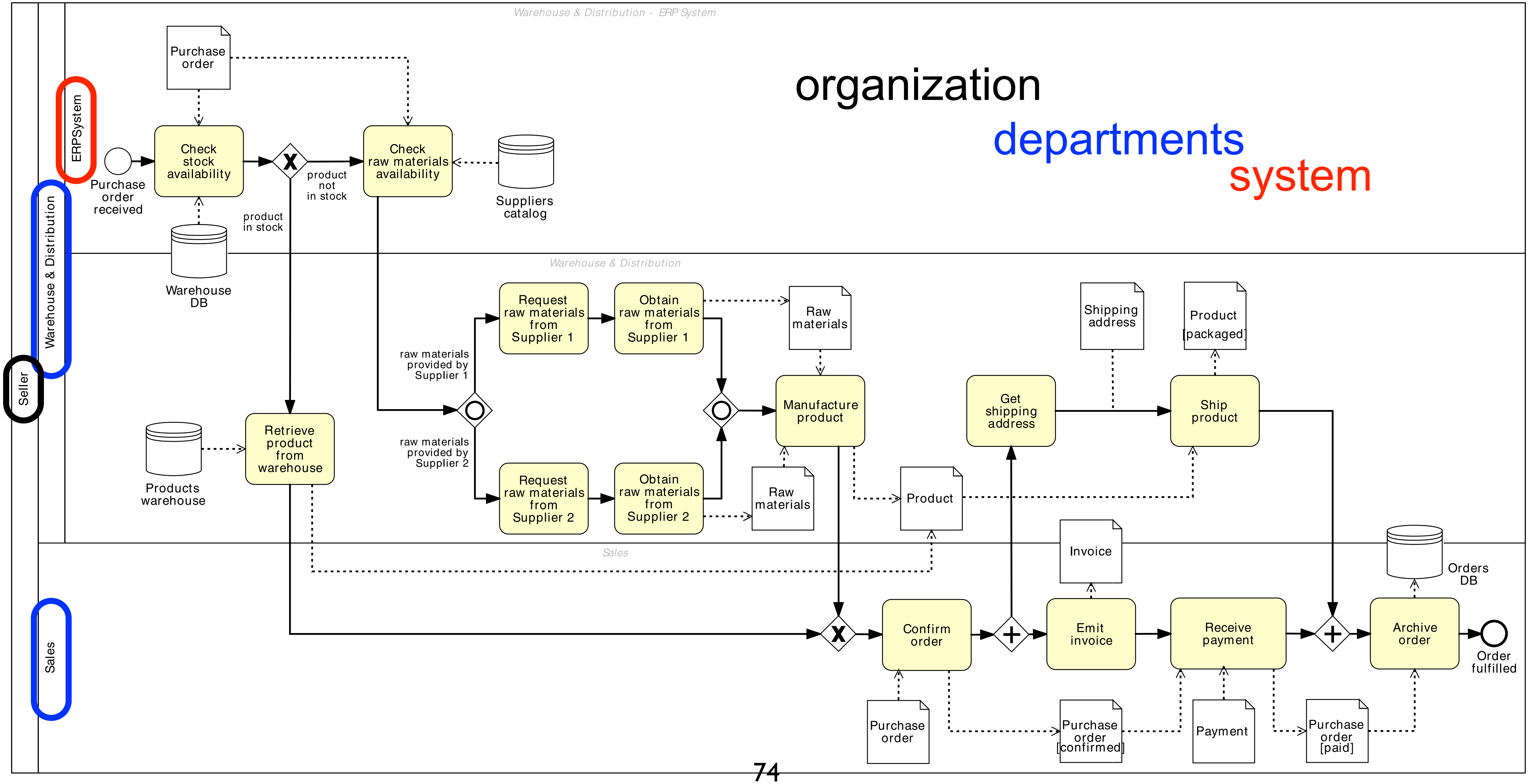
data objects (for convenience, the same object can be repeated several times)



shorthand

state of the object

Resources as lanes: order fulfillment



organization

departments

system

Placing items

events: must be placed in the proper lane

activities: must be placed in the proper lane

data-objects: placement is irrelevant

gateways:
(X)OR-splits: same lane as preceding decision activity
AND-split, joins: placement is irrelevant

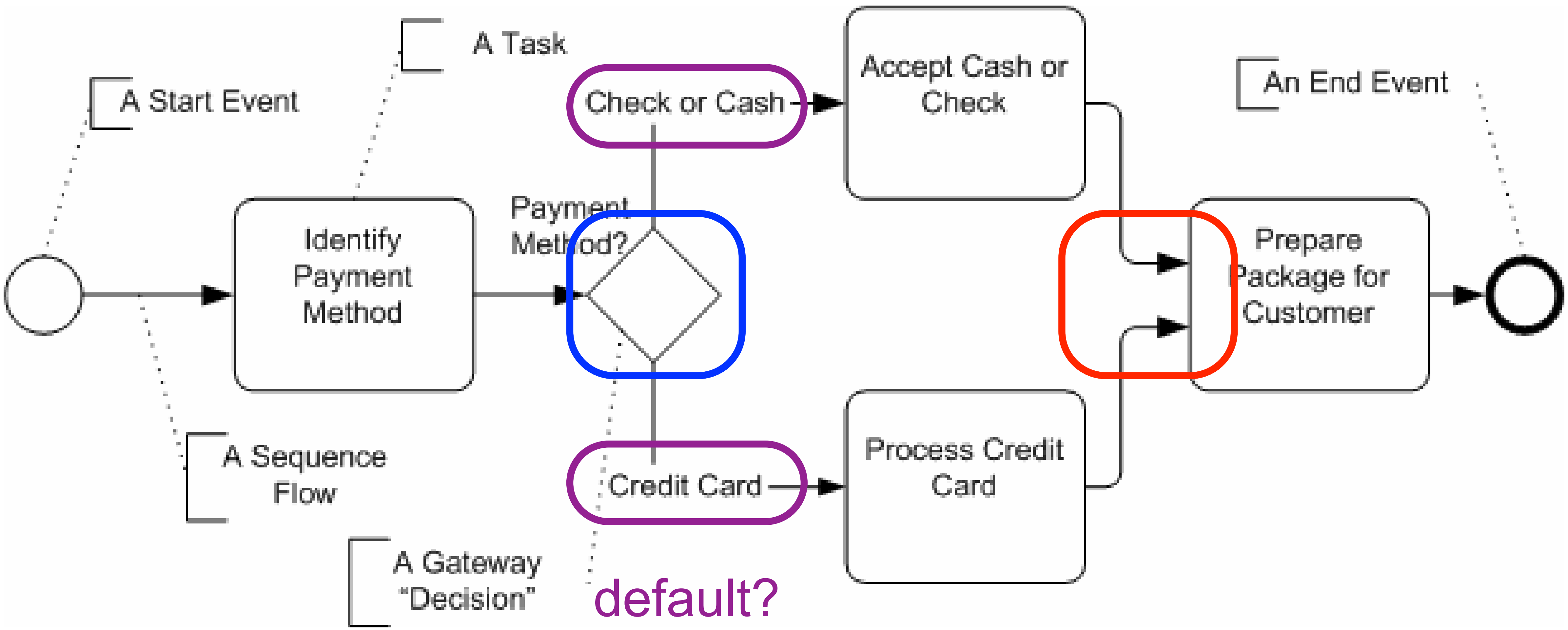
Some remarks

Lanes are often used to separate activities associated with a specific company function or role

Sequence flow may cross the boundaries of Lanes within the same Pool

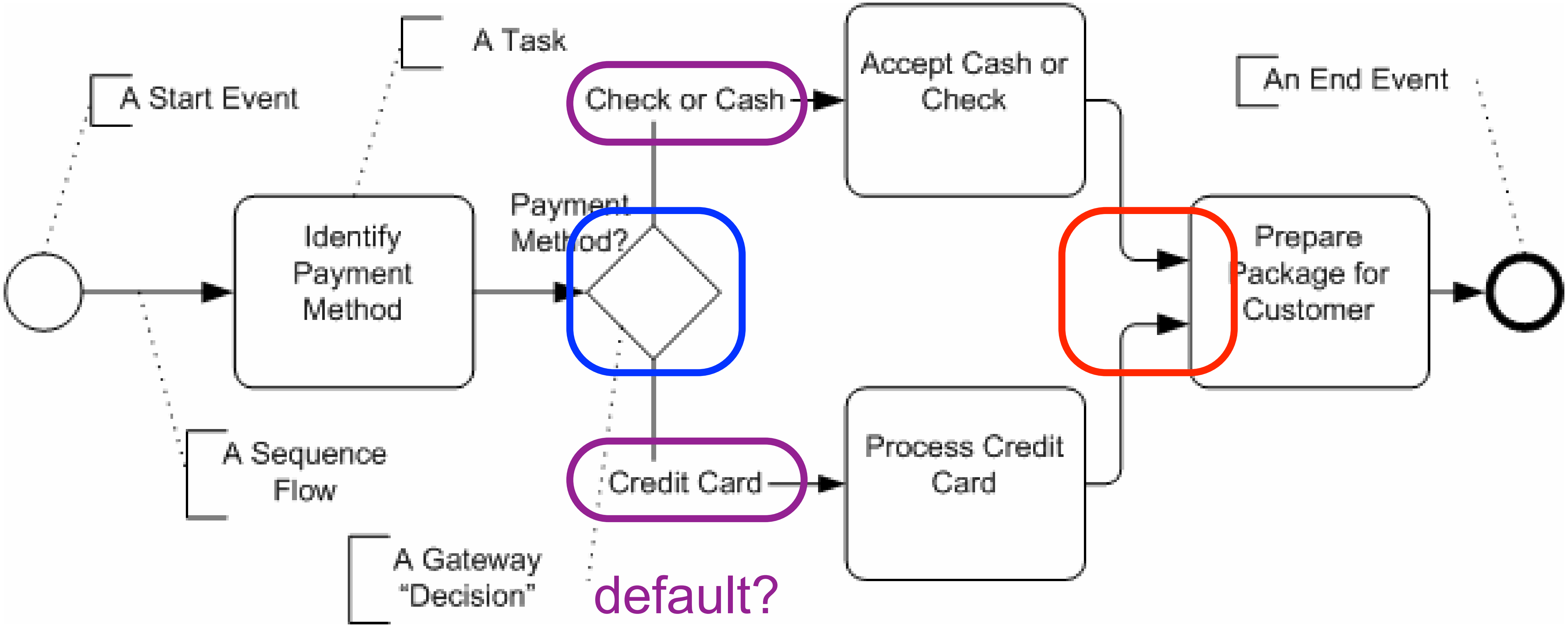
Message flow may not be used between Flow objects in Lanes of the same Pool

Question time



which symbol? which implicit gateway?

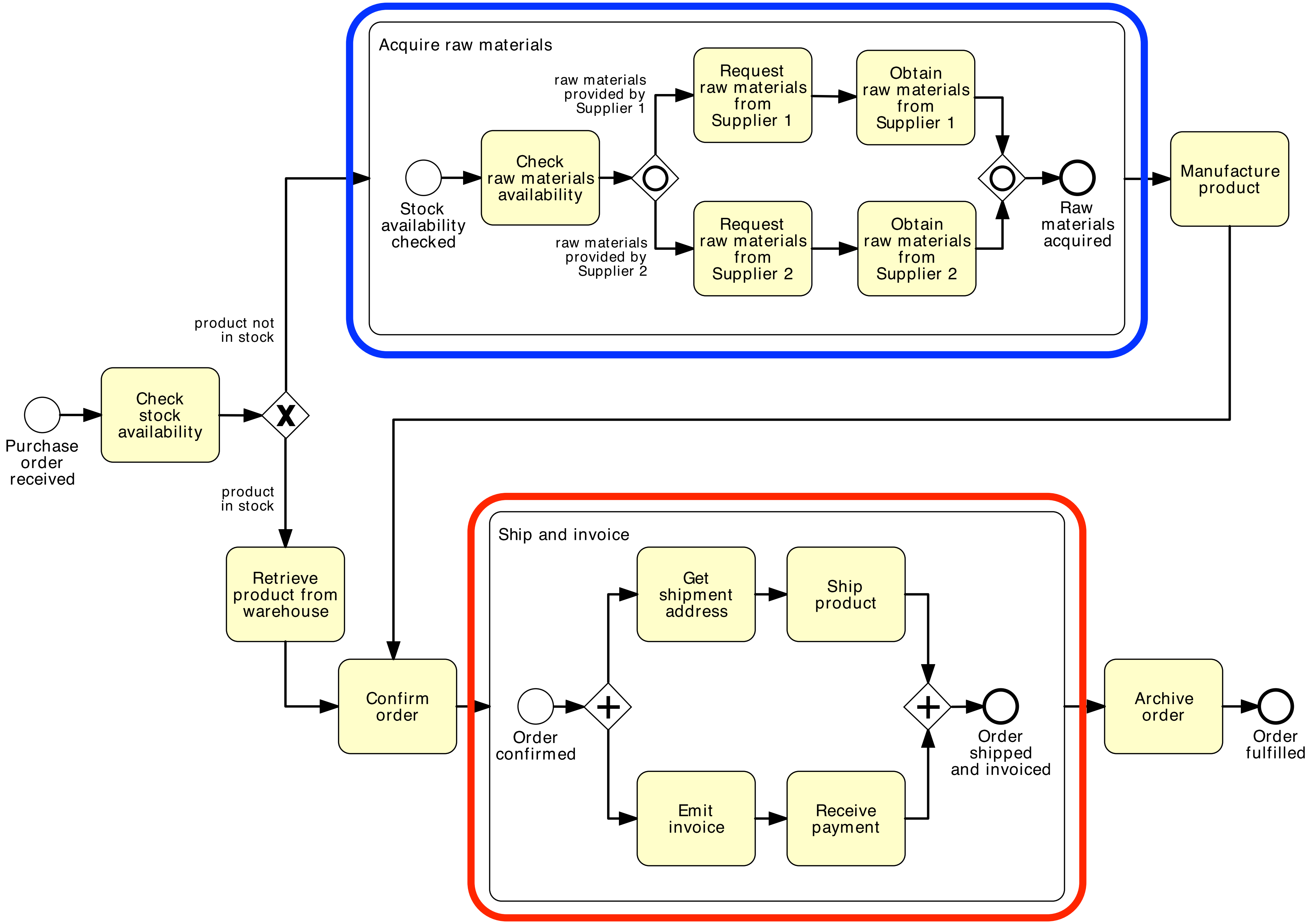
Question time



which symbol?
XOR

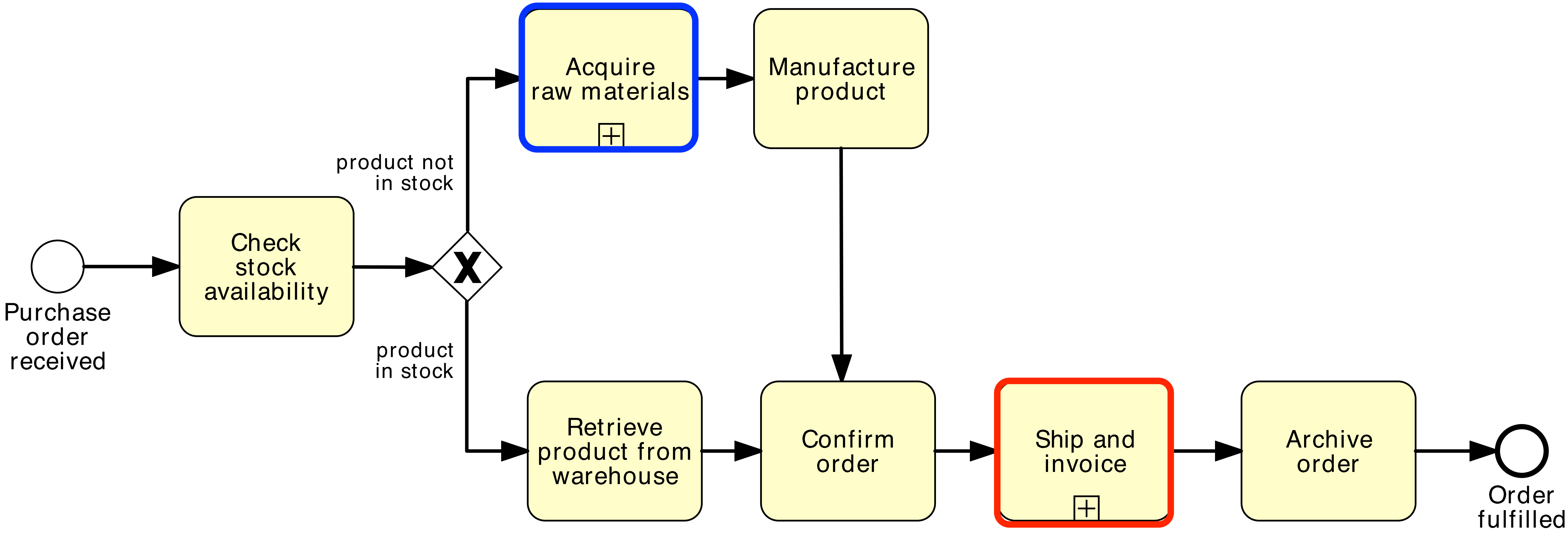
which implicit gateway?
XOR

Identify sub-processes: order fulfillment

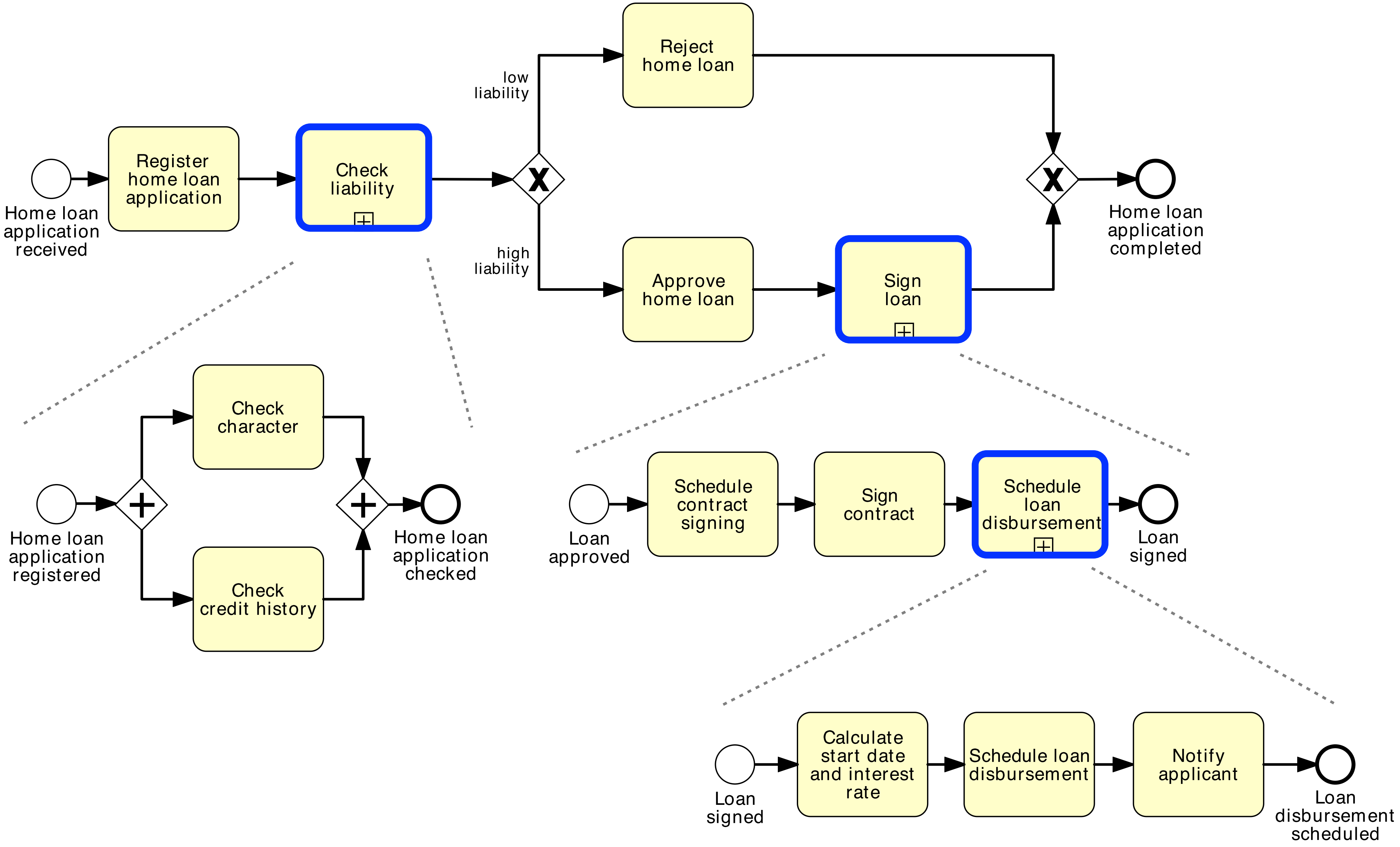


Acquire raw materials
Stock availability checked
Check raw materials availability
raw materials provided by Supplier 1
Request raw materials from Supplier 1
Obtain raw materials from Supplier 1
raw materials provided by Supplier 2
Request raw materials from Supplier 2
Obtain raw materials from Supplier 2
Raw materials acquired
Manufacture product
product not in stock
Purchase order received
Check stock availability
product in stock
Retrieve product from warehouse
Confirm order
Ship and invoice
Order confirmed
Get shipment address
Ship product
Emit invoice
Receive payment
Order shipped and invoiced
Archive order
Order fulfilled

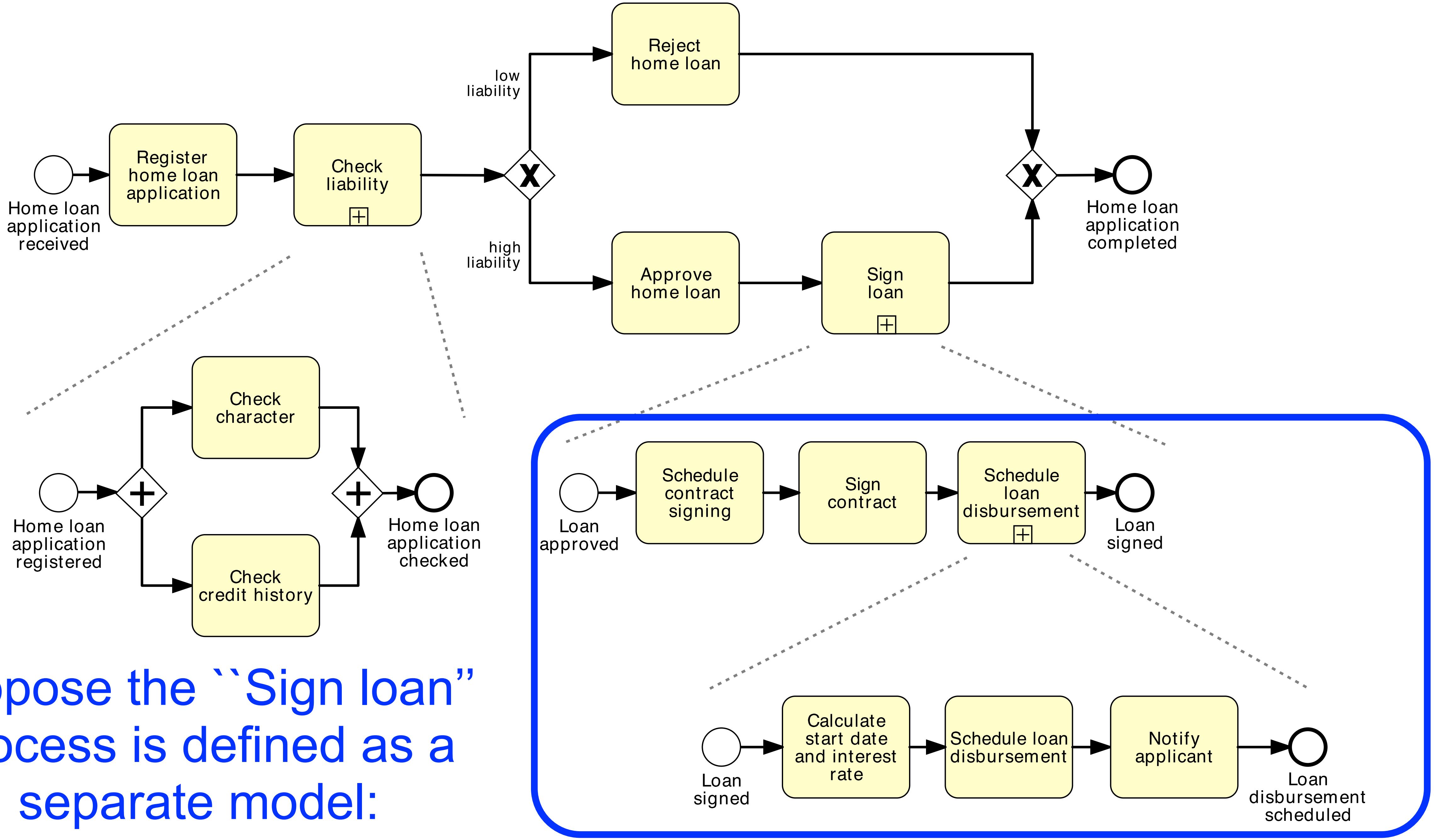
Hiding sub-processes: order fulfillment



Nesting sub-processes: home loans


Register home loan application
Check liability
Home loan application received
low liability
high liability
Reject home loan
Approve home loan
Sign loan
Home loan application completed
Check character
Check credit history
Home loan application registered
Home loan application checked
Schedule contract signing
Sign contract
Schedule loan disbursement
Loan approved
Loan signed
Calculate start date and interest rate
Schedule loan disbursement
Notify applicant
Loan signed
Loan disbursement scheduled

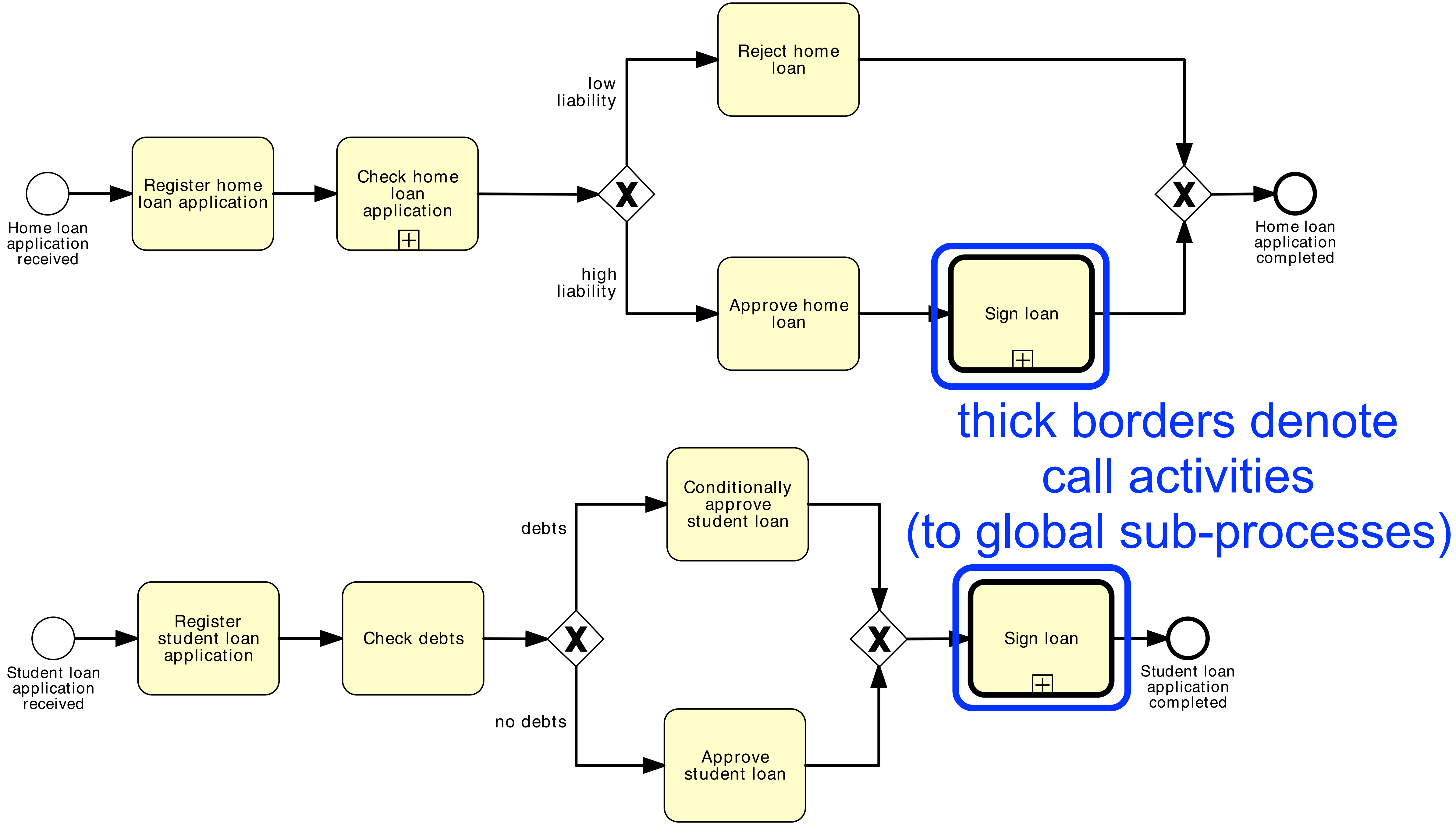
Global sub-processes: home / student loans



Home loan application received
Register home loan application
Check liability
low liability
high liability
Reject home loan
Approve home loan
Sign loan
Home loan application completed
Home loan application registered
Check character
Check credit history
Home loan application checked
Loan approved
Schedule contract signing
Sign contract
Schedule loan disbursement
Loan signed
Loan signed
Calculate start date and interest rate
Schedule loan disbursement
Notify applicant
Loan disbursement scheduled

suppose the ``Sign loan” process is defined as a separate model: it can be reused

Call activities: home / student loans


Home loan application received
Register home loan application
Check home loan application
low liability
high liability
Reject home loan
Approve home loan
Sign loan
Home loan application completed
Student loan application received
Register student loan application
Check debts
debts
no debts
Conditionally approve student loan
Approve student loan
Sign loan
Student loan application completed

thick borders denote call activities (to global sub-processes)

Global processes: advantages

Readability: processes tend to be smaller

Reusability: define once, use many time

Sharing: any change made to a global process
is automatically propagated to all models that invoke it

Exercises

Model the following fragments of business processes for assessing loan applications:

Exercise: loan application 1

Once a loan application has been **approved** by the loan provider, an acceptance pack is **prepared** and **sent** to the customer.

The acceptance pack includes a repayment schedule which the customer needs to agree upon by **sending the signed documents** back to the loan provider.

The latter then verifies the repayment agreement:
if the applicant disagreed with the repayment schedule, the loan provider **cancels** the application;
if the applicant agreed, the loan provider **approves** the application.
In either case, the process completes with the loan provider **notifying** the applicant of the application status.

Exercise: loan application 2

A loan application is **approved** if it passes **two checks**:
(i) the applicant's loan **risk assessment**, which is done automatically by a system, and
(ii) the **appraisal** of the property for which the loan has been asked, carried out by a property appraiser.

The risk assessment requires a **credit history check** on the applicant, which is performed by a financial officer.

Once both the loan risk assessment and the property appraisal have been performed, a loan officer can **assess** the applicant's eligibility.

If the applicant is not eligible, the application is **rejected**,
otherwise the acceptance pack is **prepared and sent** to the applicant.

Exercise: loan application 3

A loan application may be coupled with a home insurance which is offered at discounted prices.
The applicant may express their interest in a home insurance plan at the time of submitting their loan application to the loan provider.

Based on this information, **if** the loan application is **approved**, the loan provider may **either only** send an **acceptance pack** to the applicant, **or also** send a **home insurance quote**.

The process then continues with the **verification** of the repayment agreement.

Exercise: loan application 4

Once a loan application is **received** by the loan provider, and before proceeding with its assessment, the application itself needs to be **checked** for completeness.

If the application is incomplete, it is **returned** to the applicant, so that they can **fill out** the missing information and **send it back** to the loan provider.

This process is **repeated** until the application is complete.

Exercise: loan application 5

Put together the four fragments of the loan assessment process that you created in previous Exercises.

Then extend the resulting model by adding all the required artifacts.

Moreover, attach annotations to specify the business rules behind:
(i) checking an application completeness,
(ii) assessing an application eligibility, and
(iii) verifying a repayment agreement.

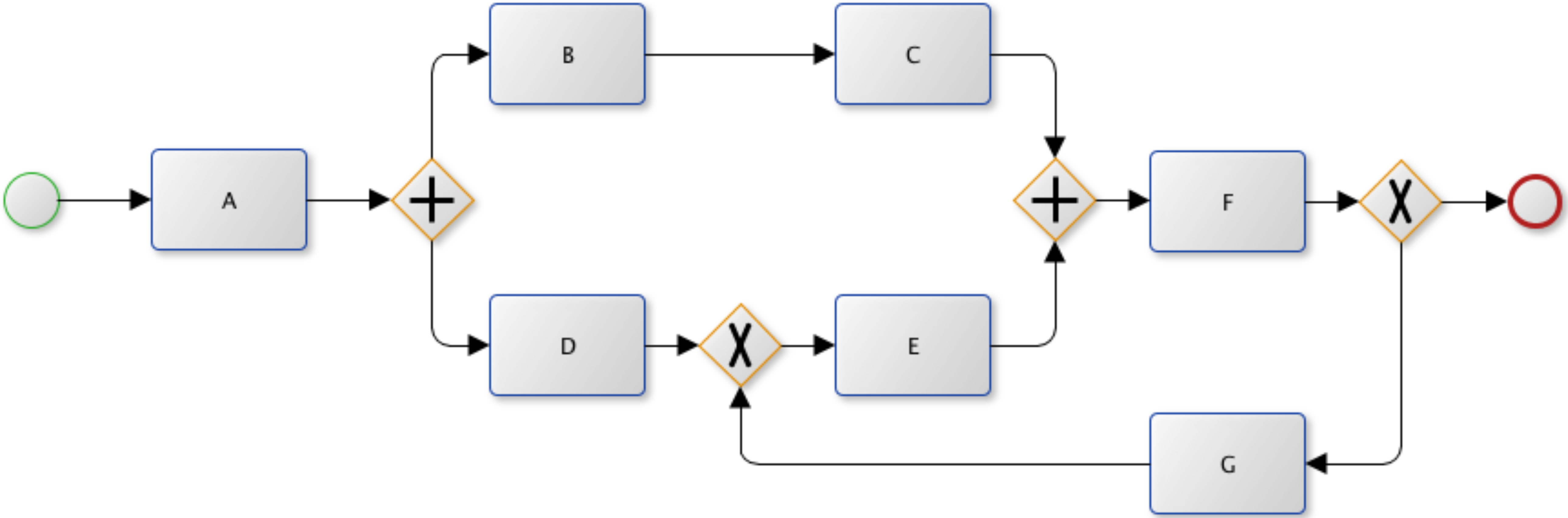
Exercise: loan application 6

Extend the business process for assessing loan applications that you created in previous exercises by considering the following resource aspects.

The process for assessing loan applications is executed by four roles within the **loan provider**:
a **financial officer** takes care of checking the applicant's credit history;
a **property appraiser** is responsible for appraising the property;
an **insurance sales representative** sends the home insurance quote to the applicant if this is required.
All other activities are performed by the **loan officer** who is the main point of contact with the applicant.

Exercises: refactoring

Can the process model below execute correctly?
If not, how can it be fixed without affecting the cycle, i.e. such that F, G, and E all remain in a cycle?



Semantics annotations

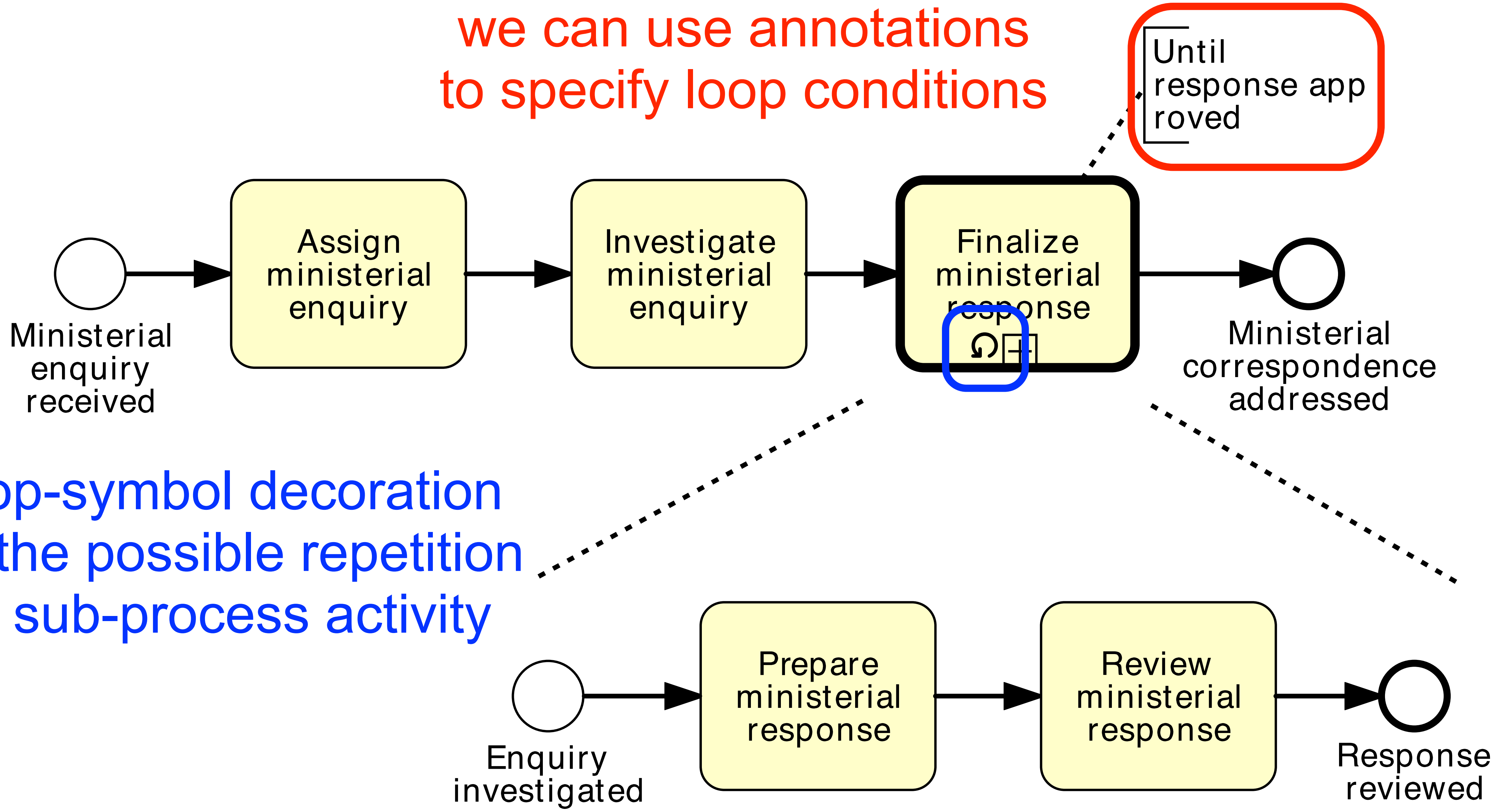
The graphical syntax is not expressive enough
to model exactly all interesting situations

In many cases part of the behaviour is moved
to decorations and annotations
(without them no implementation is possible)

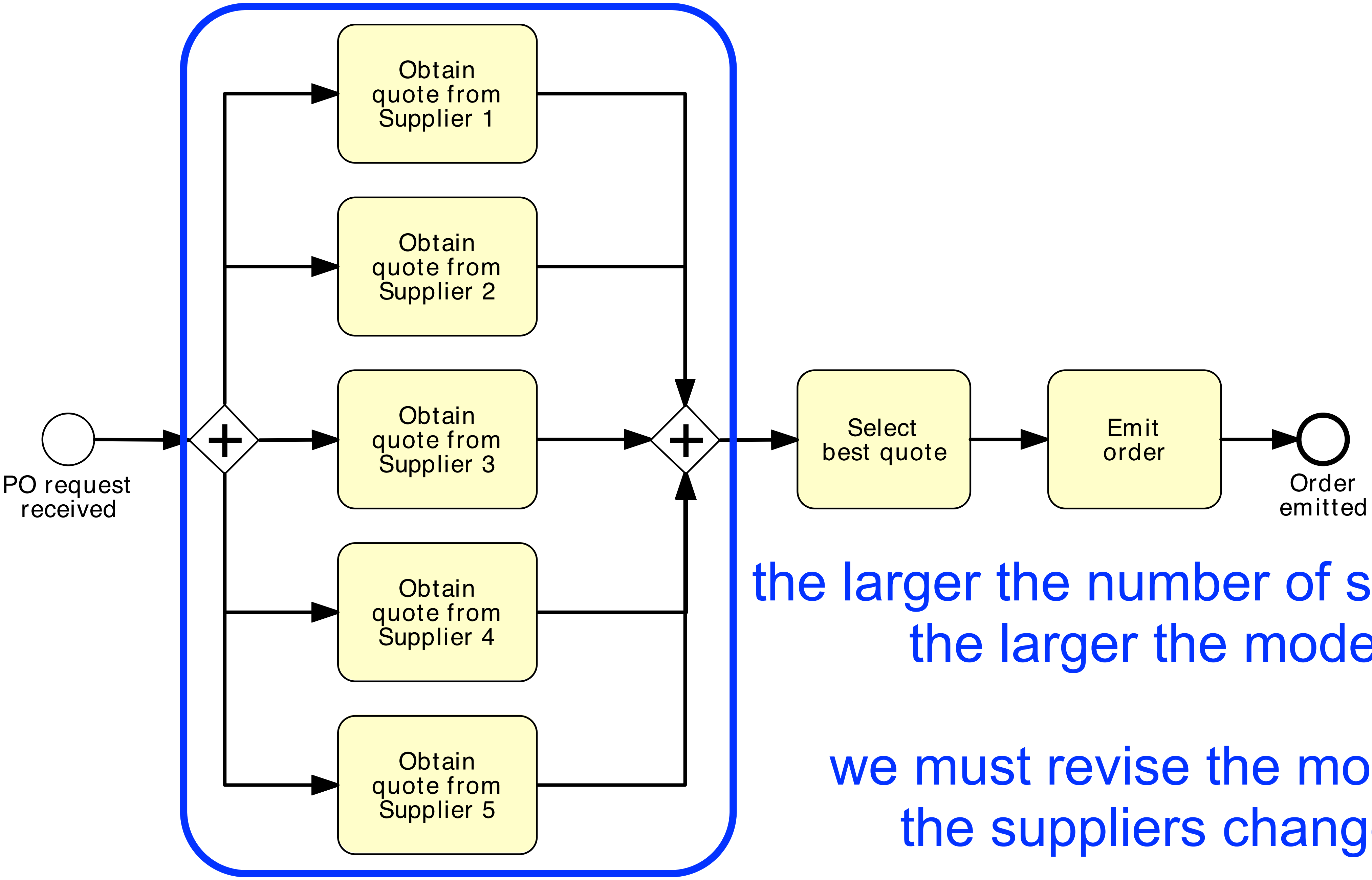
Loop annotation: ministerial correspondence

we can use annotations to specify loop conditions

the loop-symbol decoration marks the possible repetition of the sub-process activity



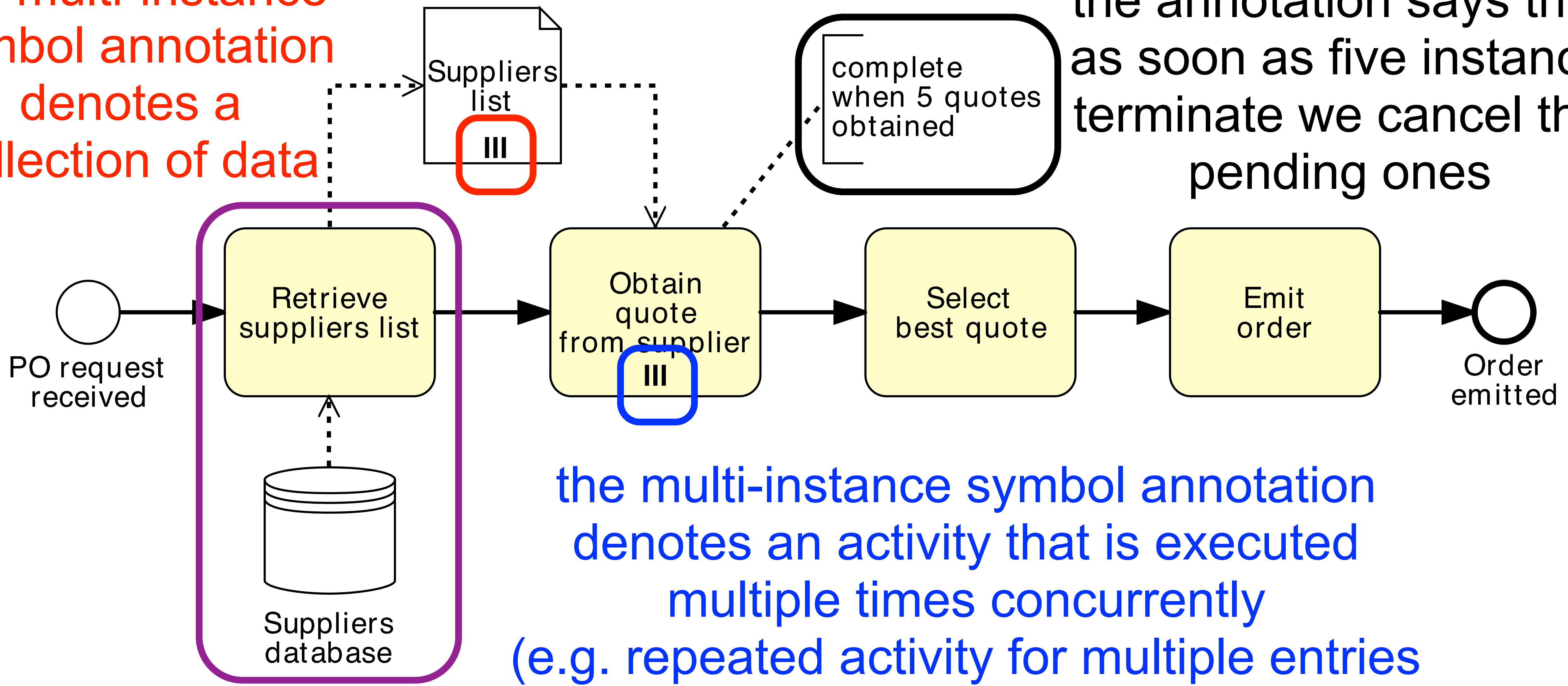
Parallel repetition: procurement process


Obtain quote from Supplier 1
Obtain quote from Supplier 2
Obtain quote from Supplier 3
Obtain quote from Supplier 4
Obtain quote from Supplier 5
PO request received
Select best quote
Emit order
Order emitted

the larger the number of suppliers the larger the model!

we must revise the model if the suppliers change!

Multi-instance activities: procurement process



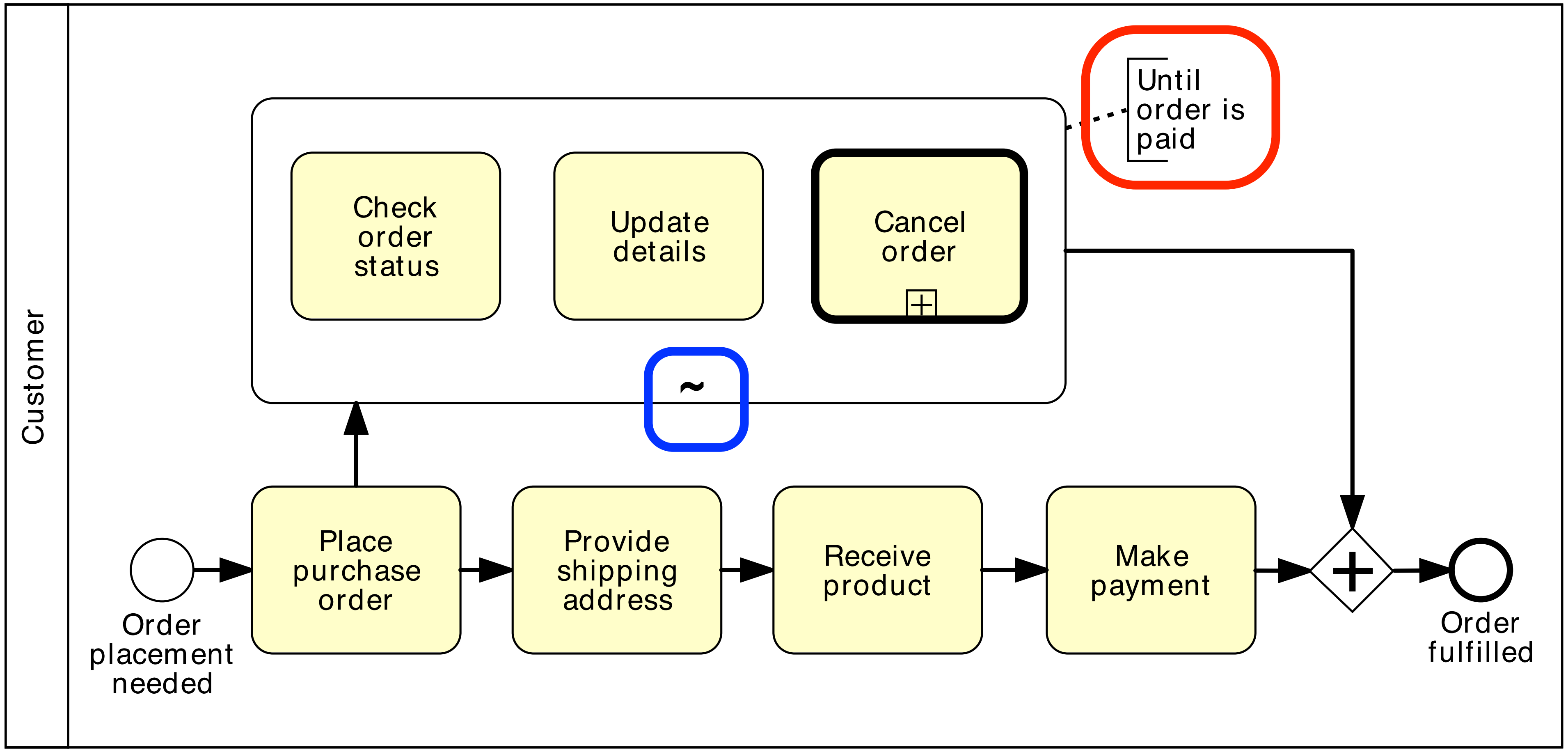
the multi-instance symbol annotation denotes a collection of data

the annotation says that as soon as five instance terminate we cancel the pending ones

the multi-instance symbol annotation denotes an activity that is executed multiple times concurrently (e.g. repeated activity for multiple entries or data-items)

the list of instances is determined dynamically

Ad-hoc sub-processes: customer process



we can use annotations to specify loop conditions

the ad-hoc symbol annotation
denotes an uncontrolled repetition of activities:
they may be repeated multiple times with no specific order
or not occur at all, until a condition is met

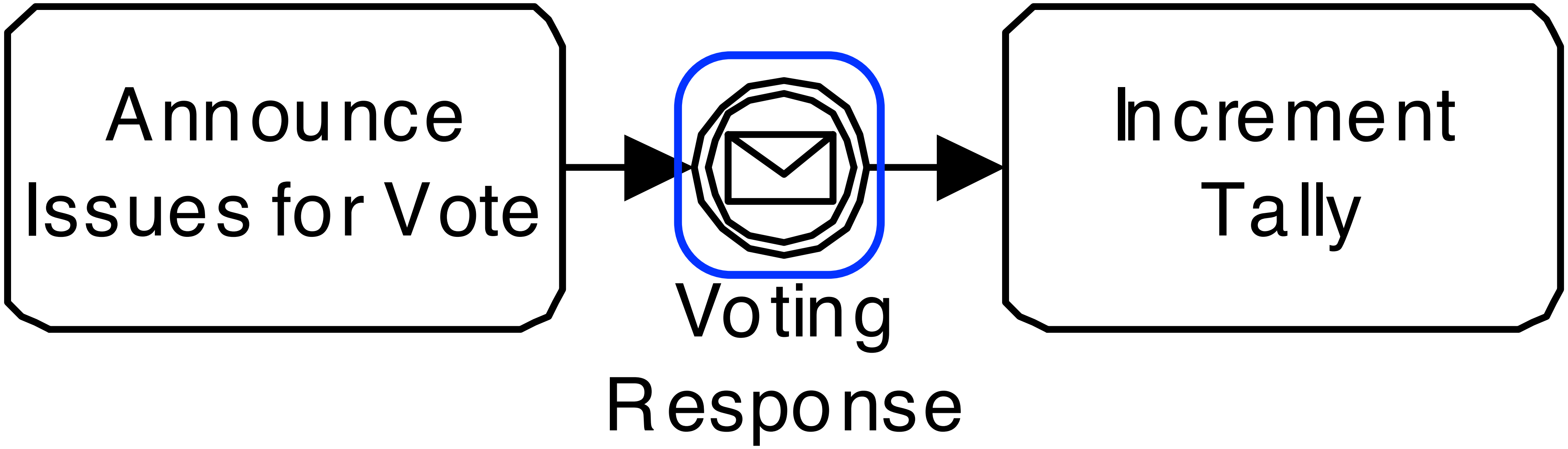
Message annotated events and activities

A start event can be annotated with a white-envelope:
a process instance is created
when a certain message is received

An end event can be annotated with a black-filled envelope:
the process concludes by sending a message

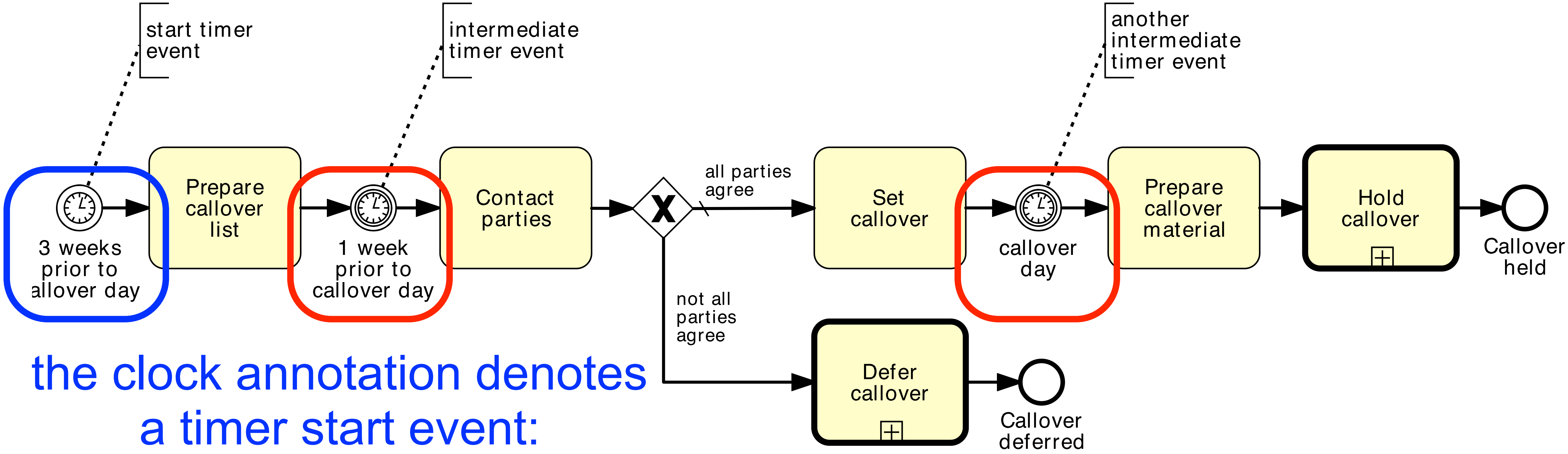
Intermediate events and activities can be annotated with
both kinds of envelope
(white = receipt of a message,
black = the sending of a message)

Process break (event waiting)



the envelope annotation denotes an intermediate message event: it signals the receipt of a message

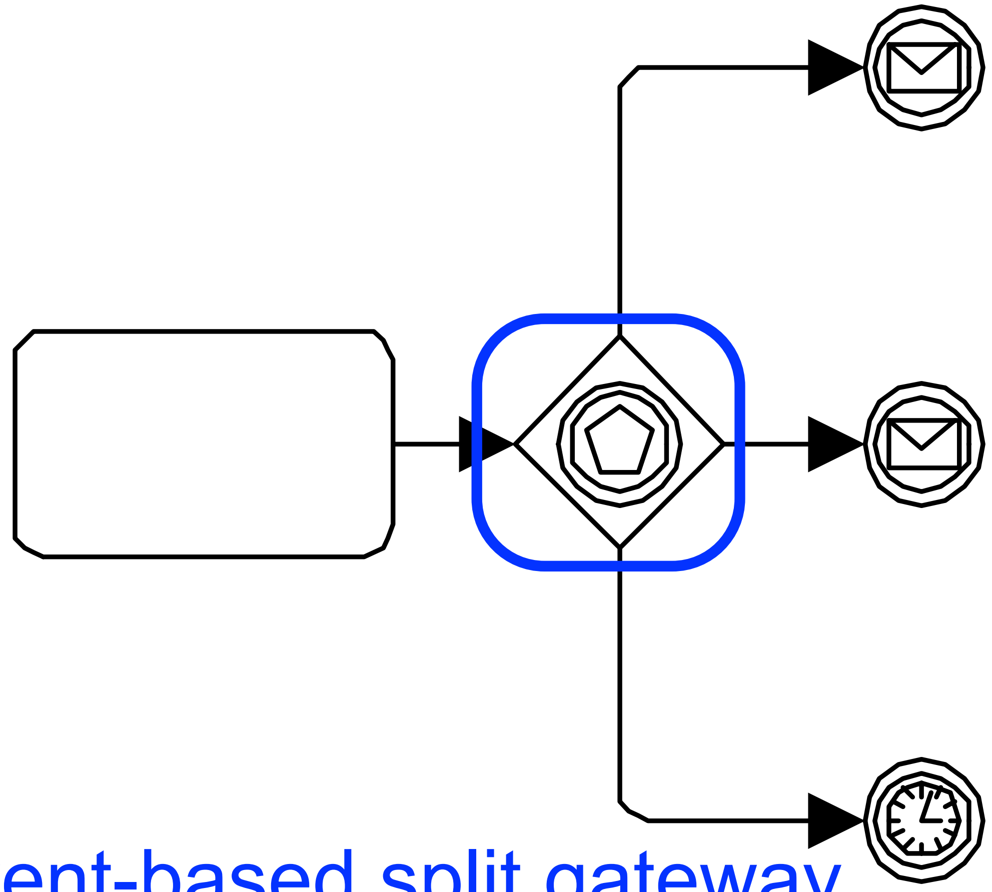
Timer events: small claims tribunal

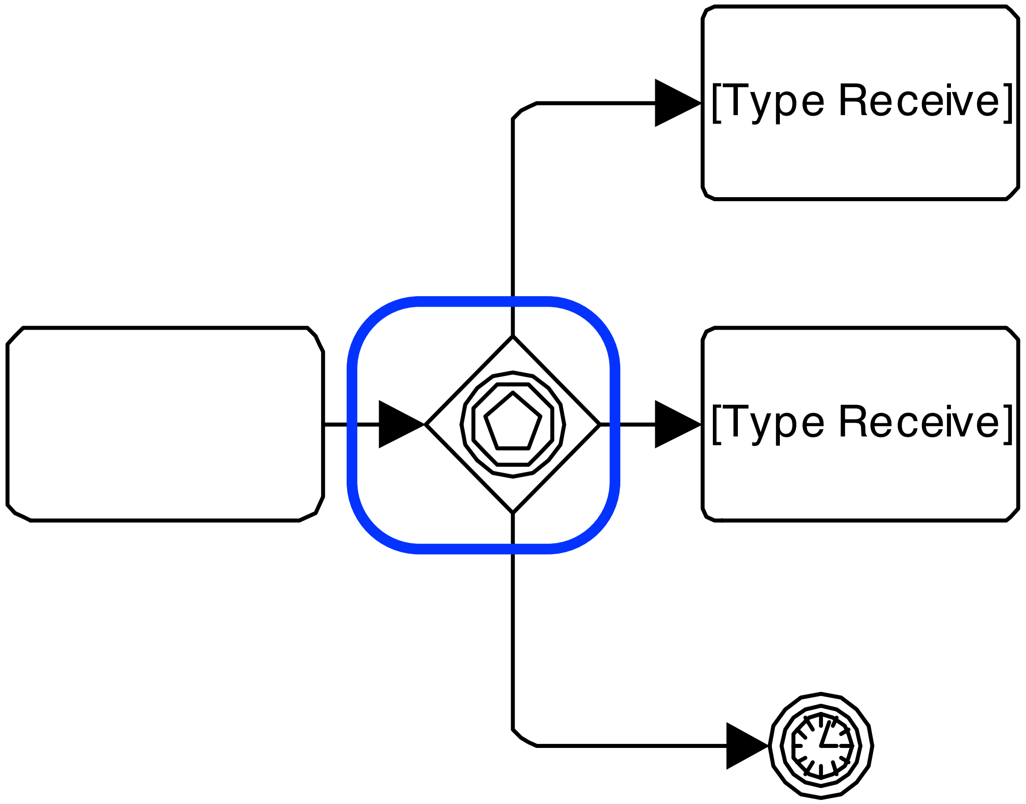


the clock annotation denotes a timer start event: an instance of the process is created when some temporal event happens

the clock annotation denotes a timer intermediate event: the process is blocked until a time-out expires

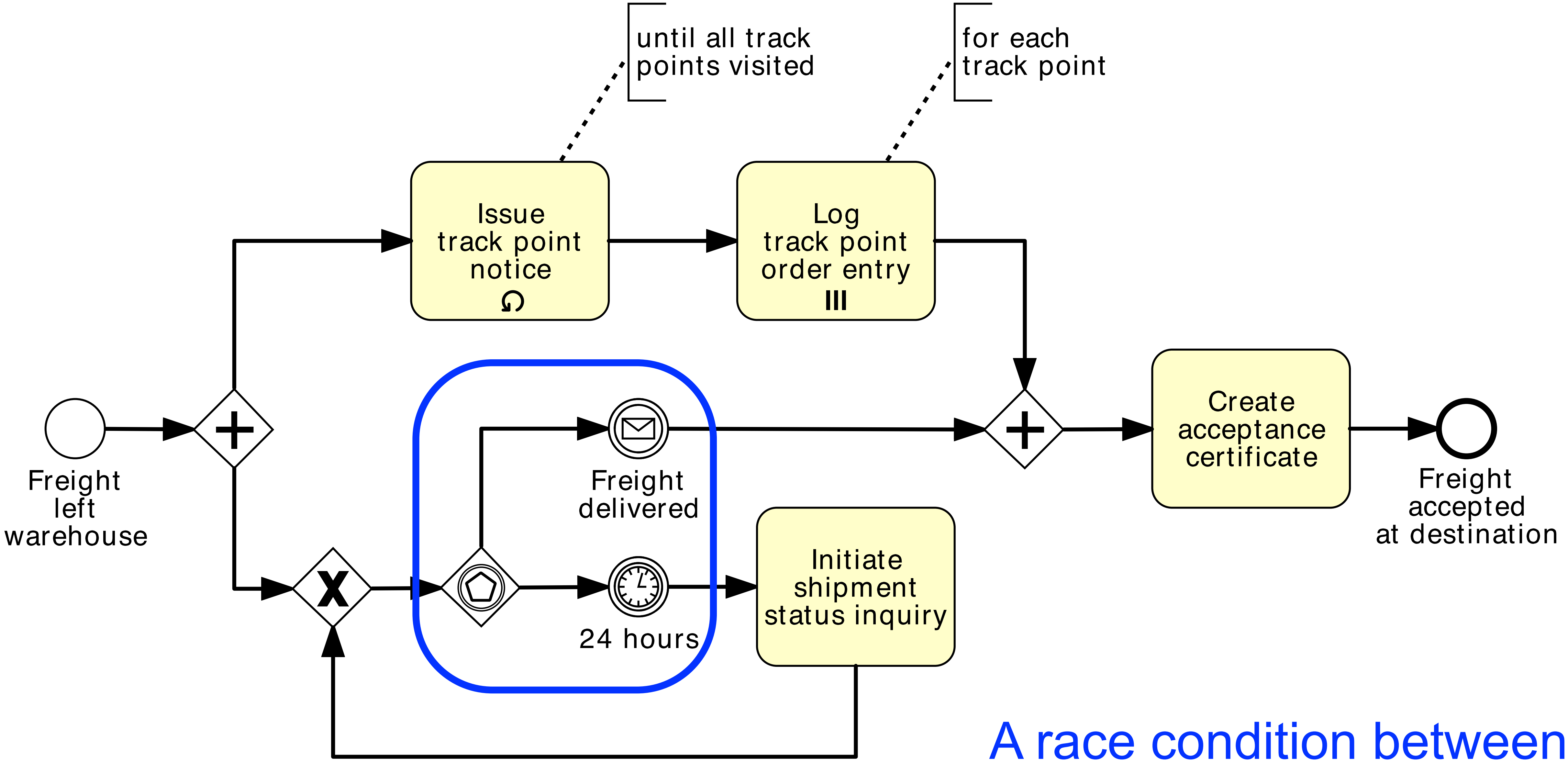
Event-based decisions (also deferred choice)





Event-based split gateway can be used to select a branch based on some external event

Deferred choice


until all track points visited
for each track point
Issue track point notice
Log track point order entry
Freight left warehouse
Freight delivered
24 hours
Initiate shipment status inquiry
Create acceptance certificate
Freight accepted at destination

A race condition between an incoming message and a timer

Exceptions: rainy-days vs sunny-days

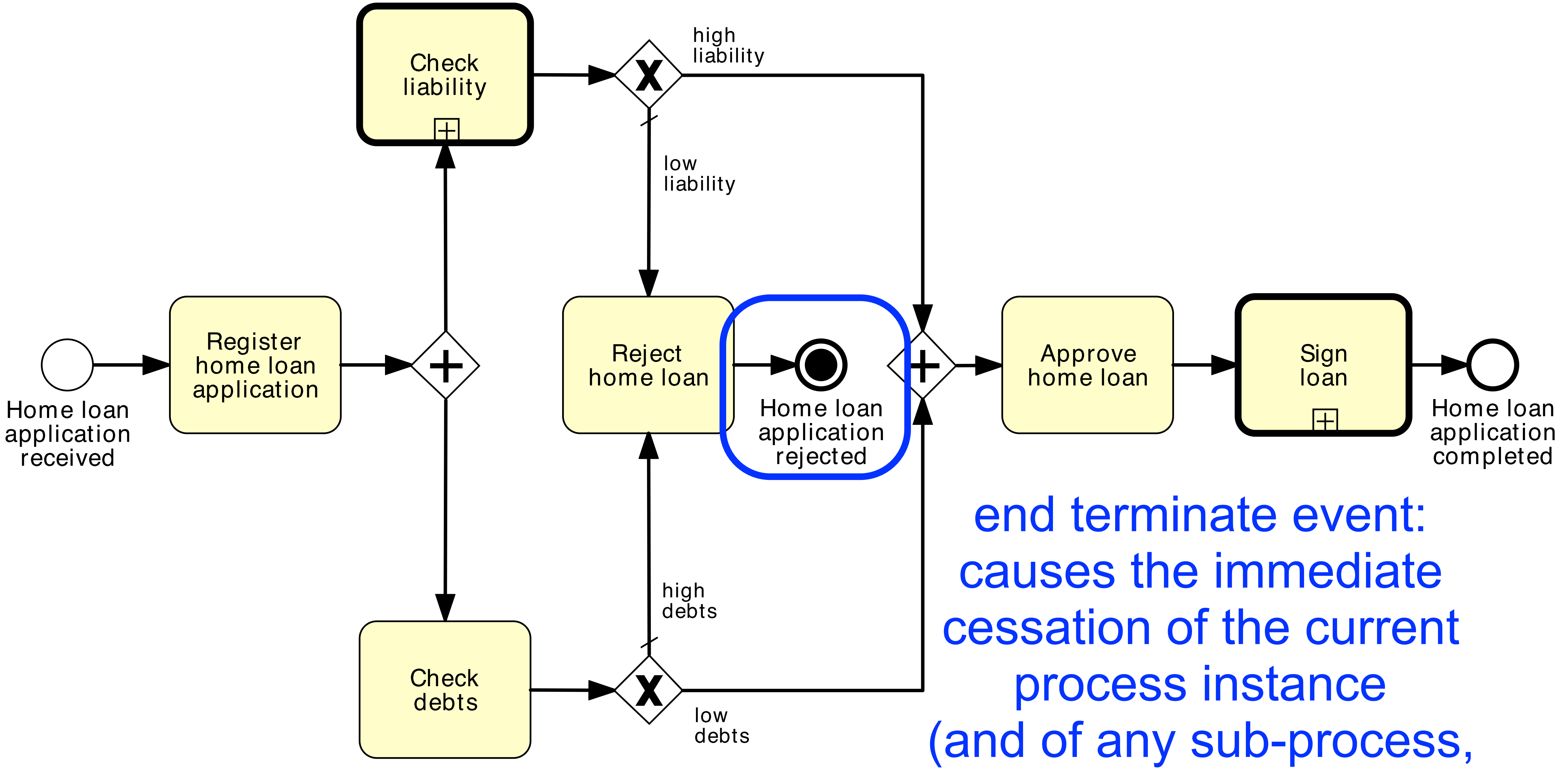
Exceptions are events
that deviate a process from its normal course

They include: business faults (e.g., out of stock),
technology faults (e.g., database crash)

Exceptions provoke the interruption or abortion
of the running process instance

Before adding exceptions it is important to have
the sunny-day scenario well understood

Process abortion: home loan


Check liability
high liability
low liability
Home loan application received
Register home loan application
Reject home loan
Home loan application rejected
Approve home loan
Sign loan
Home loan application completed
high debts
Check debts
low debts

end terminate event:
causes the immediate
cessation of the current
process instance
(and of any sub-process,
but not of the parent process if any)

Handling exceptions: rainy-days vs sunny-days

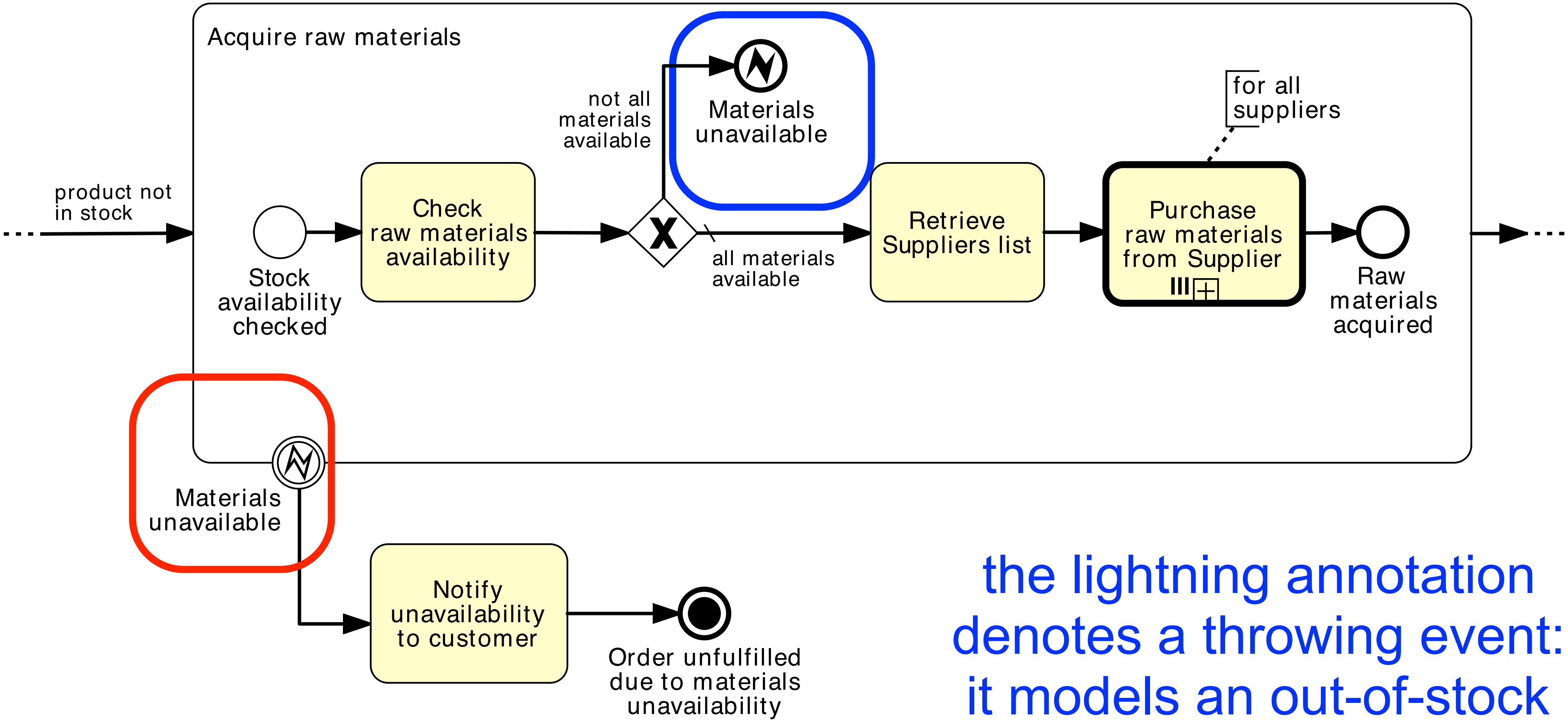
We can handle exceptions of sub-processes
by interrupting the activity that caused the exception
and moving the control flow to another process

The recovery procedure can try to bring the
process back to a consistent state

Error end events are used to interrupt the execution

Boundary events trigger the recovery procedure
(called exception flow)

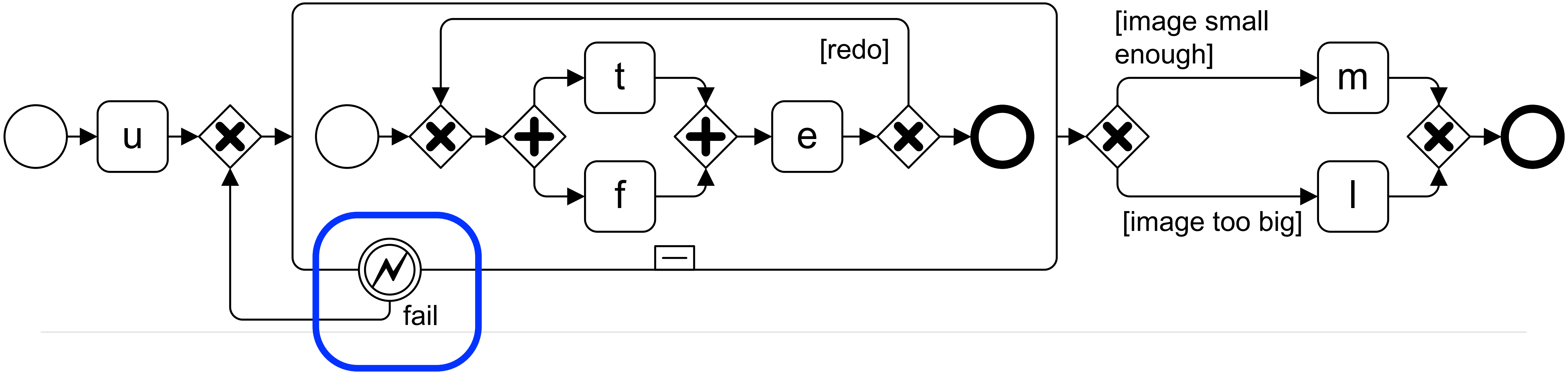
Throwing and catching: order fulfillment


Acquire raw materials
product not in stock
Stock availability checked
Check raw materials availability
not all materials available
Materials unavailable
all materials available
Retrieve Suppliers list
for all suppliers
Purchase raw materials from Supplier
Raw materials acquired
Materials unavailable
Notify unavailability to customer
Order unfulfilled due to materials unavailability

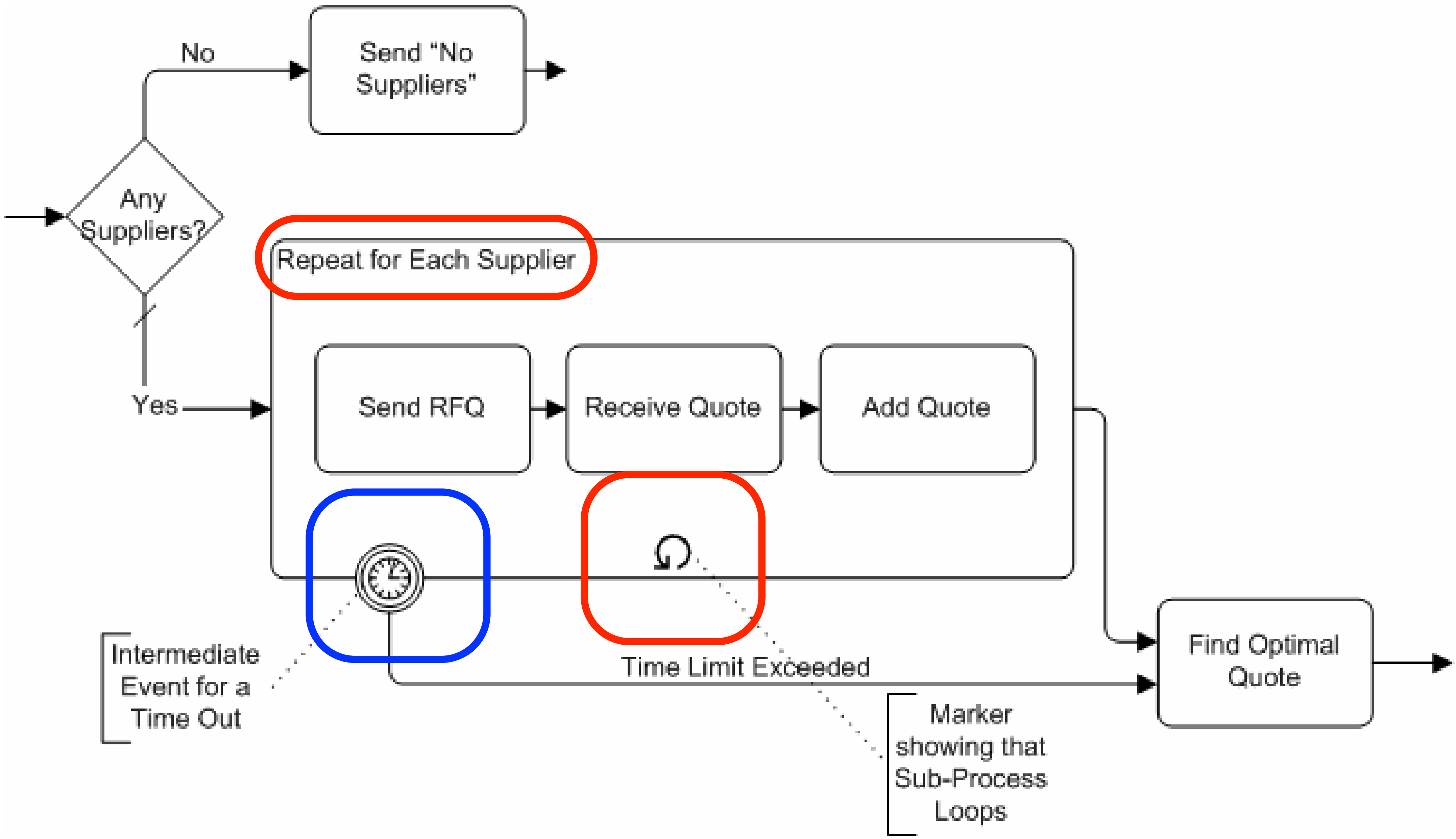
the lightning annotation denotes an error-catching event

the lightning annotation denotes a throwing event: it models an out-of-stock exception

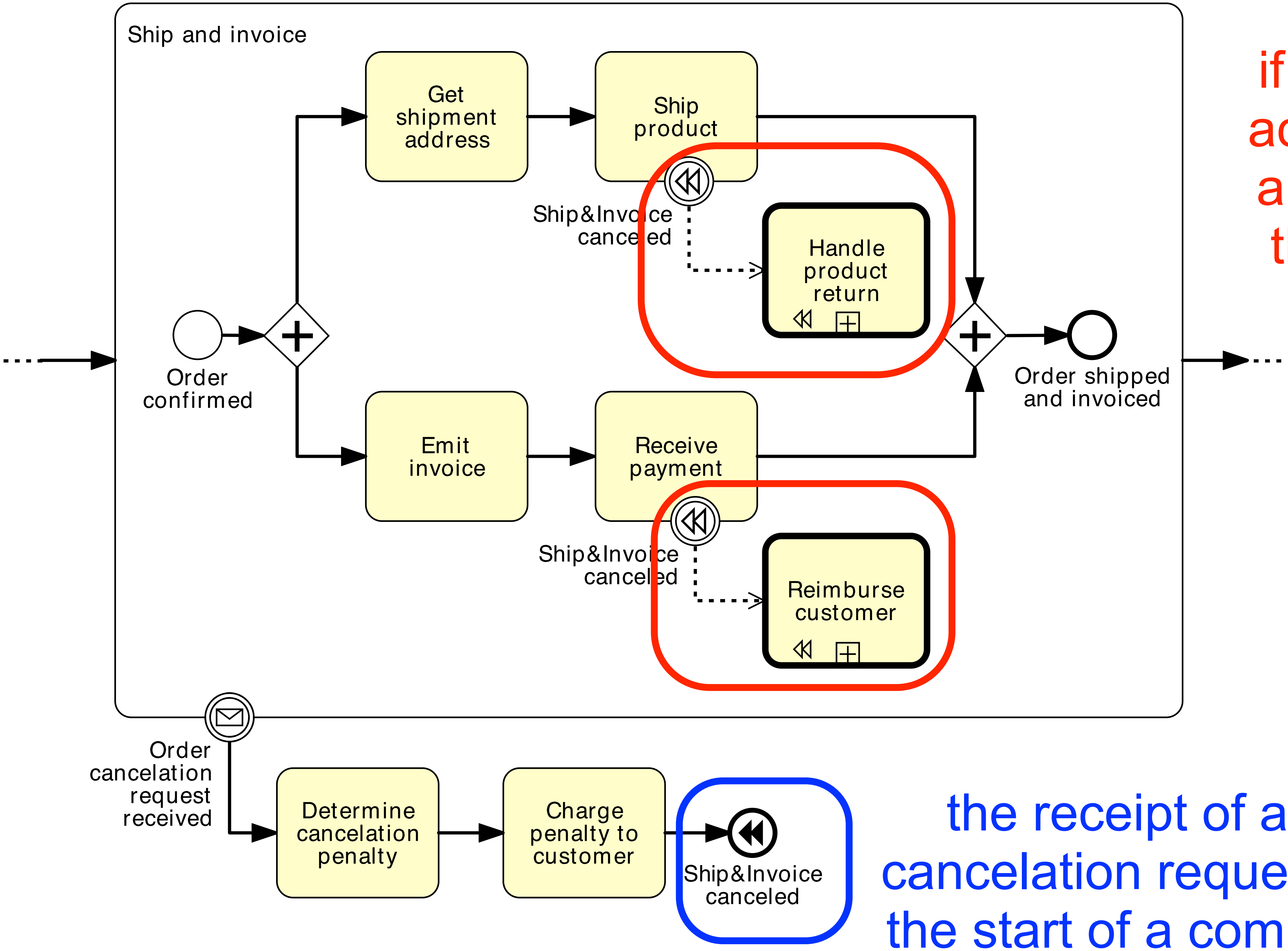
Recovery from faults: image manipulation



Intermediate time out and a loop



Compensations



if the compensable activities have been already completed, then they must be compensated

the receipt of an order cancelation request triggers the start of a compensation

Exercises

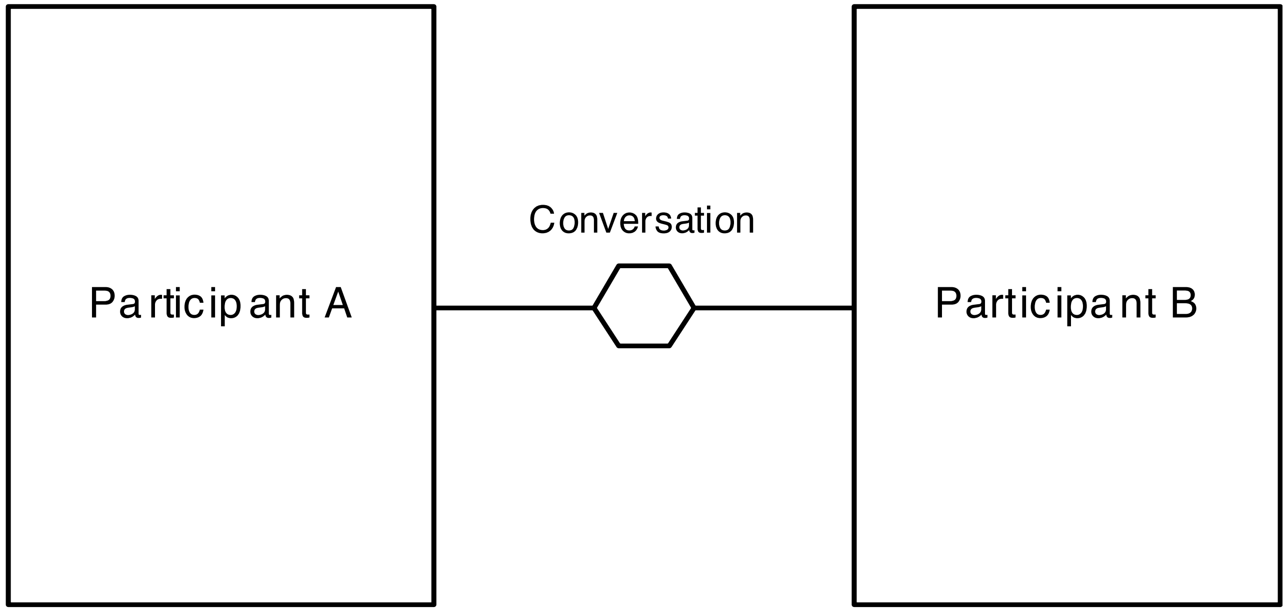
Model the following process fragment:

After a car accident, a statement is sought from two witnesses out of the five that were present, in order to lodge the insurance claim.
As soon as the first two statements are received, the claim can be lodged with the insurance company without waiting for the other statements.

Conversations, choreographies, and collaborations

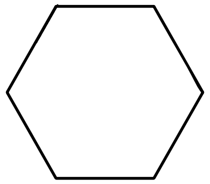
Conversation

A **Conversation** is the logical relation of (correlated) Message exchanges

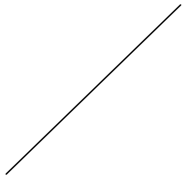


communication element

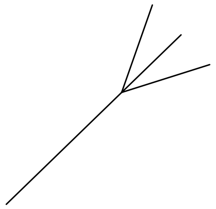
Conversation diagram



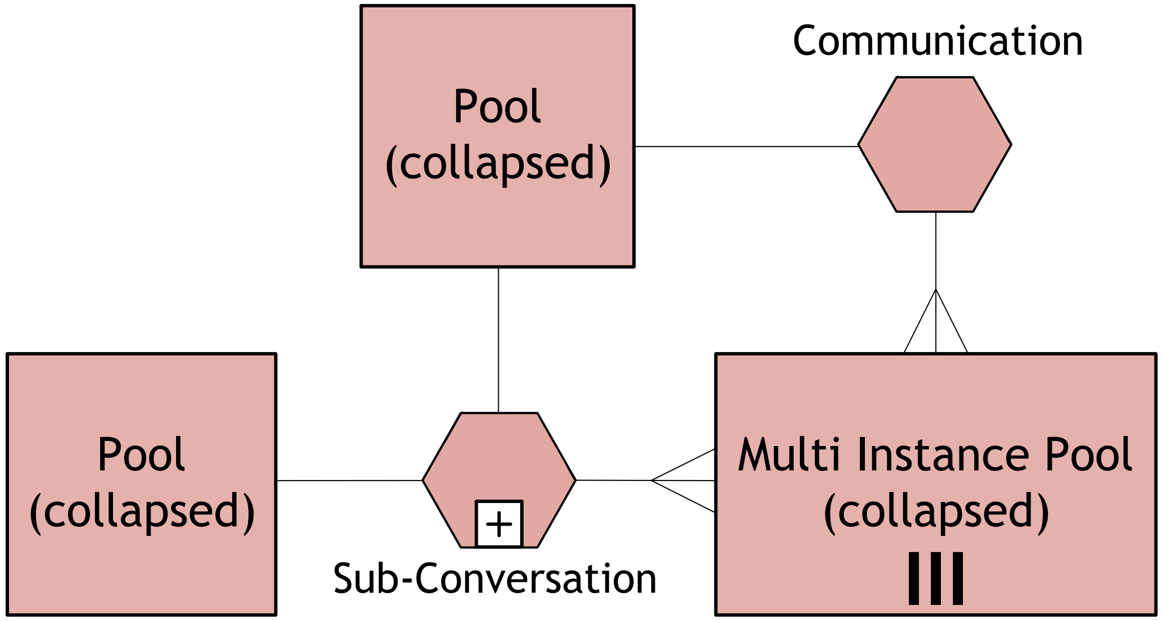
A **Communication** defines a set of logically related message exchanges. When marked with a ⊞ symbol it indicates a Sub-Conversation, a compound conversation element.



A **Conversation Link** connects Communications and Participants.



A **Forked Conversation Link** connect Communications and multiple Participants.



Choreography

The behaviour of different Conversations is modelled through separate Choreographies

A **Choreography** defines the sequence of interaction between participants

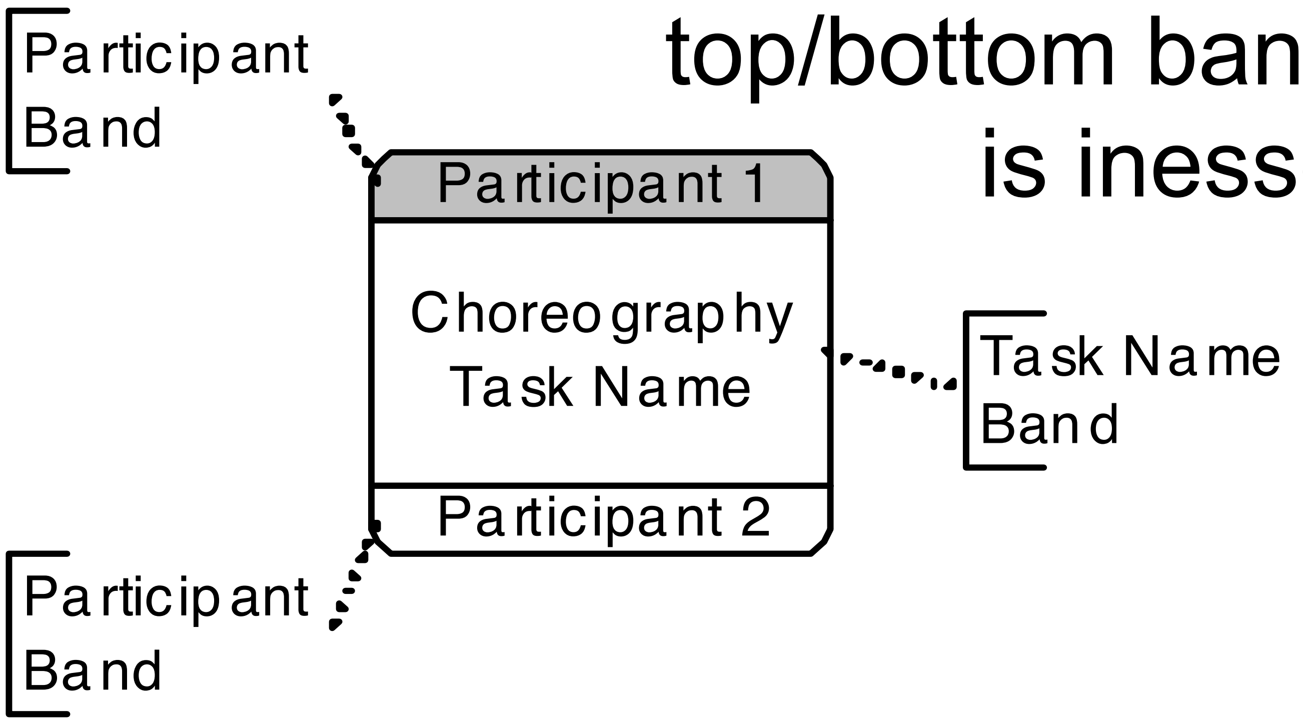
A choreography does not exists in a pool and it is not executable

It describes how the participants are supposed to behave

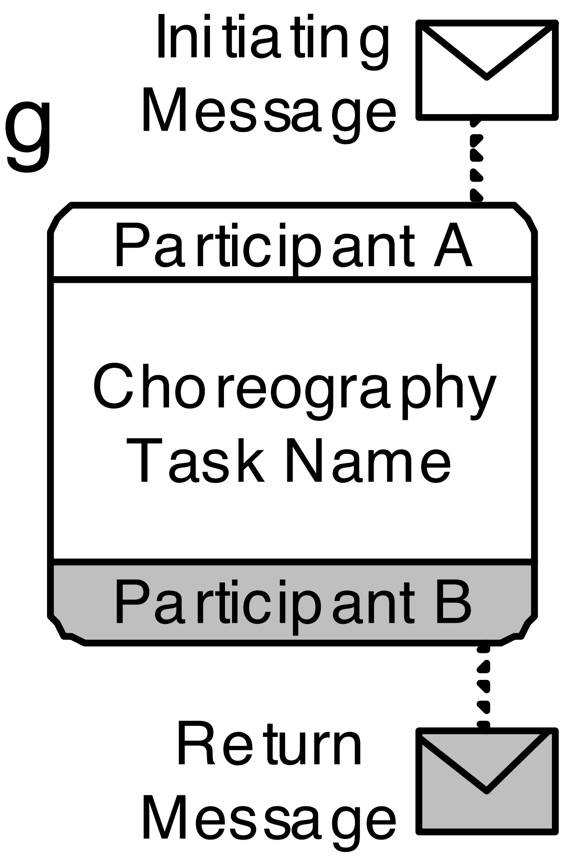
Choreography task

A **Choreography task** is an activity in a choreography that consists of a set (one or more) Message exchanges

A choreography task involves two or more participants that are displayed in different bands

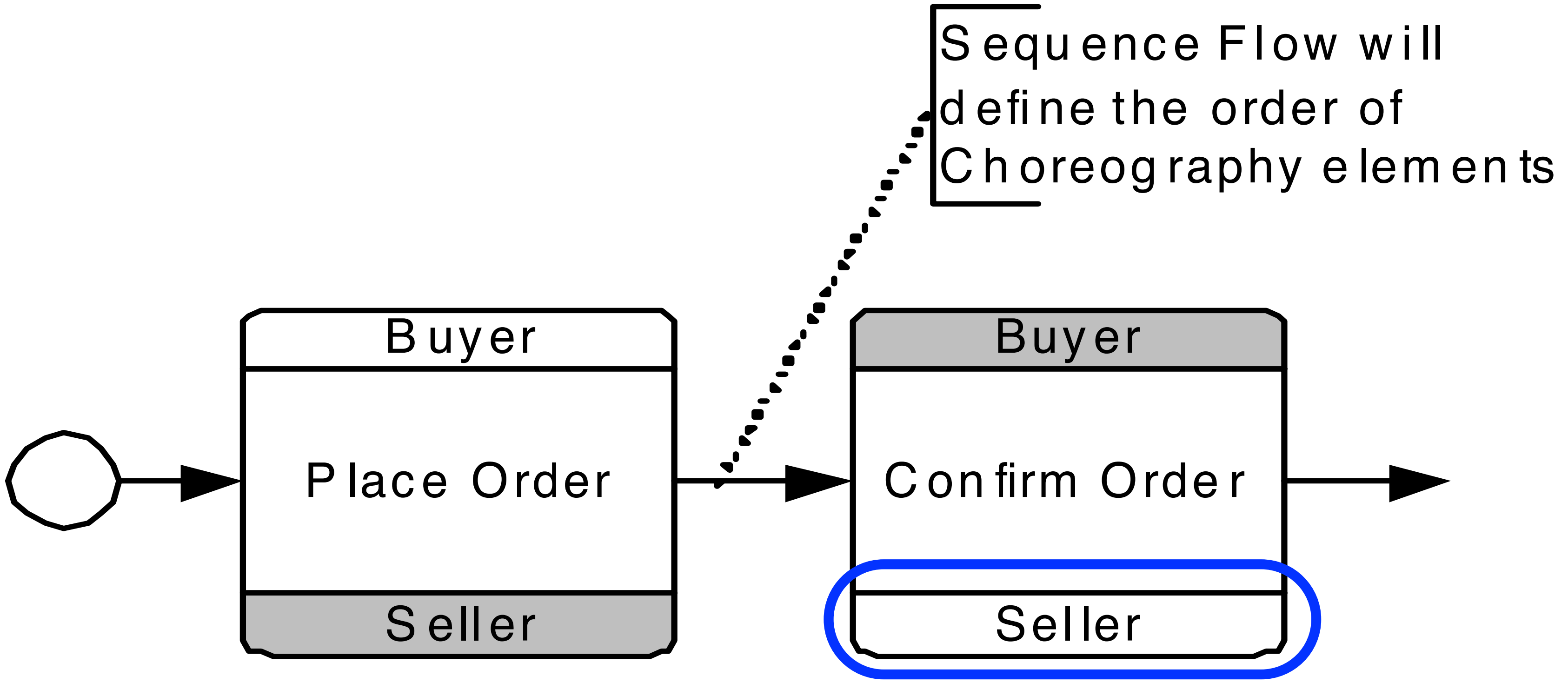


top/bottom band positioning is inessential



Sequence flow in a choreography

Sequence Flow are used within Choreographies
to show the sequence of the
Choreography Activities, Events, and Gateways


Sequence Flow will define the order of Choreography elements
Buyer
Place Order
Seller
Buyer
Confirm Order
Seller

the initiator of the second interaction
must be involved in the previous one

Collaboration

A **Collaboration** contains two or more Pools, representing the Participants in the Collaboration

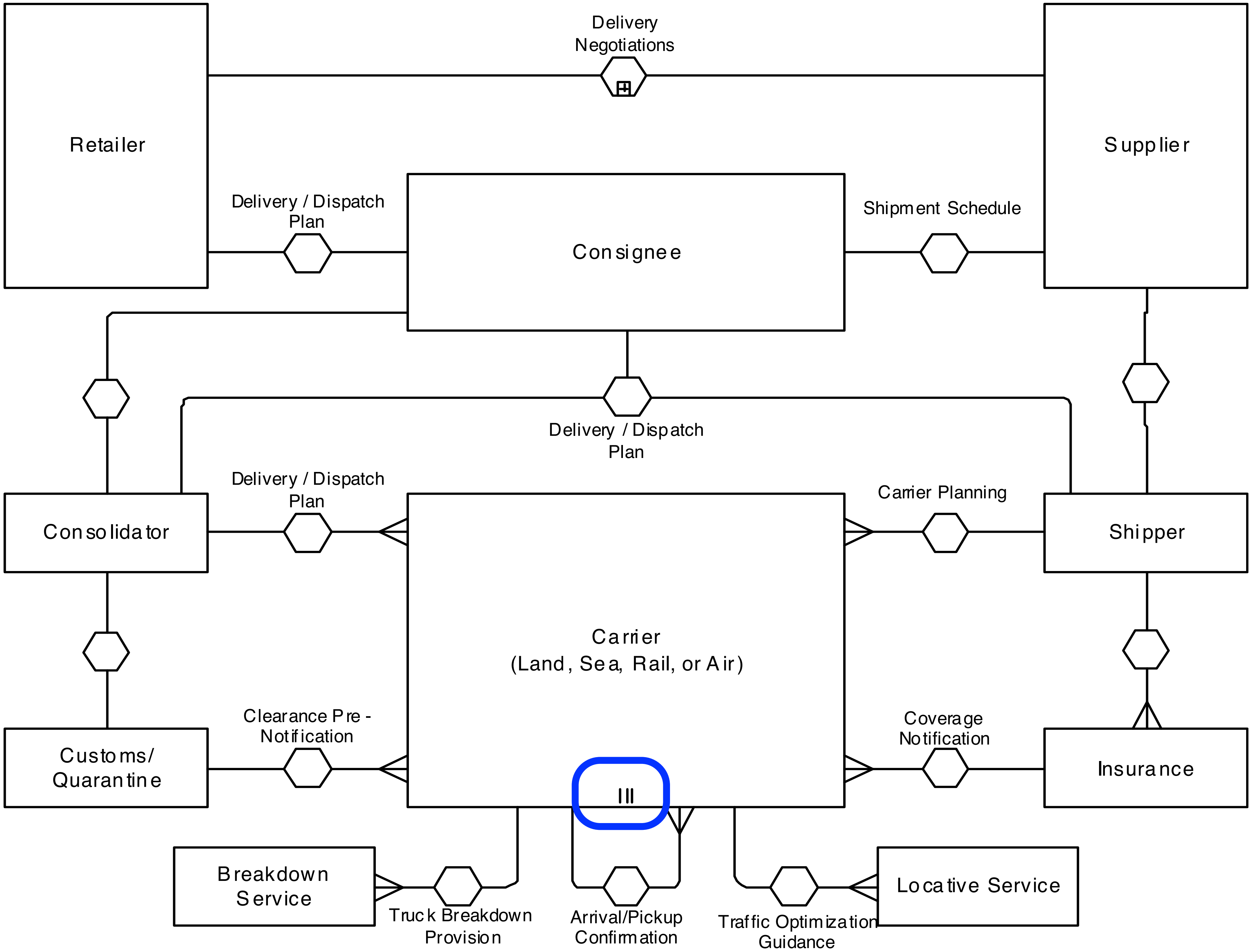
A Pool may be empty or show a Process within

The Message exchange is shown by a Message Flow that connects Pools or the objects within the Pools The Messages associated with the Message Flow may also be shown

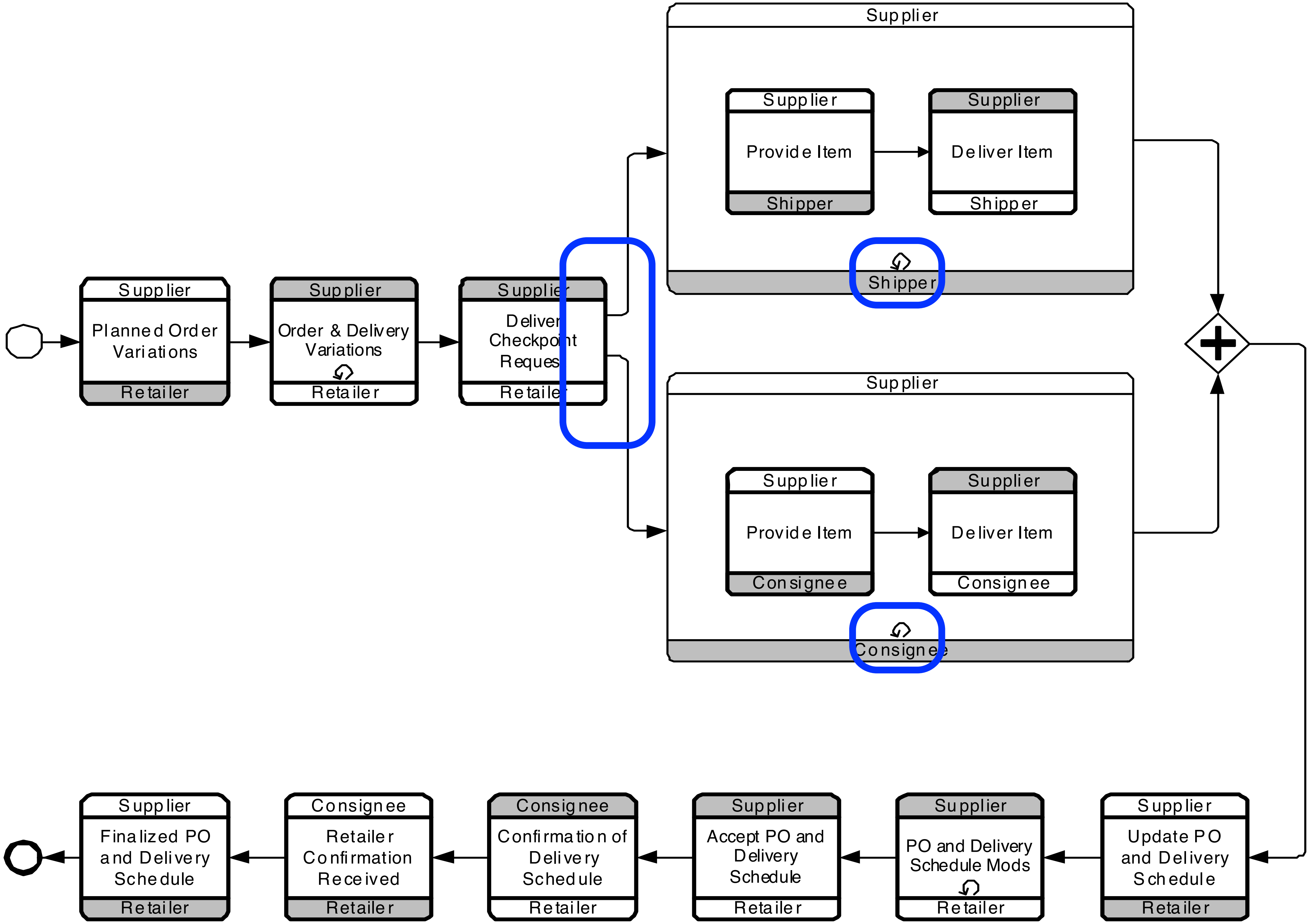
Choreographies may be shown “in between” the Pools as they bisect the Message Flow

Examples
(a taste of BPMN)

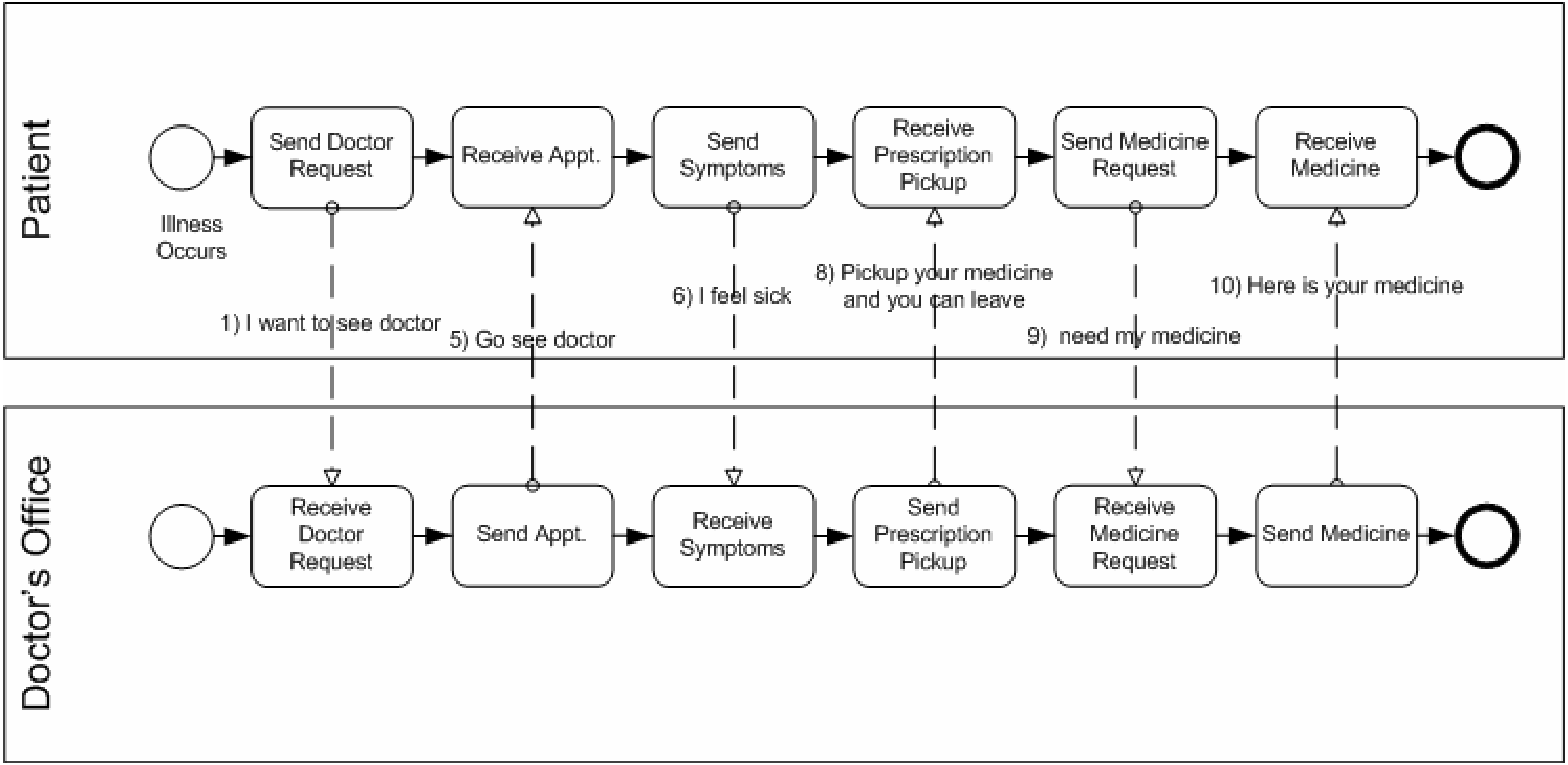
A conversation



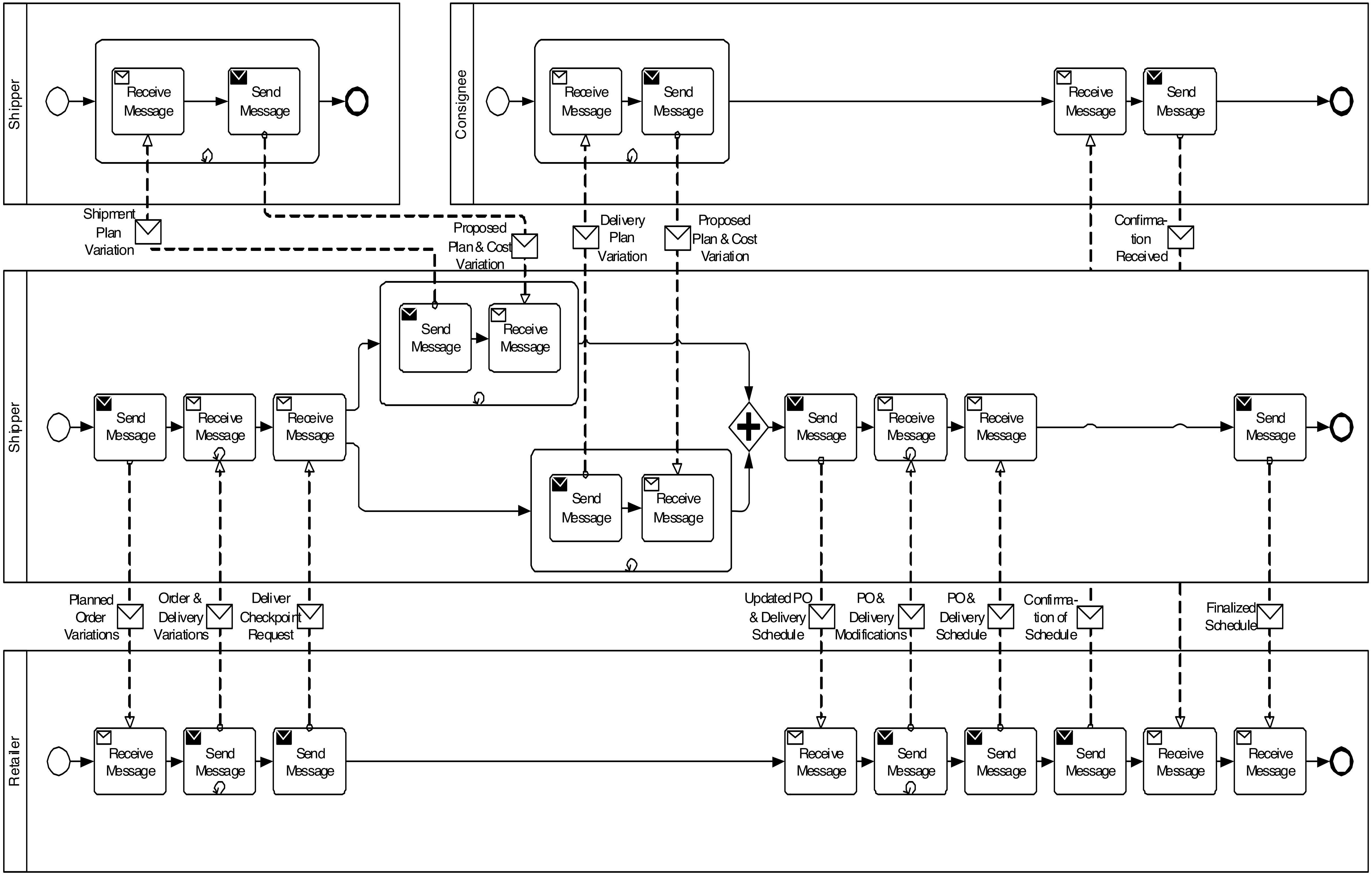
A choreography



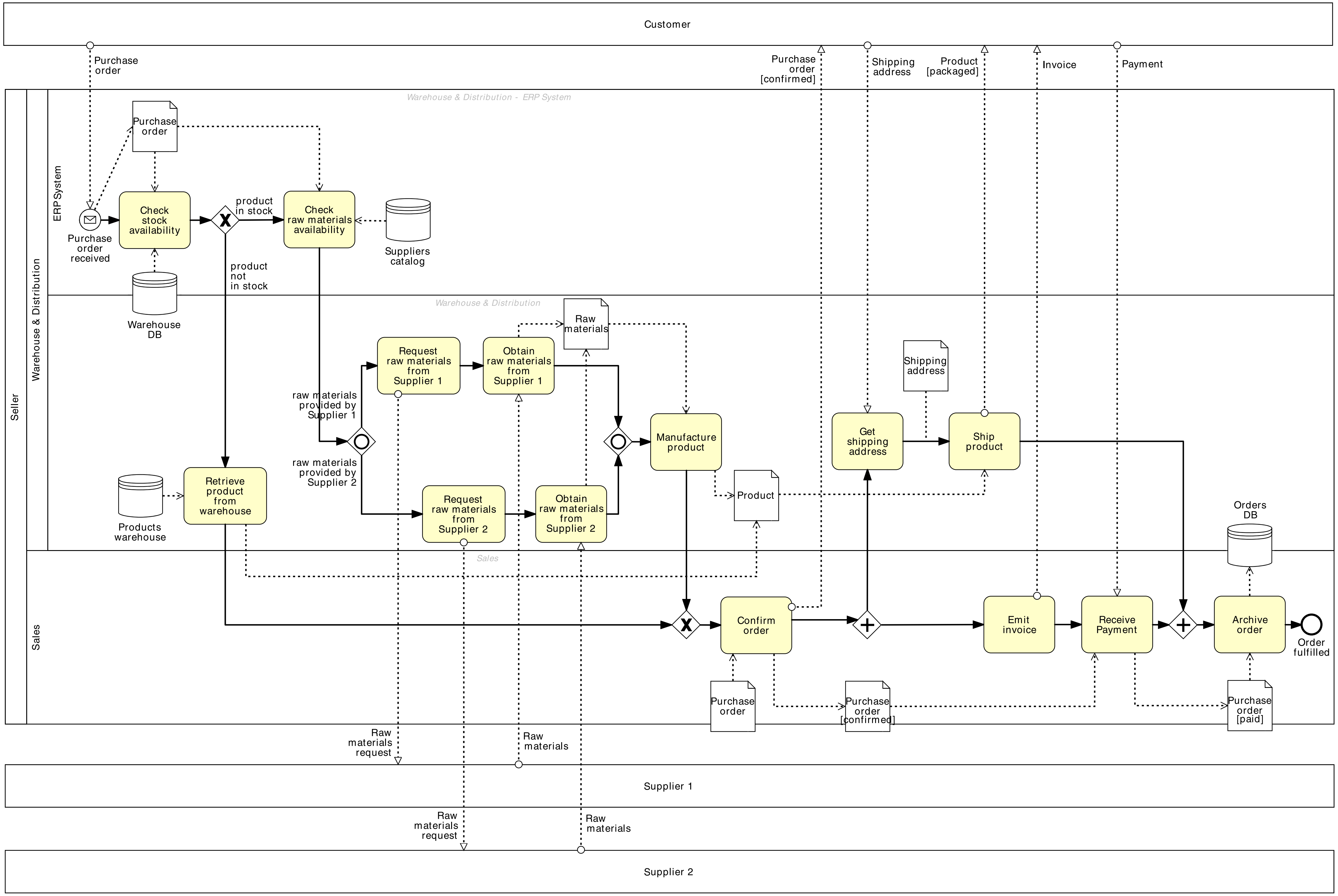
A collaboration with two pools



A collaboration diagram



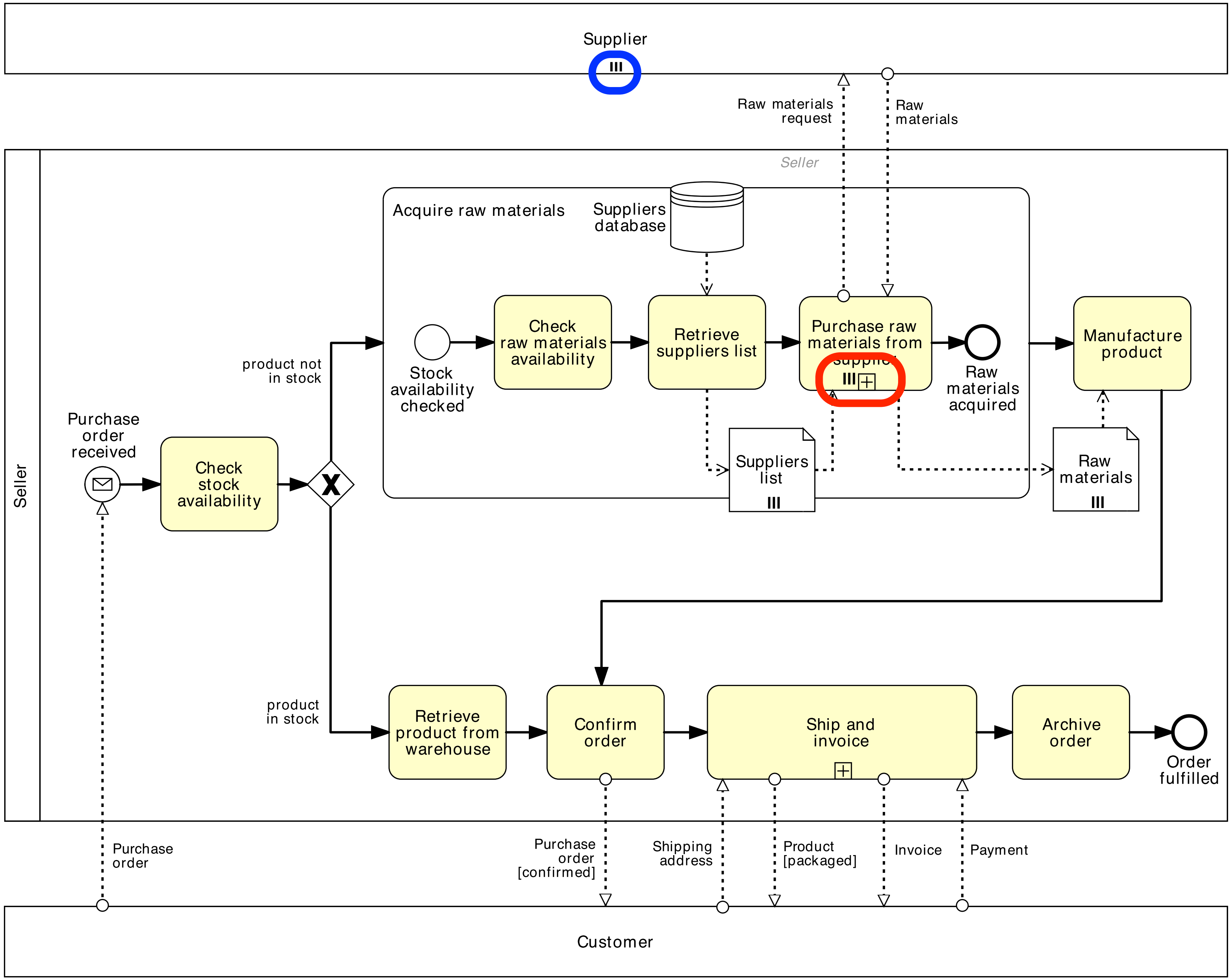
A collaboration diagram: order fulfillment



Multi-instance pools: order fulfillment

the multi-instance symbol annotation denotes
a set of resources
with similar characteristics

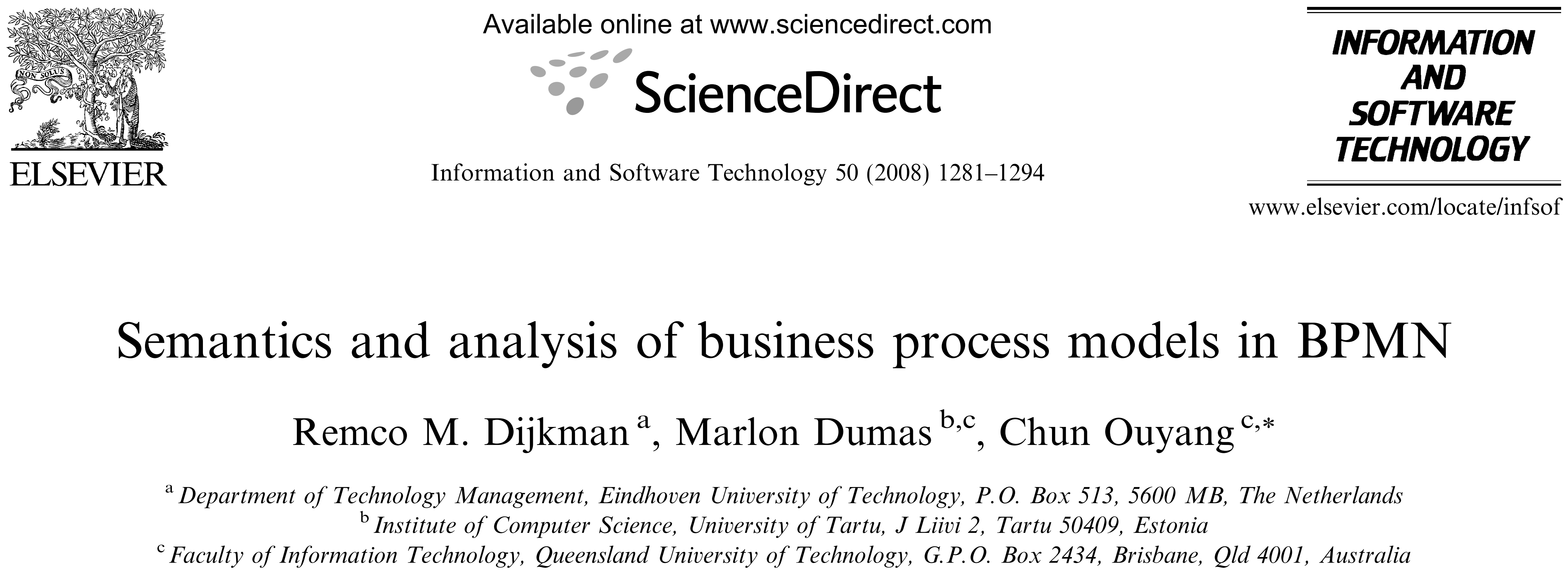
multi-instance sub-process



Exercises: loan application

Extend the loan application model by representing the interactions between the loan provider and the applicant.

From BPMN to Petri nets



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Semantics and analysis of business process models in BPMN

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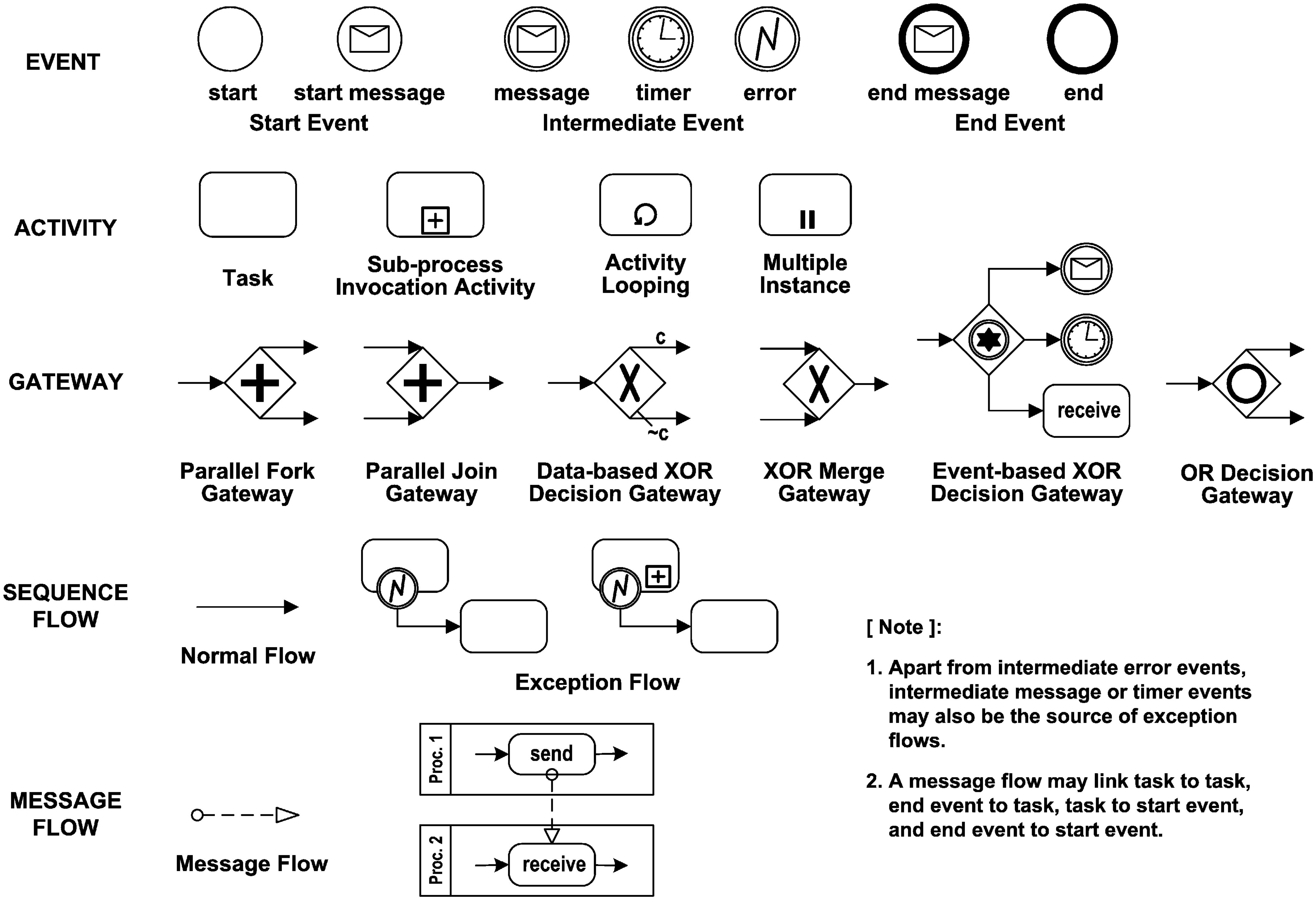
[c] *Faculty of Information Technology, Queensland University of Technology, G.P.O. Box 2434, Brisbane, Qld 4001, Australia*

Overview



EVENT

start · start message — Start Event

message · timer · error — Intermediate Event

end message · end — End Event

ACTIVITY

Task

Sub-process Invocation Activity

Activity Looping

Multiple Instance

GATEWAY

Parallel Fork Gateway

Parallel Join Gateway

Data-based XOR Decision Gateway

XOR Merge Gateway

Event-based XOR Decision Gateway

OR Decision Gateway

SEQUENCE FLOW

Normal Flow

Exception Flow

MESSAGE FLOW

Message Flow

Interacting processes

[Note]:

1. Apart from intermediate error events, intermediate message or timer events may also be the source of exception flows.
2. A message flow may link task to task, end event to task, task to start event, and end event to start event.

Simplified BPMN

a start / exception event has just one outgoing flow
and no incoming flow

an end event has just one incoming flow
and no outgoing flow

all activities and intermediate events have exactly
one incoming flow and one outgoing flow

all gateways have either
one incoming flow (and multiple outgoing)
or one outgoing flow (and multiple incoming)

Simplified BPMN

The previous constraints are no real limitation:

events or activities with multiple incoming flows:
insert a preceding XOR-join gateway

events or activities with multiple outgoing flows:
insert a following AND-split gateway

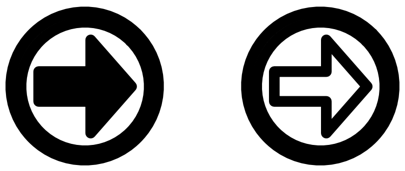
gateways with multiple incoming and outgoing flows:
decompose in two gateways

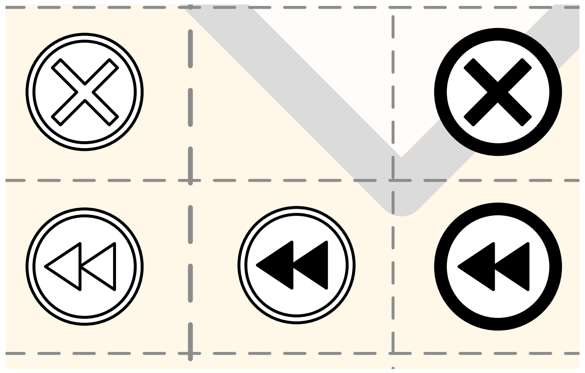
insert start / end event if needed

Simplified BPMN

No link events

they are just a notational convenience
to spread a model into several pages
(no effect on the semantics)



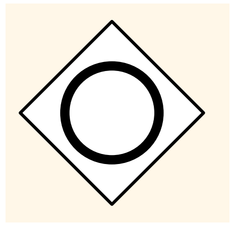


No transactions and compensations

Limited form of sub-processing

no OR-split

(can be expressed in terms of AND-split and XOR-split)



no OR-join

Roughly

A place for each arc

one transitions for each event

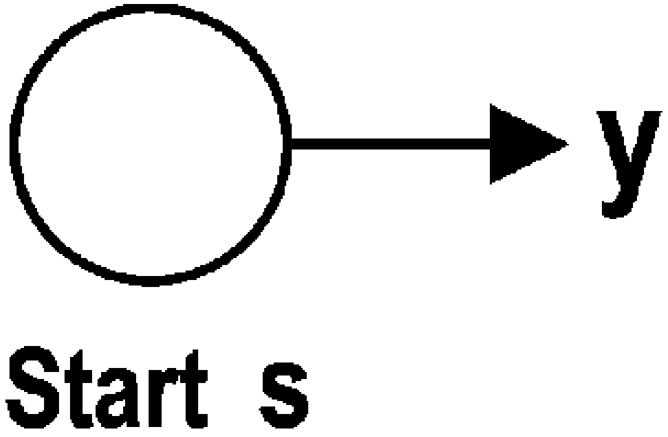
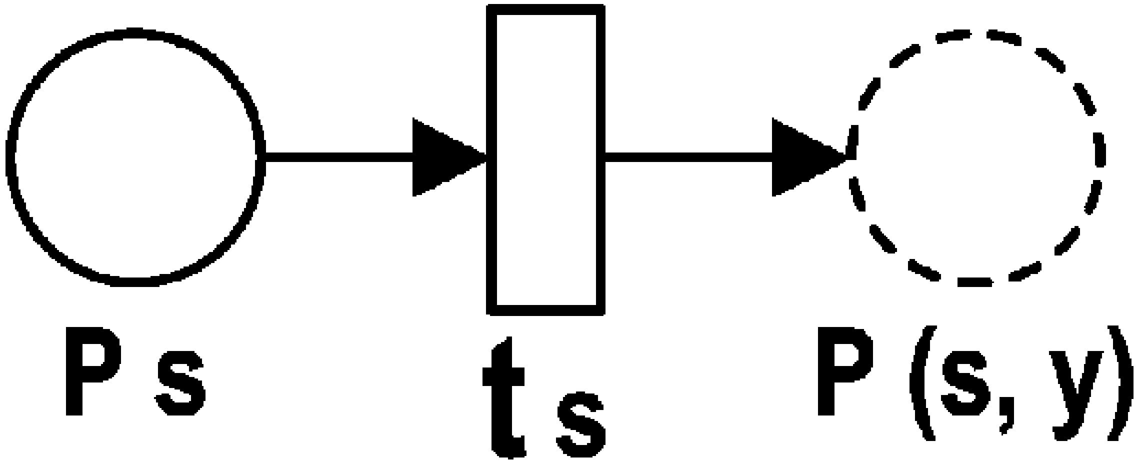
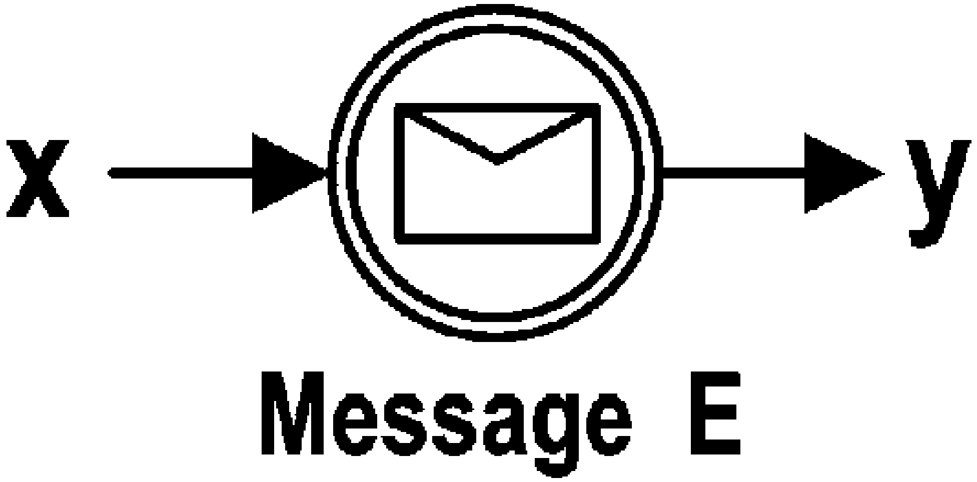
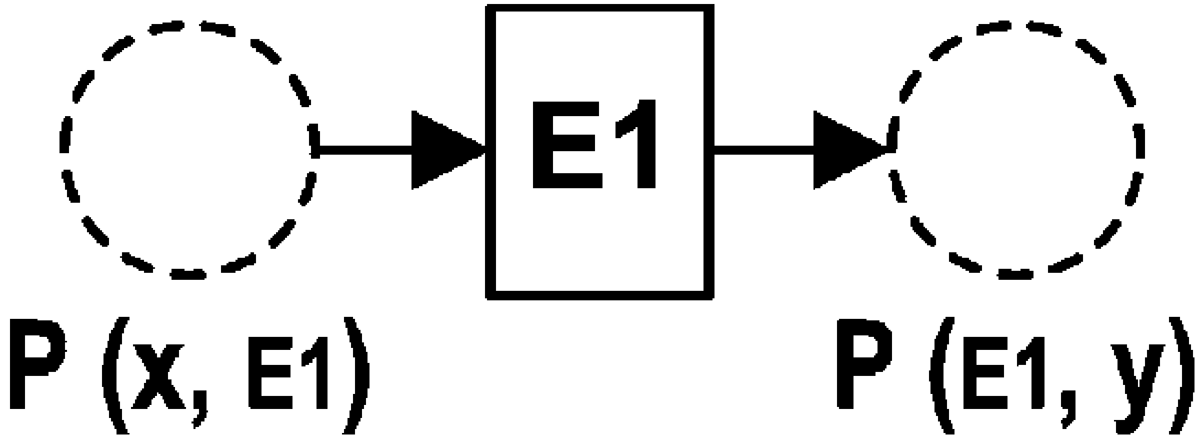
one transition for each activity

one or two transitions for each gateway

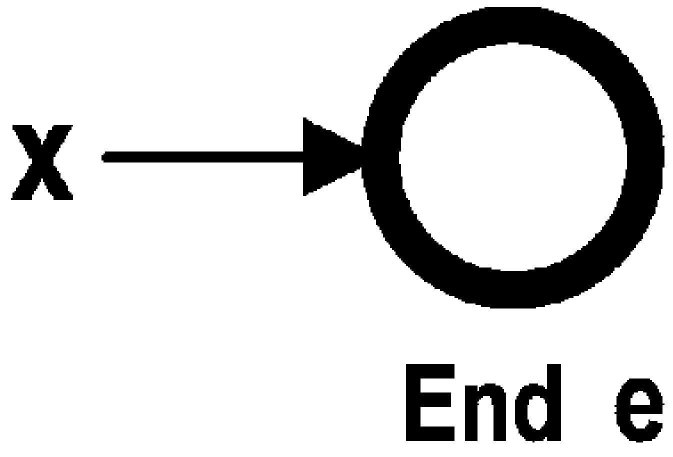
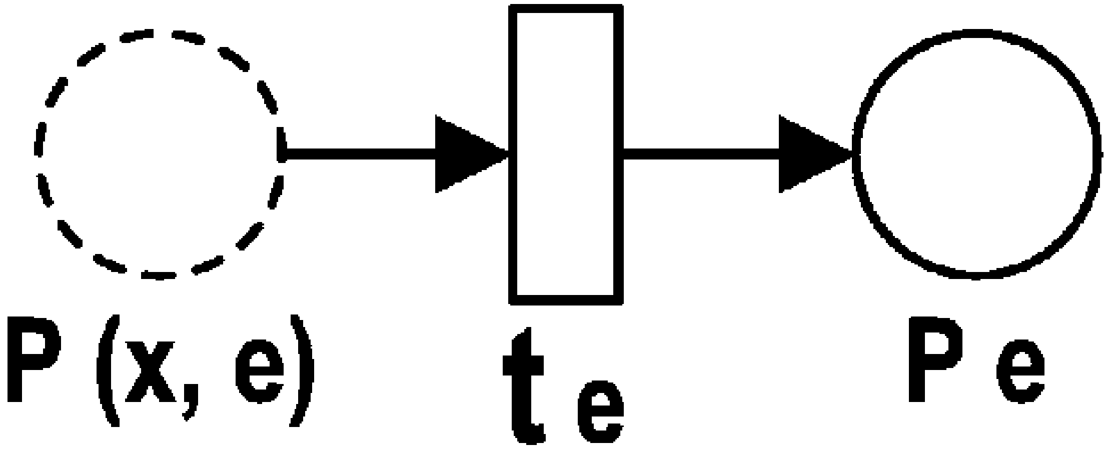
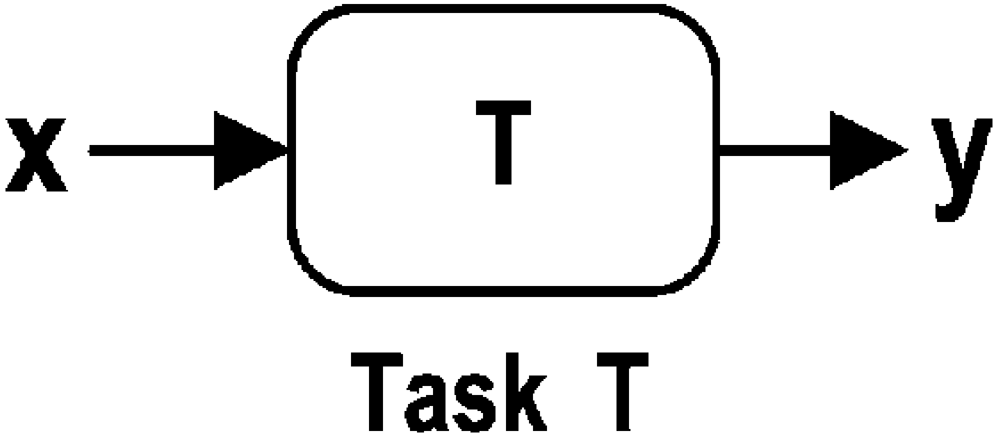
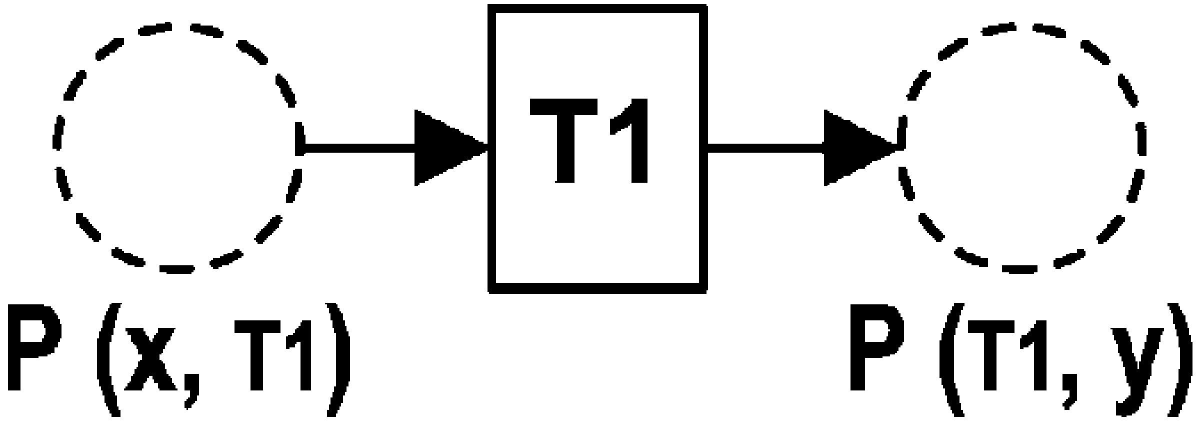
…

with some exceptions!
(start event, end event, event-based gateways, loops, …)

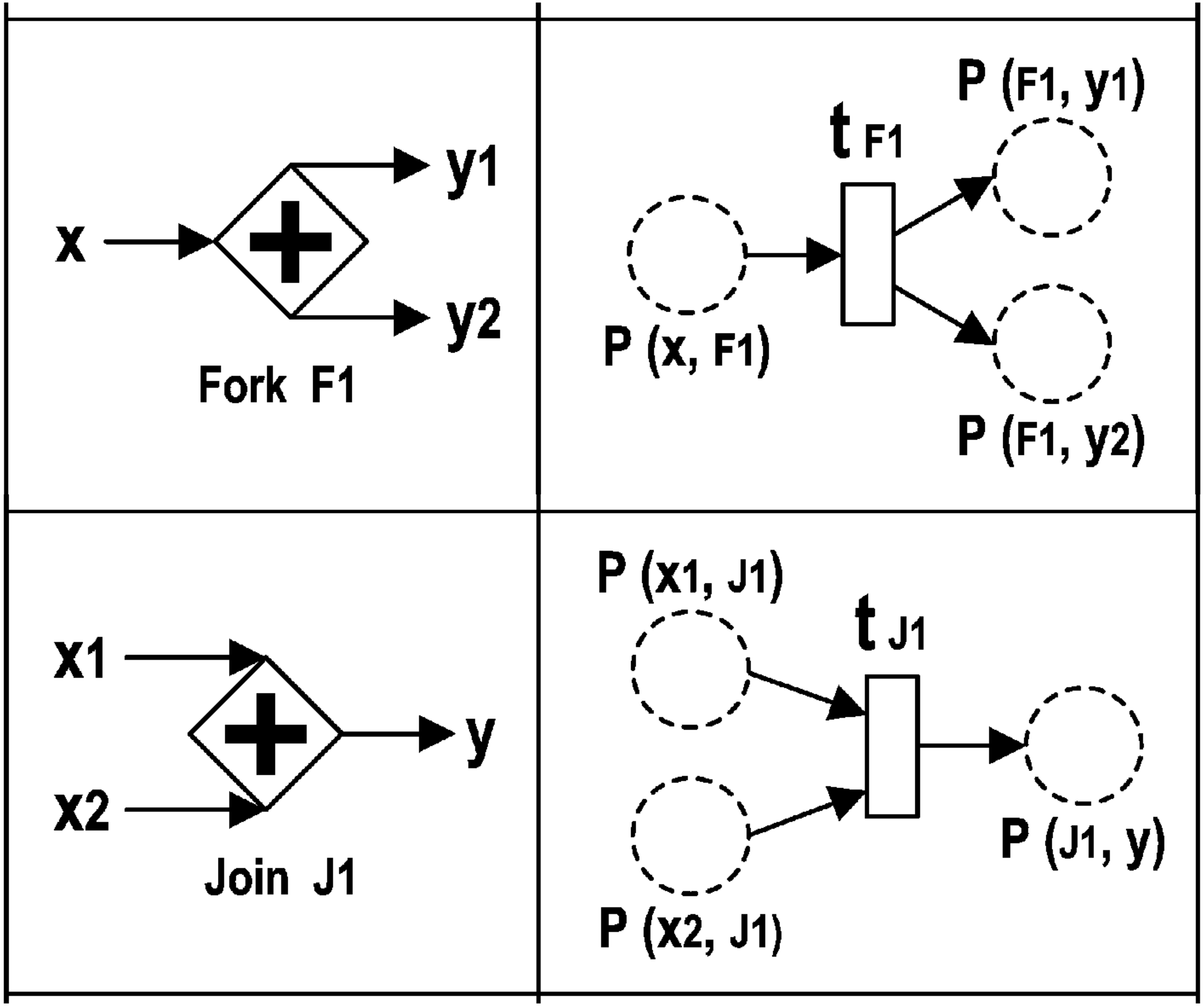
Zoom in: start, intermediate

BPMN Object	Petri-net Module
	
	

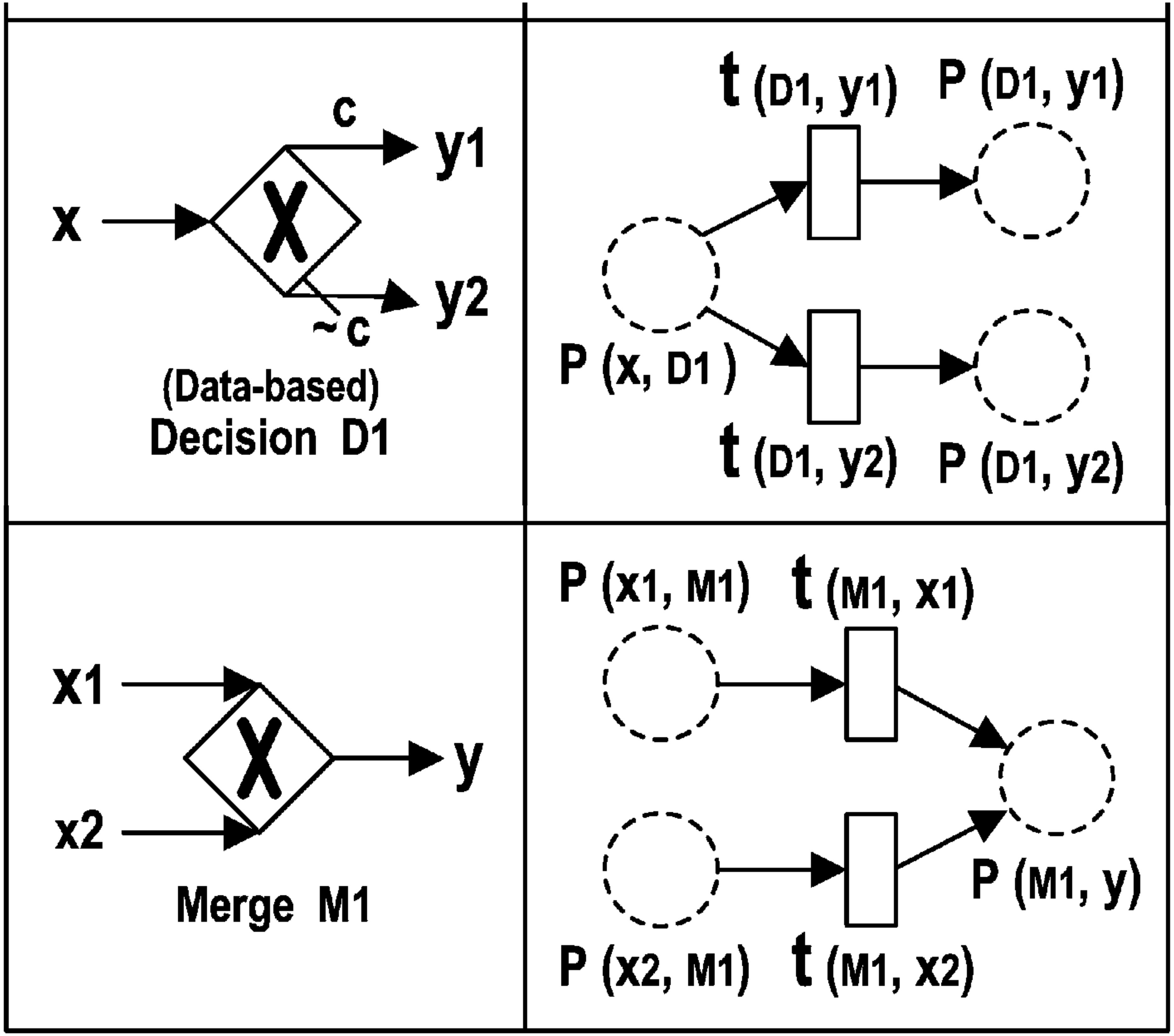
Zoom in: end event, task

BPMN Object	Petri-net Module
	
	

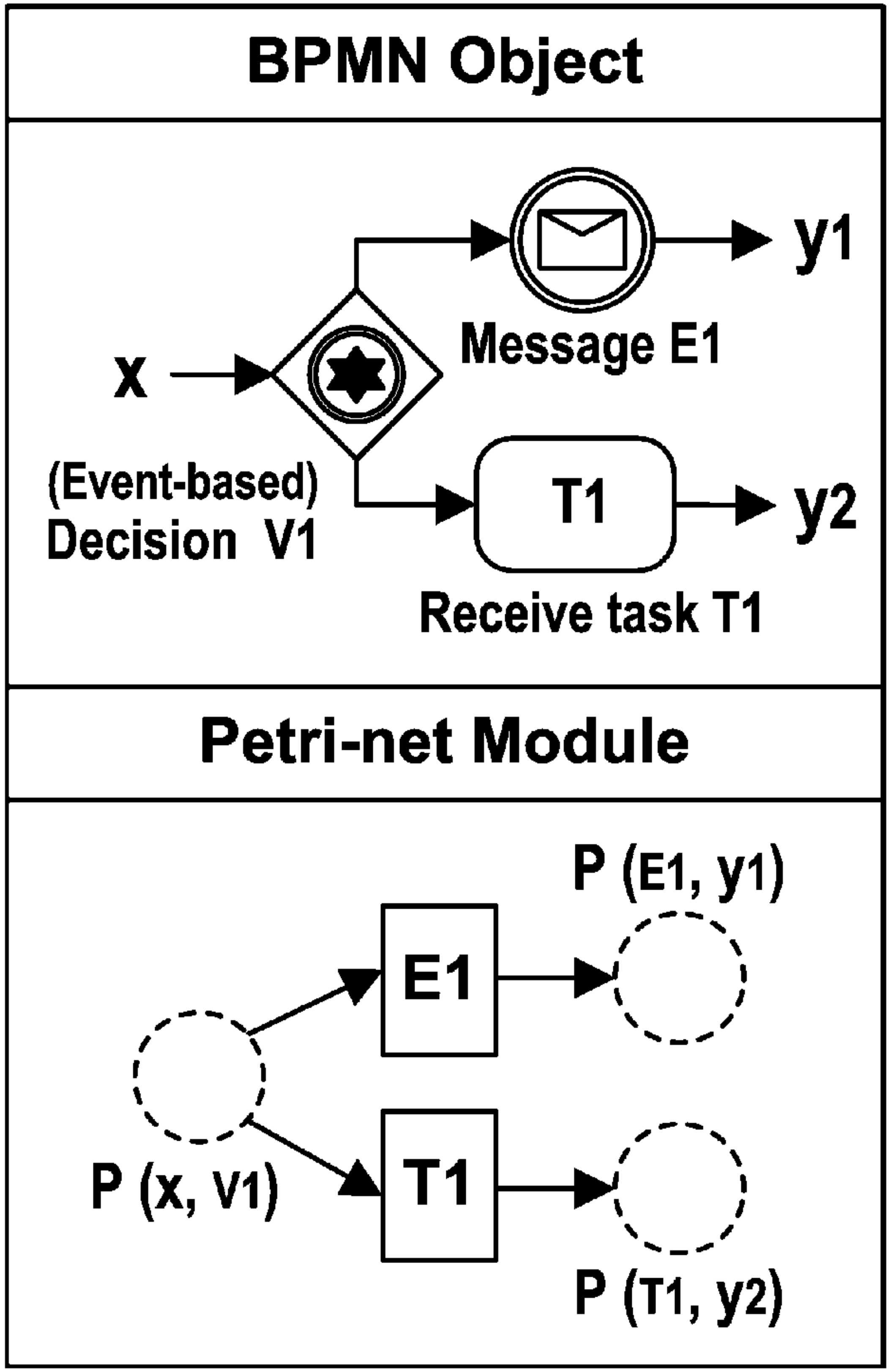
Zoom in: parallel gateway



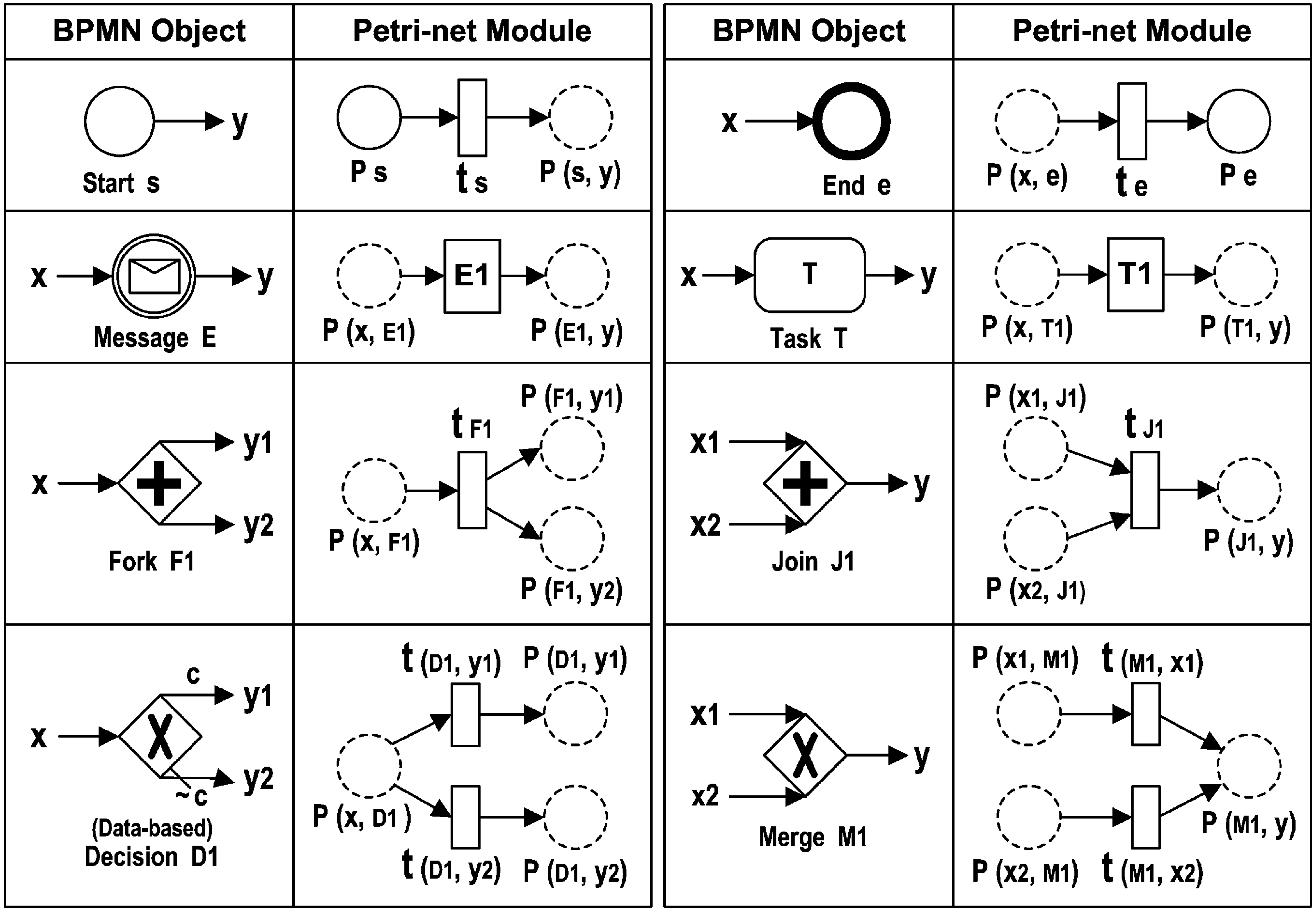
Zoom in: choice gateway

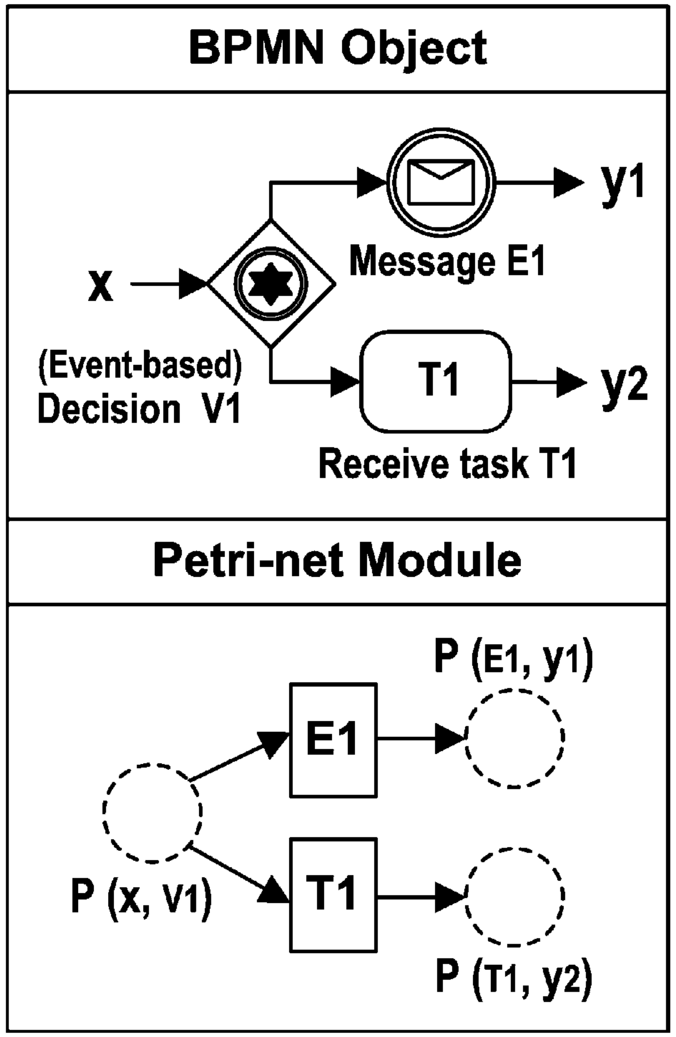


Zoom in: event based gateway



Task, events and gateways as nets

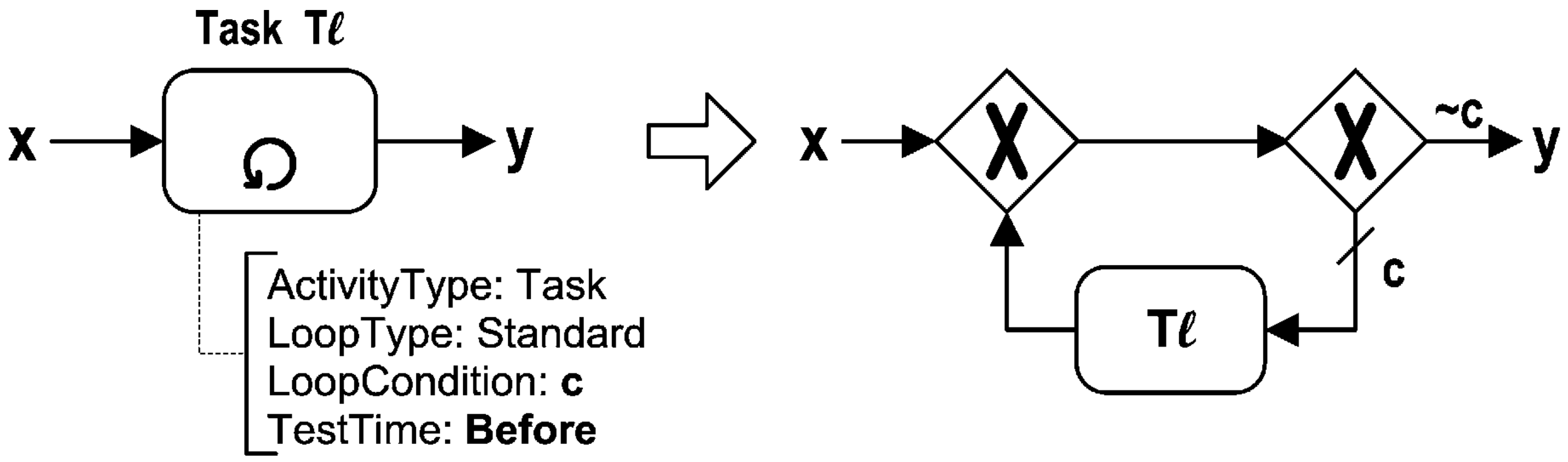




[Note]:

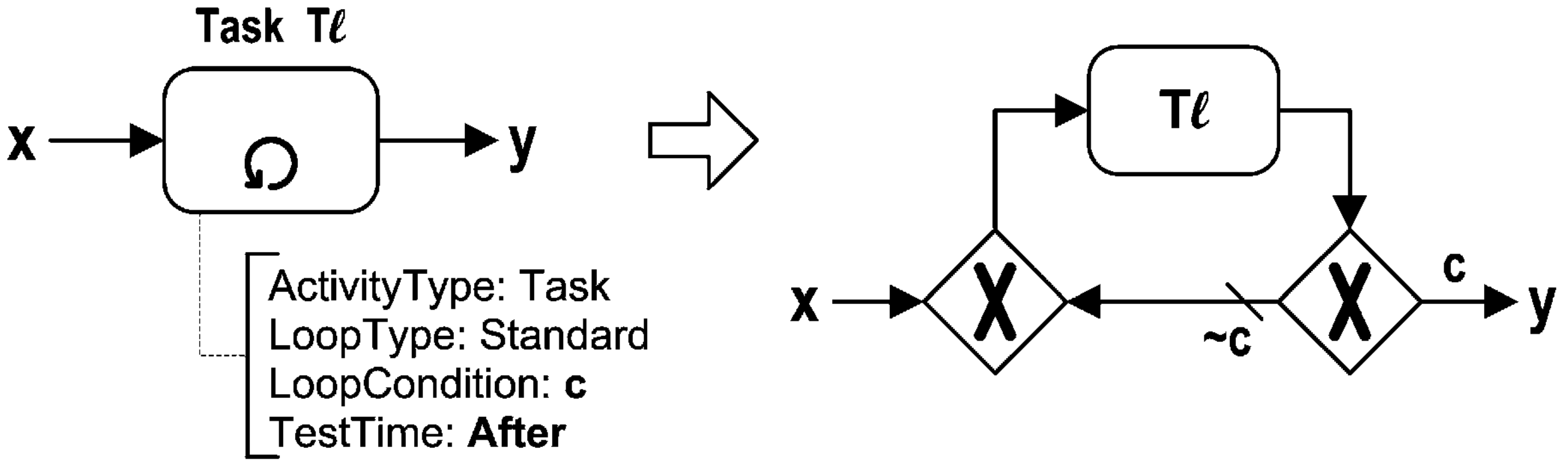
x, x1 or x2 represents an input object, and y, y1 or y2 represents an output object.

Activity looping



ActivityType: Task
LoopType: Standard
LoopCondition: **c**
TestTime: **Before**

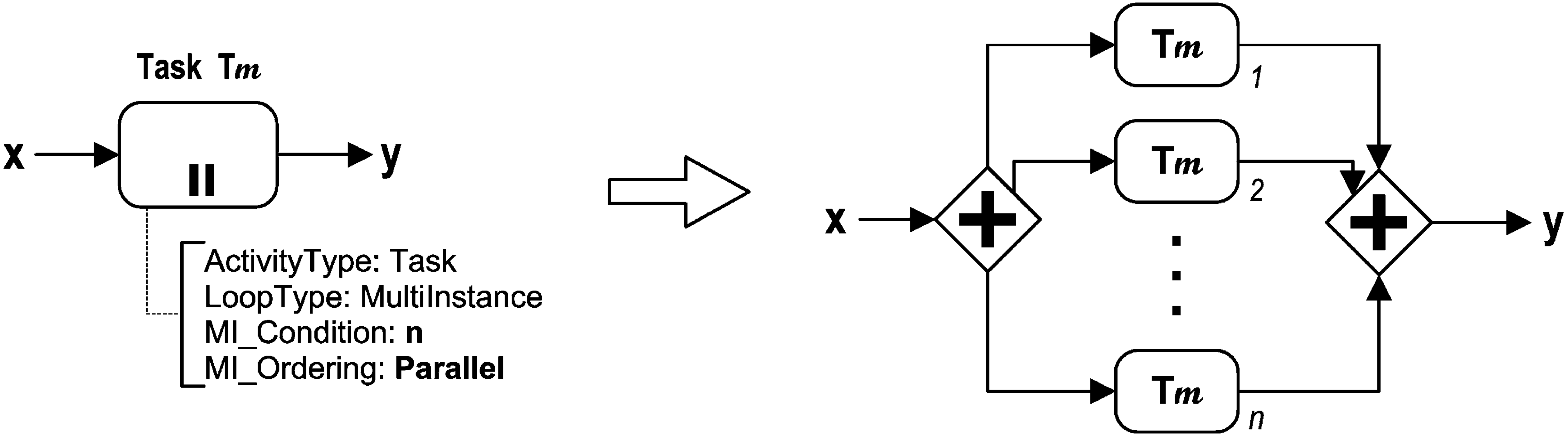
(a) “while-do” loop



ActivityType: Task
LoopType: Standard
LoopCondition: **c**
TestTime: **After**

(b) “do-until” loop

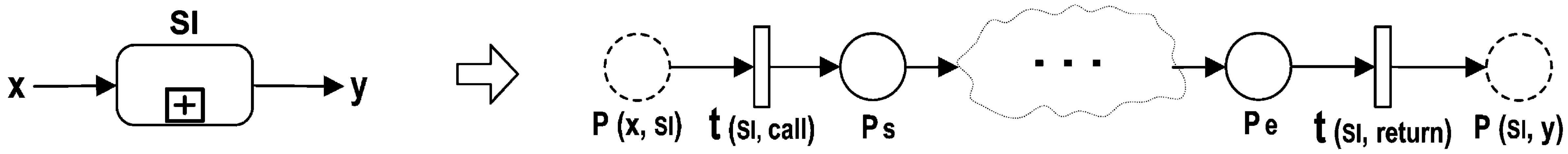
Multiple instances (design-time bounded)

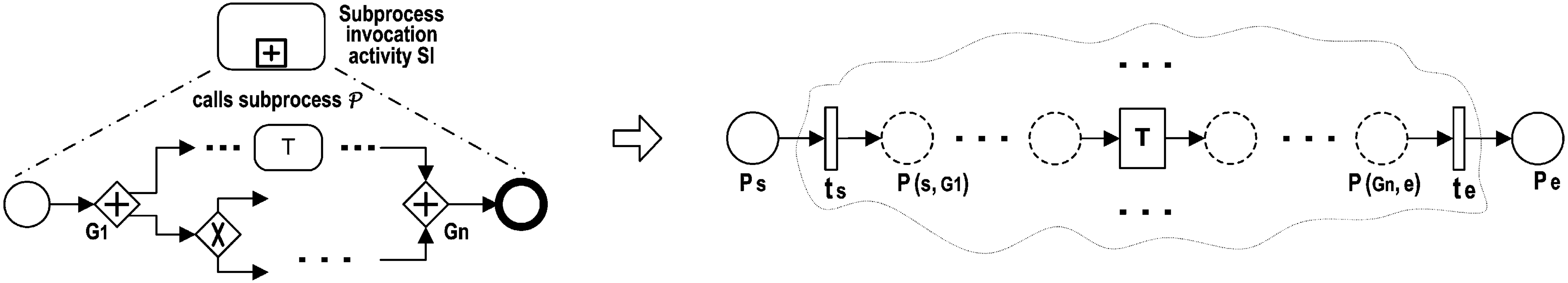


Task T*m*

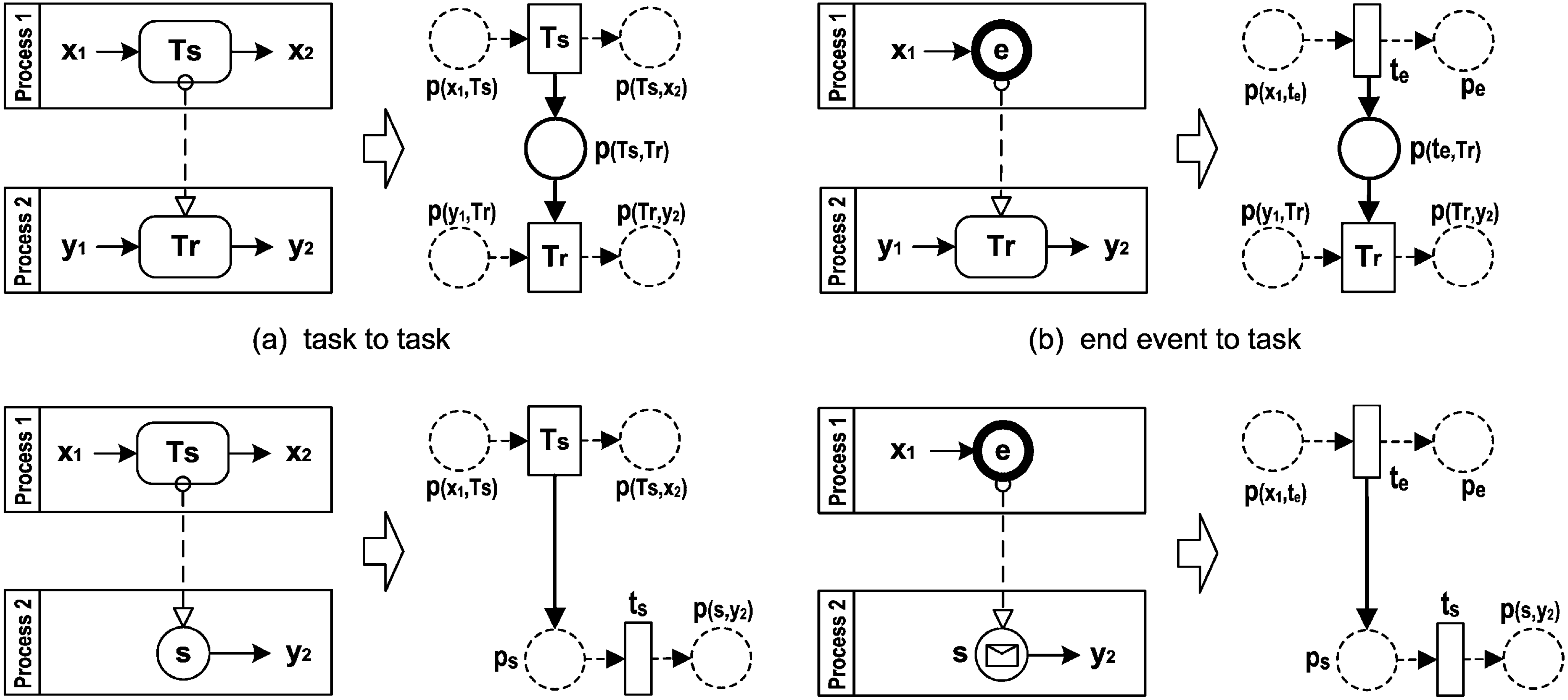
ActivityType: Task
LoopType: MultiInstance
MI_Condition: **n**
MI_Ordering: **Parallel**

Sub-processes





Message flow



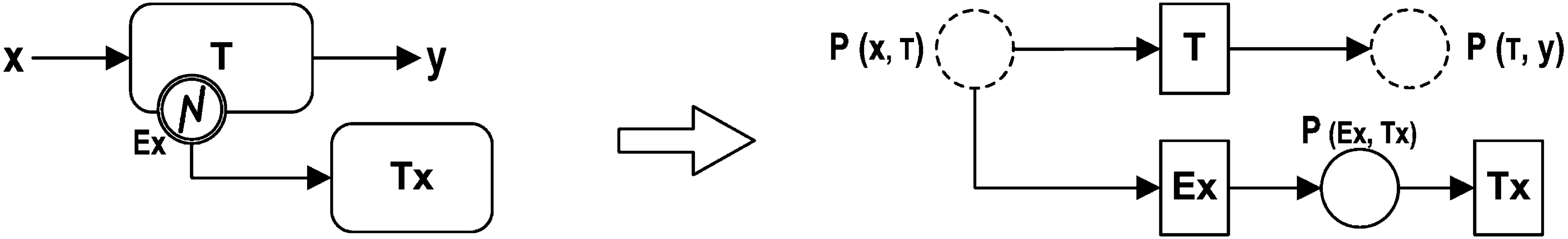
(a) task to task

(b) end event to task

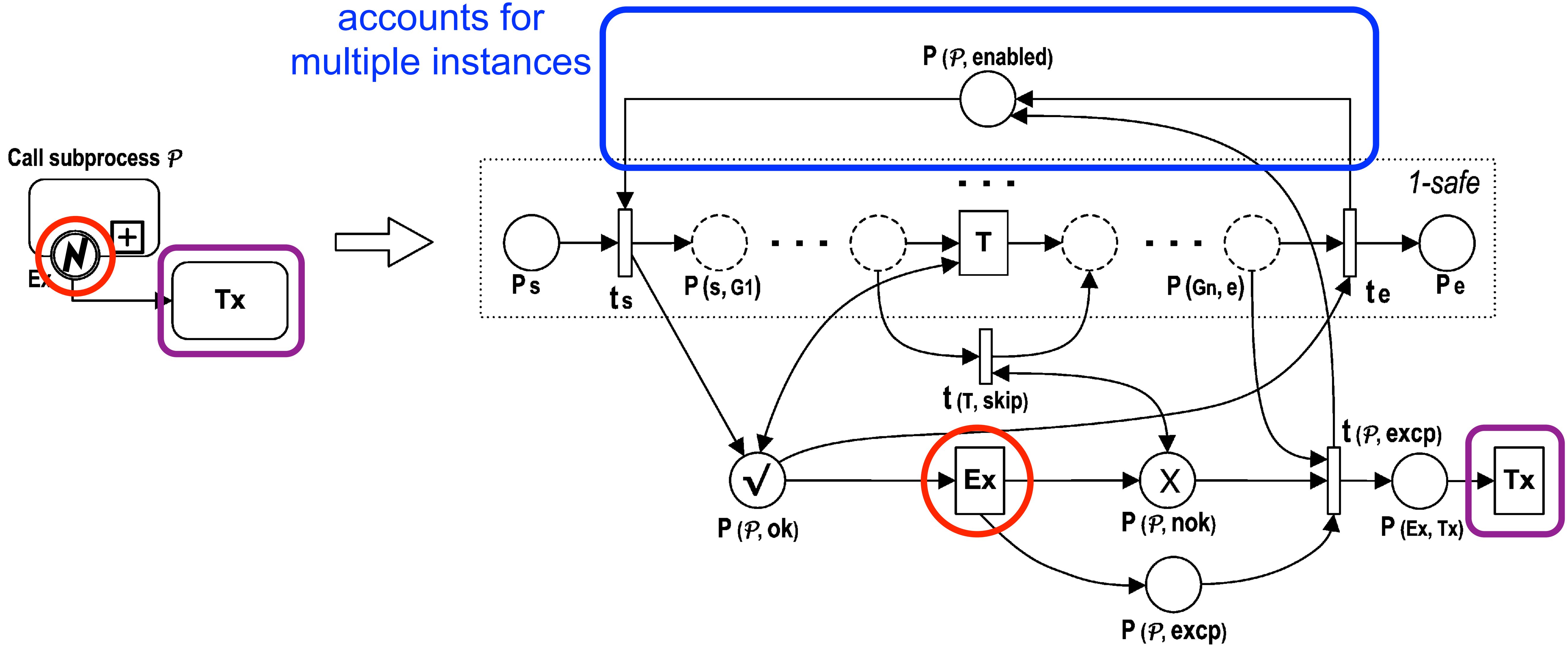
(c) task to start event

(d) end event to start event

Exception handling: single task

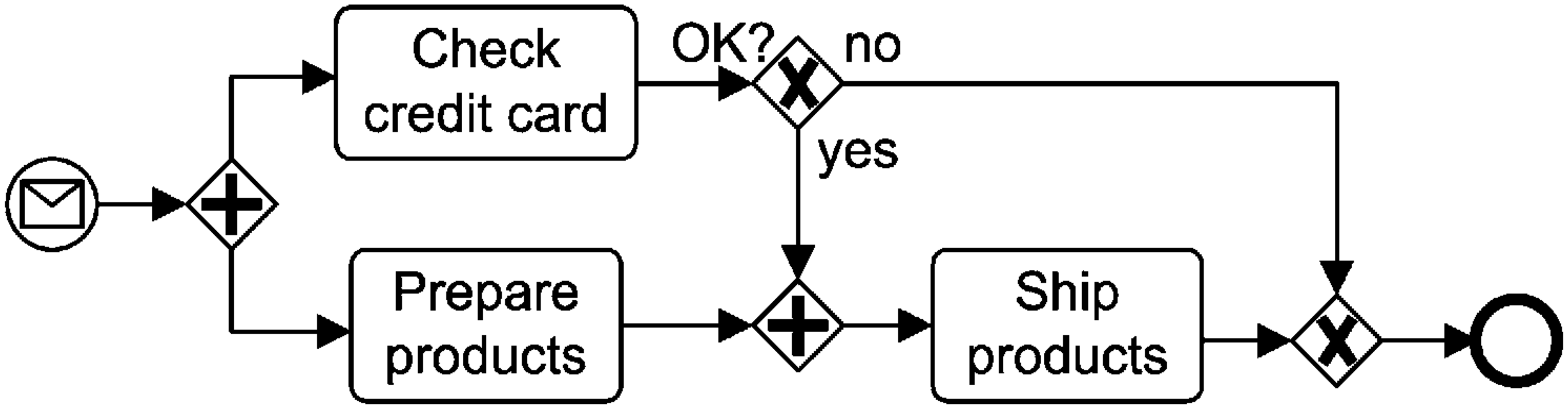


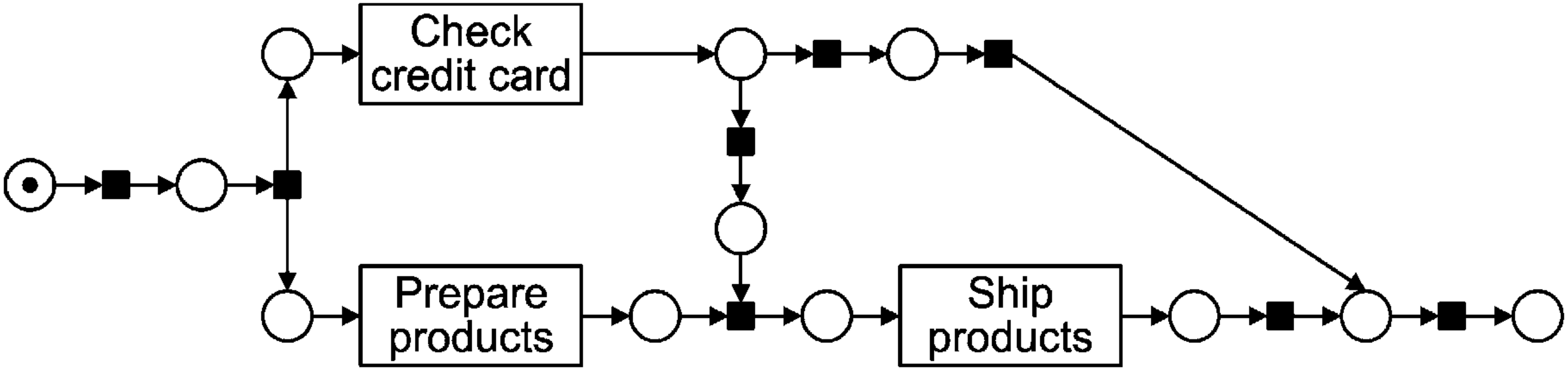
Exception handling: sub-processes



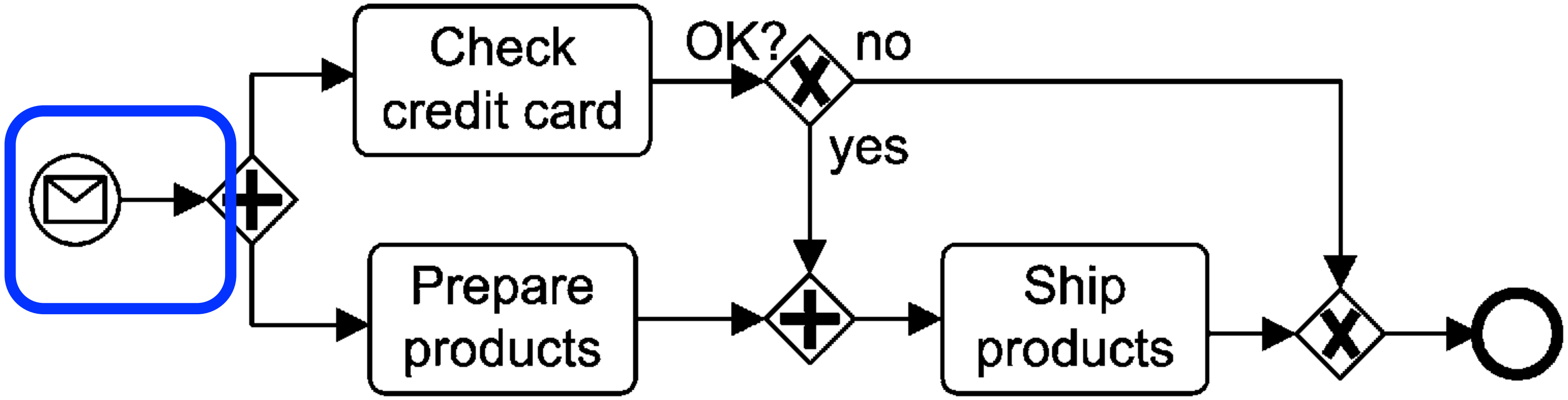
accounts for multiple instances

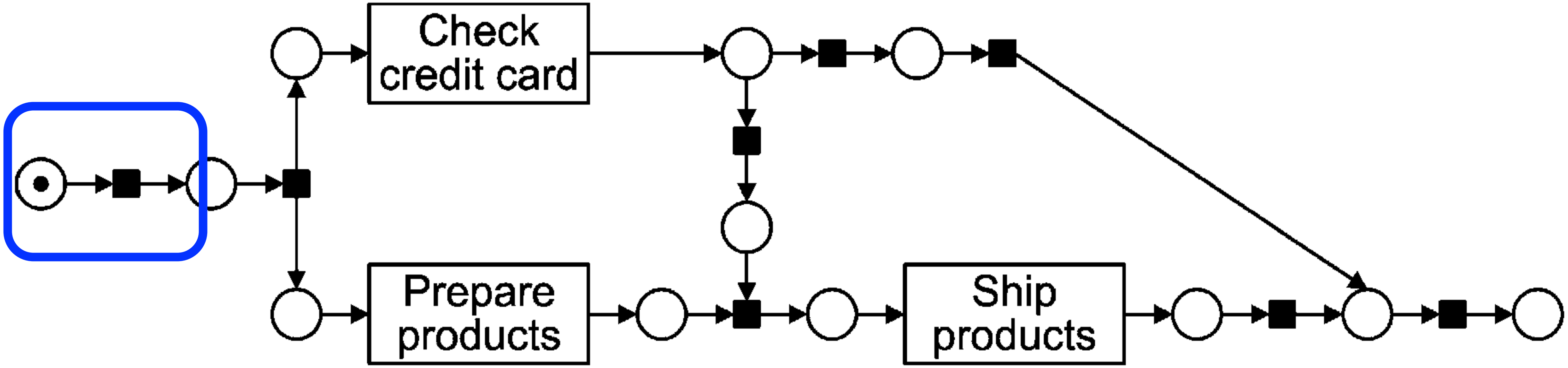
Example: Order process



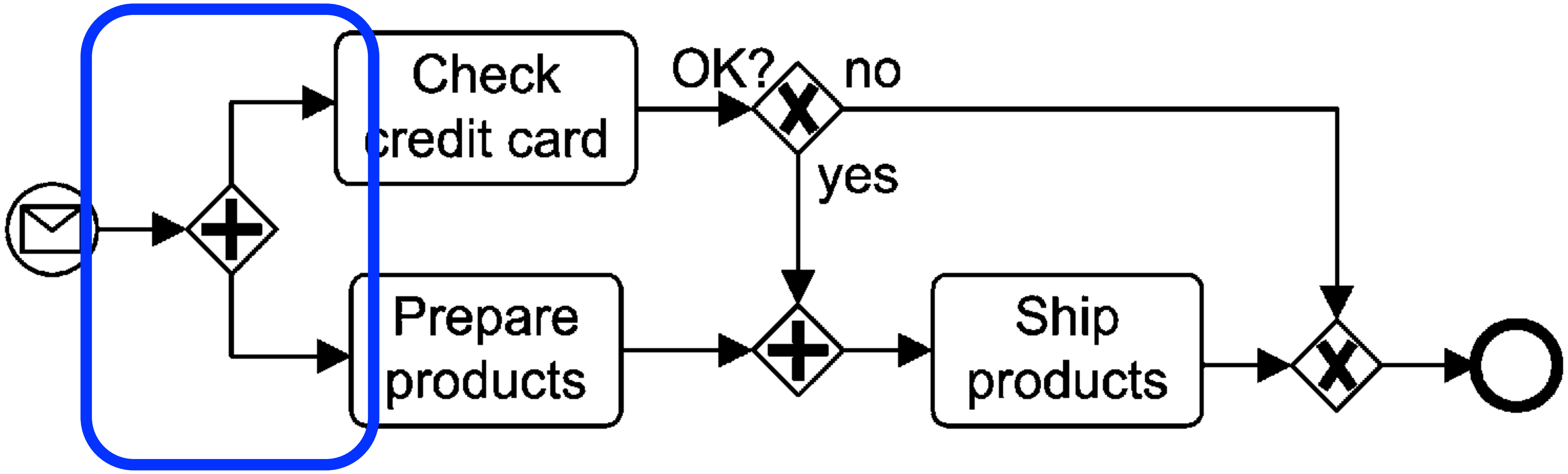


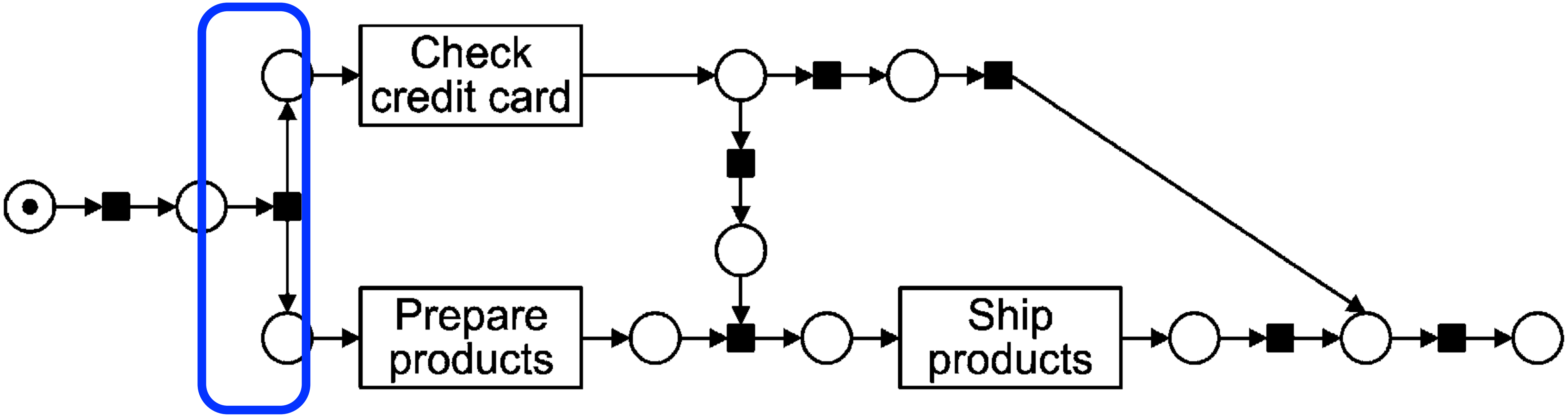
Example: Order process



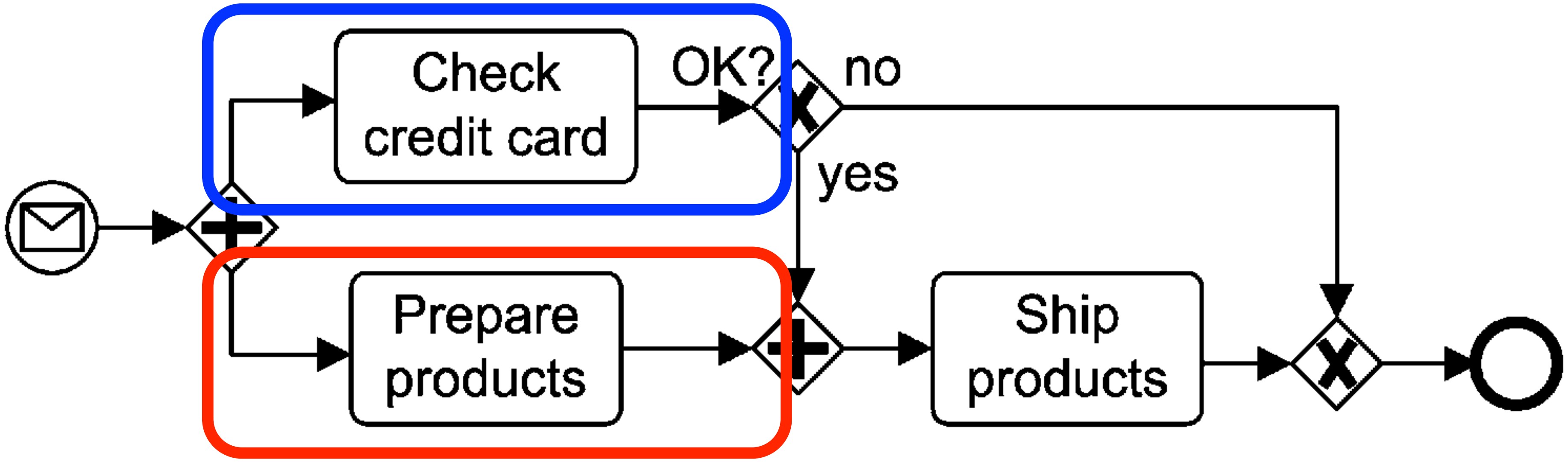


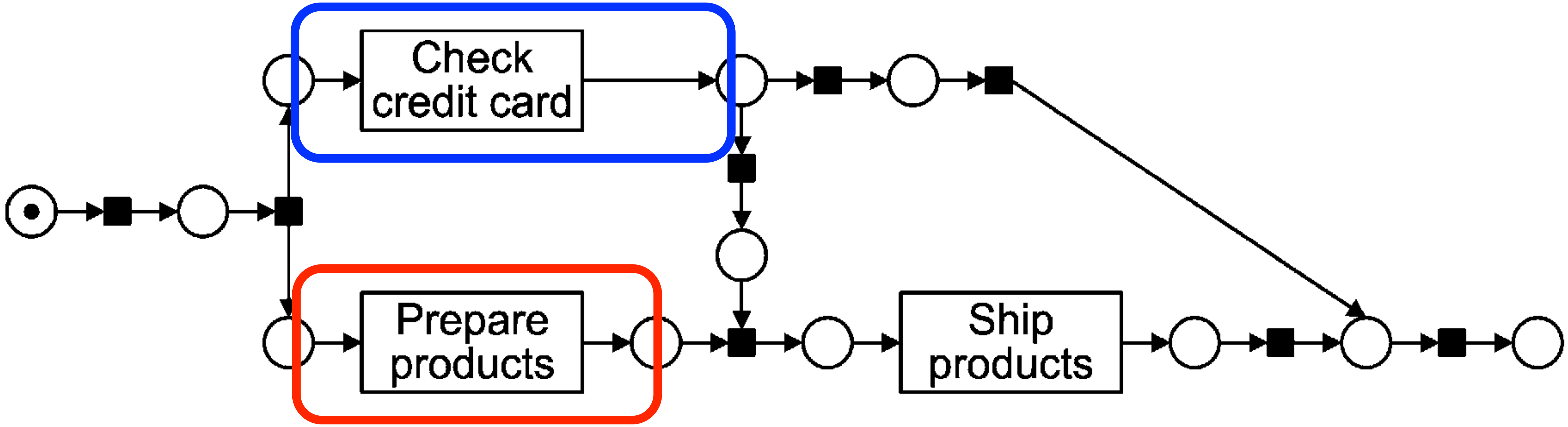
Example: Order process



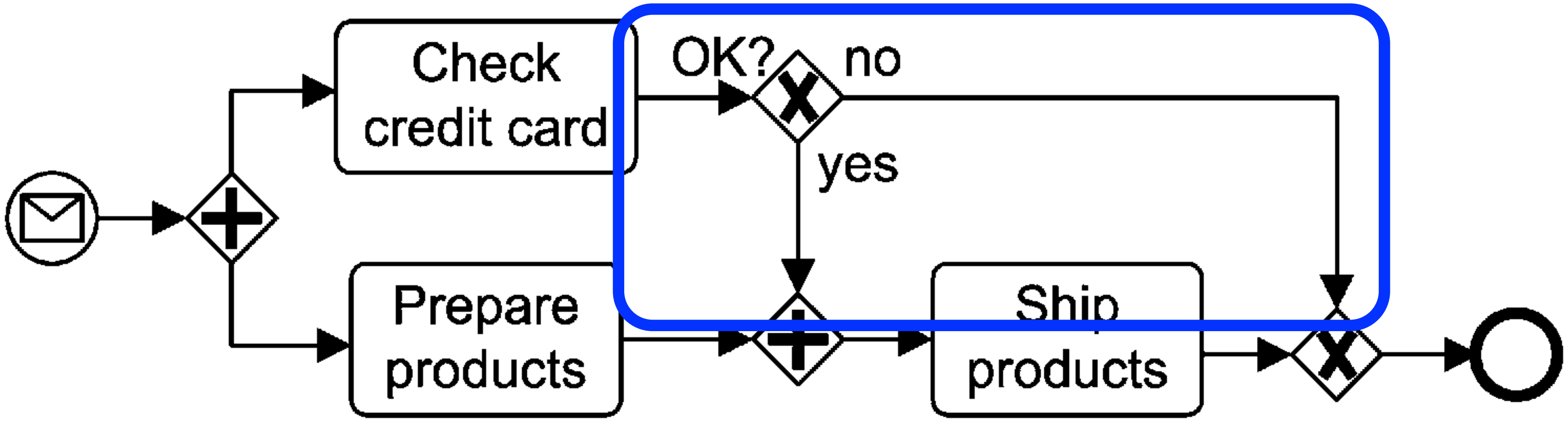


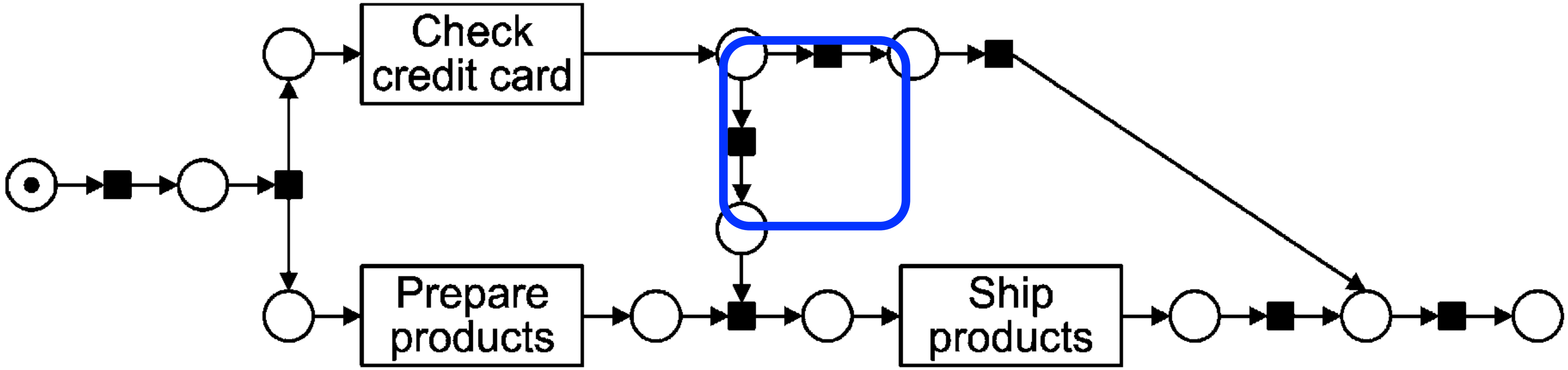
Example: Order process



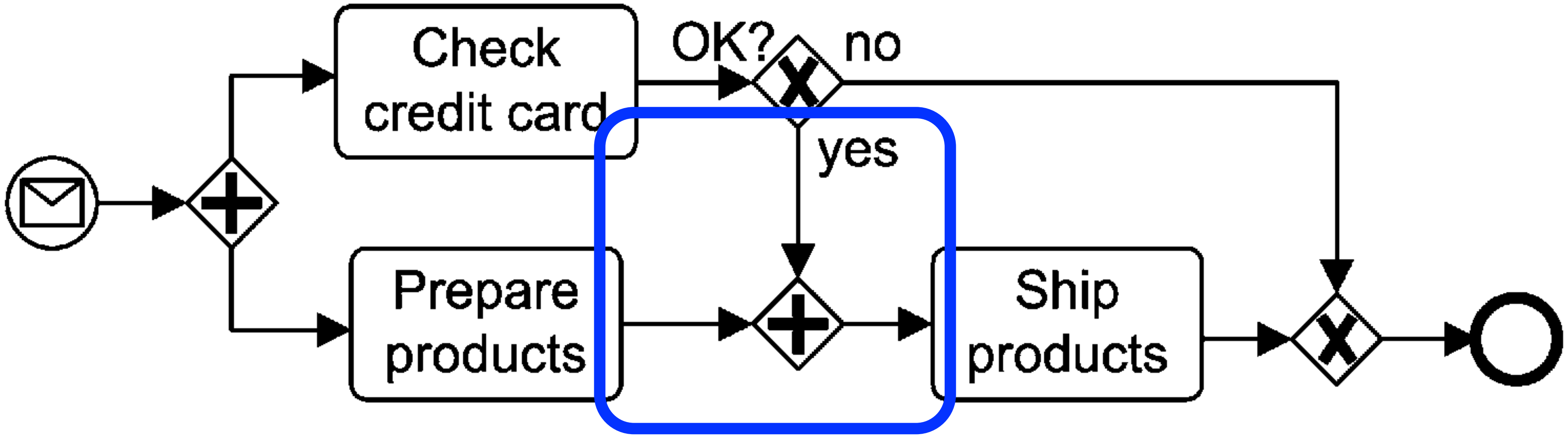


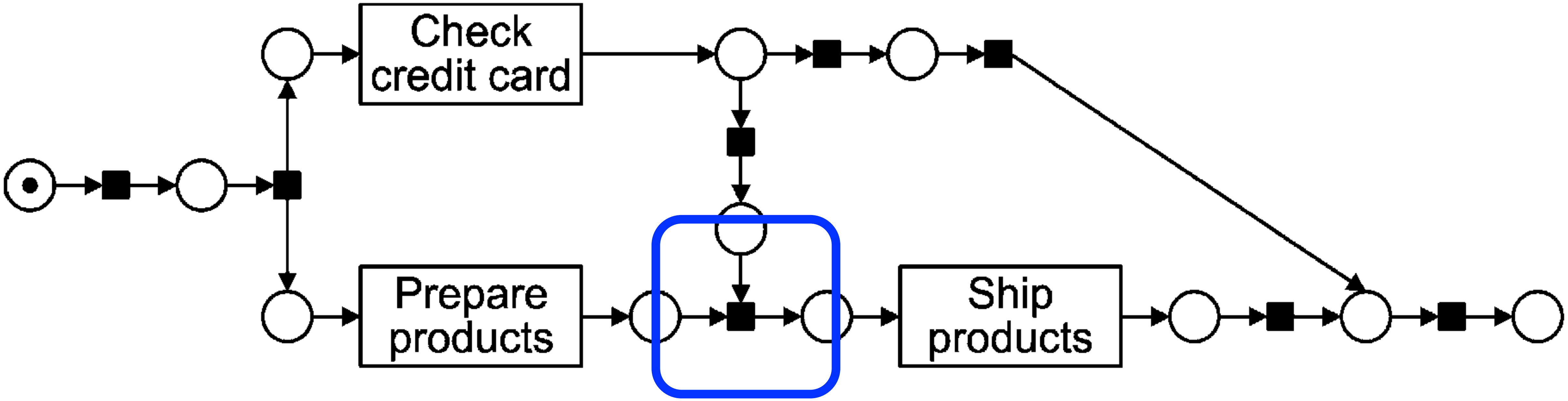
Example: Order process



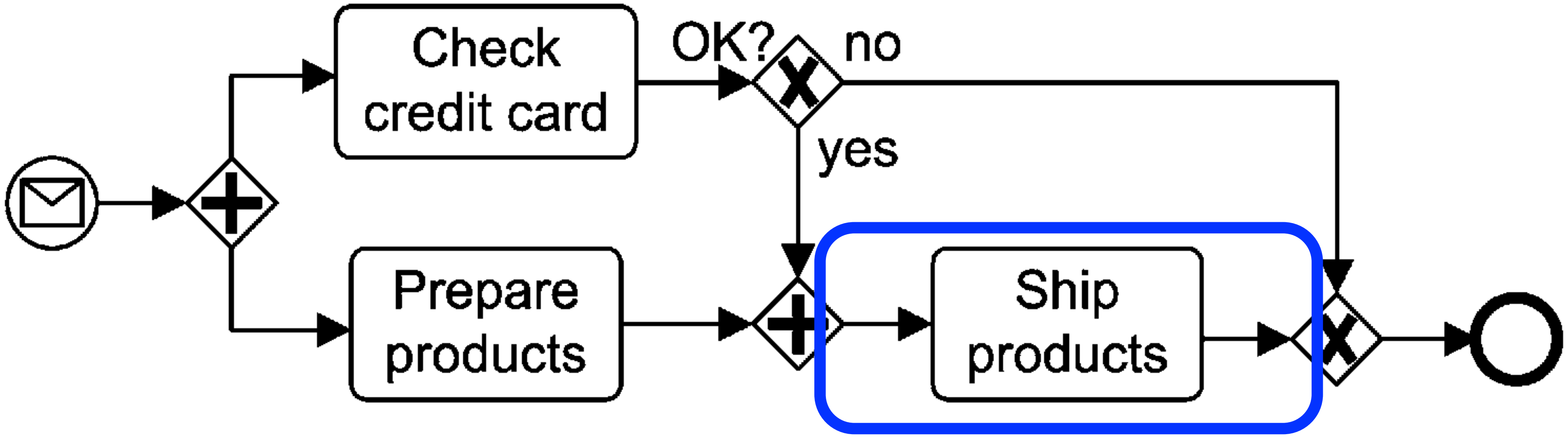


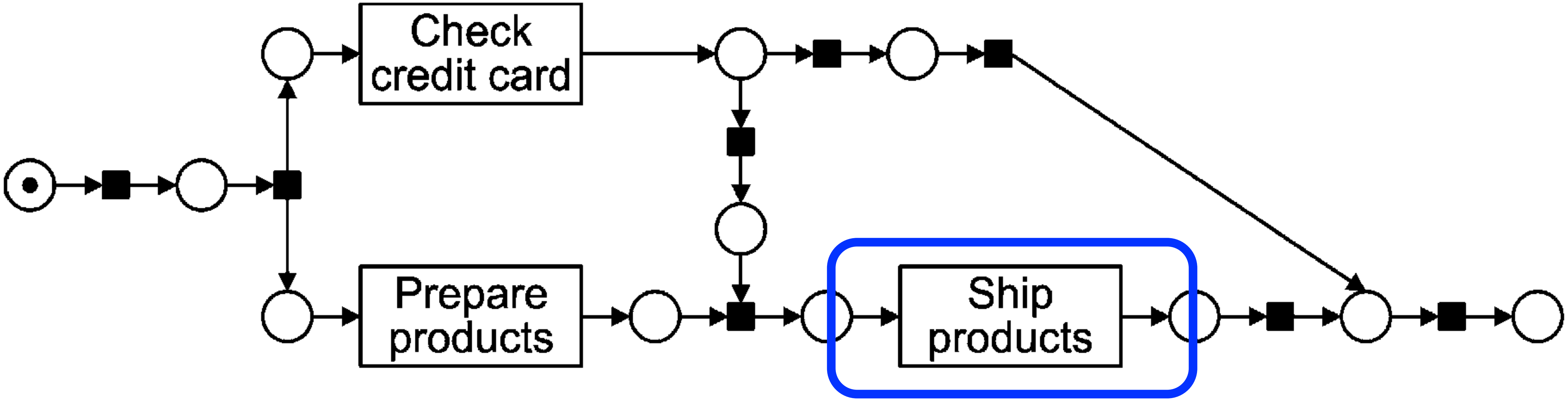
Example: Order process



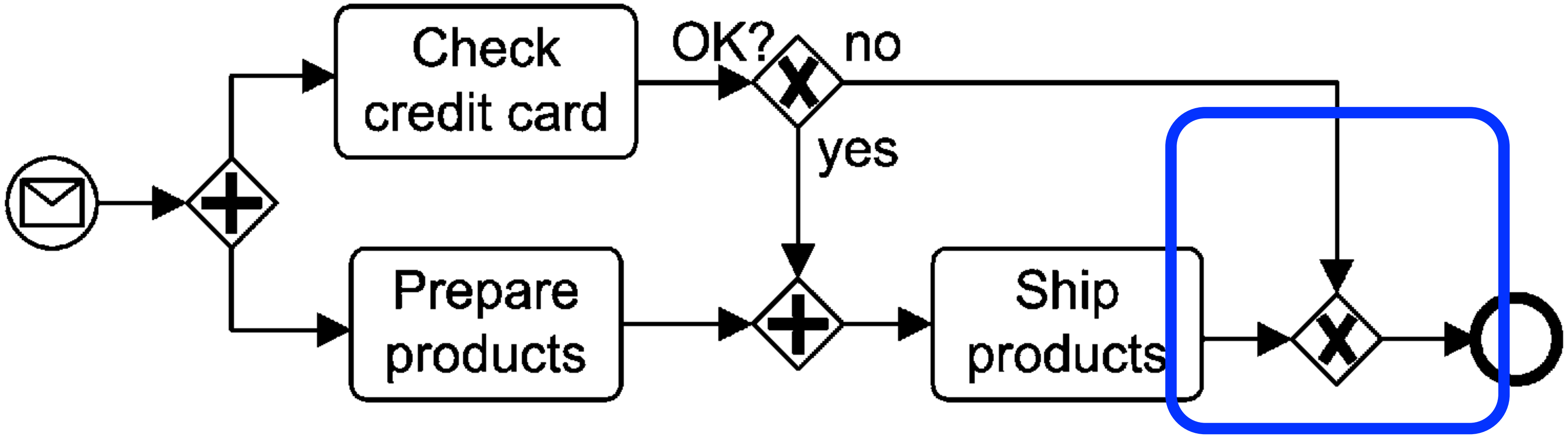


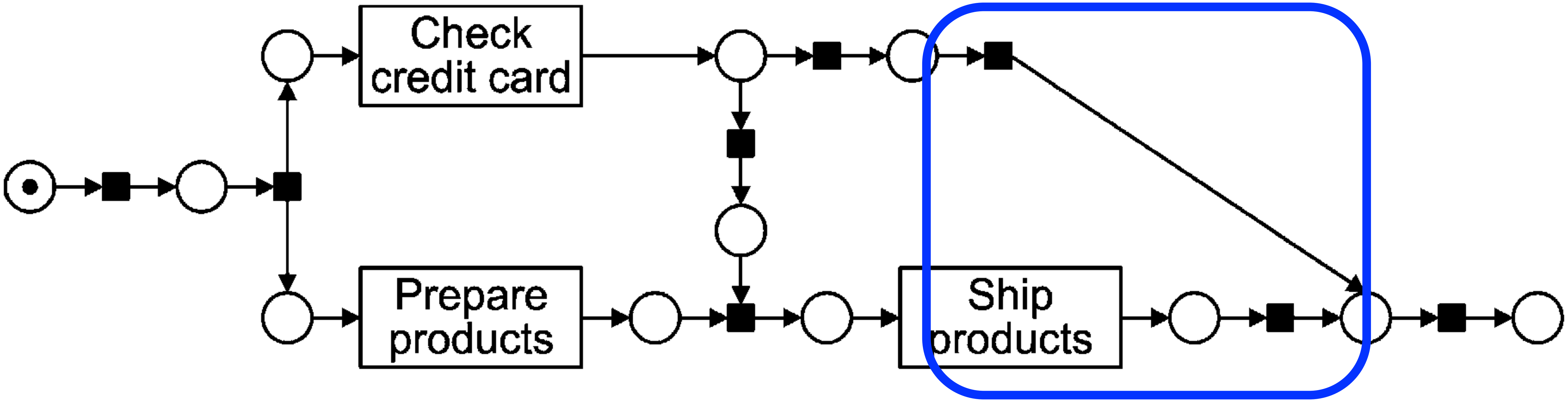
Example: Order process



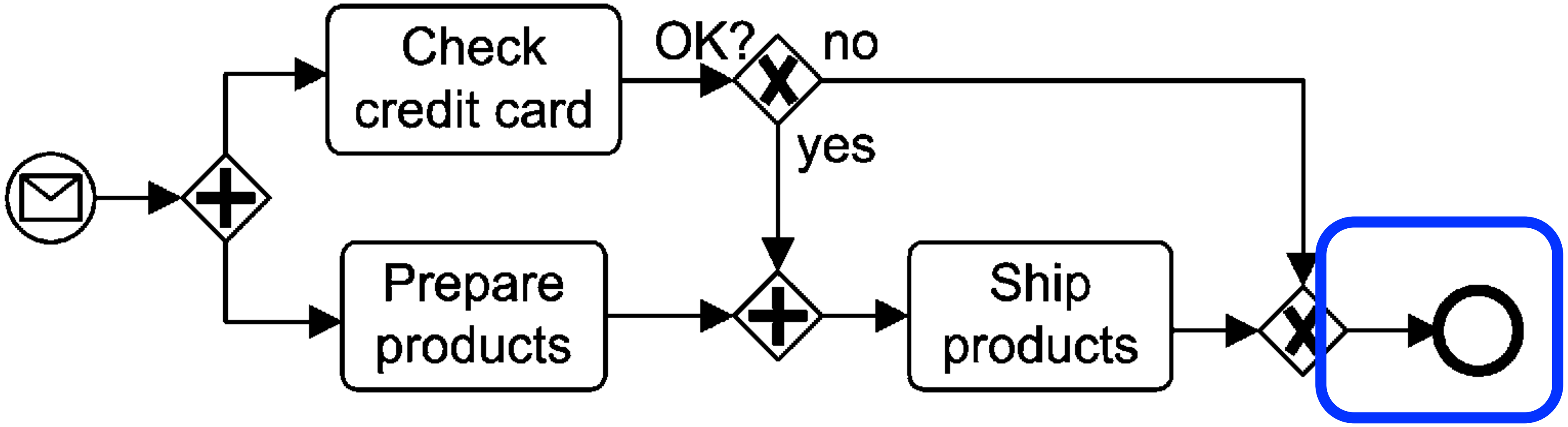


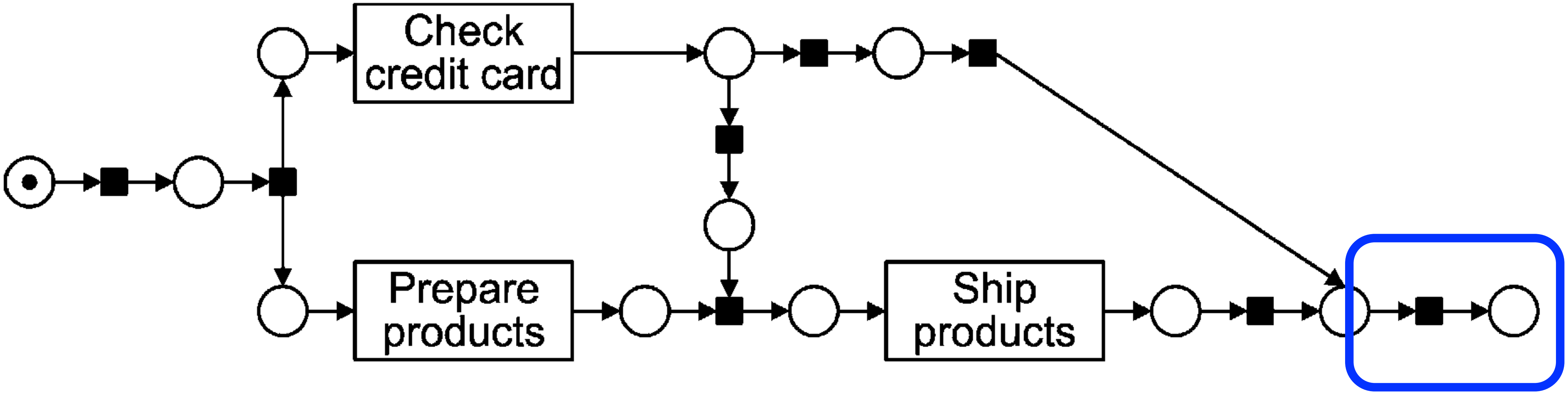
Example: Order process



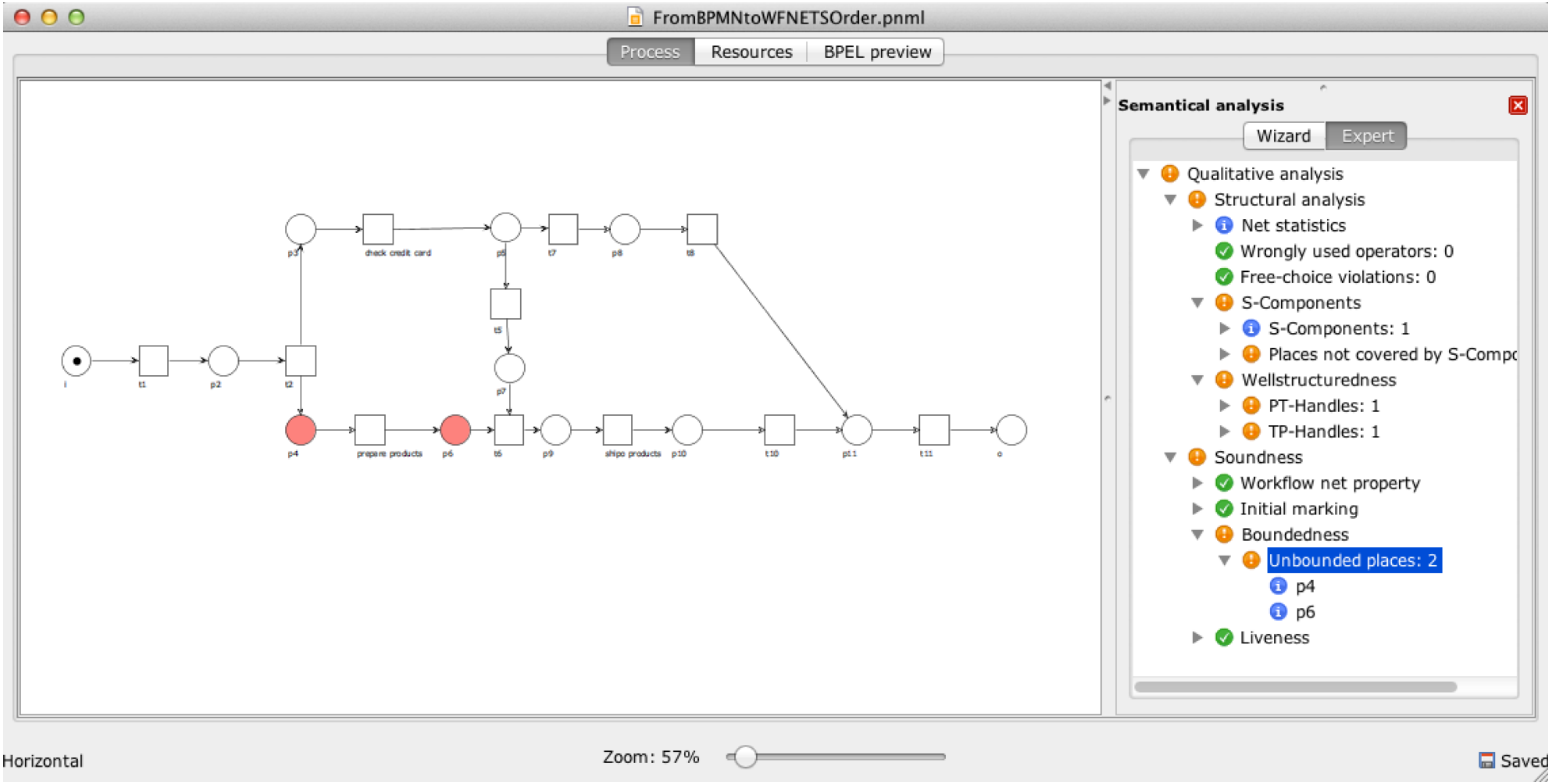


Example: Order process



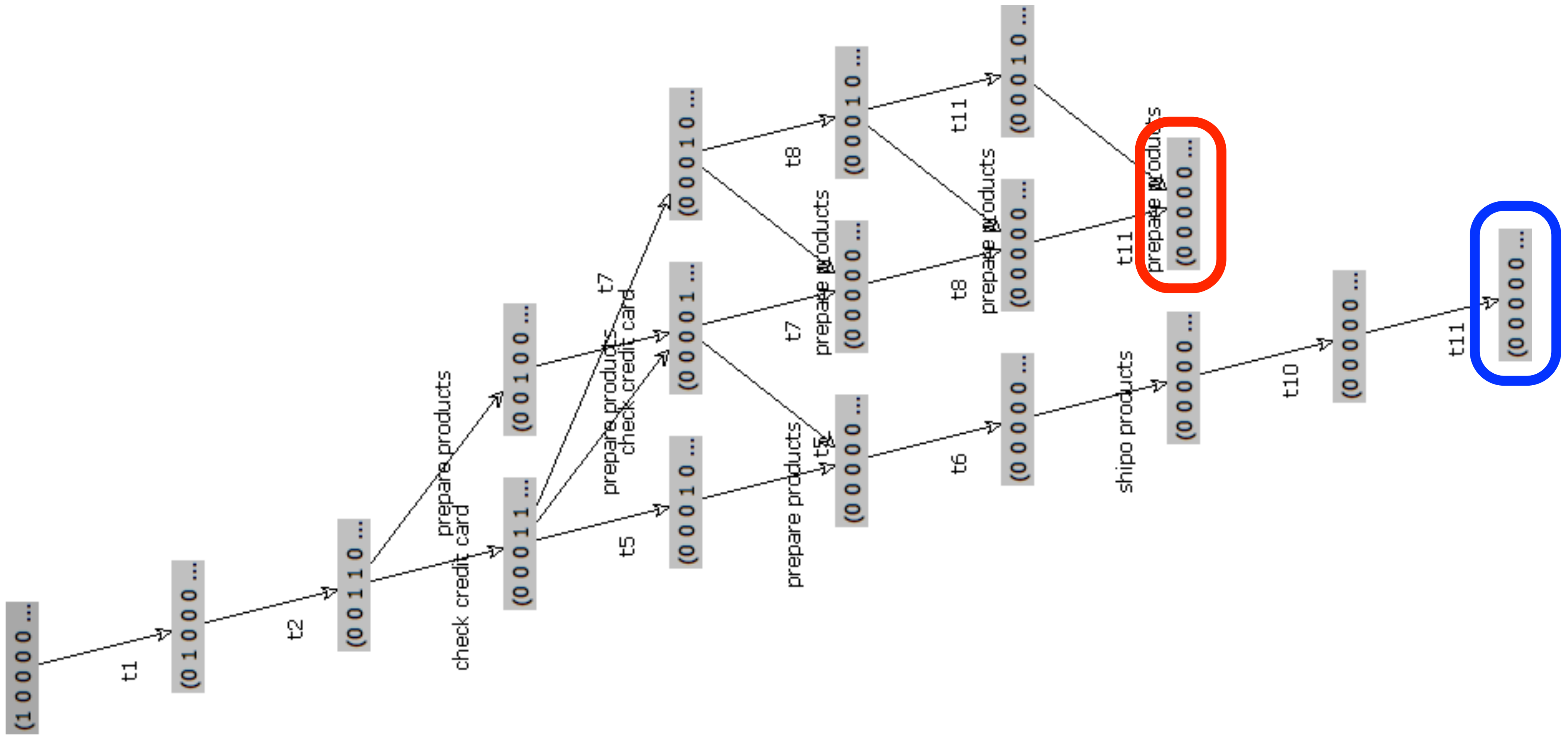


Example: Order process

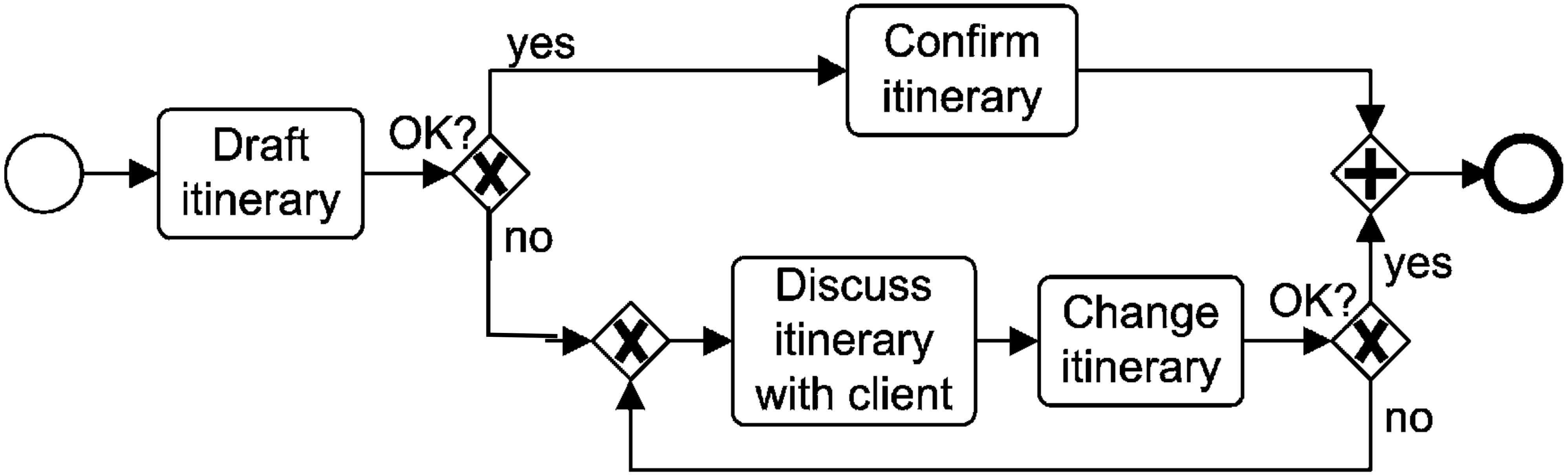


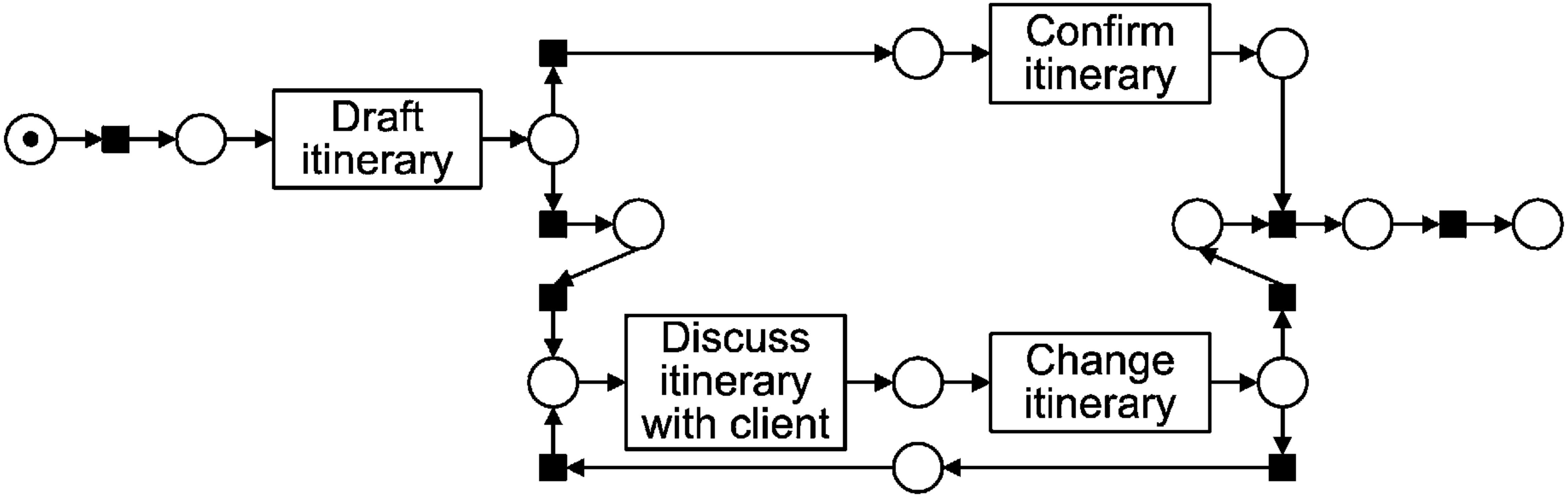
- Qualitative analysis
  - Structural analysis
    - Net statistics
    - Wrongly used operators: 0
    - Free-choice violations: 0
    - S-Components
      - S-Components: 1
      - Places not covered by S-Compo
    - Wellstructuredness
      - PT-Handles: 1
      - TP-Handles: 1
  - Soundness
    - Workflow net property
    - Initial marking
    - Boundedness
      - Unbounded places: 2
        - p4
        - p6
    - Liveness

Example: Order process

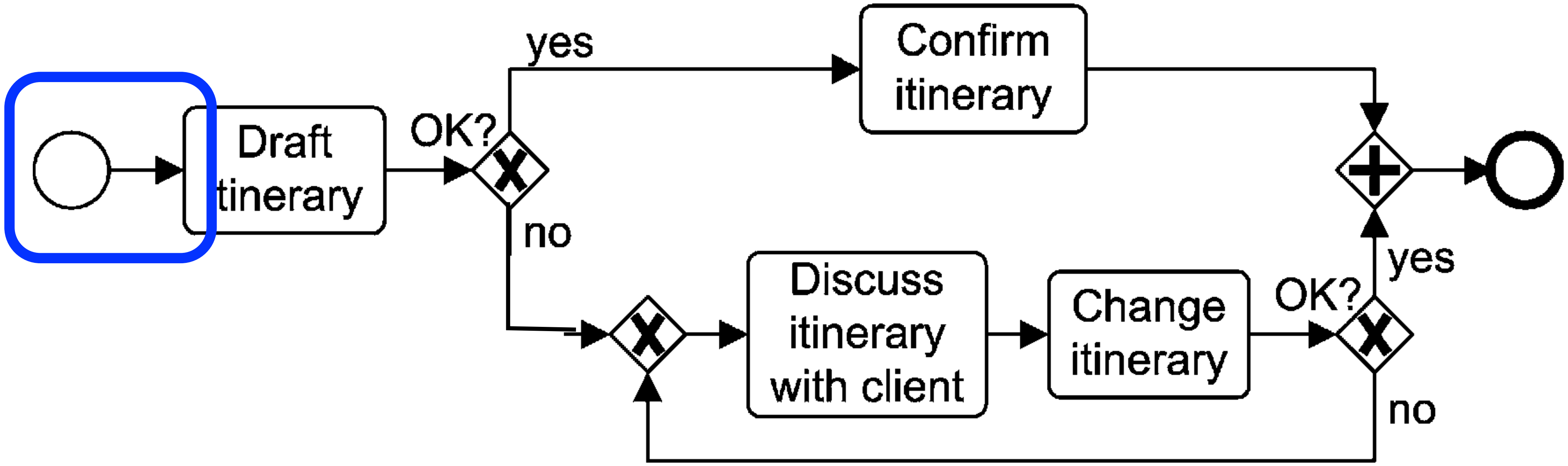


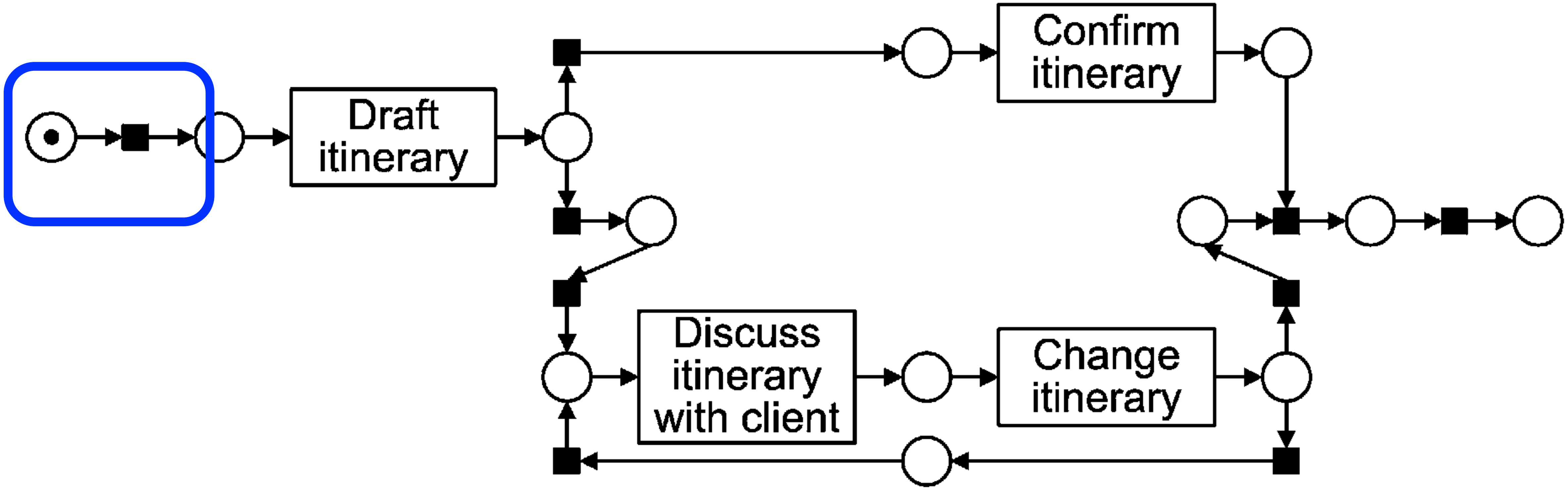
Example: Travel itinerary



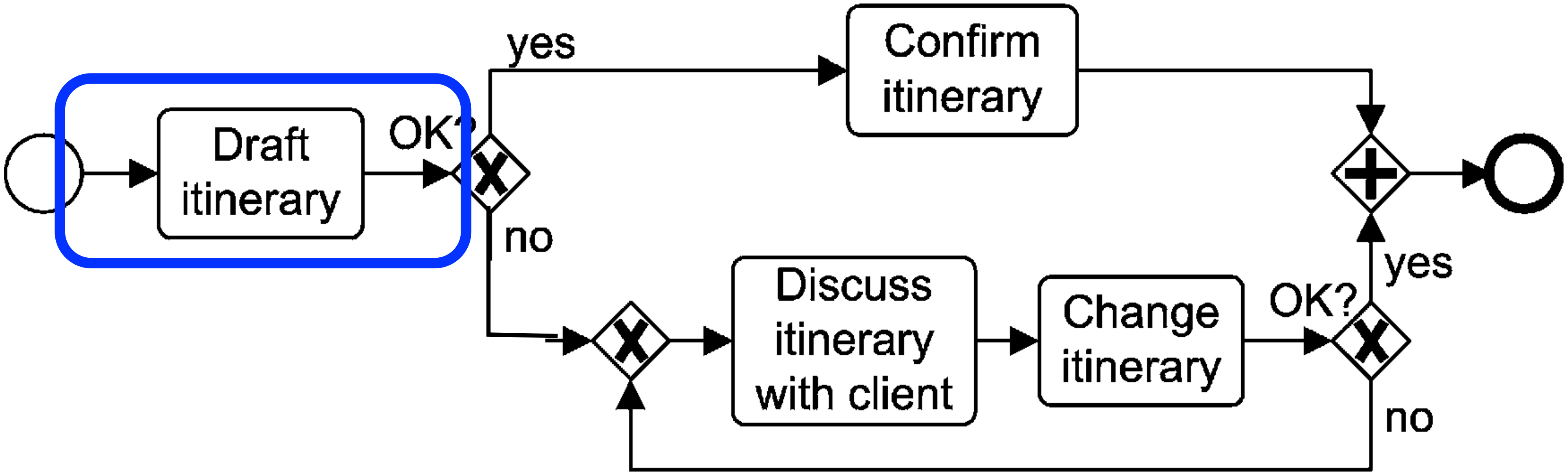


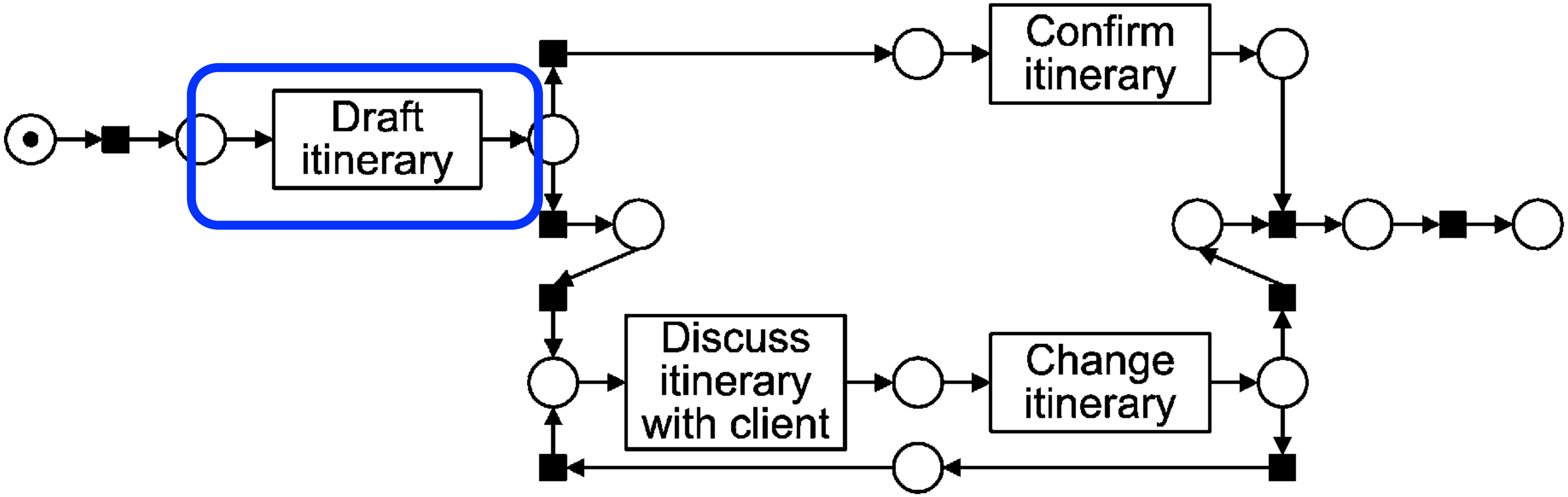
Example: Travel itinerary



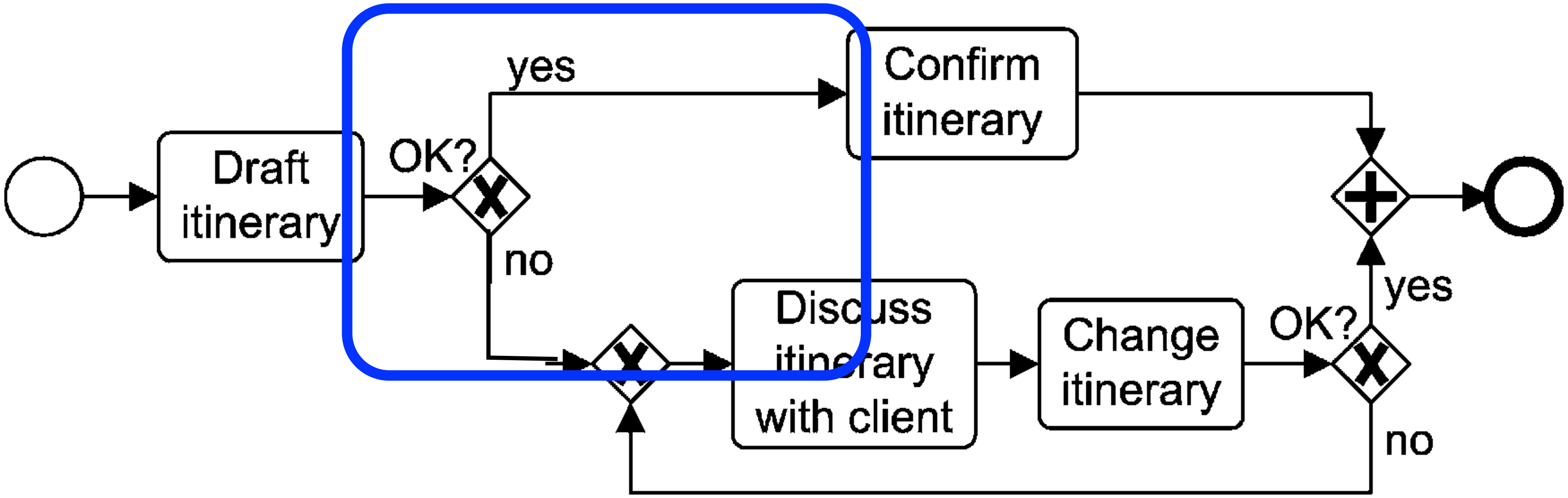


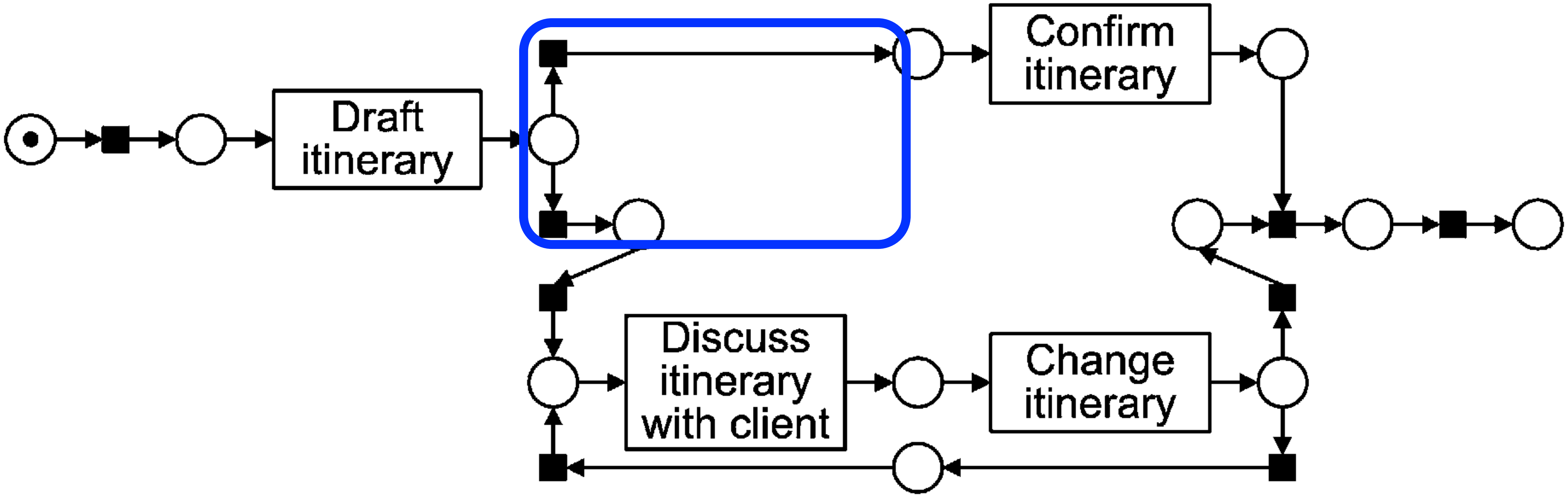
Example: Travel itinerary



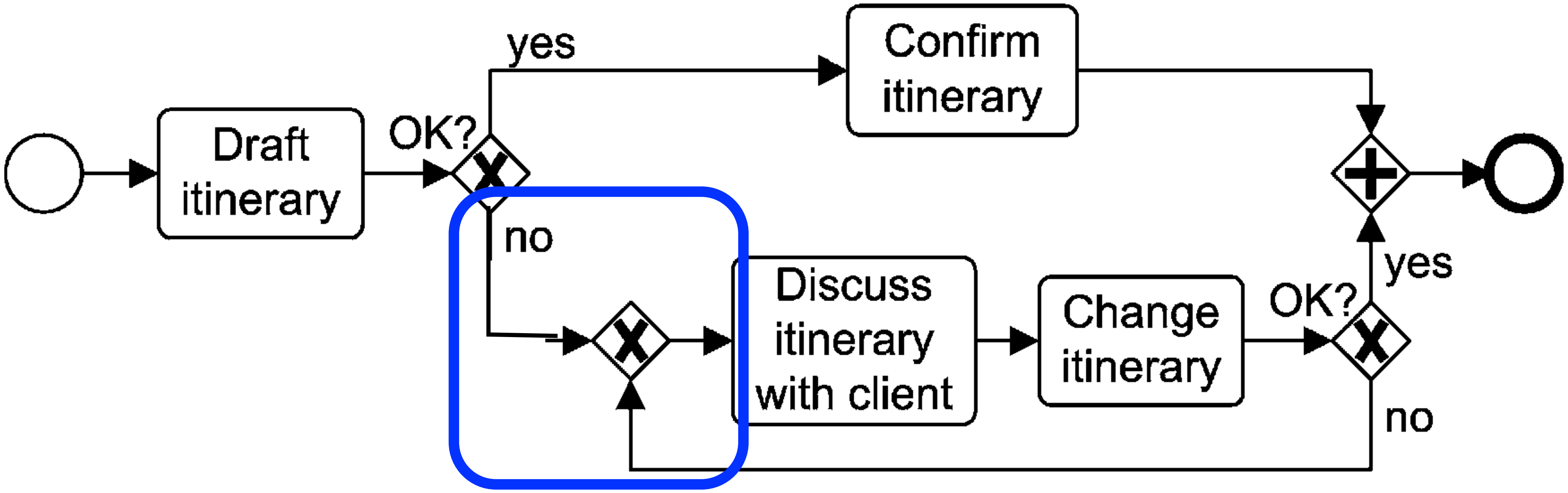


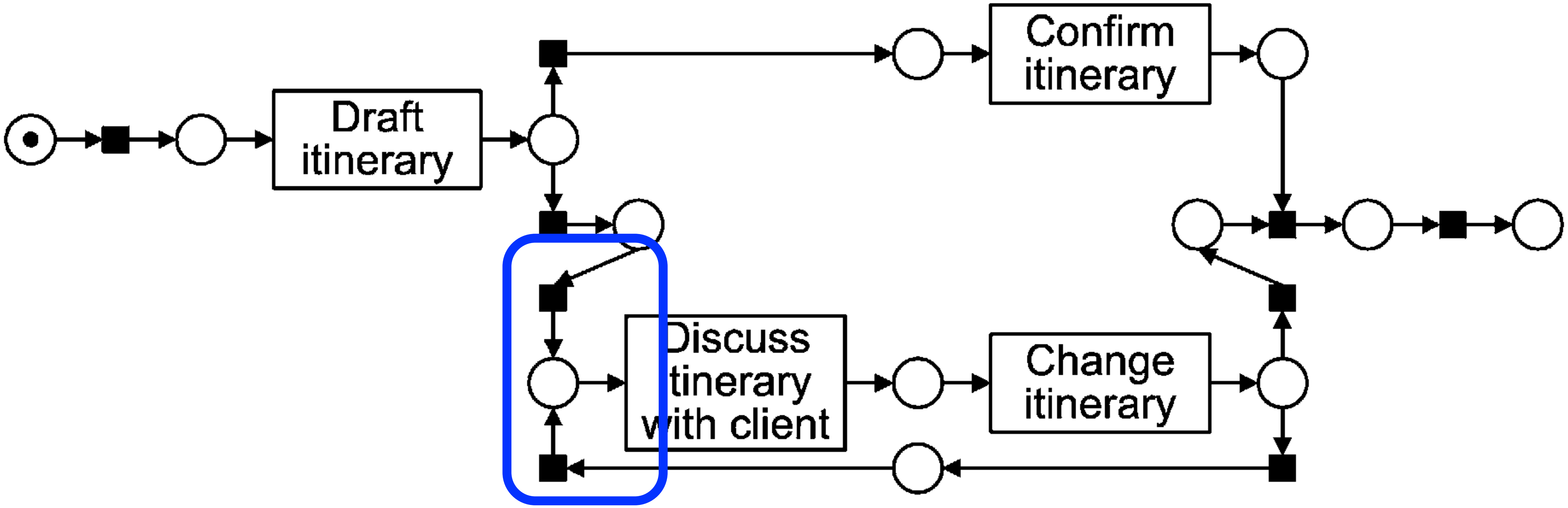
Example: Travel itinerary



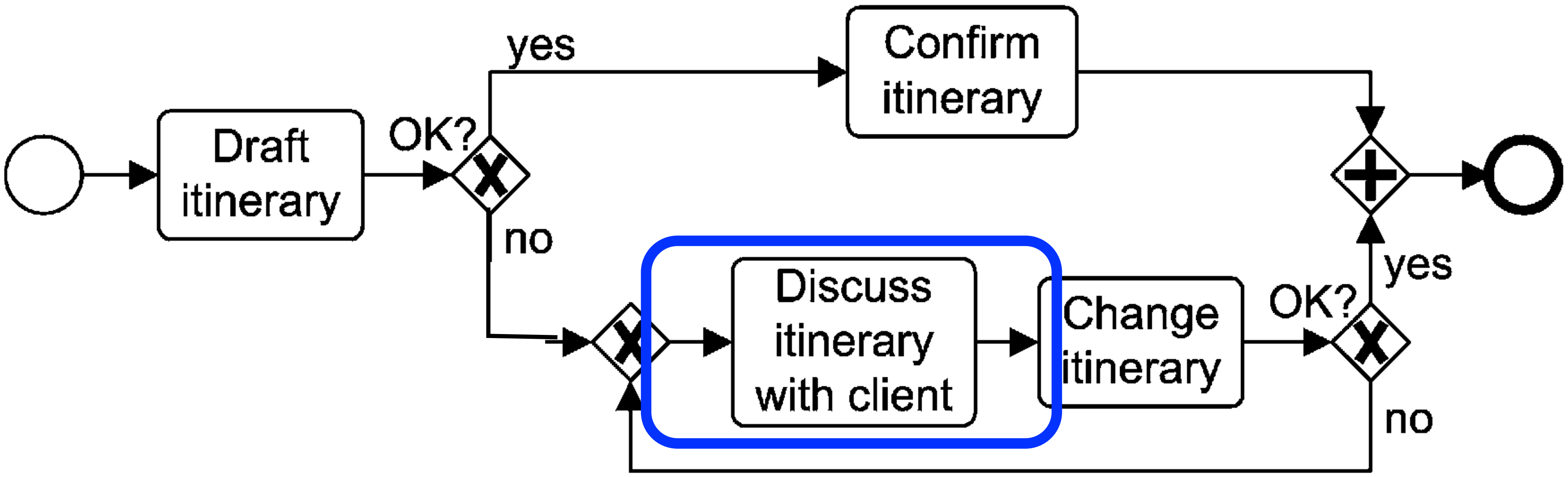


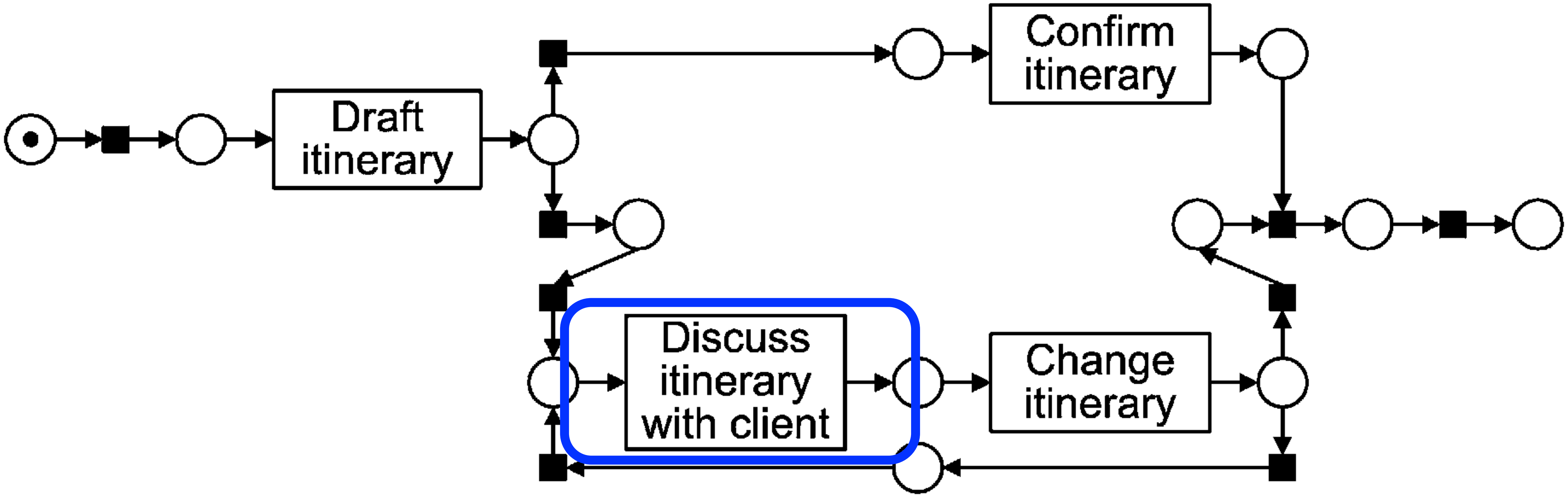
Example: Travel itinerary



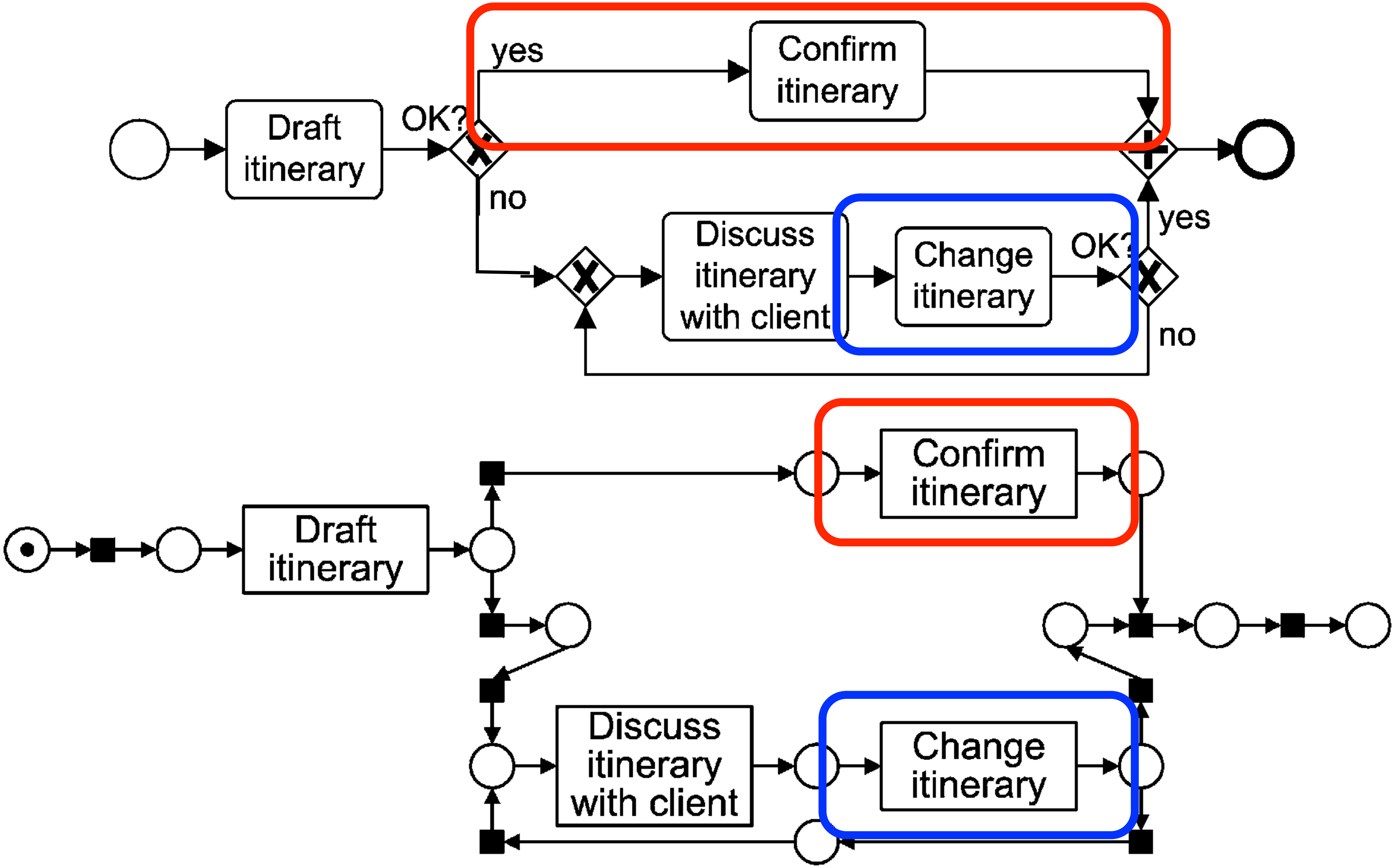


Example: Travel itinerary

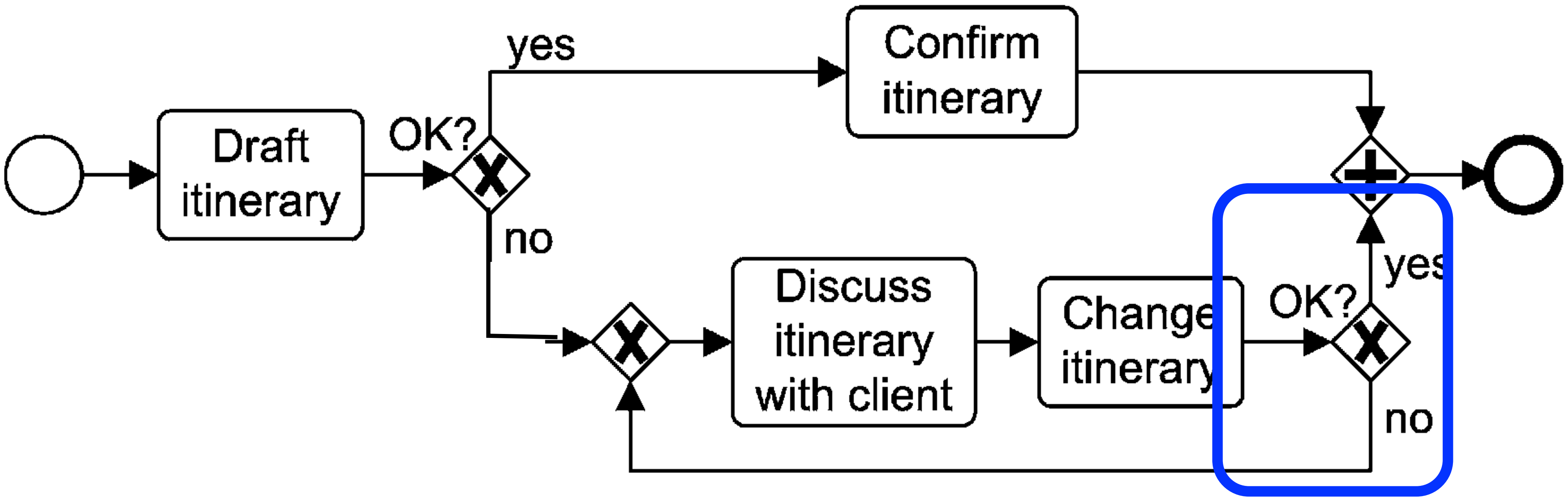


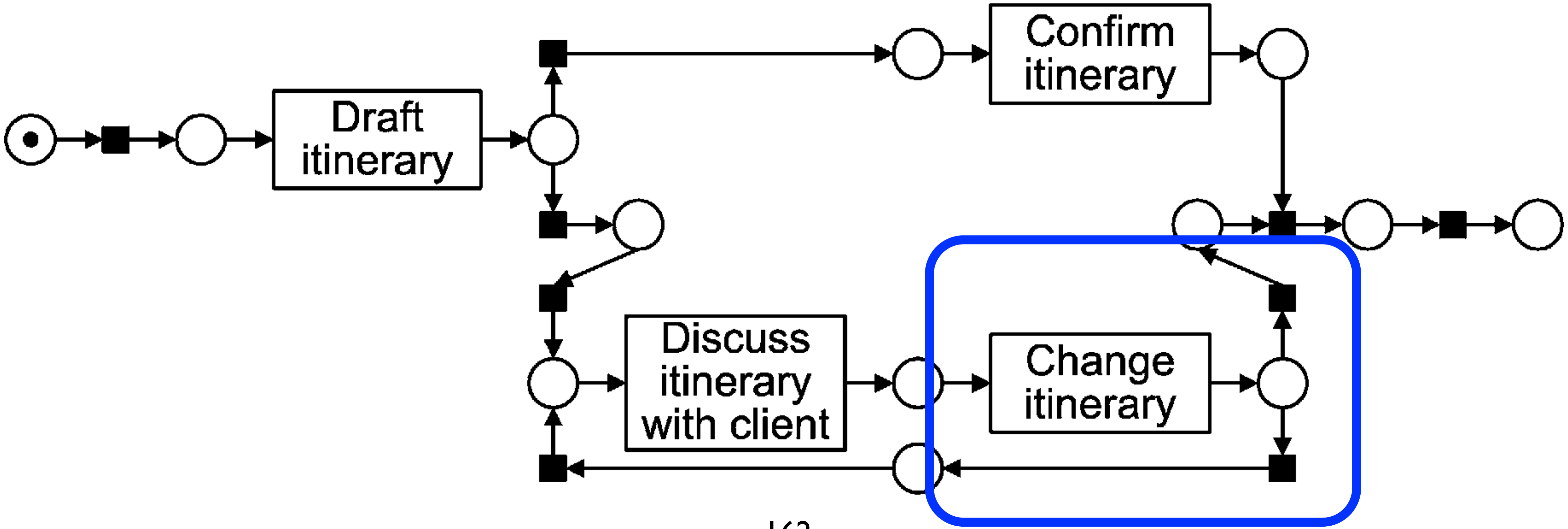


Example: Travel itinerary

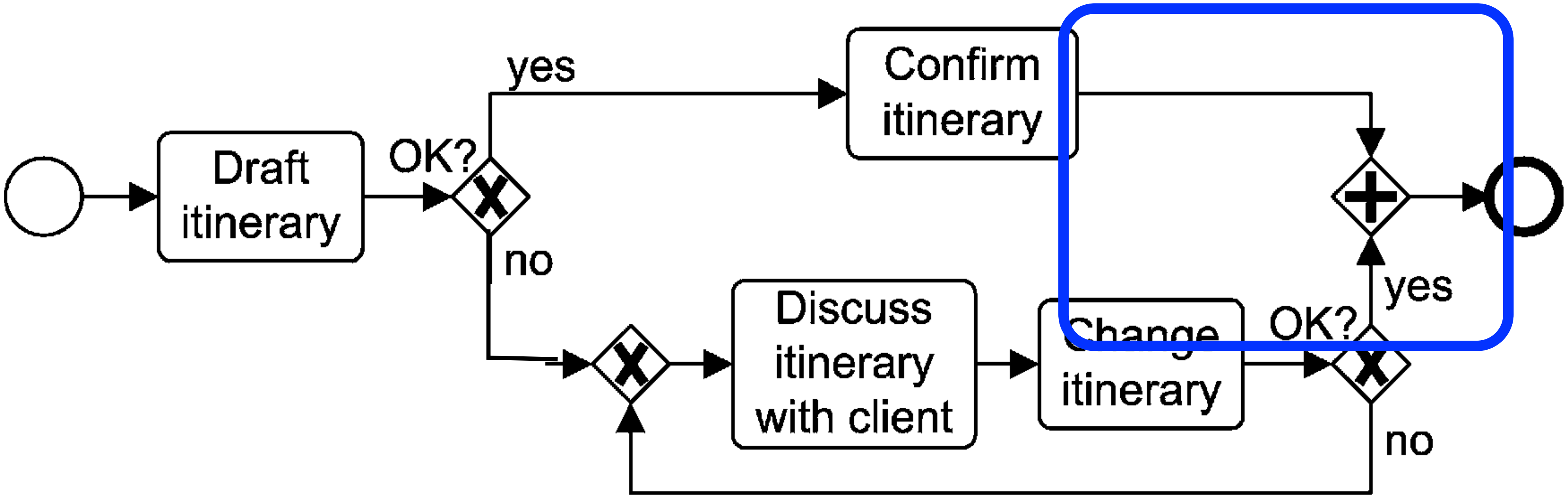


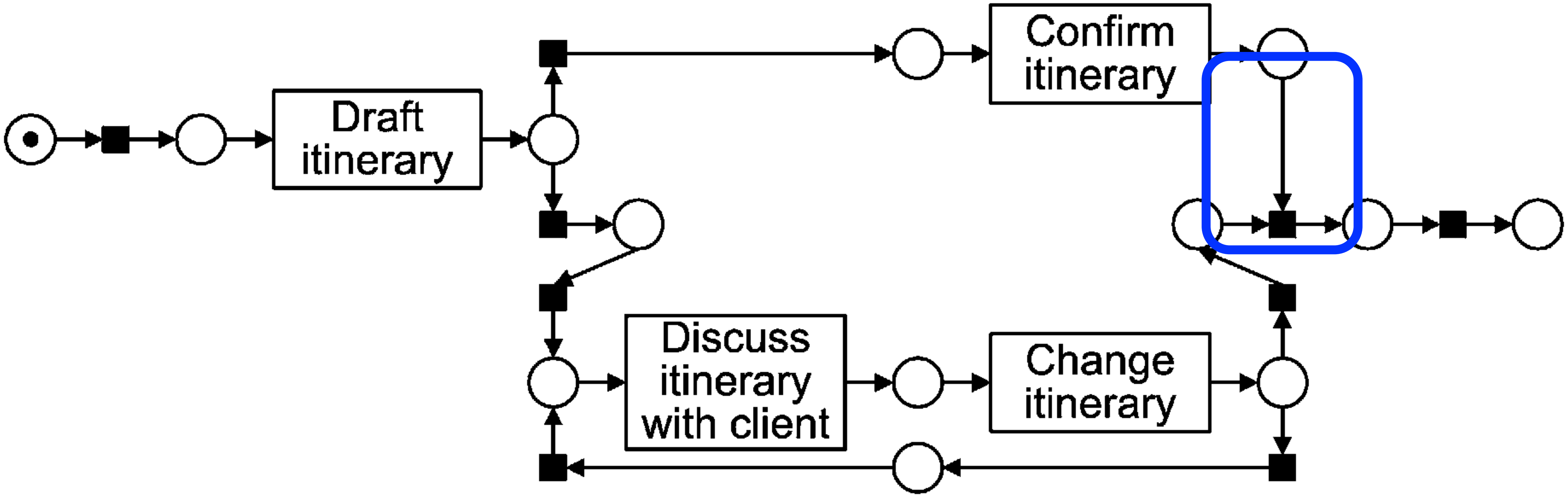
Example: Travel itinerary



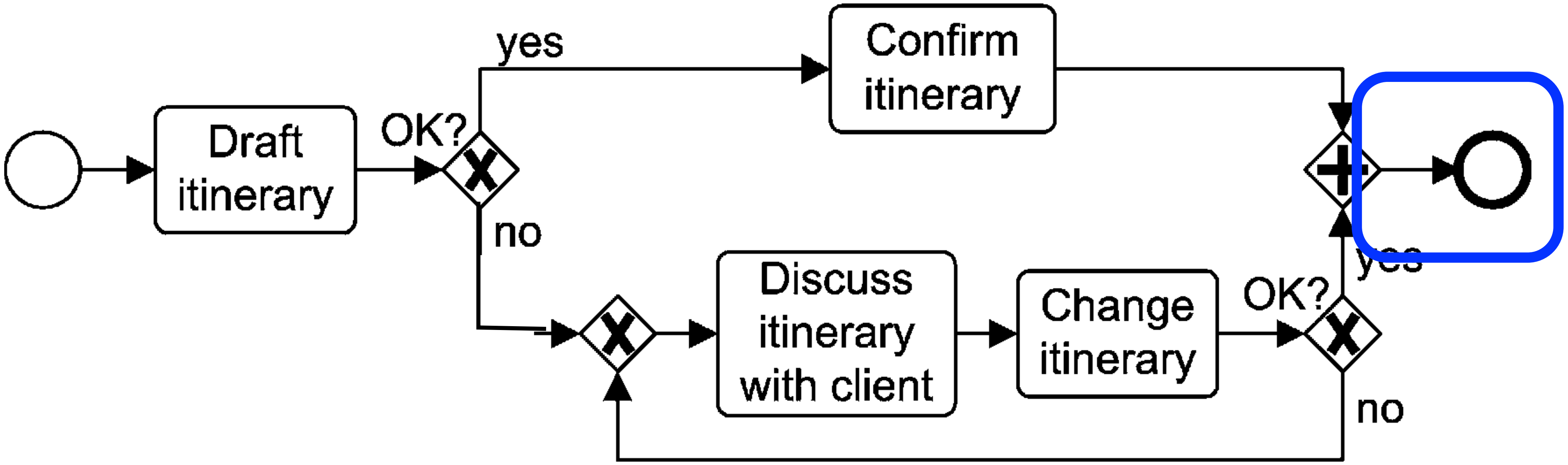


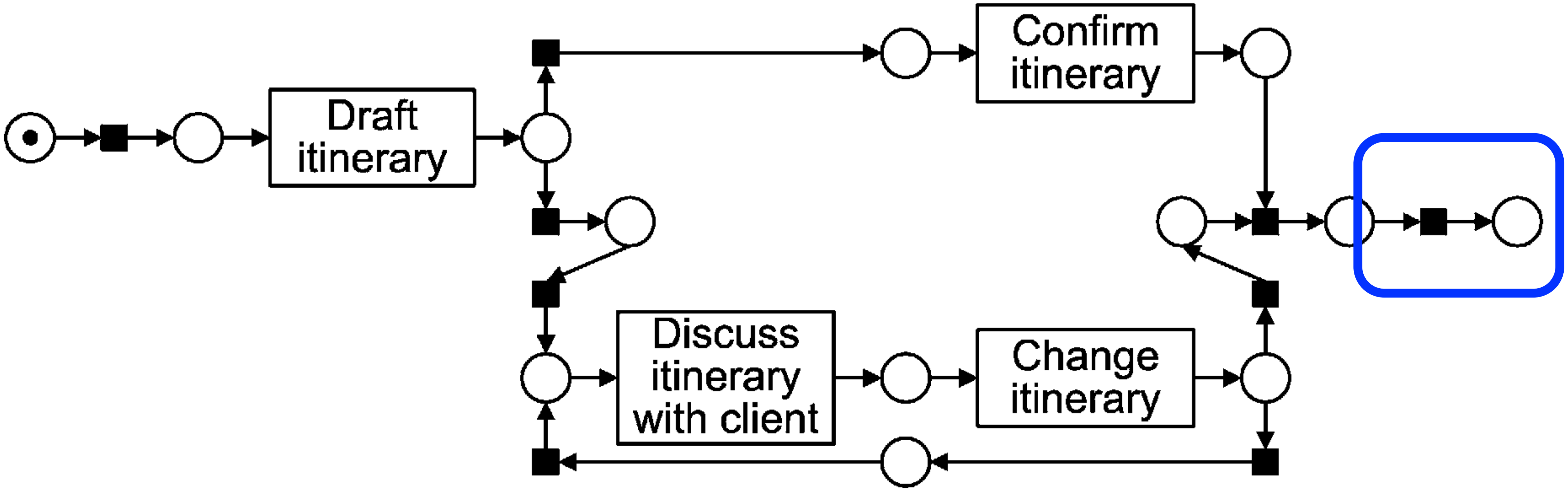
Example: Travel itinerary



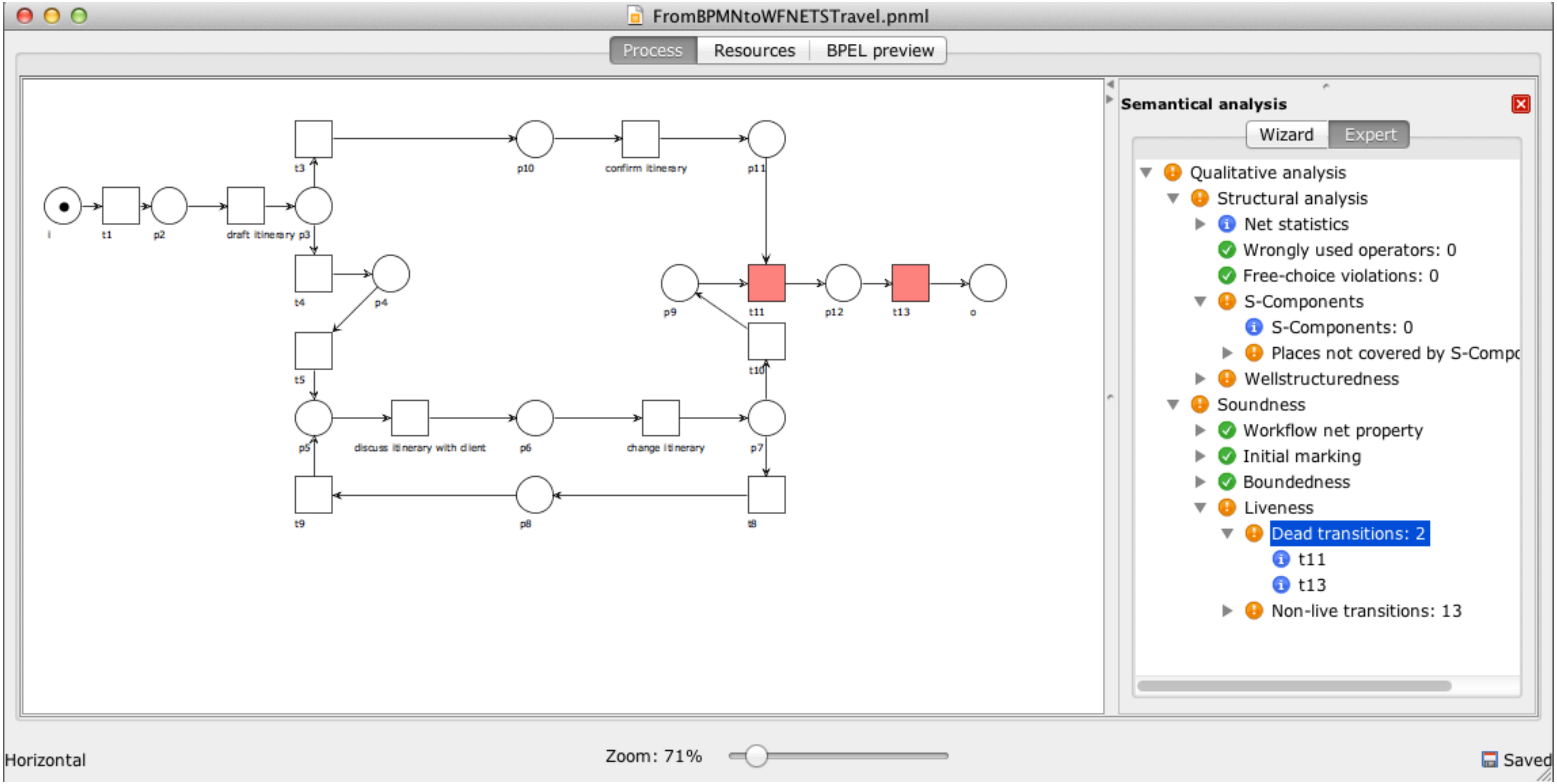


Example: Travel itinerary





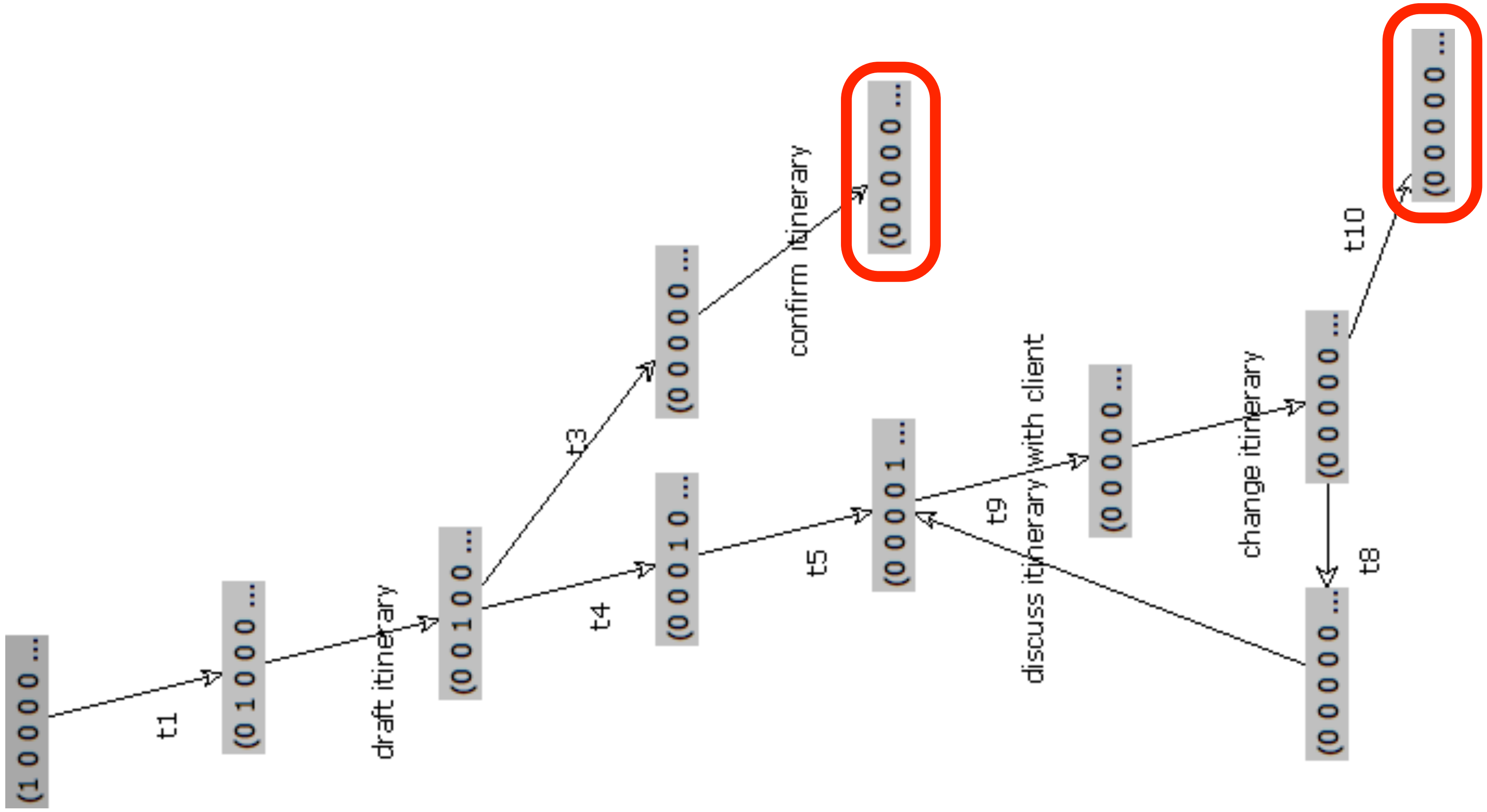
Example: Travel itinerary



Semantical analysis

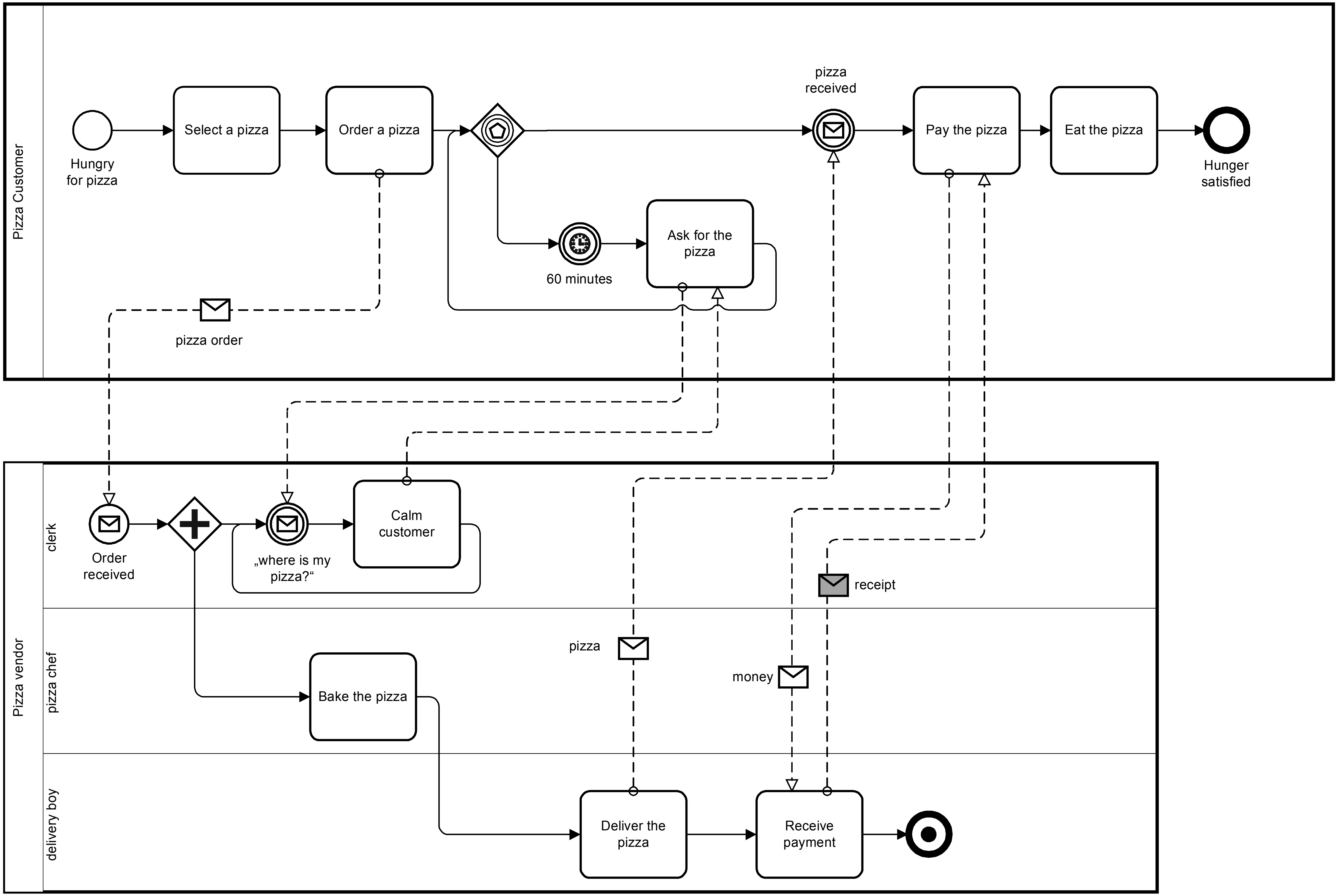
```
Qualitative analysis
  Structural analysis
    Net statistics
    Wrongly used operators: 0
    Free-choice violations: 0
    S-Components
      S-Components: 0
      Places not covered by S-Compo
    Wellstructuredness
  Soundness
    Workflow net property
    Initial marking
    Boundedness
    Liveness
      Dead transitions: 2
        t11
        t13
      Non-live transitions: 13
```

Example: Travel itinerary



Exercise

Translate the BPMN collaboration diagram to nets and discuss problematic issues


Pizza Customer
Hungry for pizza
Select a pizza
Order a pizza
pizza received
Pay the pizza
Eat the pizza
Hunger satisfied
60 minutes
Ask for the pizza
pizza order
Pizza vendor
clerk
Order received
„where is my pizza?“
Calm customer
receipt
pizza chef
Bake the pizza
pizza
money
delivery boy
Deliver the pizza
Receive payment