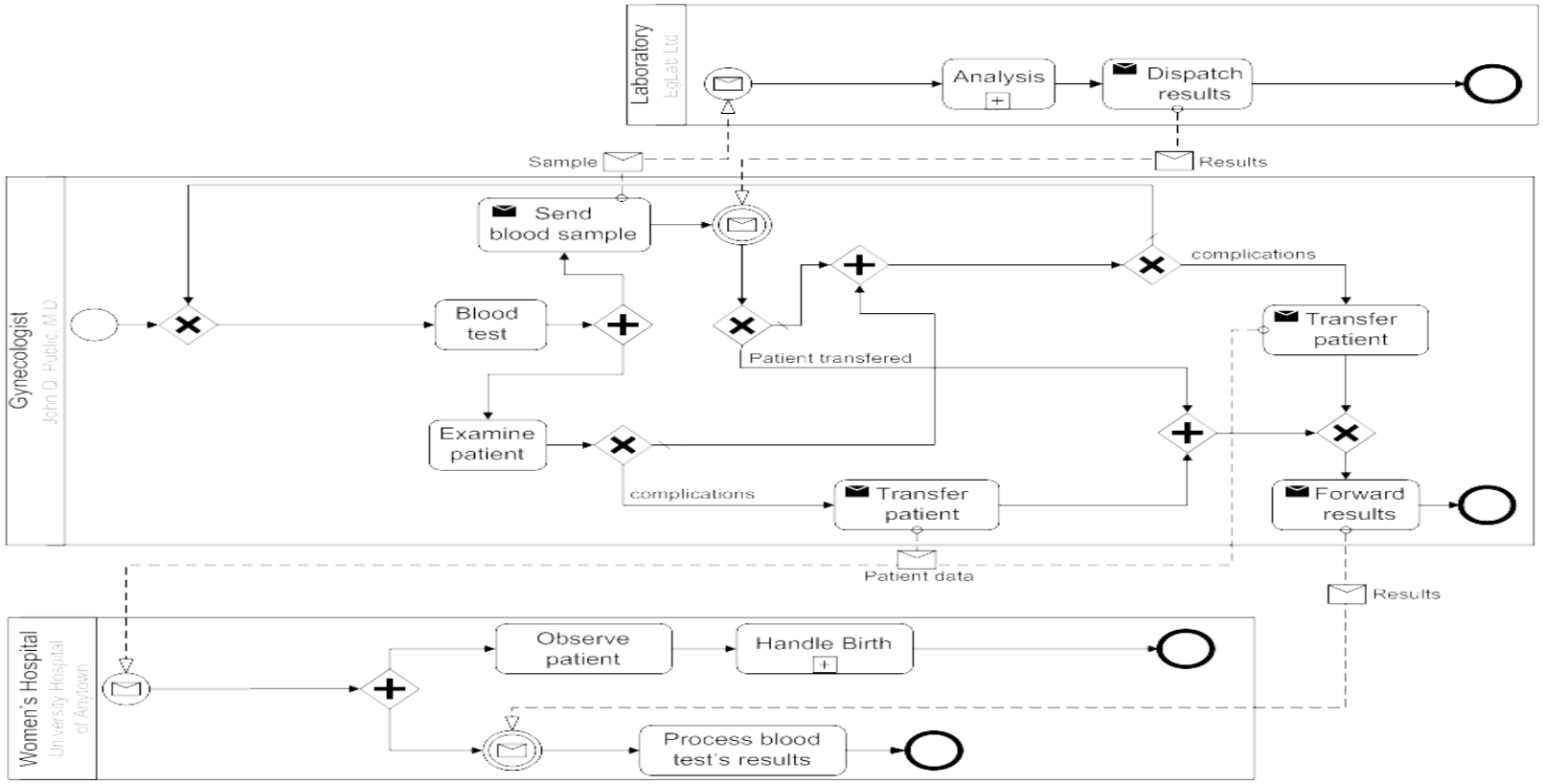
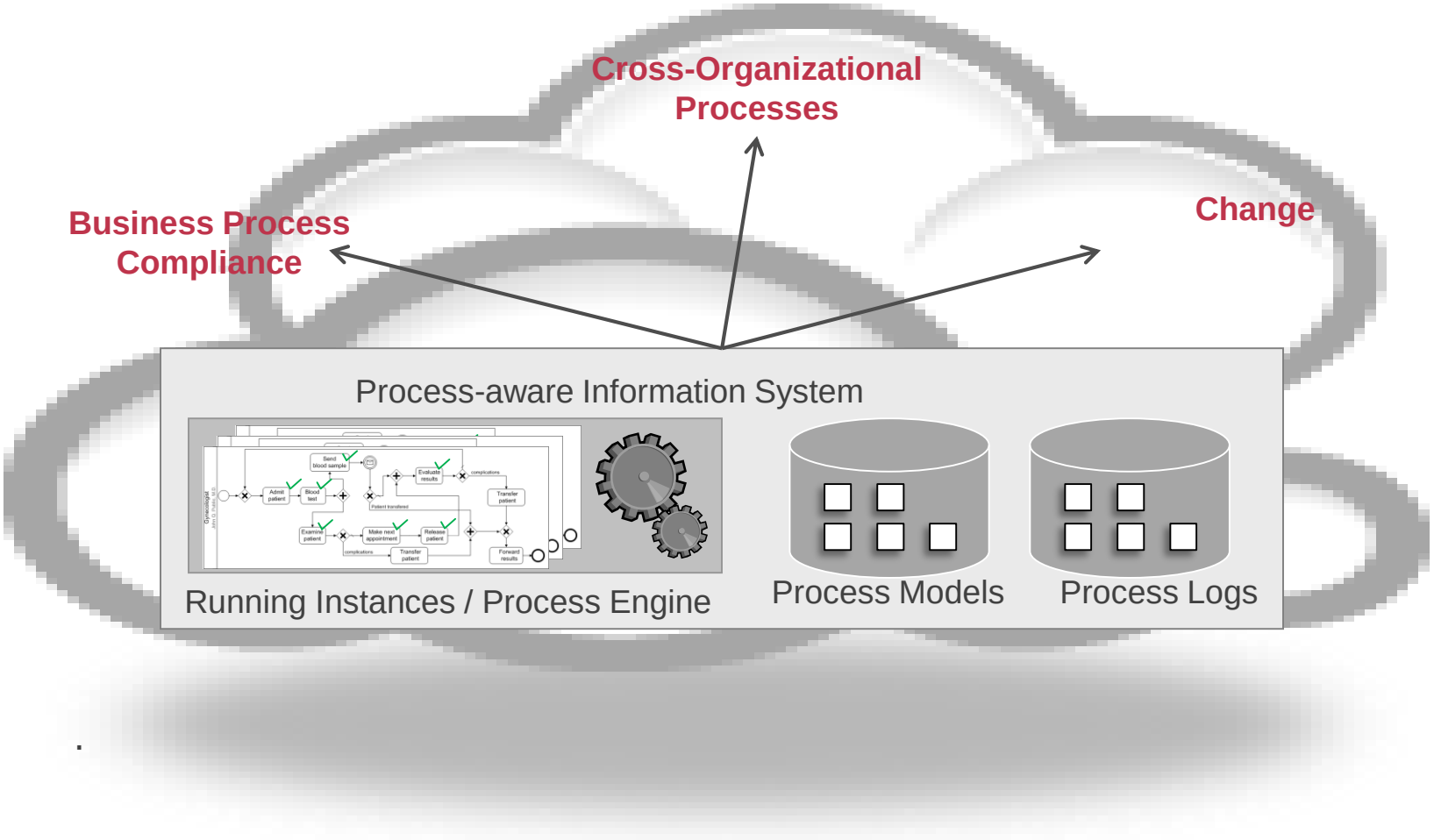
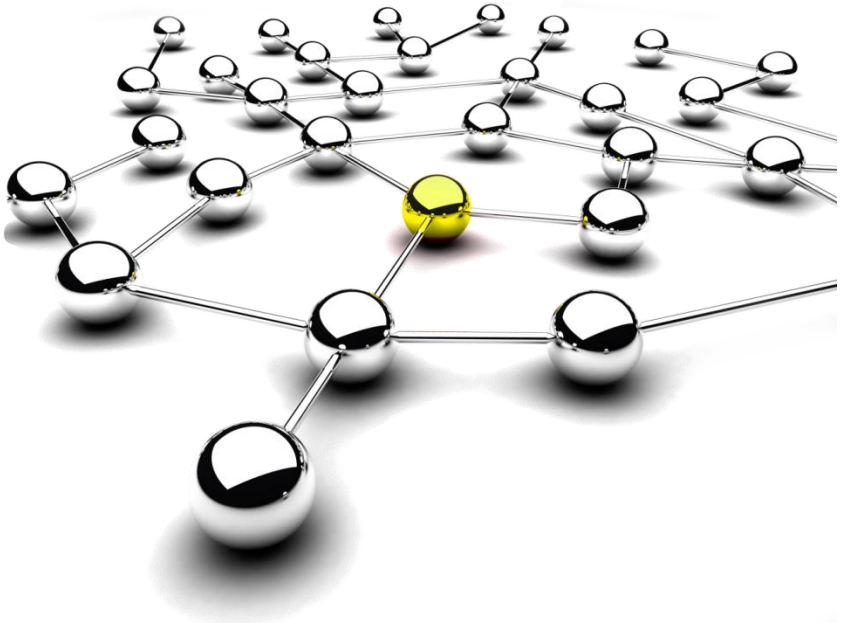


The Challenges of Modeling and Evolving Cross-Organizational Processes

Manfred Reichert

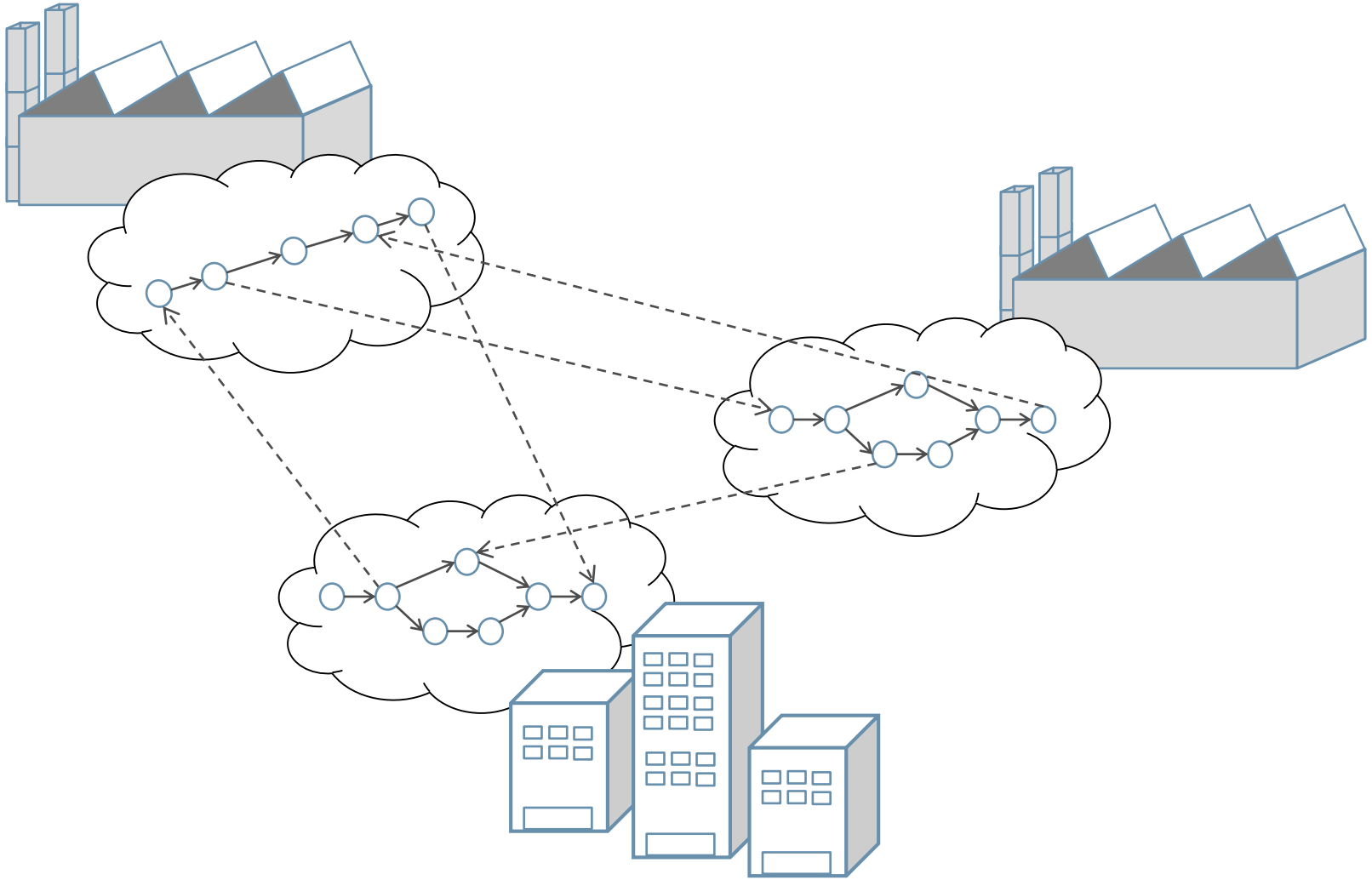
Introduction



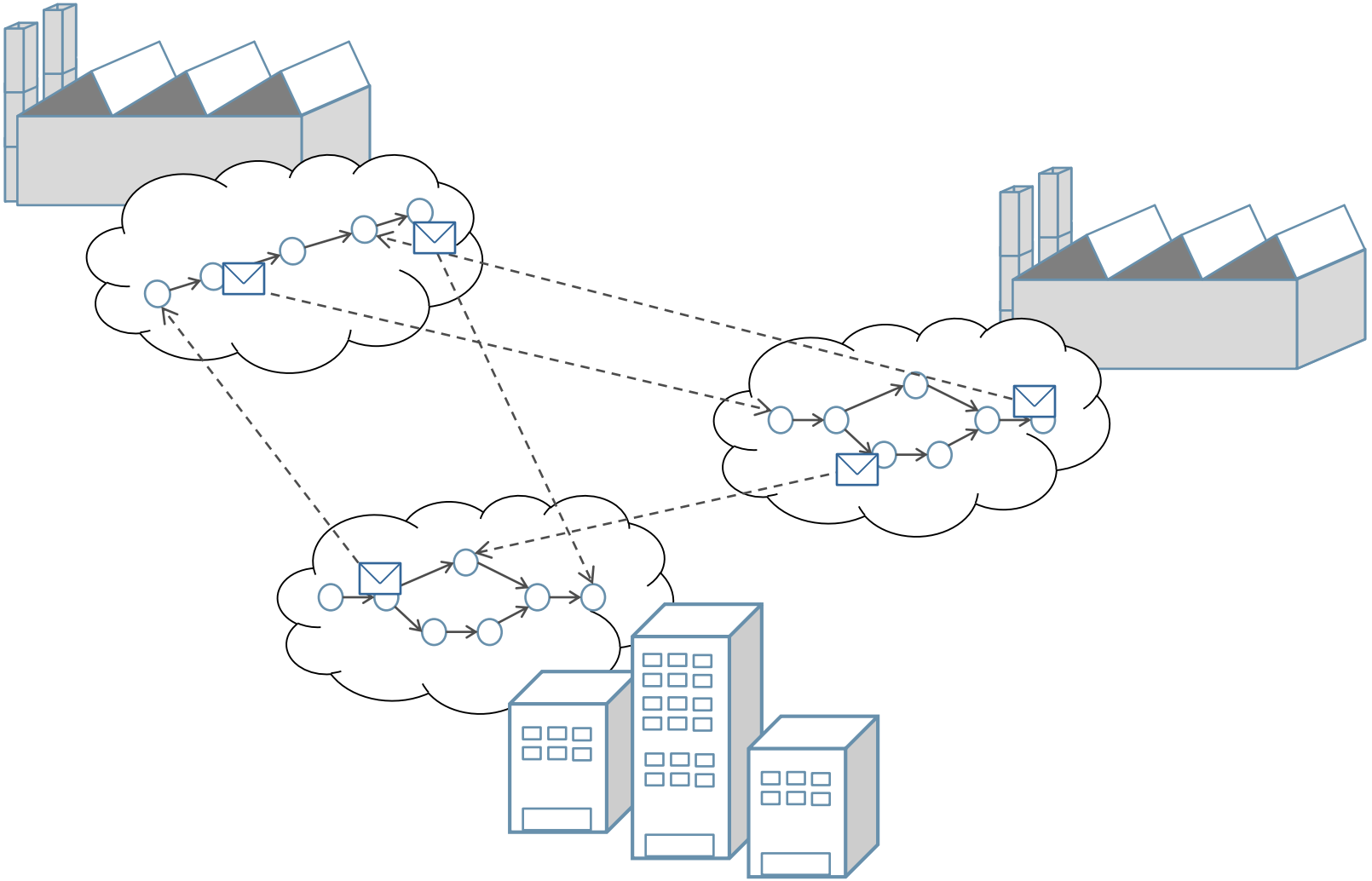


Modeling Cross-Organizational Processes: Interaction Modeling

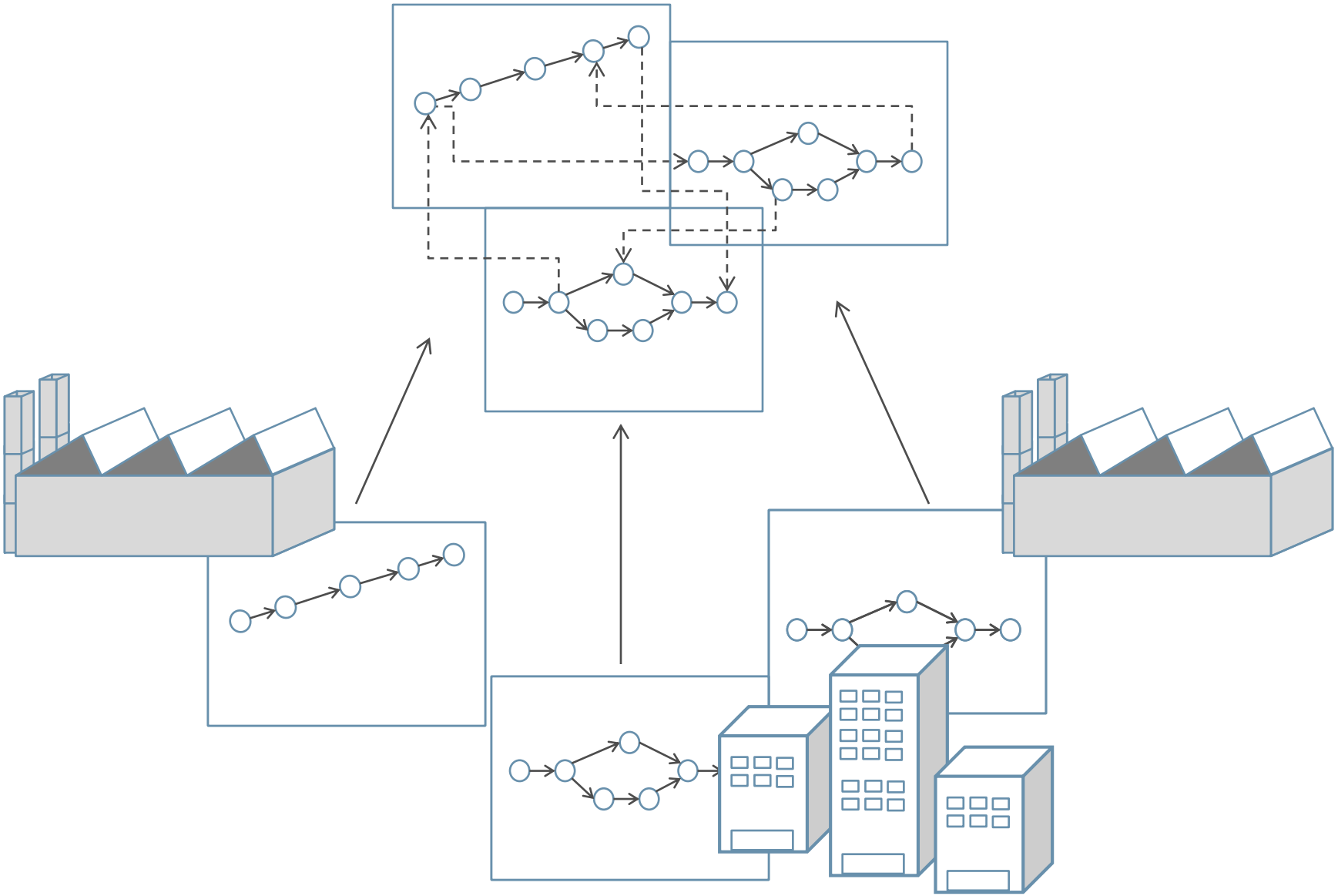
Cross-Organizational Processes



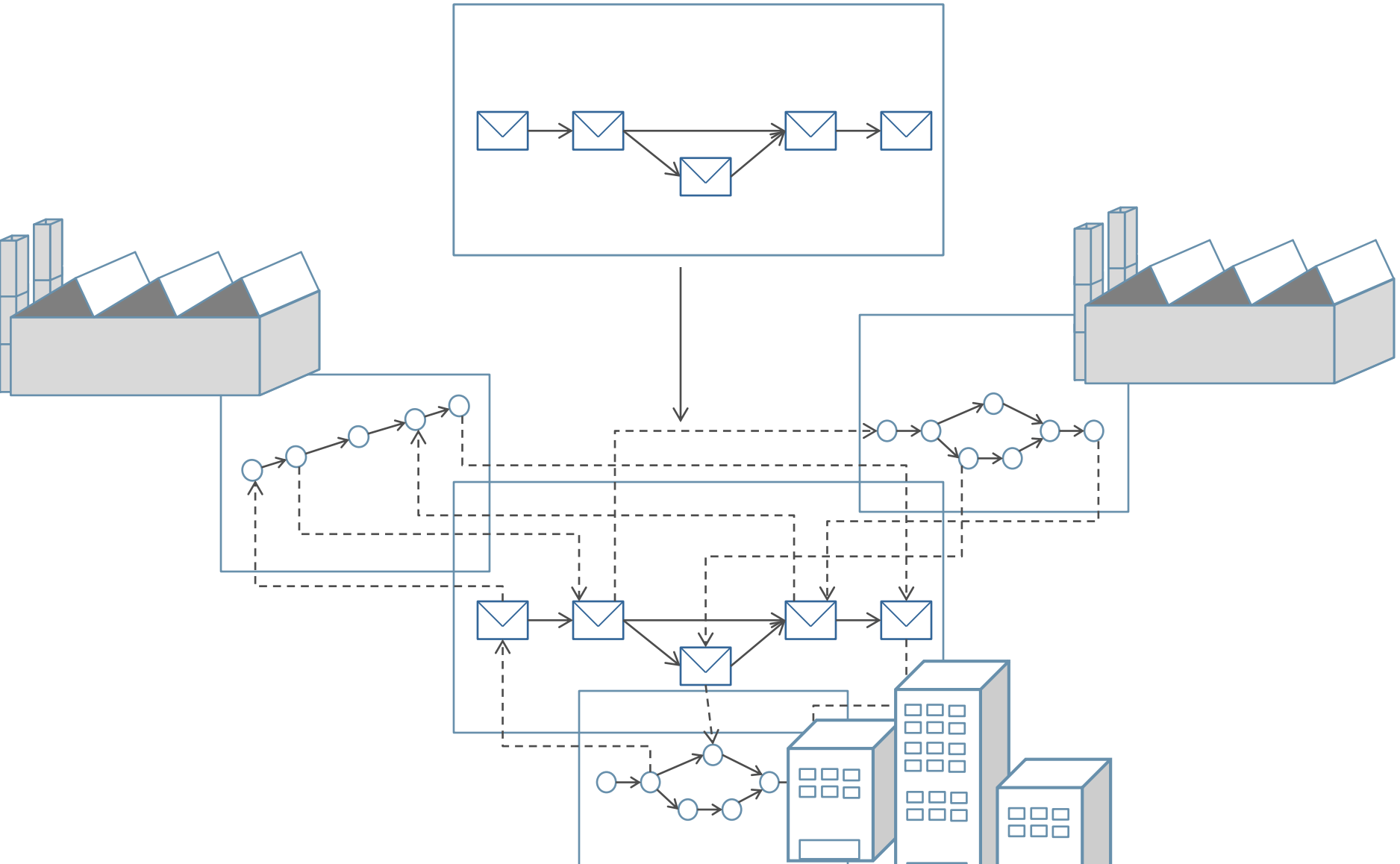
Cross-Organizational Processes



Cross-Organizational Processes:
Interconnection Modeling



Cross-Organizational Processes:
Interaction Modeling



Interaction Modeling:
Languages, Notations, Standards

- Chor
- Conversation protocols
- Interaction Petri-Nets
- Let‘s Dance
- iBPMN
- WS-CDL
- BPMN 2.0 Choreography

$$
\begin{array}{lll}
A & ::= & BA \quad \text{(basic activities)} \\
 & | & A;A \quad \text{(sequential composition)} \\
 & | & A \sqcap A \quad \text{(choice)} \\
 & | & A \parallel A \quad \text{(parallel composition)} \\
BA & ::= & \mathsf{skip} \quad \text{(no action)} \\
 & | & a^i \quad \text{(activity in role } R^i\text{)} \\
 & | & c^{[i,j]} \quad \text{(communication)}
\end{array}
$$

Basic: $[\![\mathsf{skip}]\!] \mathrel{\widehat{=}} \{\langle\rangle\} \qquad [\![a]\!] \mathrel{\widehat{=}} \{\langle a\rangle\}$
$[\![c^{[i,j]}]\!] \mathrel{\widehat{=}} \{\langle c^{[i,j]}\rangle\}$

Sequential: $[\![A_1;A_2]\!] \mathrel{\widehat{=}} [\![A_1]\!] \frown [\![A_2]\!]$

Choice: $[\![A_1 \sqcap A_2]\!] \mathrel{\widehat{=}} [\![A_1]\!] \cup [\![A_2]\!]$

Parallel: $[\![A_1 \parallel A_2]\!] \mathrel{\widehat{=}} \mathit{interlv}([\![A_1]\!], [\![A_2]\!])$

Qiu Zongyan, Zhao Xiangpeng, Cai Chao, and Yang Hongli:
Towards the Theoretical Foundation of Choreography, WWW’07, 2007.

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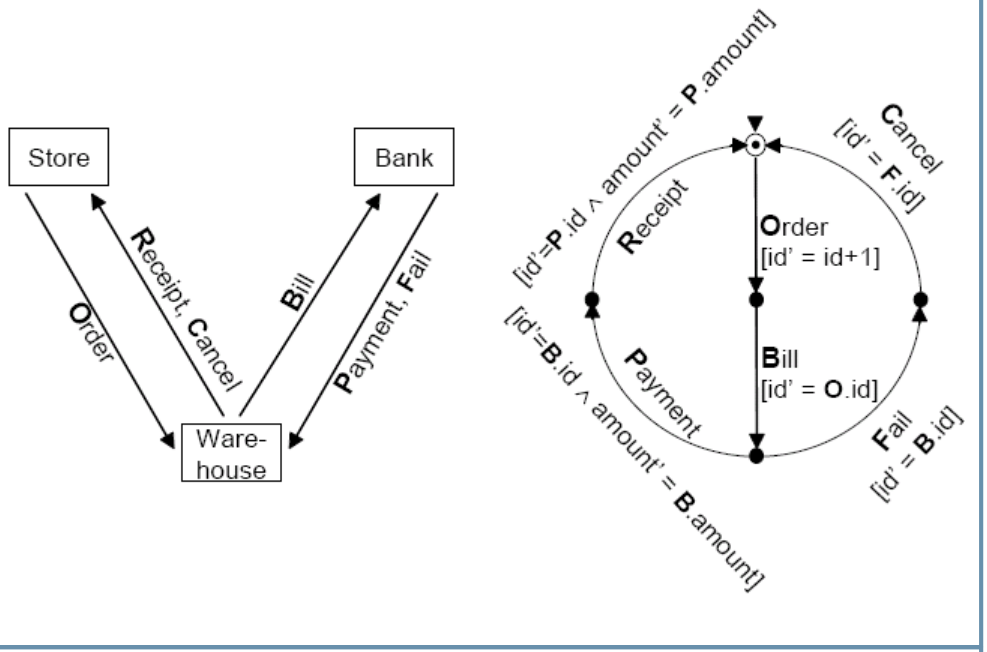

Xiang Fu, Tevfik Bultan, Jianwen Su: *Conversation Protocols: A Formalism for Specification and Verification of Reactive Electronic Services.* CIAA'04, 2004.

Xiang Fu, Tevfik Bultan, Jianwen Su: *Realizability of conversation protocols with message contents*. Web Services Research 2(4), 2005.

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Languages, Notations, Standards

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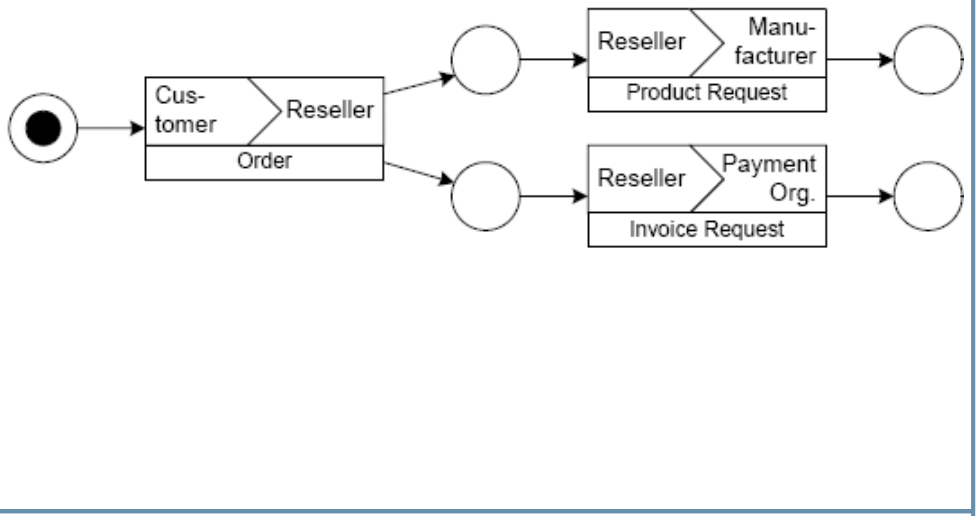

Gero Decker, Mathias Weske:
Local Enforceability in Interaction Petri Nets, BPM’07, 2007.

Interaction Modeling:
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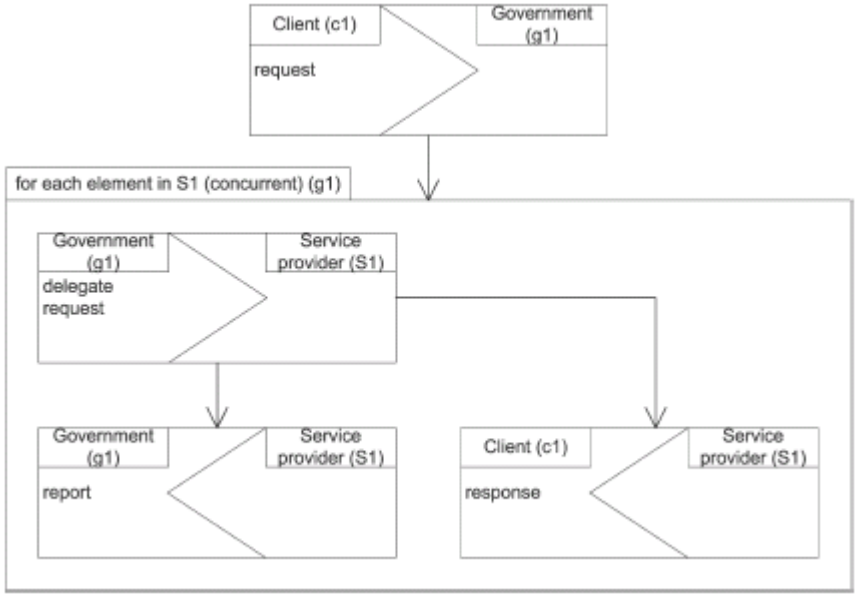

Johannes Maria Zaha, Alistair Barros, Marlon Dumas, Arthur ter Hofstede: *Let’s dance: A language for service behavior modeling*. CoopIS’07, 2007.

Interaction Modeling:
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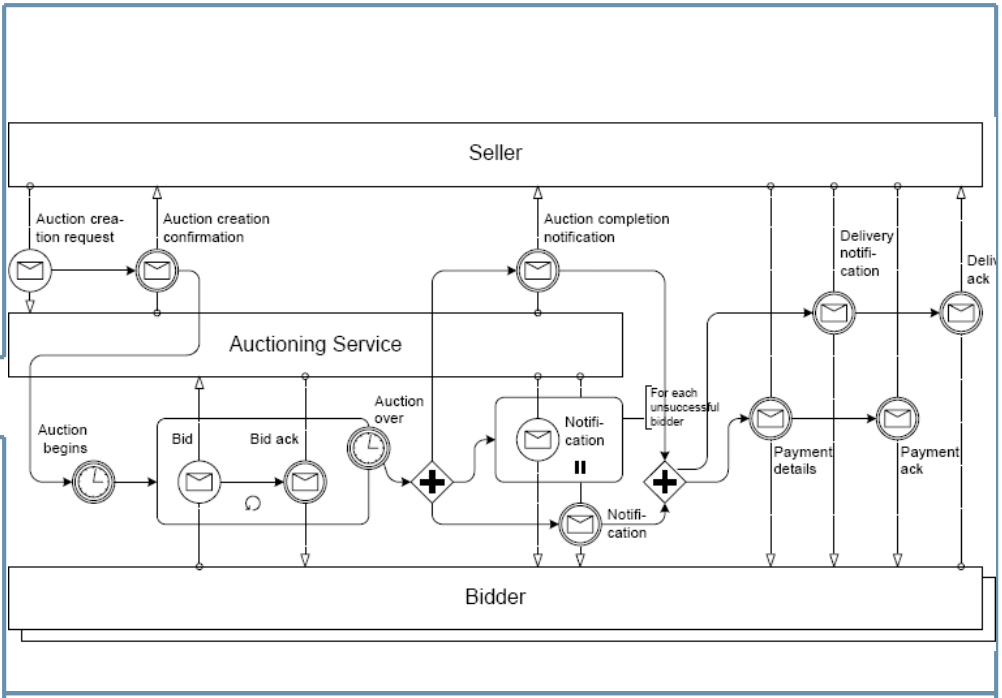

Gero Decker, Alistair Barros: *Interaction Modeling using BPMN*, BPM’07, 2007.

Interaction Modeling:
Languages, Notations, Standards

- Chor
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- Interaction Petri-Nets
- Let‘s Dance
- iBPMN
- WS-CDL
- BPMN 2.0 Choreography

```
<informationType name="creditDeniedType" />

<!-- Coordinated CreditAuthorization Choreography without finalizerBlocks-->
<choreography name="CreditAuthorization" root="false" coordination="true">
   <relationship type="tns:CreditReqCreditResp"/>
   <variableDefinitions>
      <variable name="CreditExtended" informationType="xsd:int" silent="true"
                roleTypes="tns:CreditResponder"/>
      <variable name="creditRequest"/>
      <variable name="creditAuthorized"/>
      <variable name="creditDenied" informationType = "tns:creditDeniedType"/
   </variableDefinitions>

   <!-- the normal work - receive the request and decide whether to approve --
   <interaction name="creditAuthorization" channelVariable="tns:CreditRequest
                operation="authorize">
      <participate relationshipType="SuperiorInferior"
                   fromRoleTypeRef="tns:Superior"
                   toRoleTypeRef="tns:Inferior"/>
      <exchange name="creditRequest" informationType="creditRequest"
                action="request">
         <send variable="getVariable('tns:creditRequest','','')"/>
         <receive variable="getVariable('tns:creditRequest','','')"/>
      </exchange>
      <exchange name="creditAuthorized" informationType="creditAuthorizedType
                action="respond">
         <send variable="getVariable('tns:creditAuthorized','','')"/>
         <receive variable="getVariable('tns:creditAuthorized','','')"/>
      </exchange>
```

W3C: Web services choreography description language 1.0, 2005.

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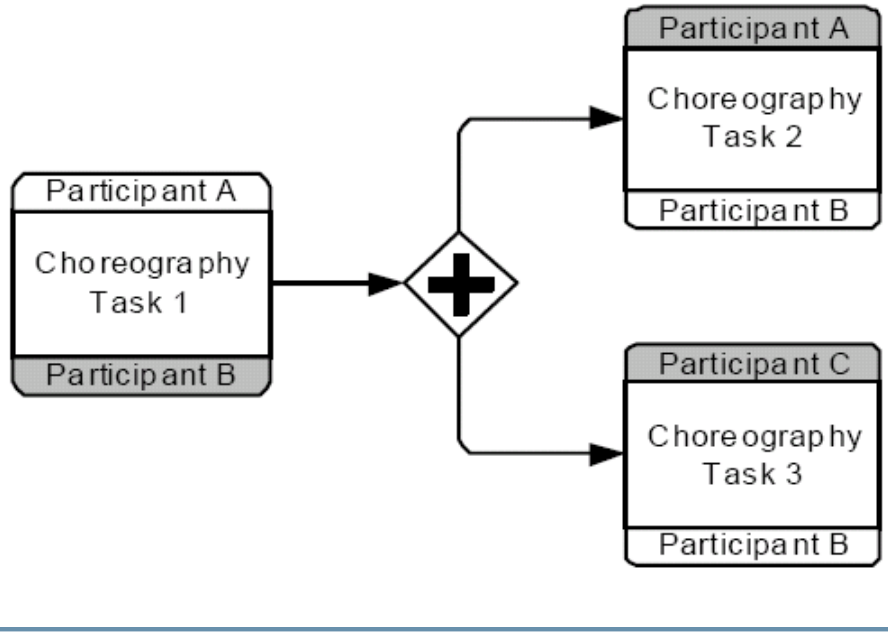

OMG/BPMI: BPMN 2.0, 2011.

What about Data?

Interaction Modeling:
Languages, Notations, Standards

- Chor
- Conversation protocols
- Interaction Petri-Nets
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- iBPMN
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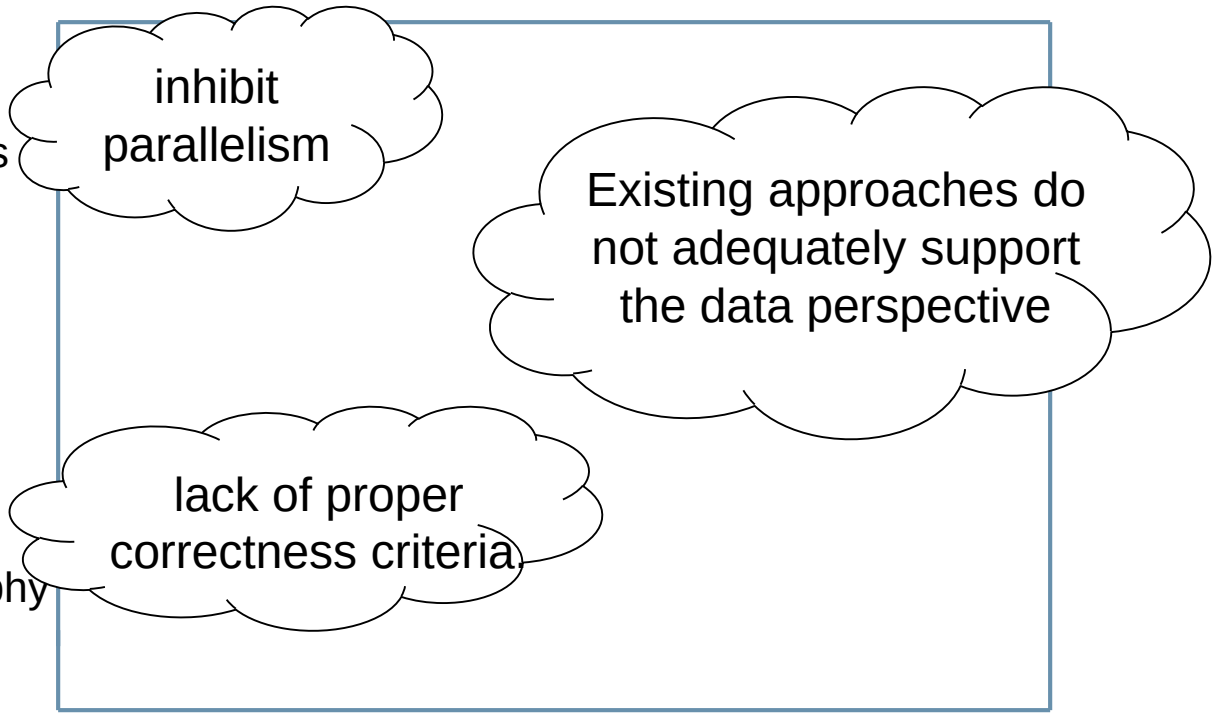
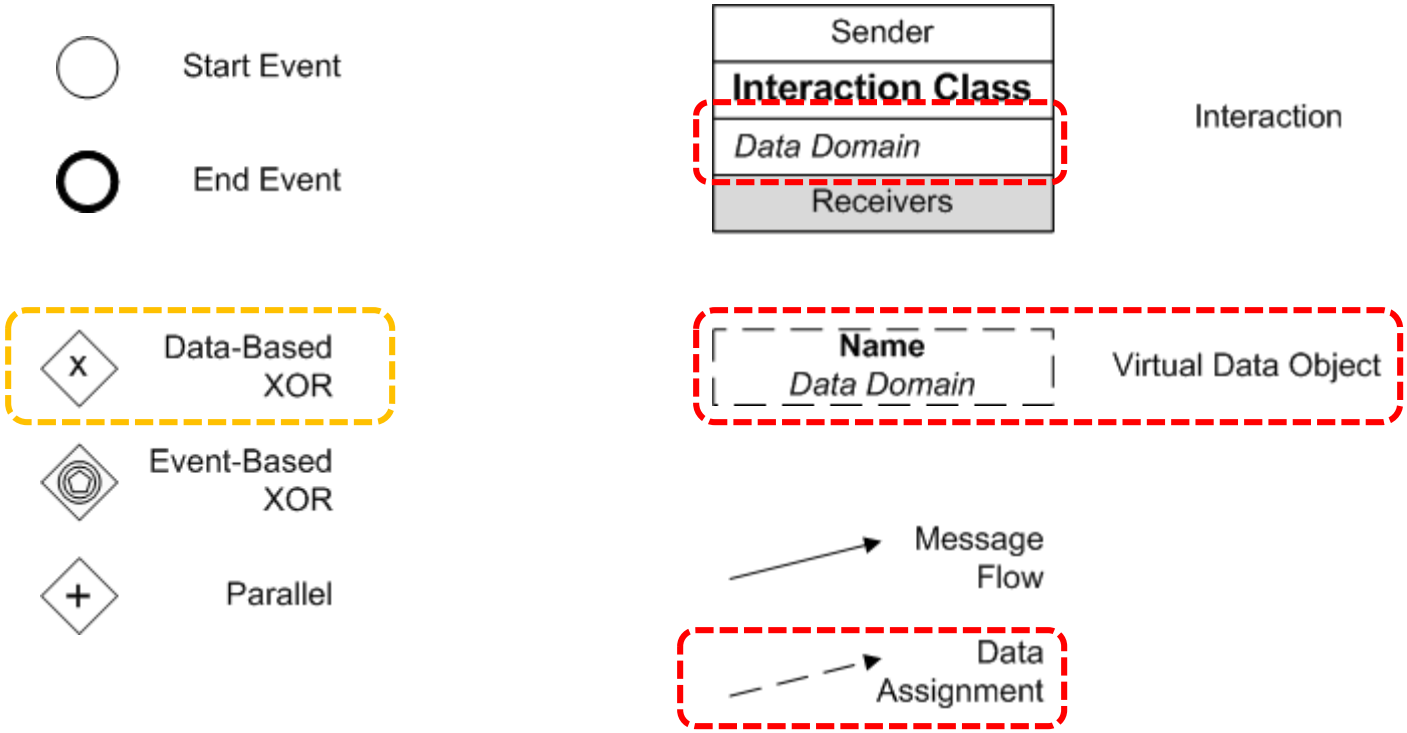
- BPMN 2.0 Choreography



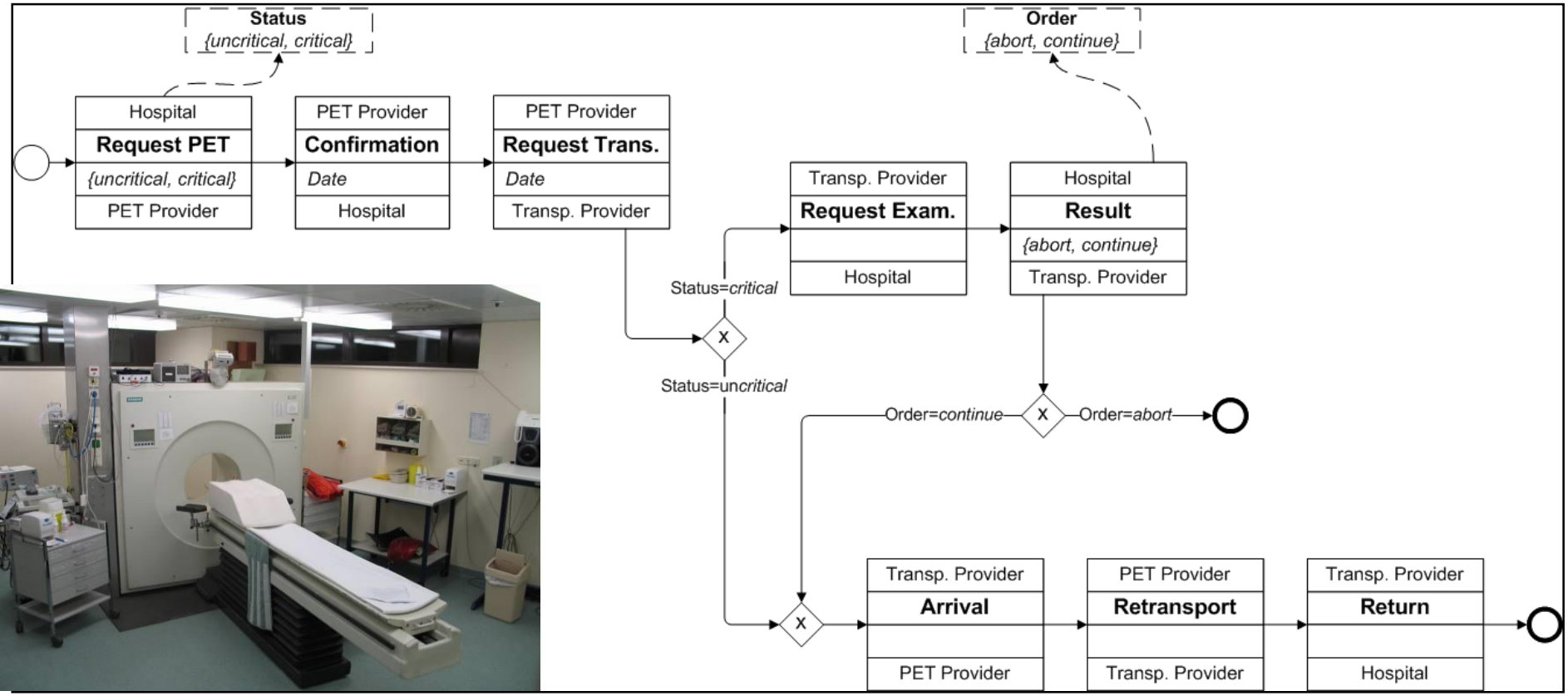
What about Data?

Data-Aware Interaction Modeling:
DAChor – A Data-Aware Interaction Modeling Language

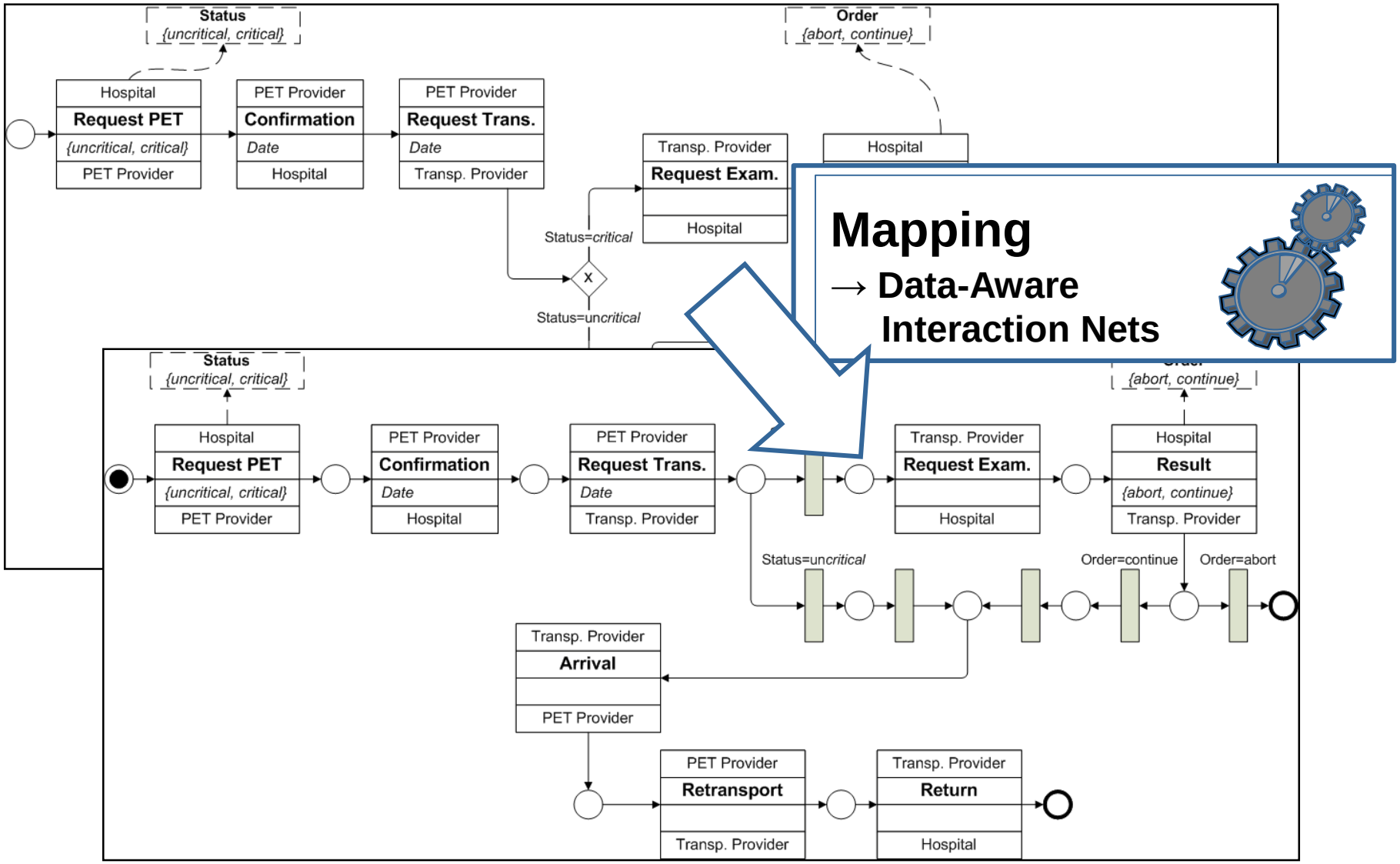


D. Knuplesch, R. Pryss, M. Reichert (2012) *Data-Aware Interaction in Distributed and Collaborative Workflows: Modeling, Semantics, Correctness.* Proc IEEE CollaborateCom 2012, Pittsburgh, 2012, pp. 223-232.

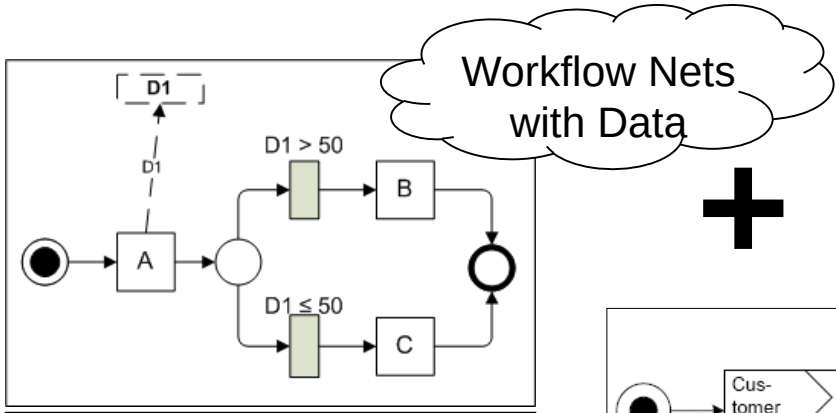
Data-Aware Interaction Modeling:
DAChor Example



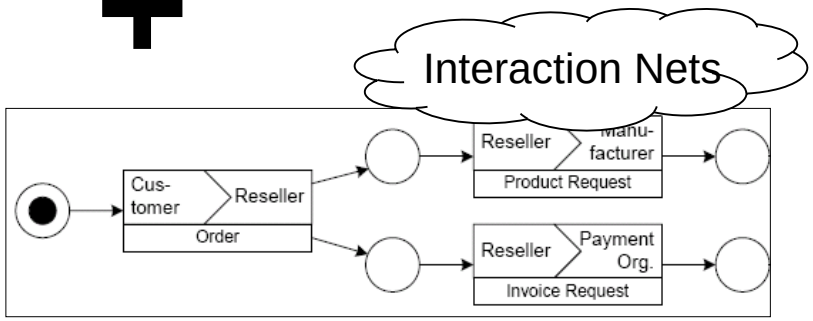
Data-Aware Interaction Modeling:
DAChor Semantics



Data-Aware Interaction Modeling:
DAChor Semantics - Data-Aware Interaction Nets



Trcka, N., van der Aalst, W.M.P., Sidorova, N.: *Data-flow anti-patterns: Discovering data-flow errors.* CAiSE'09, 2009.



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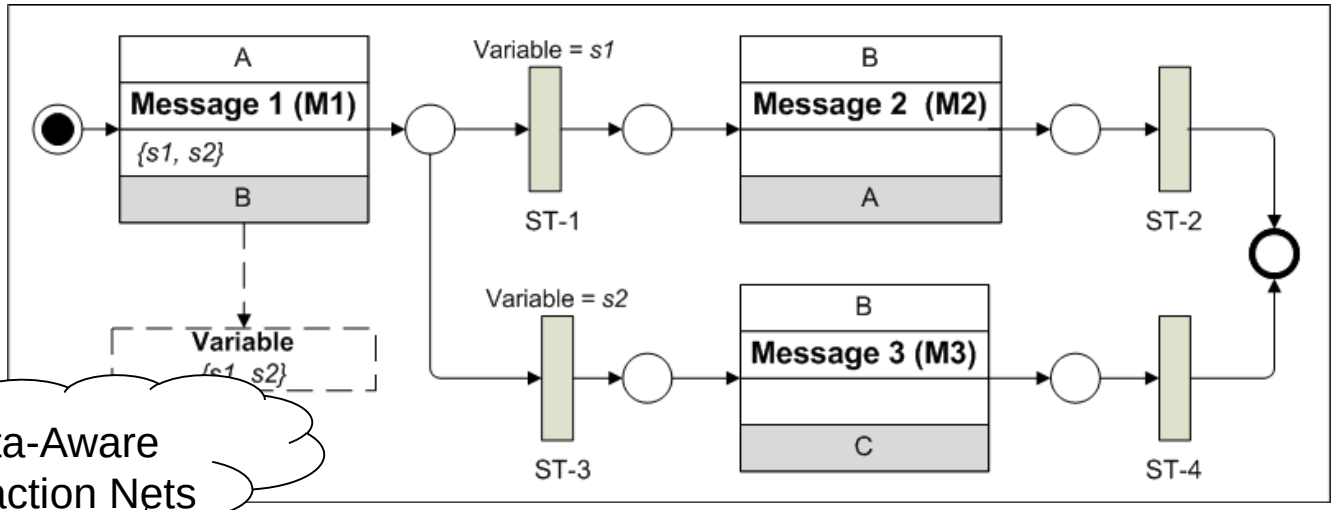
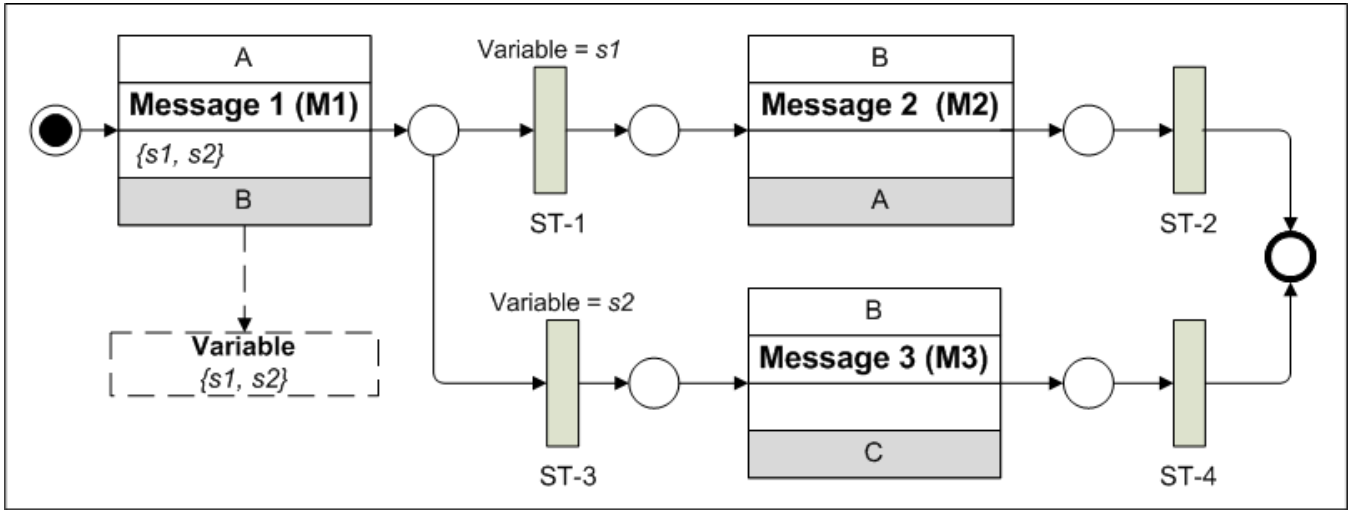


Data-Aware Interaction Nets

Data-Aware Interaction Modeling:
DAChor Semantics - Data-Aware Interaction Nets



Traces $\mathcal{T}$:

σ_1 = < (M1,s1), ST-1, (M2,ε), ST-2 >

σ_2 = < (M1,s2), ST-3, (M3, ε), ST-4 >

Conversations C:

η_1 = < (M1,s1), (M2, ε) >

η_2 = < (M1,s2), (M3,ε) >

Options:

mo(< >) = { (M1,s1), (M1,s2) }

mo (< (M1,s1) >) = {(M2,ε)}

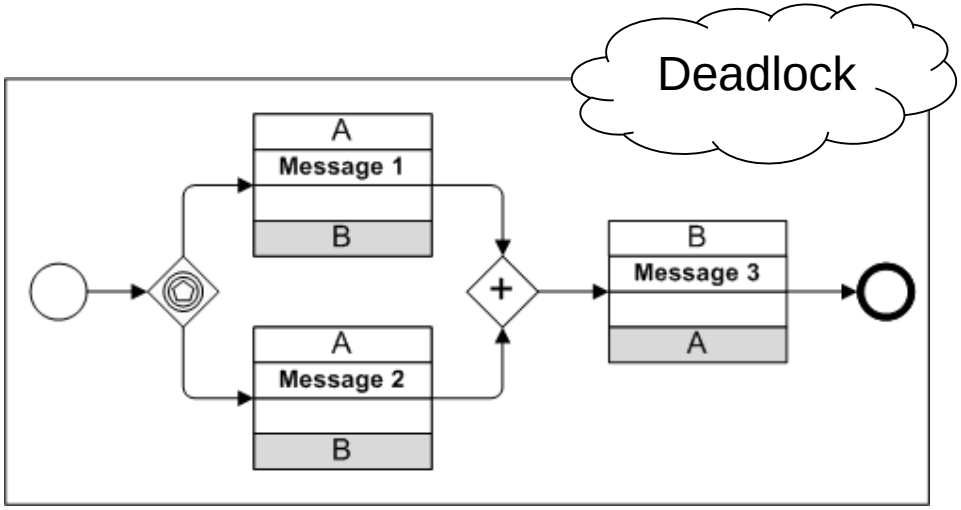
Views:

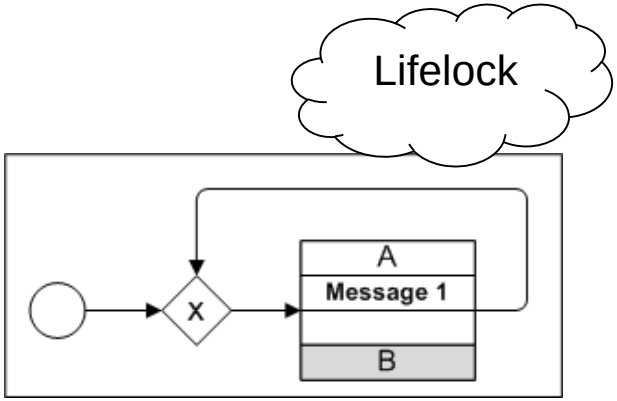
$vc_A(\eta_1)$ = < (M1,s1), (M2, ε) >

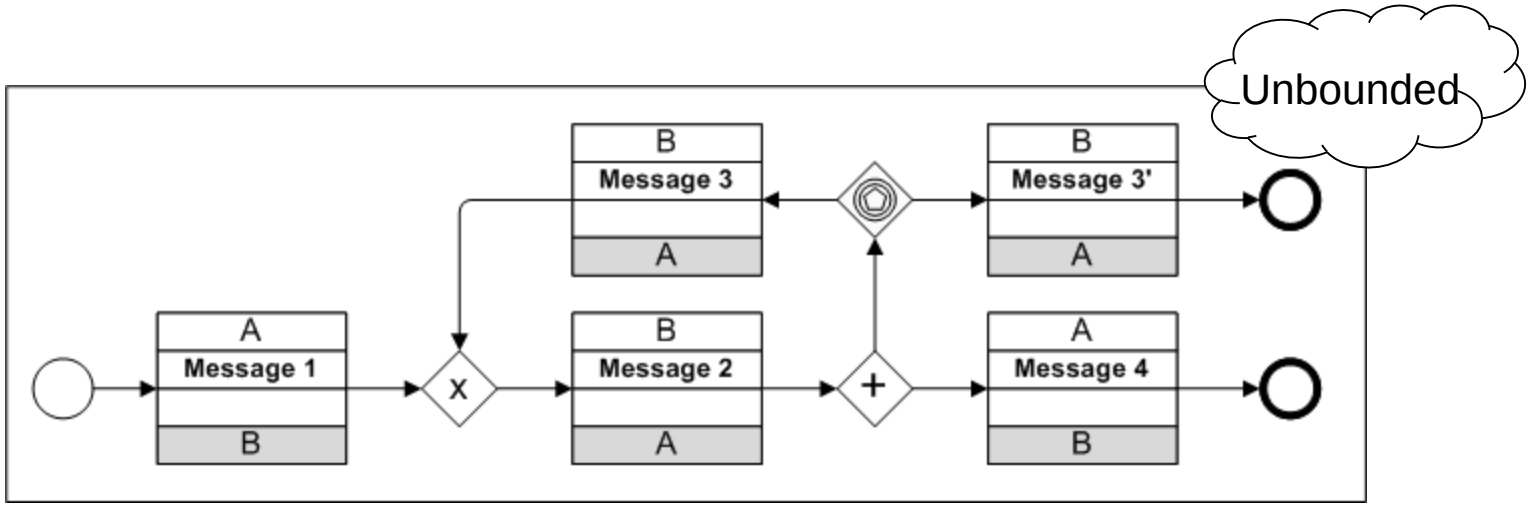
$vc_A(\eta_2)$ = < (M1,s2) >

(Data-aware) Interaction Modeling: Correctness Issues

(Data-Aware) Interaction Modeling: Correctness Issues

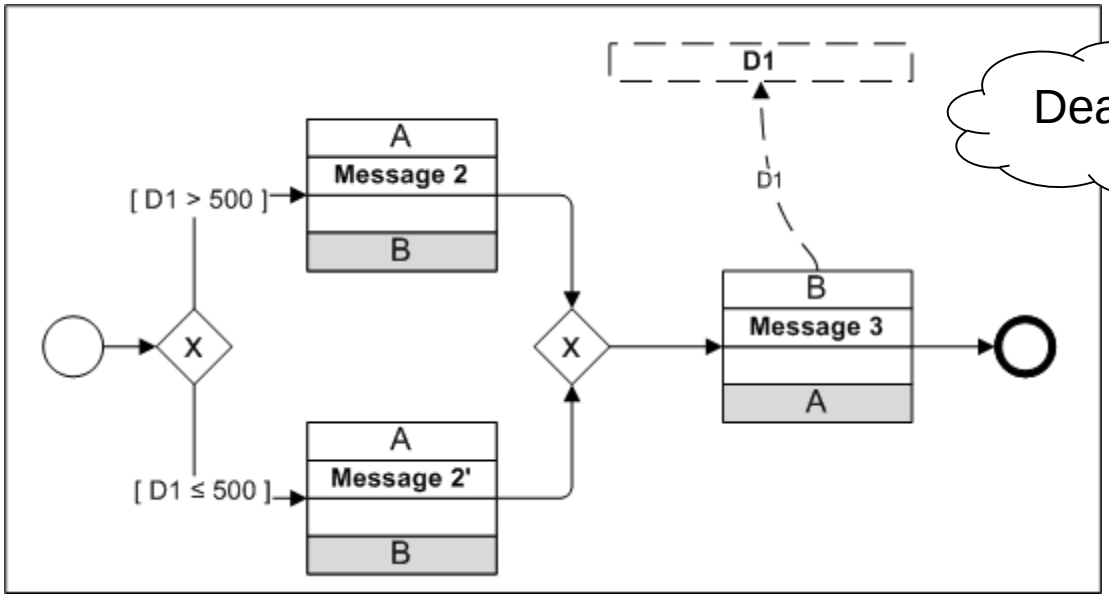


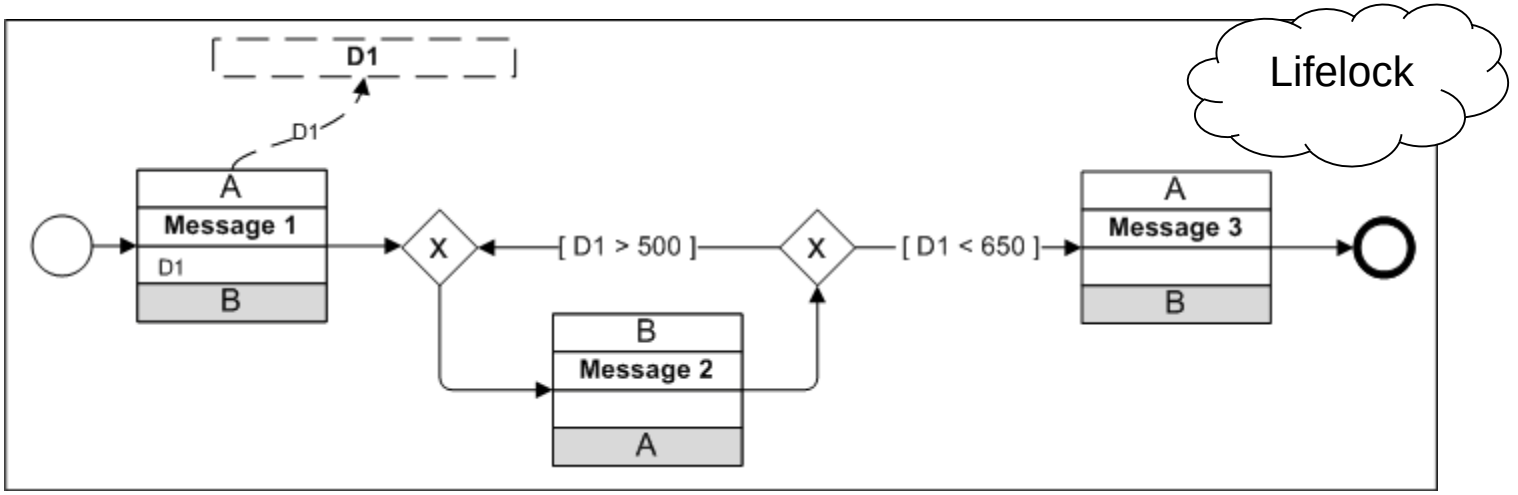




Violation of soundness

(Data-Aware) Interaction Modeling: Correctness Issues

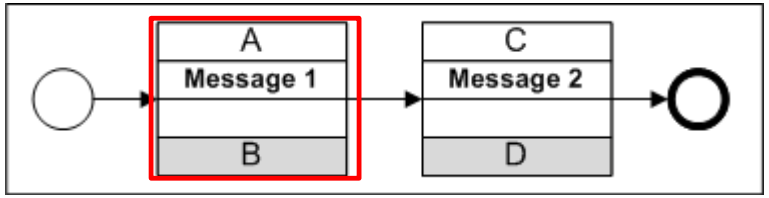


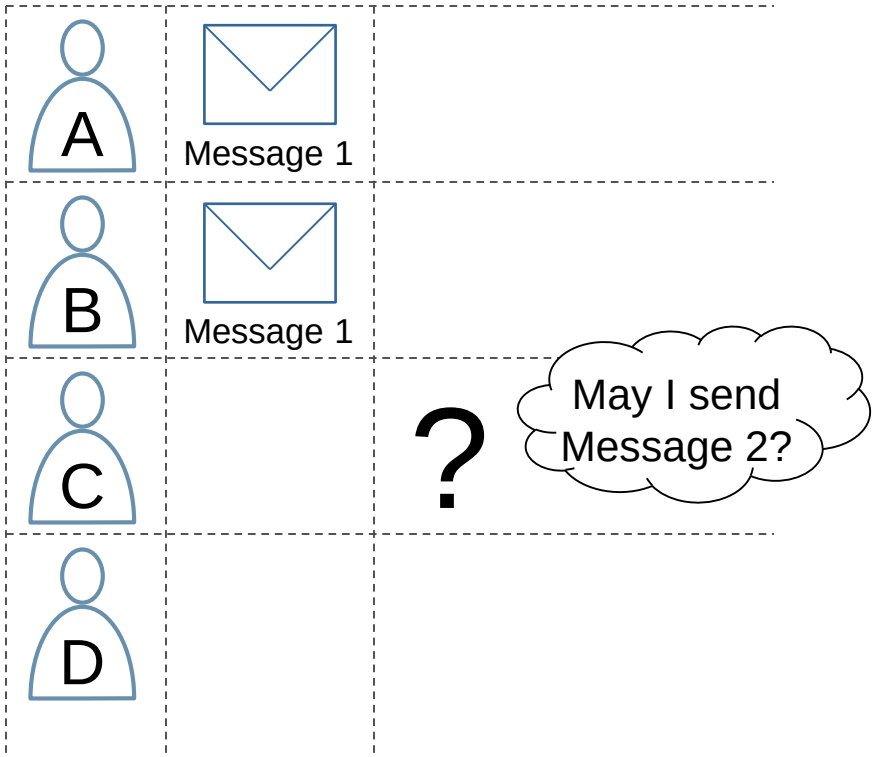


Violation of soundness

(in data-aware interaction models)

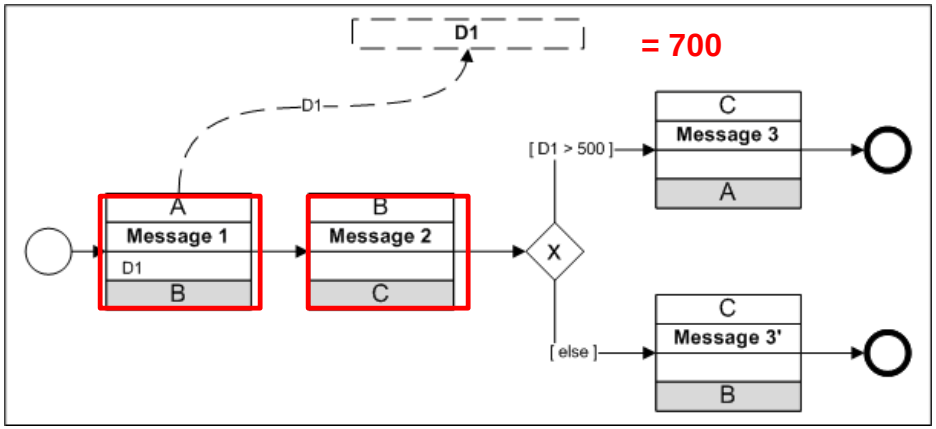
(Data-Aware) Interaction Modeling: Correctness Issues

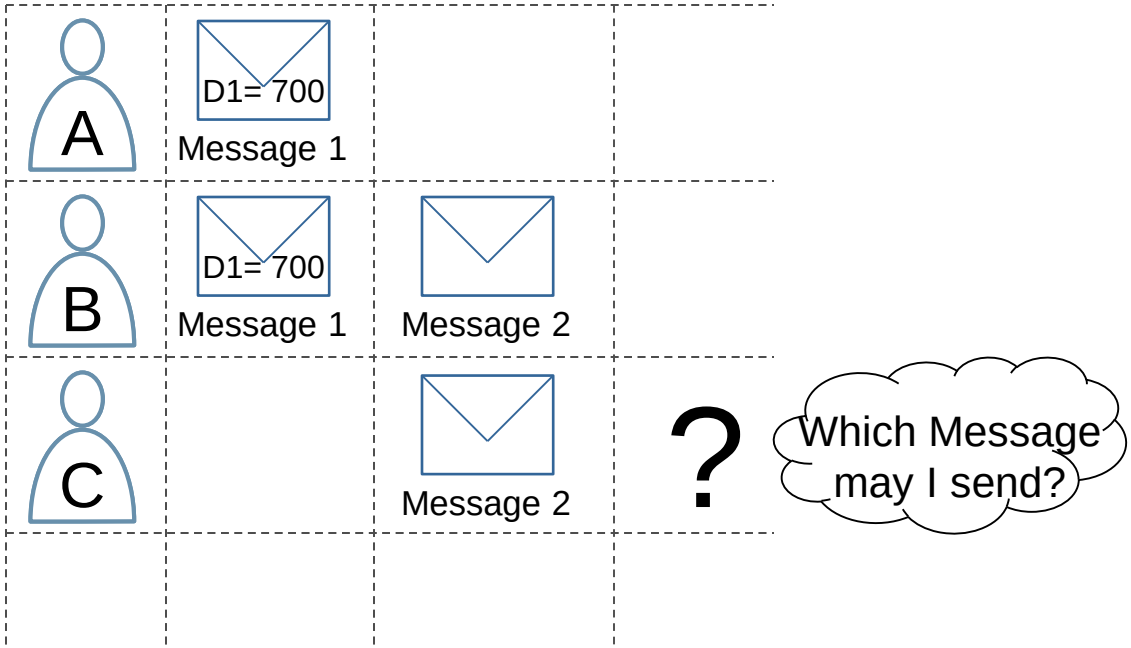




No realizability (enforceability)

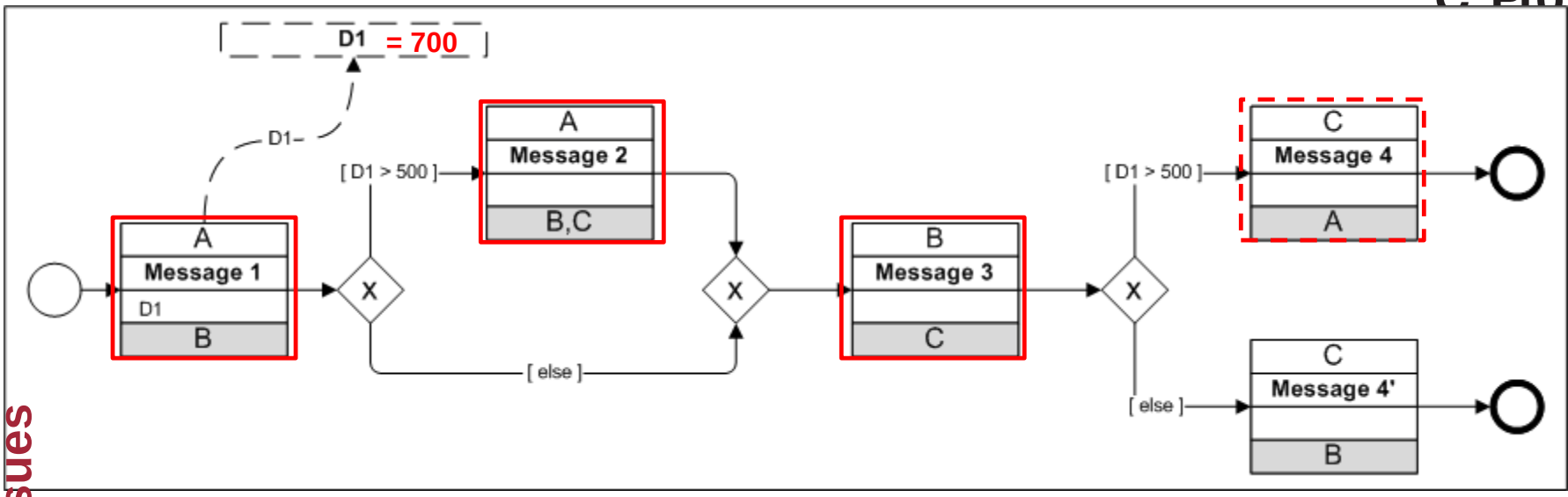
(Data-Aware) Interaction Modeling: Correctness Issues

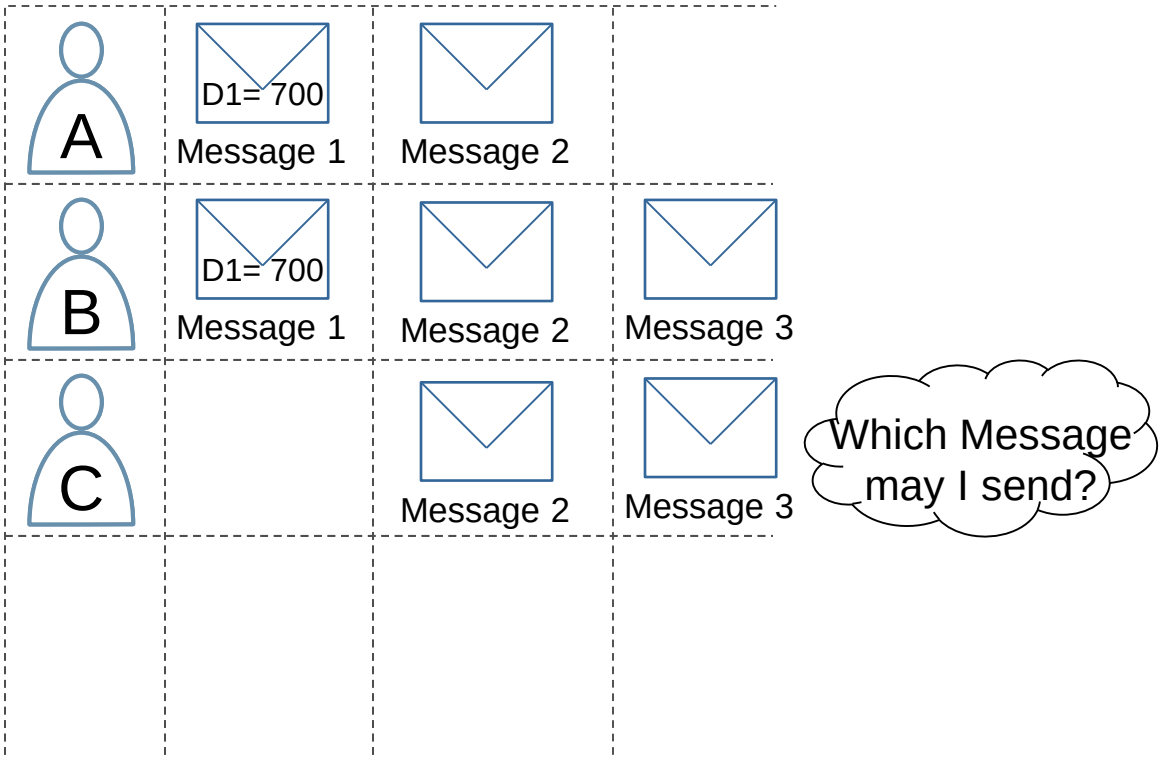




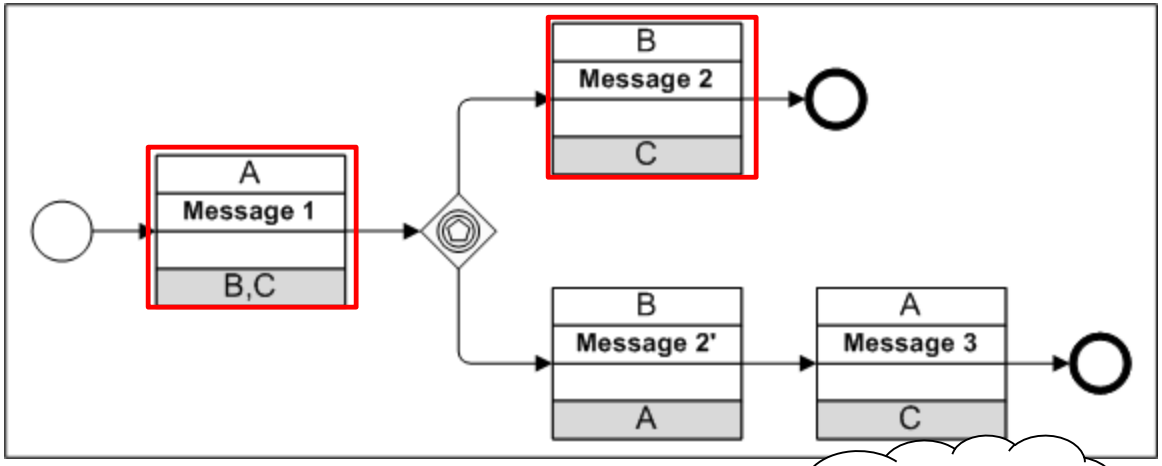
No realizability (in data-aware interaction models)

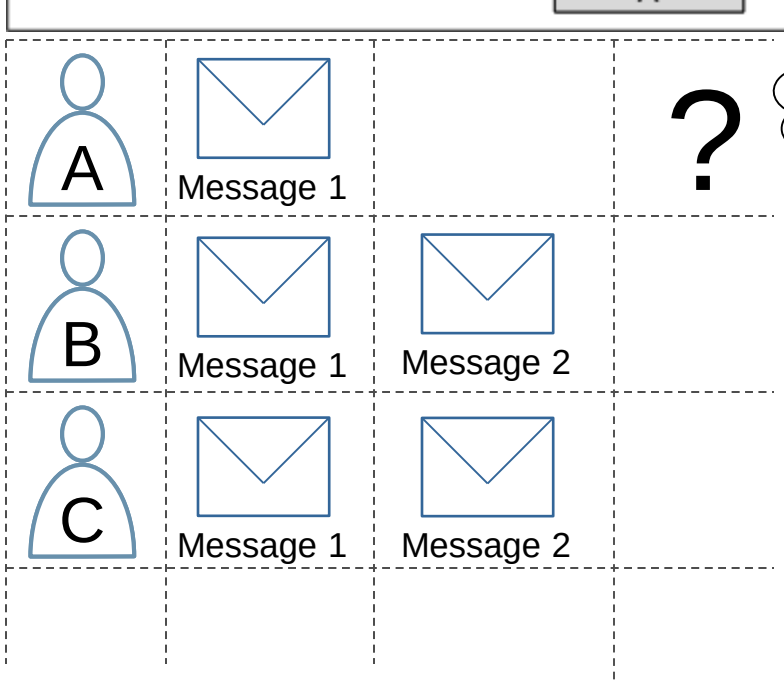
(Data-Aware) Interaction Modeling: Correctness Issues





(Data-Aware) Interaction Modeling: Correctness Issues





?

May I terminate my process?

No clear termination!

(Data-Aware) Interaction Modeling: Correctness Issues

Definition 11 (Determinism and Soundness).
(A) We call a DAI Net # deterministic, iff for each trace τ on # there exists exactly one related sequence of markings, i.e., $\forall \tau \in \mathcal{T}_{\#} : |\{m \in \mathcal{M}^{\star}_{\#} | m \sim \tau\}| = 1$.

(B) We call a deterministic DAI Net # sound, iff the following conditions hold:

- *There exist completed traces on #, i.e.,* $\mathcal{T}^{c}_{\#} \neq \emptyset$,
- *Each trace on # is a prefix of a completed trace, i.e.,* $\forall v \in \mathcal{T}_{\#} \exists \tau \in \mathcal{T}^{c}_{\#} : v \trianglelefteq \tau$.
- *The set of reachable markings is finite, i.e.,* $|\{m \in \mathcal{M}_{\#} | \exists \tau \in \mathcal{T}_{\#} : last(\tau) = m\}| \in \mathbb{N}$

Definition 15 (Realizability, Clear Termination).
Let # be a deterministic, sound, and message-deterministic DAI Net. Then, for a role $R \in \mathcal{R}$:

- *# is realizable, iff the messages role R may send solely depend on the messages R has sent and received before, i.e.,*

$$\forall R \in \mathcal{R} \quad : \quad \forall \eta, \kappa \in \mathcal{C}_{\#} : vc^{R}_{\#}(\eta) = vc^{R}_{\#}(\kappa) \Rightarrow vo^{R\mapsto}_{\#}(mo_{\#}(\eta)) = vo^{R\mapsto}_{\#}(mo_{\#}(\kappa))$$

- *# clearly terminates, iff it solely depends on the messages R has sent and received before whether further interaction with R will occur, i.e.,*

$$\forall R \in \mathcal{R} \quad : \quad \forall \eta \in \mathcal{C}^{c}_{\#} \nexists \kappa \in \mathcal{C}_{\#} : vc^{R}_{\#}(\eta) \lhd vc^{R}_{\#}(\kappa)$$

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(Data-Aware) Interaction Modeling:
Correctness Issues

Achievements

- Data-aware interaction modeling (and virtual data objects)
- Semantics based on data-aware interaction nets
- Well-defined correctness notions for data-aware interaction models
  - Determinism, Soundness, Realizability, Clear Termination

Current Work

- Complexity considerations
- Implementation
- Case studies

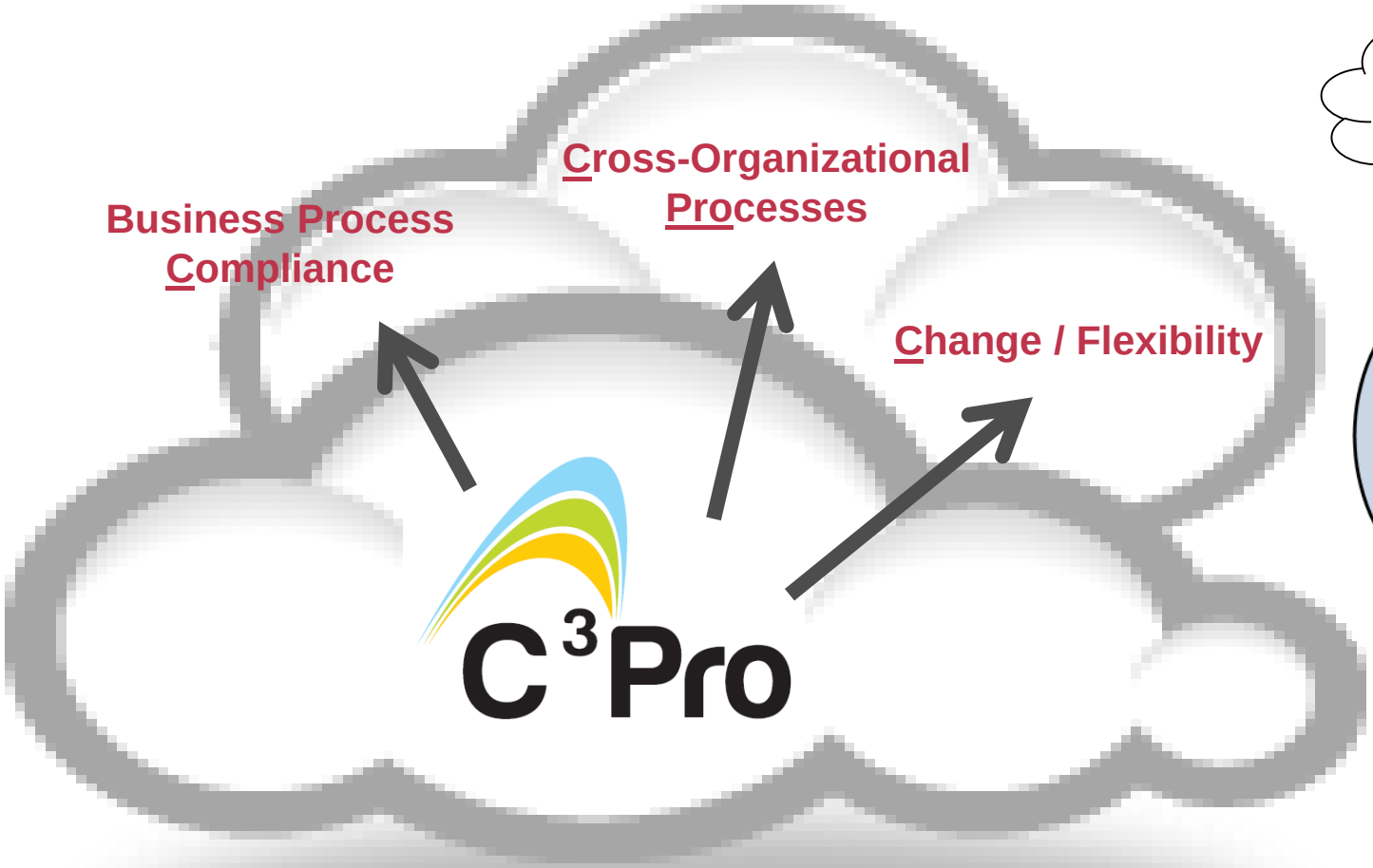
Ensuring Compliance of Cross-Organizational Processes

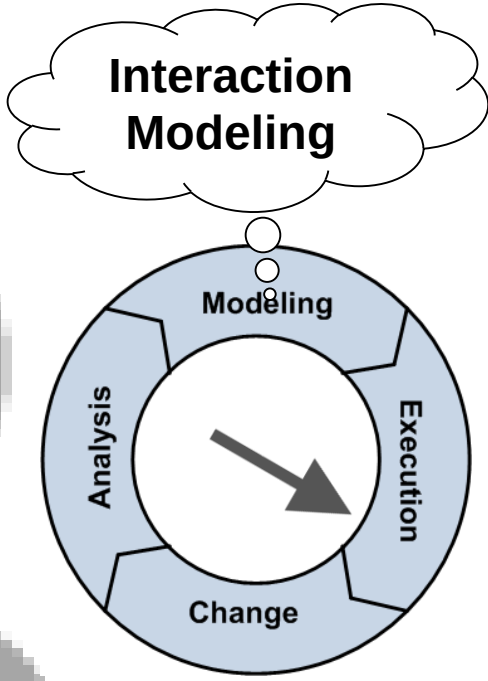
D. Knuplesch, M. Reichert, W. Fdhila, S. Rinderle-Ma, (2013) *On Enabling Compliance of Cross-Organizational Business Processes.* In: 11th Int'l Conference Business Process Management (BPM'13), Beijing, 2013

D. Knuplesch, M. Reichert, R. Pryss, W. Fdhila, S. Rinderle-Ma, Stefanie (2013) *Ensuring Compliance of Distributed and Collaborative Workflows.* In: 9th IEEE Int'l Conference on Collaborative Computing: Networking, Applications and Worksharing (CollborateCom'13), Austin, 2013, IEEE Computer Society Press

D. Knuplesch, M. Reichert, T. Ly, A. Kumar, S. Rinderle-Ma (2013) *Visual Modeling of Business Process Compliance Rules with the Support of Multiple Perspectives.* In: 32nd Int'l Conference on Conceptual Modeling (ER 2013), Hong Kong, 2013

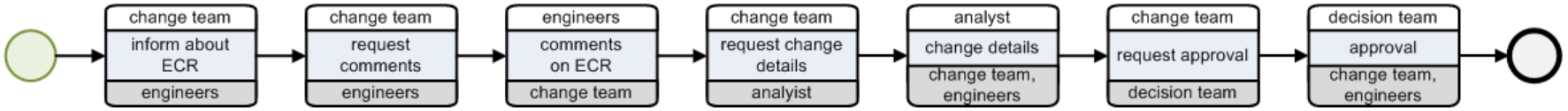
Cross-Organizational Process Compliance



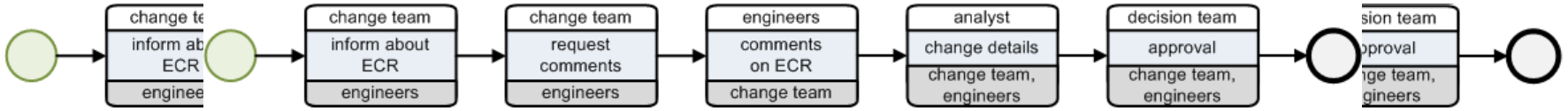


Scenario: Electronic Change Request

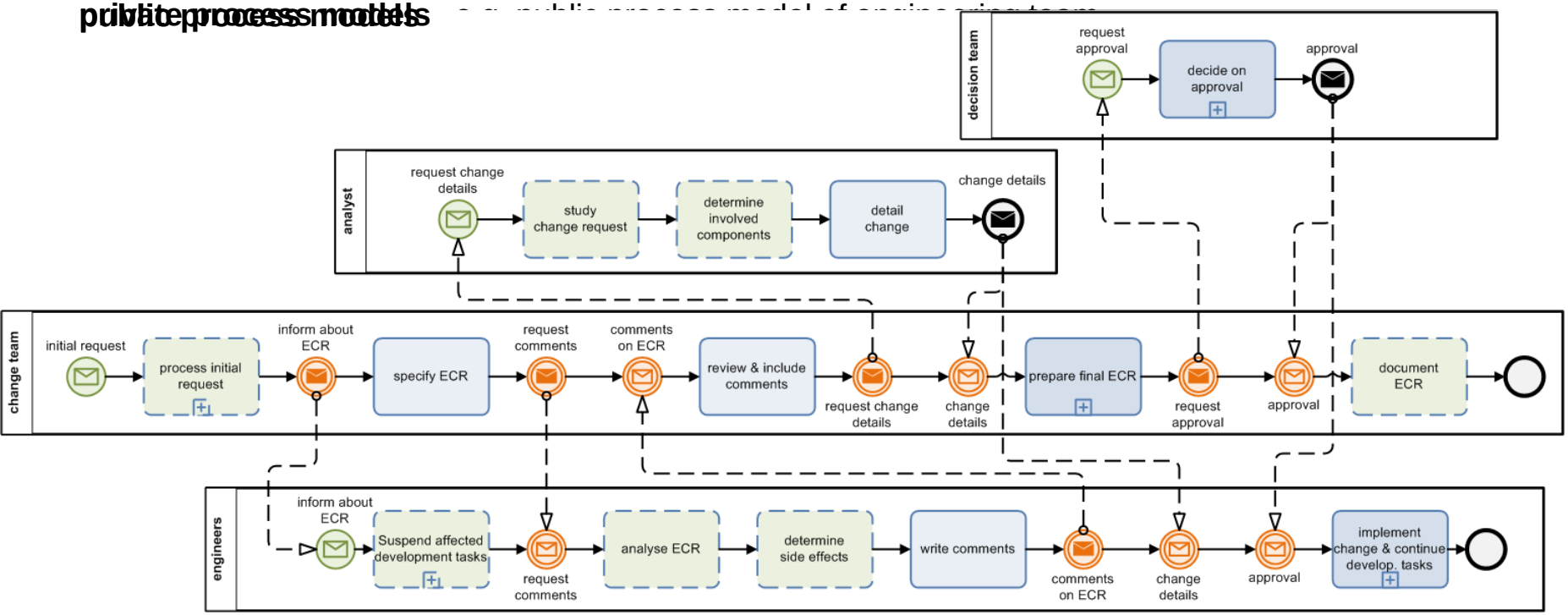
interaction model



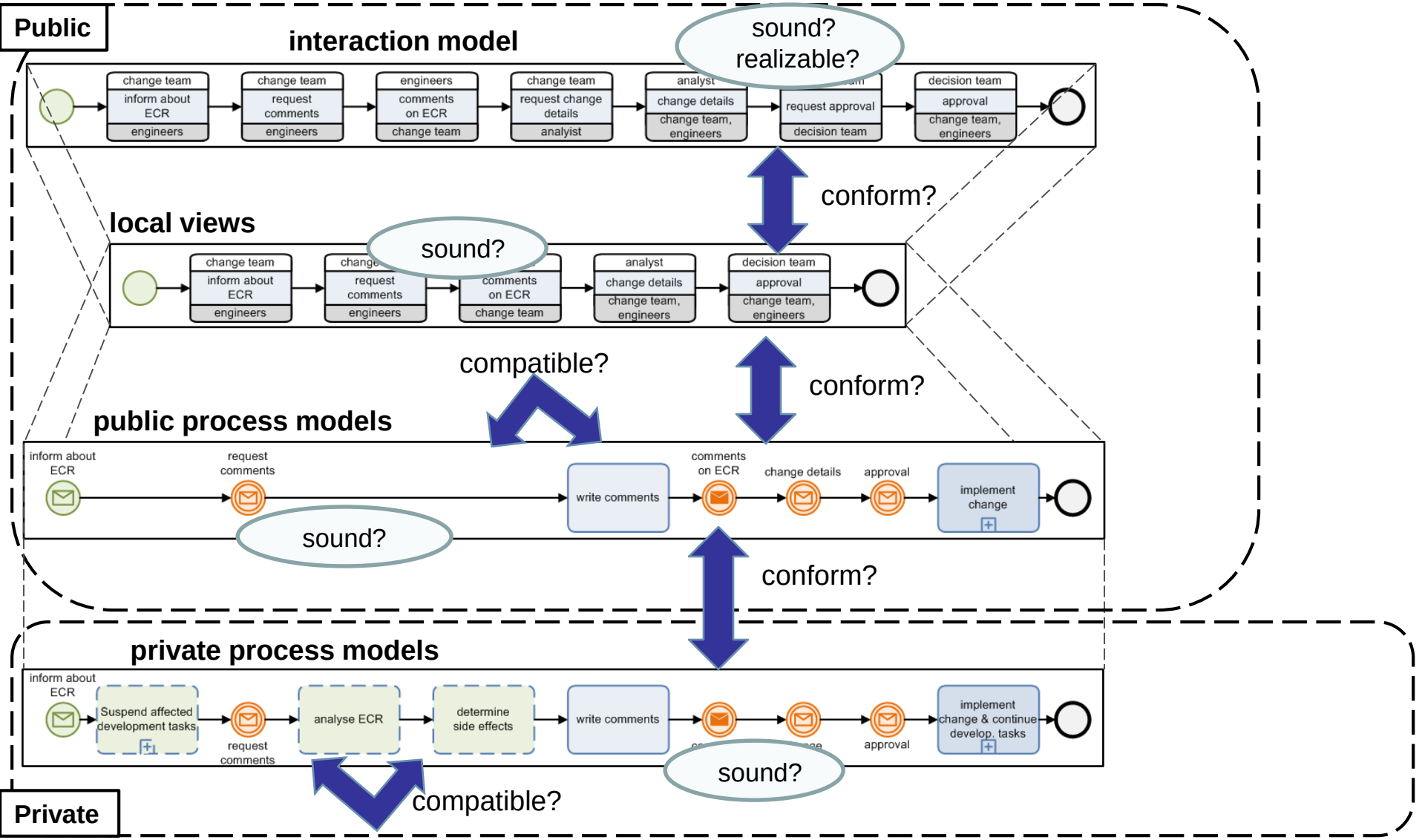
local views – e.g. local view of engineering team



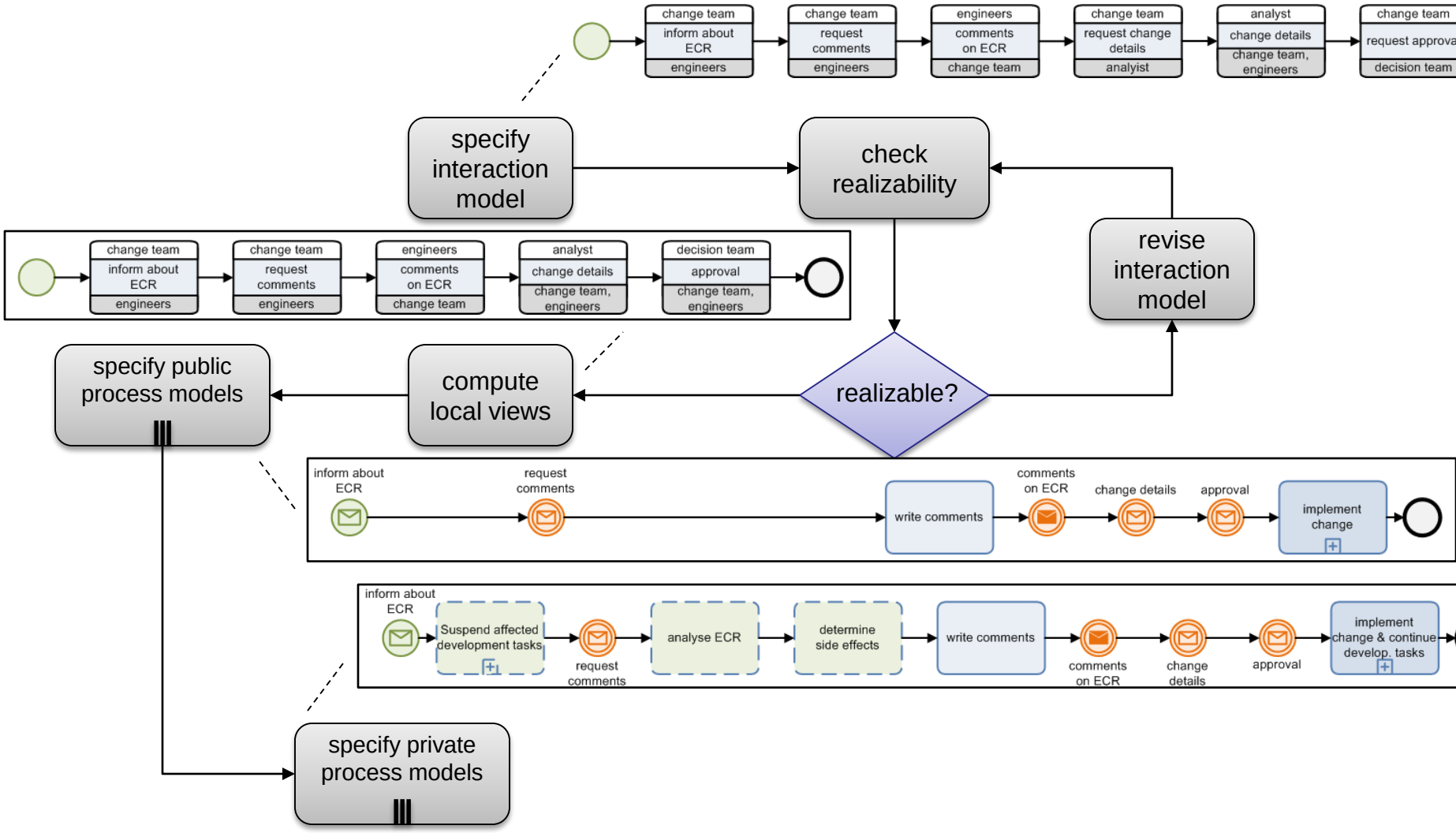
private process models – e.g. public process model of engineering team



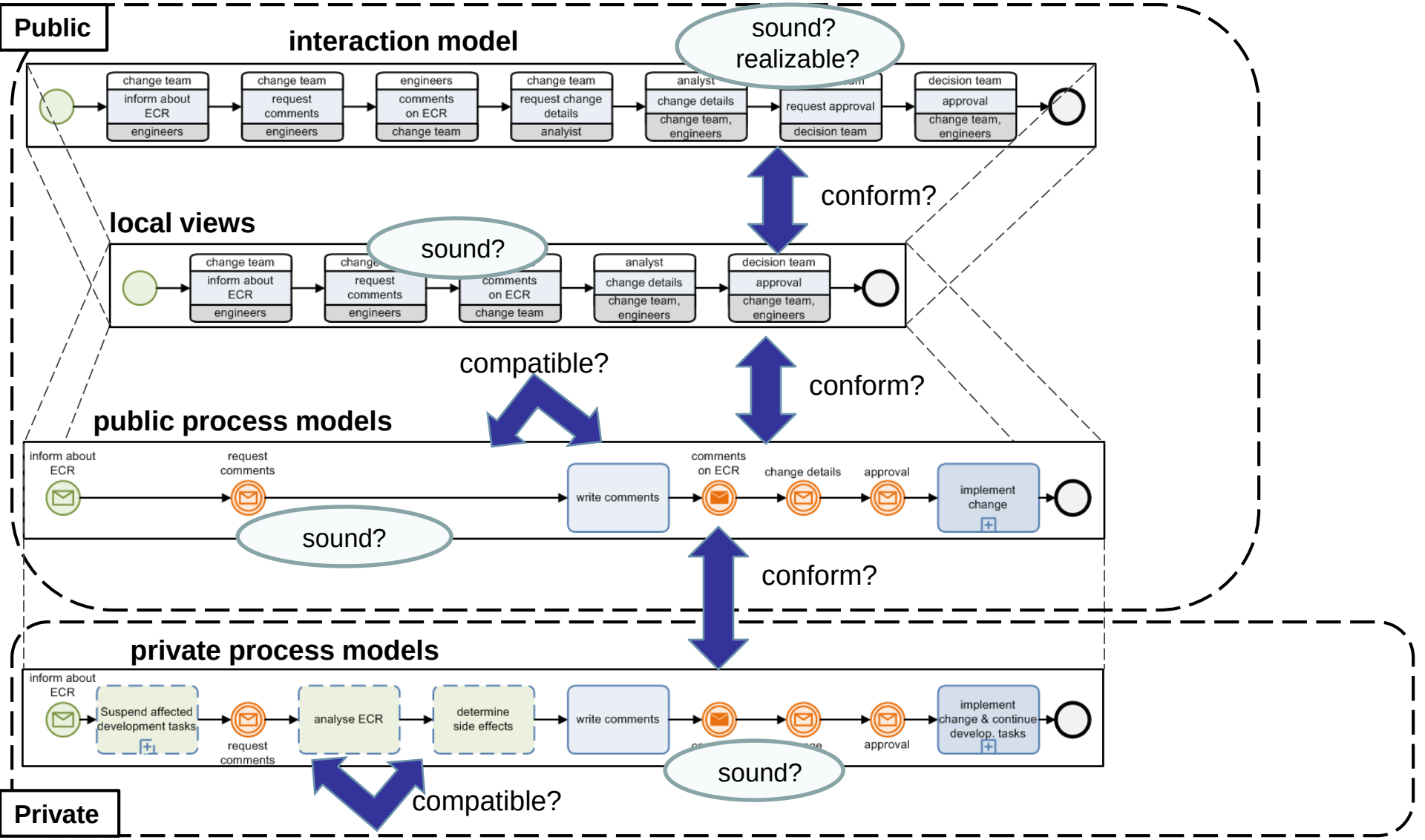
Relevant Layers



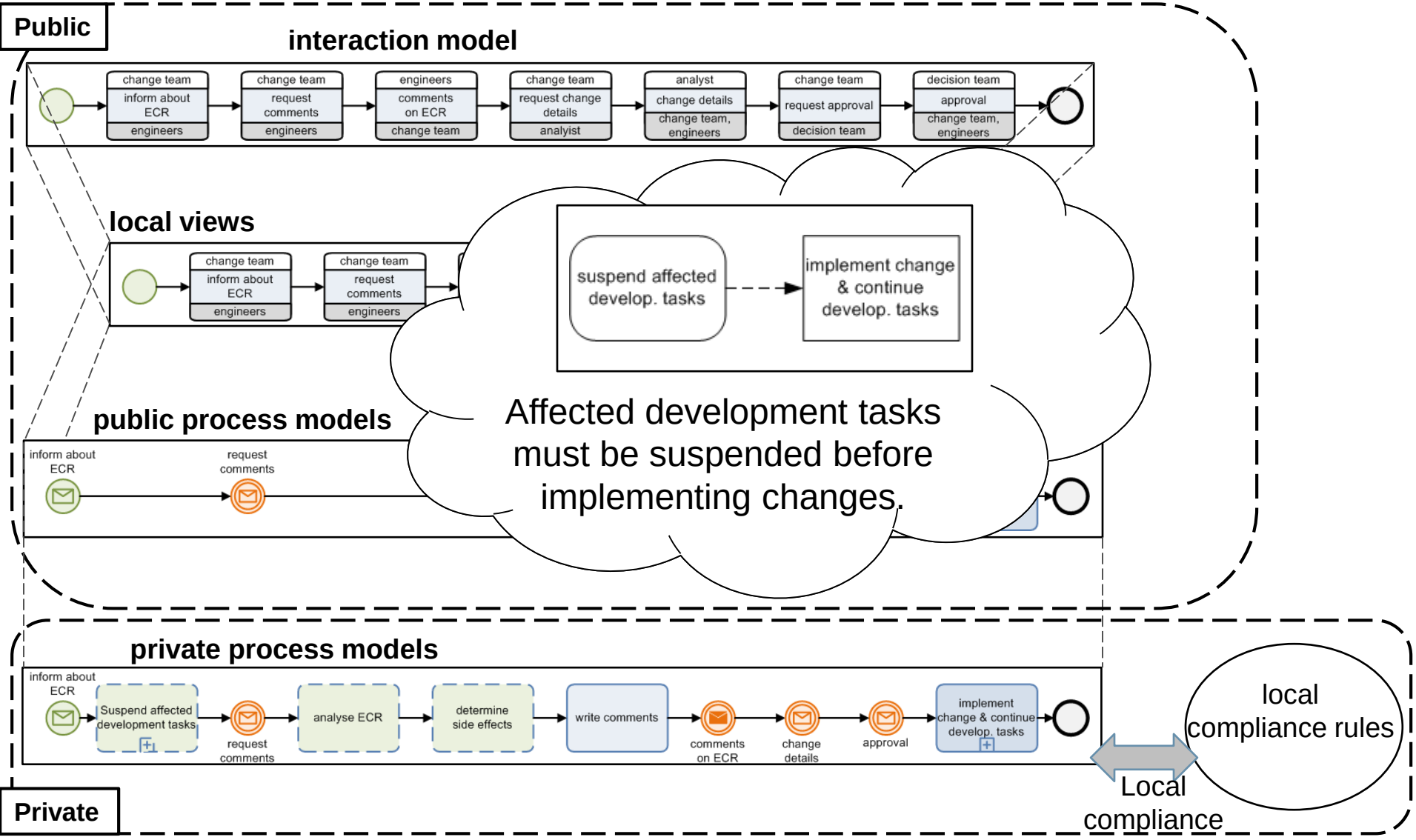
The Process of Interaction Modeling



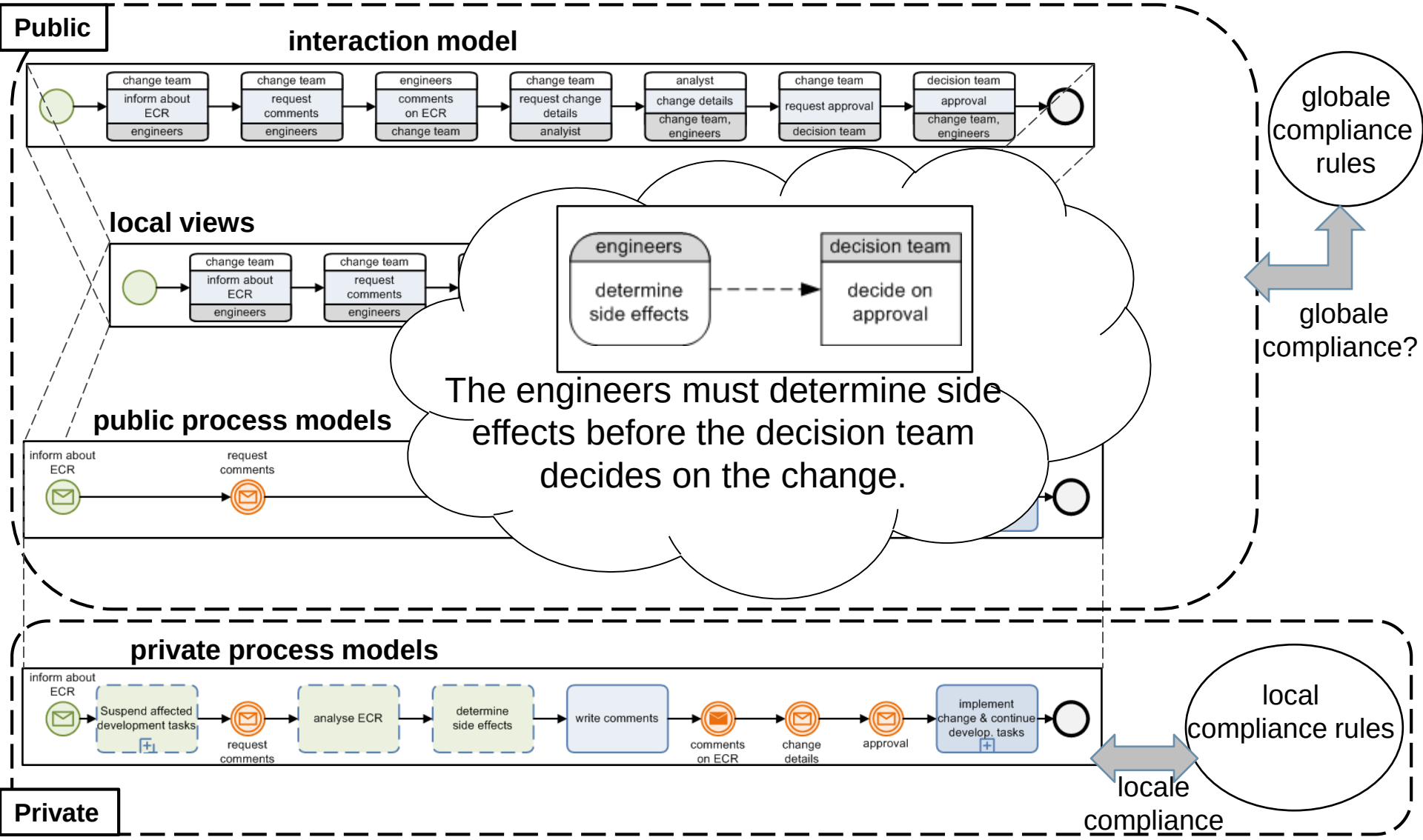
Relevant Layers and Compliance Rules



Relevant Layers and Compliance Rules



Relevant Layers and Compliance Rules



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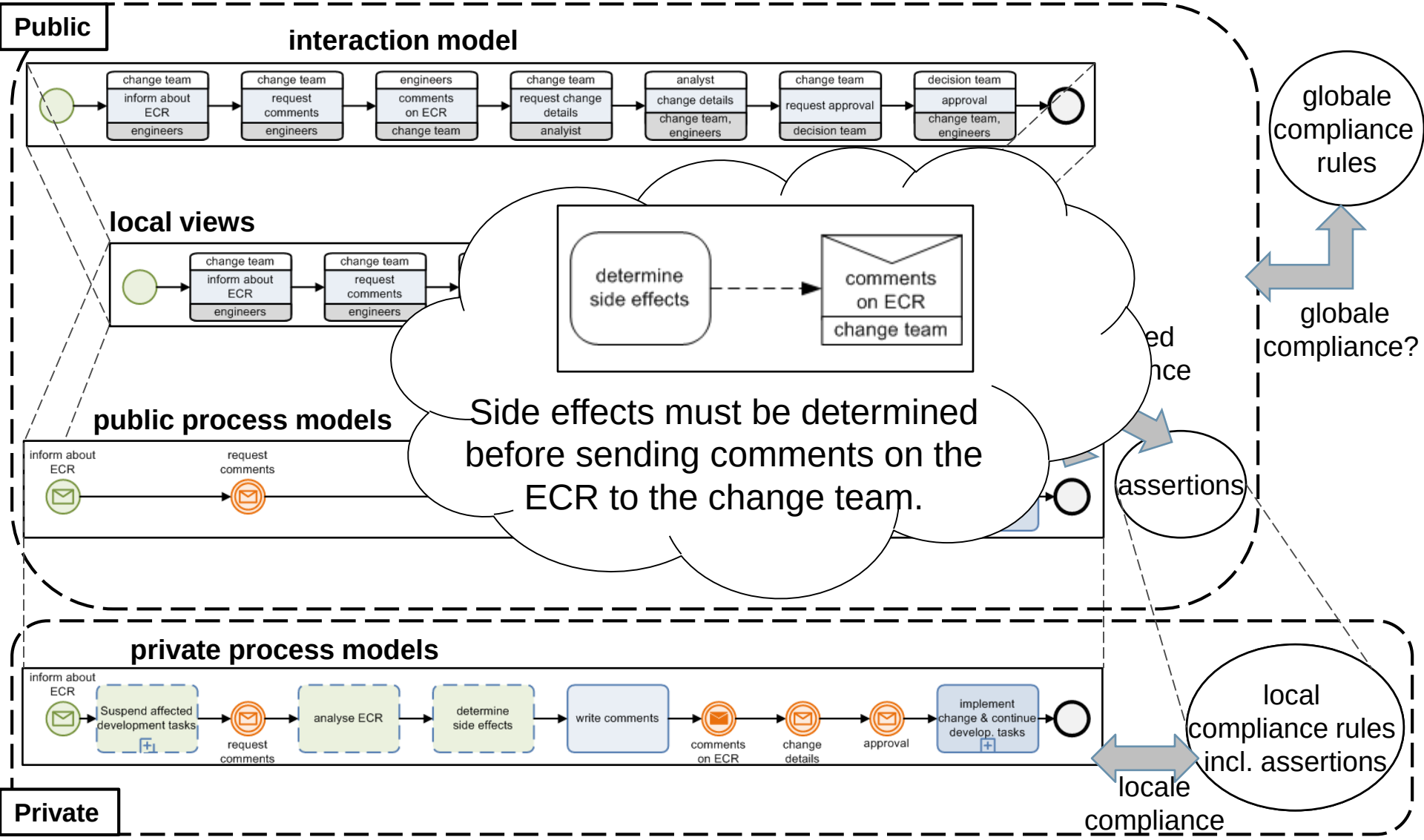
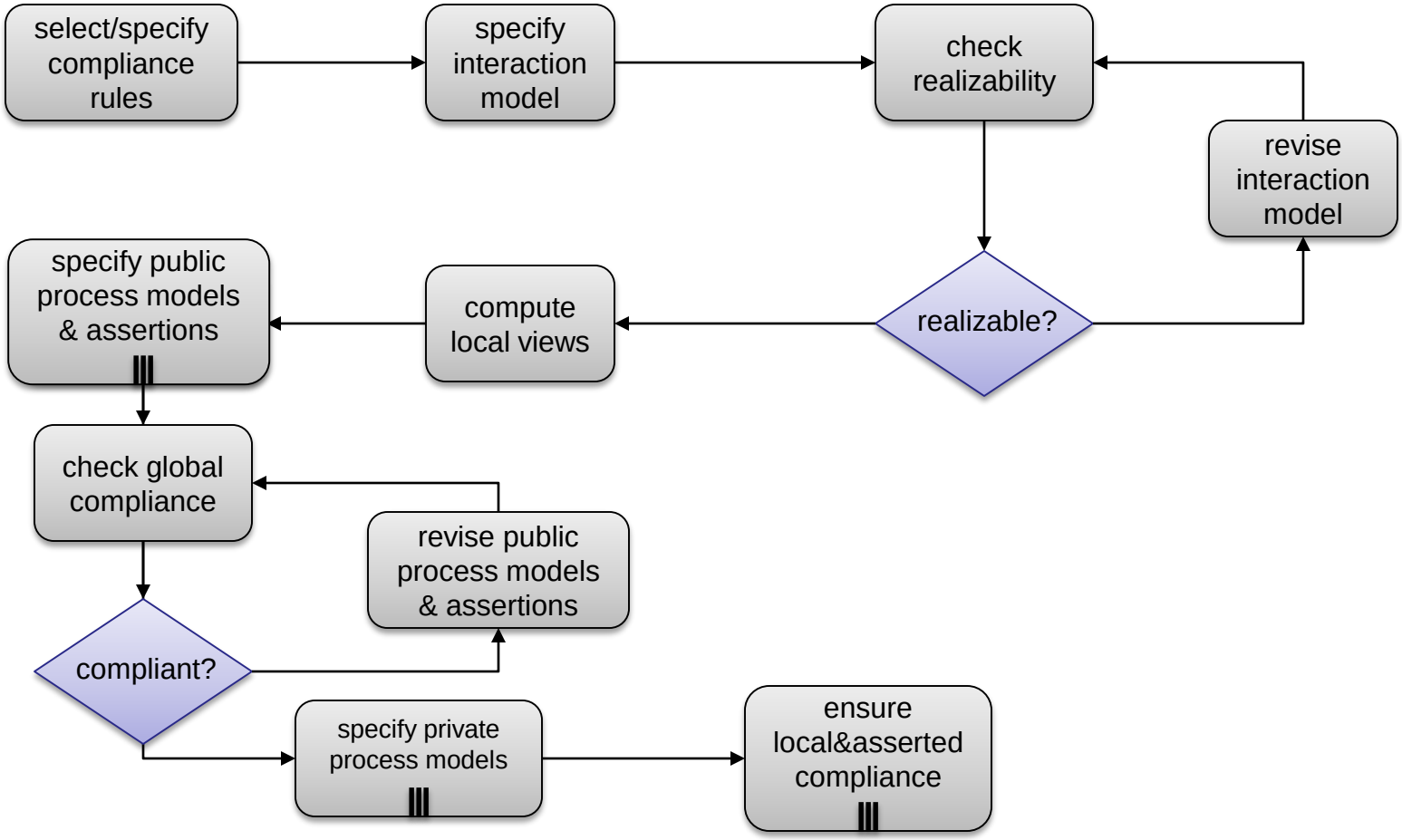
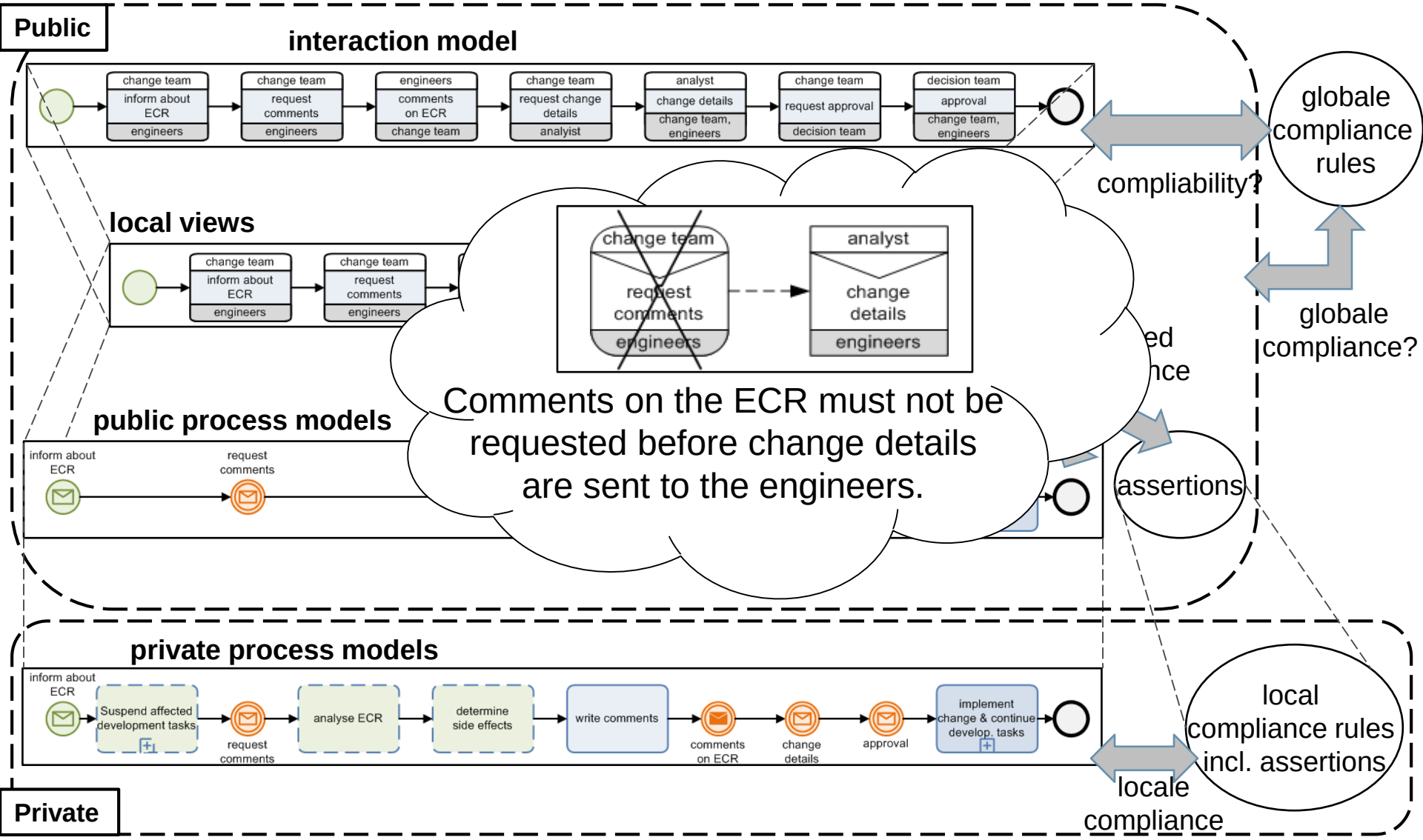


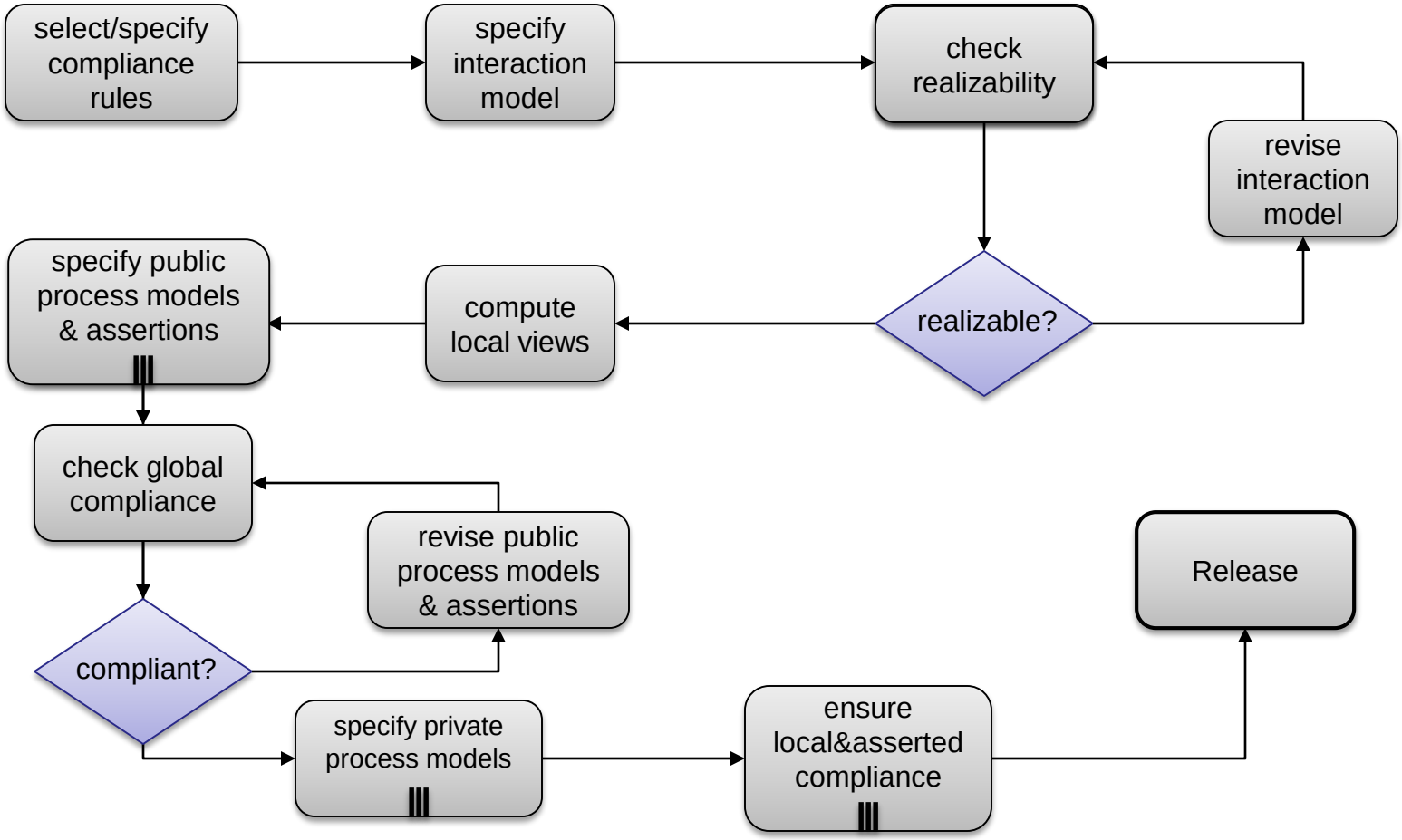
The Process of Interaction Modeling



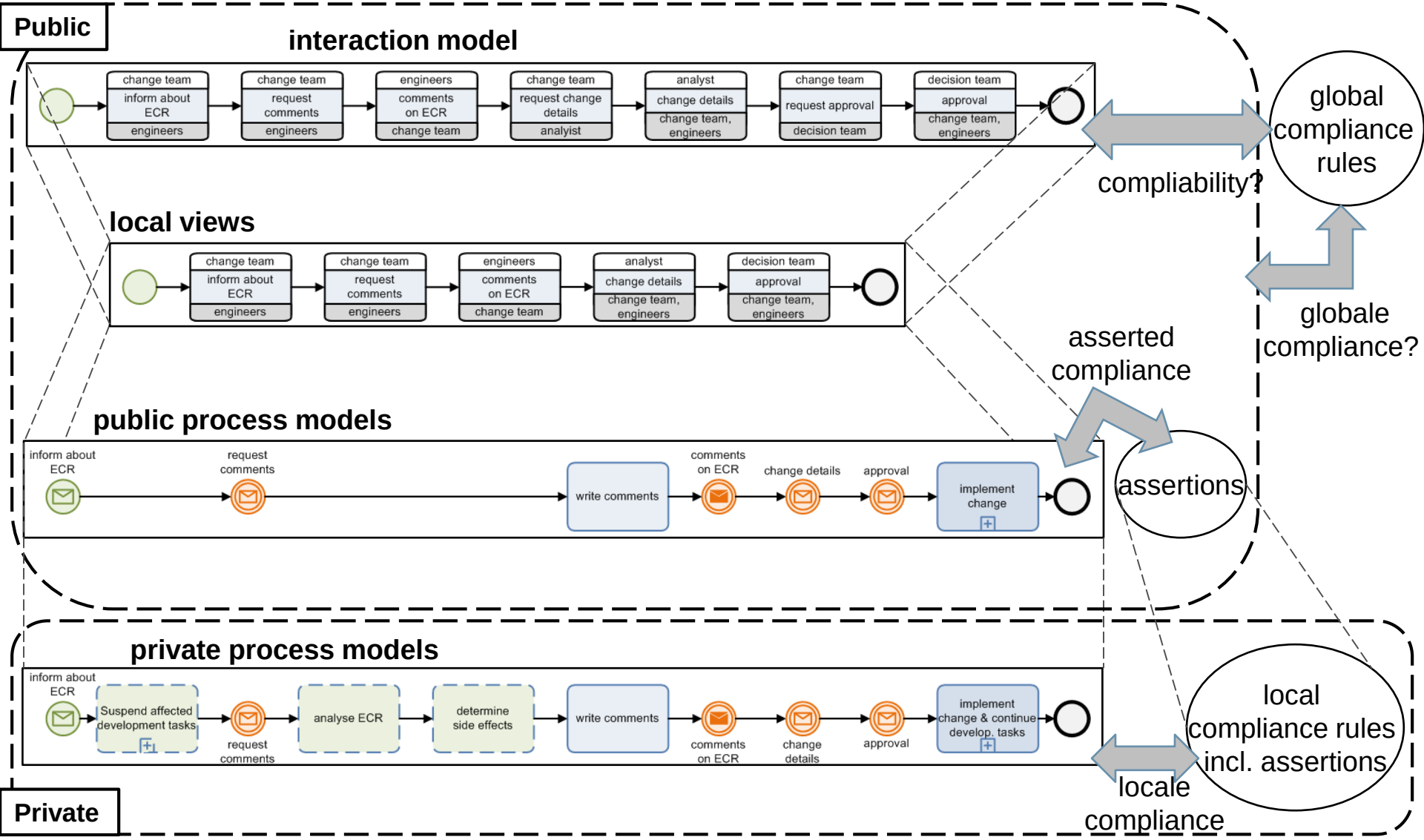
Relevant Layers and Compliance Rules



The Process of Interaction Modeling



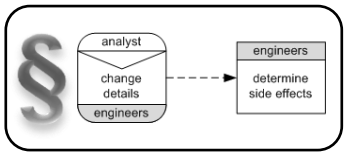
Relevant Layers and Compliance Rules

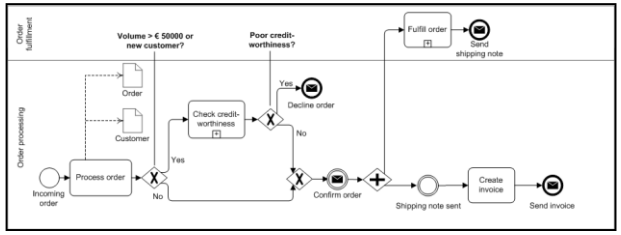


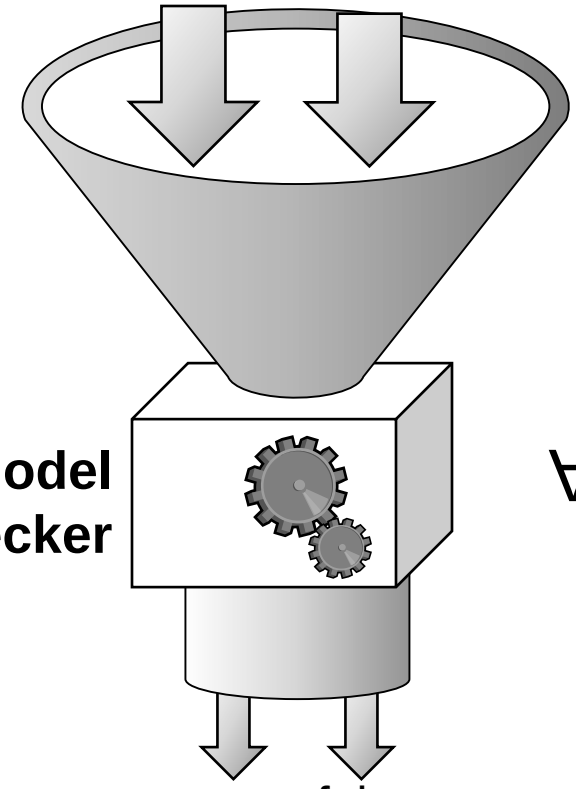
Compliance Checking

process model **M**

compliance rule **CR**







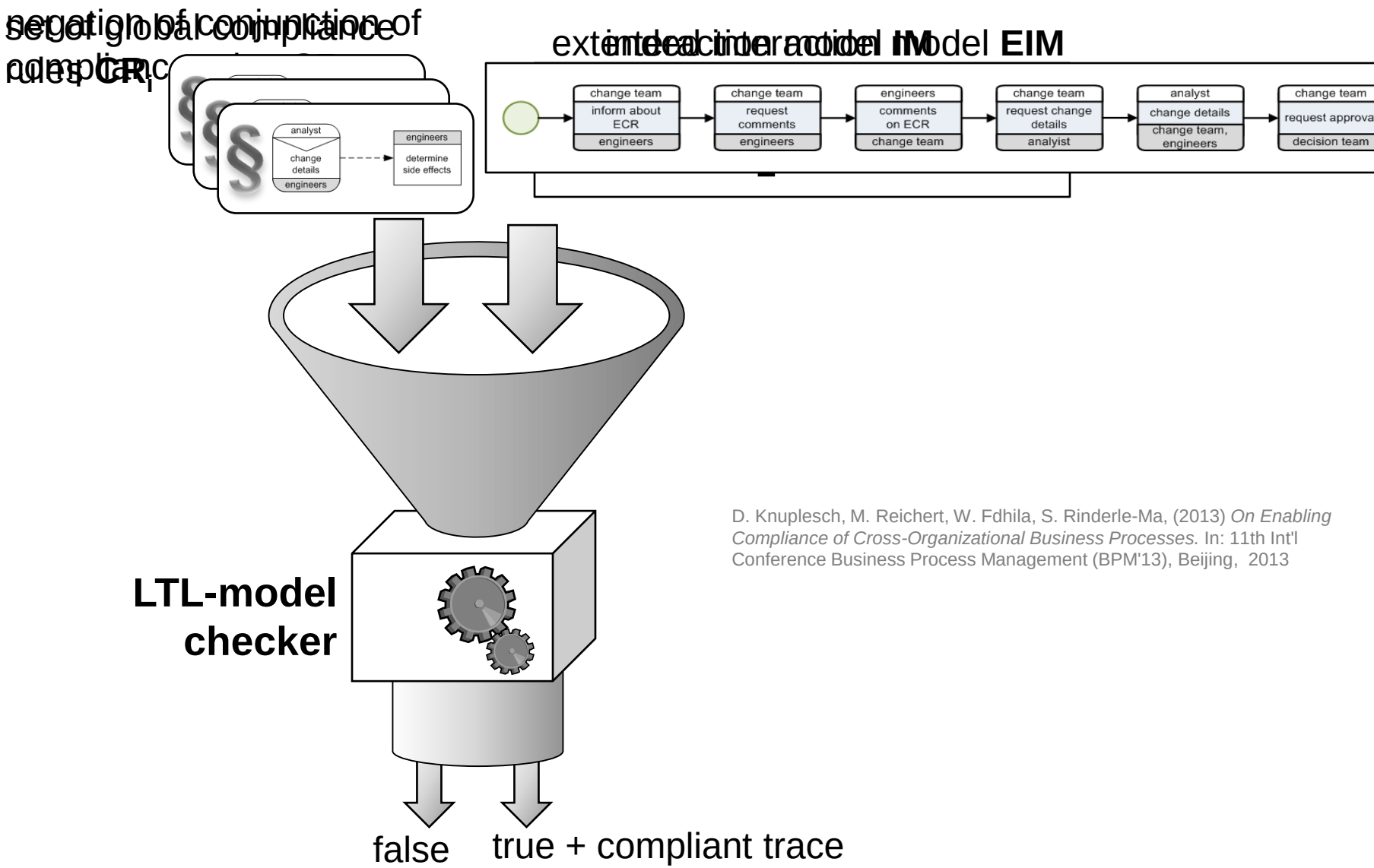
LTL-model checker

$\forall\ t \in Traces_{M} :\ t \models CR\ ?$

true

false + counter example

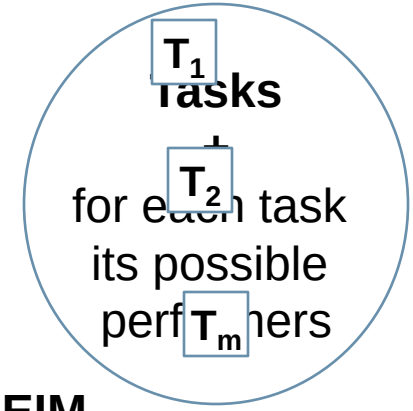
How to Check Compliability?



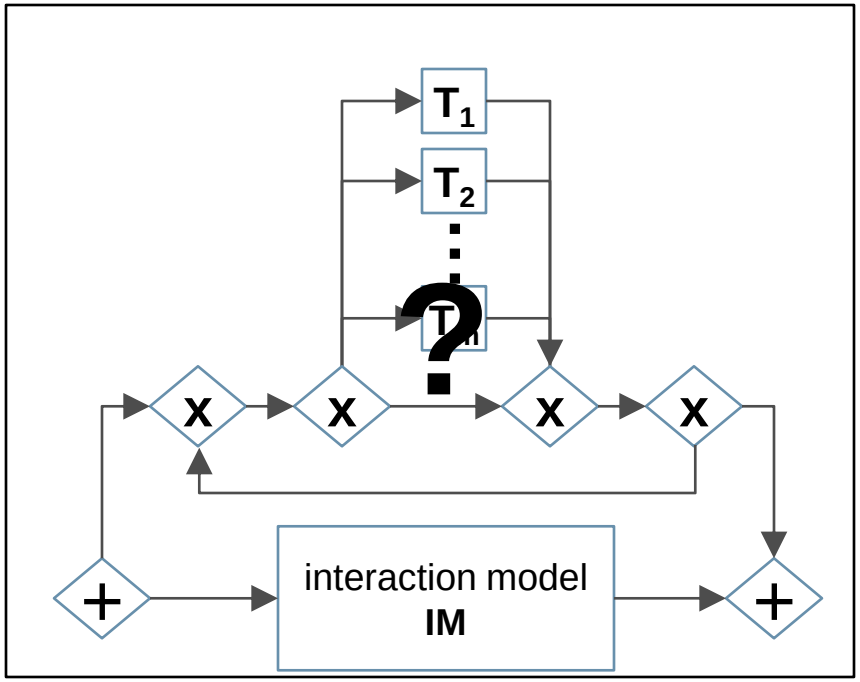
D. Knuplesch, M. Reichert, W. Fdhila, S. Rinderle-Ma, (2013) *On Enabling Compliance of Cross-Organizational Business Processes.* In: 11th Int'l Conference Business Process Management (BPM'13), Beijing, 2013

How to Construct the Extended Interaction Model?

interaction model
IM



extended interaction model **EIM**

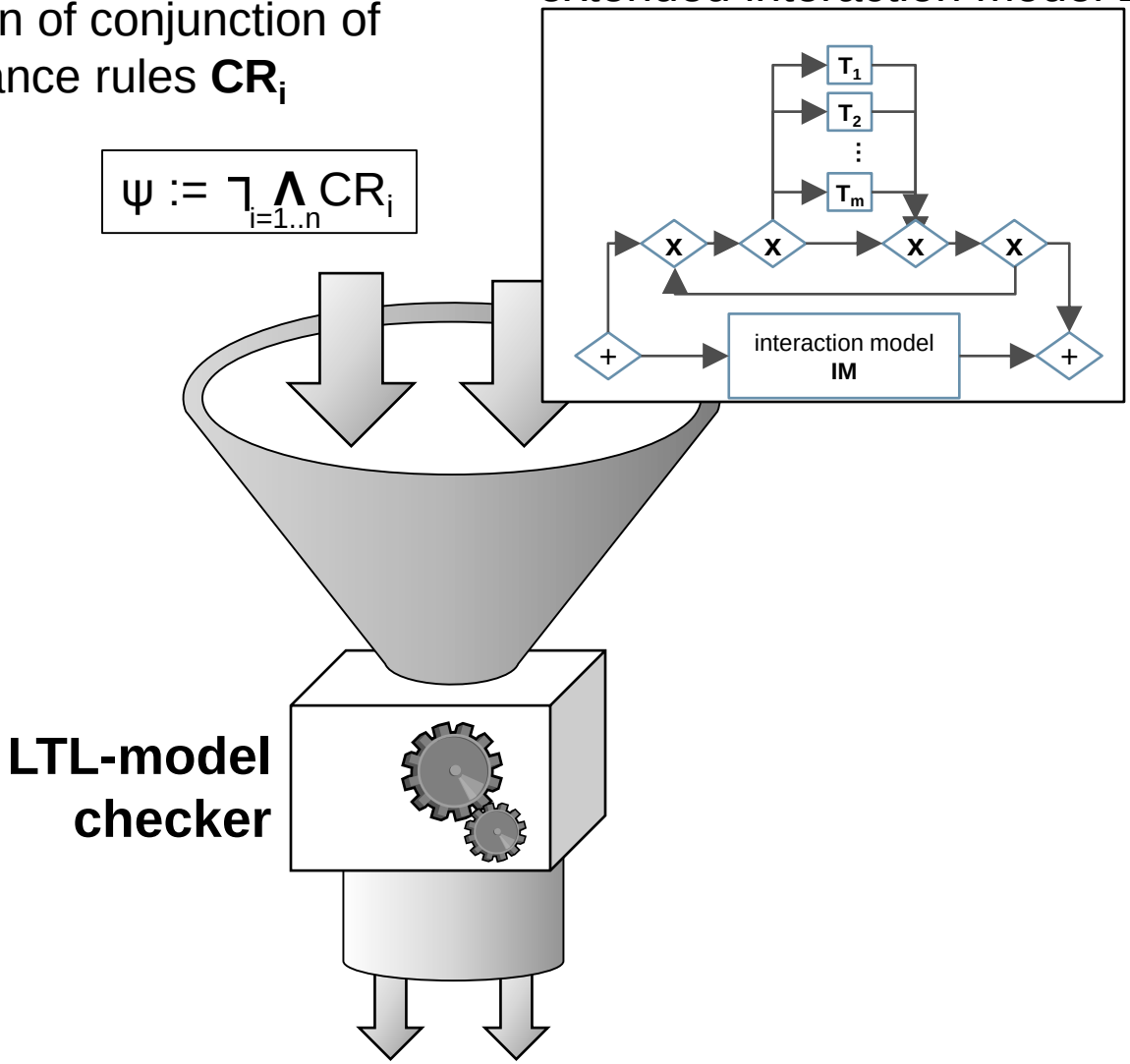


How to Check Compliability?

negation of conjunction of compliance rules **CR_i**

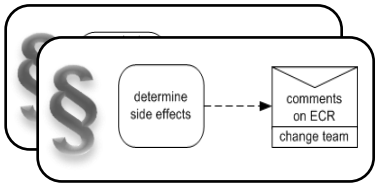
$$\psi := \neg \bigwedge_{i=1..n} CR_i$$

extended interaction model **EIM**

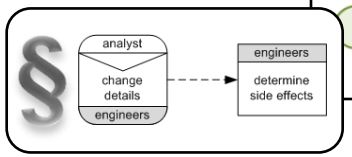


How to Check Global Compliance?

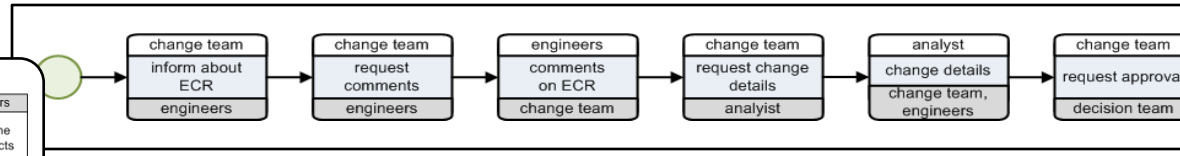
assertions A_i



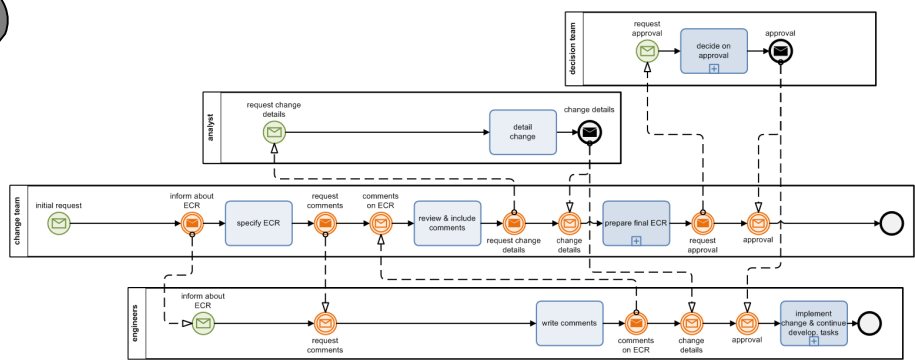
compliance rule **CR**



interaction model **IM**



public process models PM_i

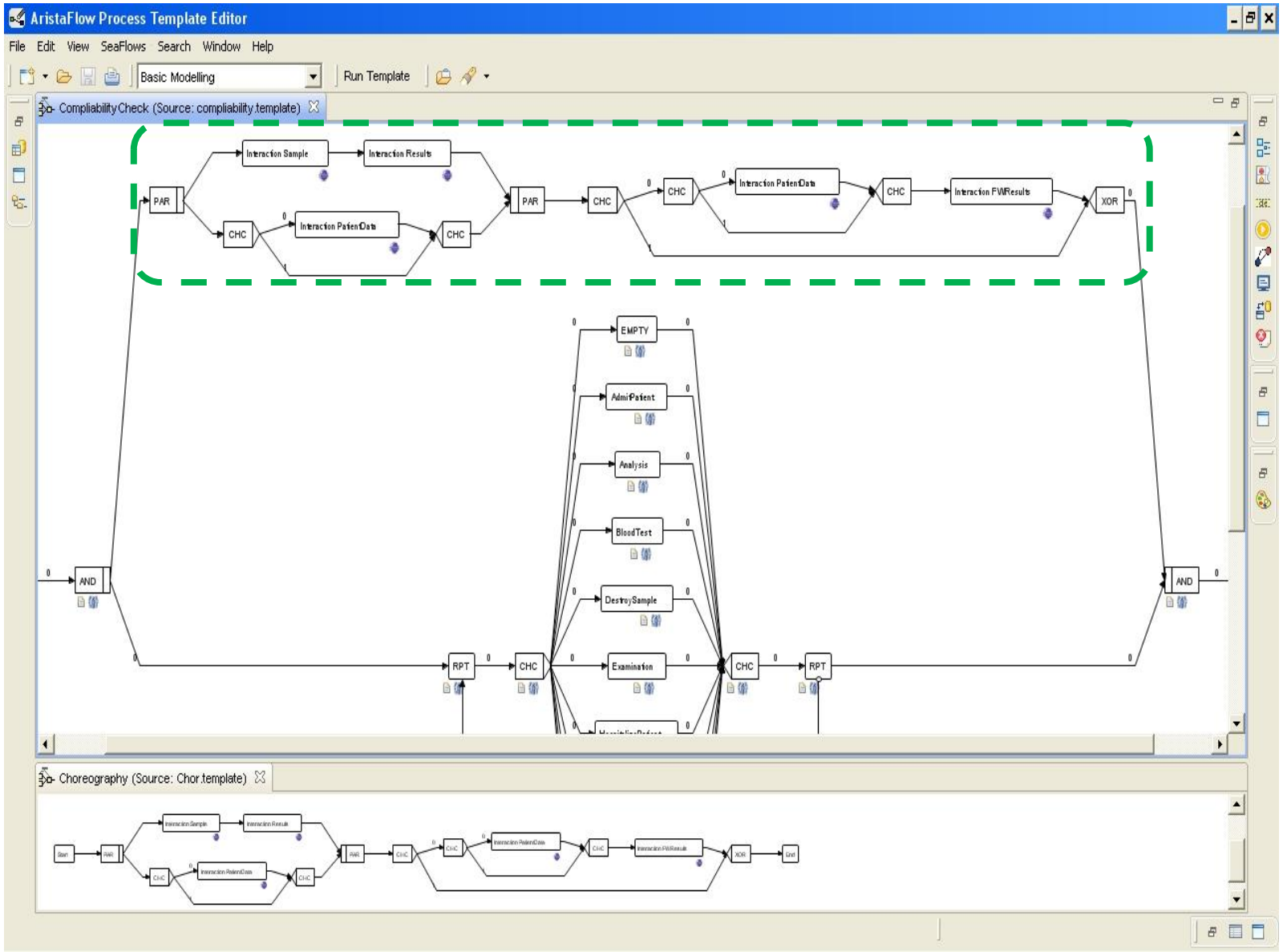


LTL model checker

true

false + counterexample

D. Knuplesch, M. Reichert, R. Pryss, W. Fdhila, S. Rinderle-Ma, Stefanie (2013) *Ensuring Compliance of Distributed and Collaborative Workflows.* In: 9th IEEE Int'l Conference on Collaborative Computing: Networking, Applications and Worksharing (CollborateCom'13), Austin, 2013, IEEE Computer Society Press


AristaFlow Process Template Editor
File Edit View SeaFlows Search Window Help
Basic Modelling
Run Template
CompliabilityCheck (Source: compliability.template)
Interaction Sample
Interaction Results
PAR
CHC
Interaction PatienData
Interaction FWResults
XOR
EMPTY
AdmiPatient
Analysis
BloodTest
DestroySample
Examination
AND
RPT
Choreography (Source: Chor.template)

Next Steps

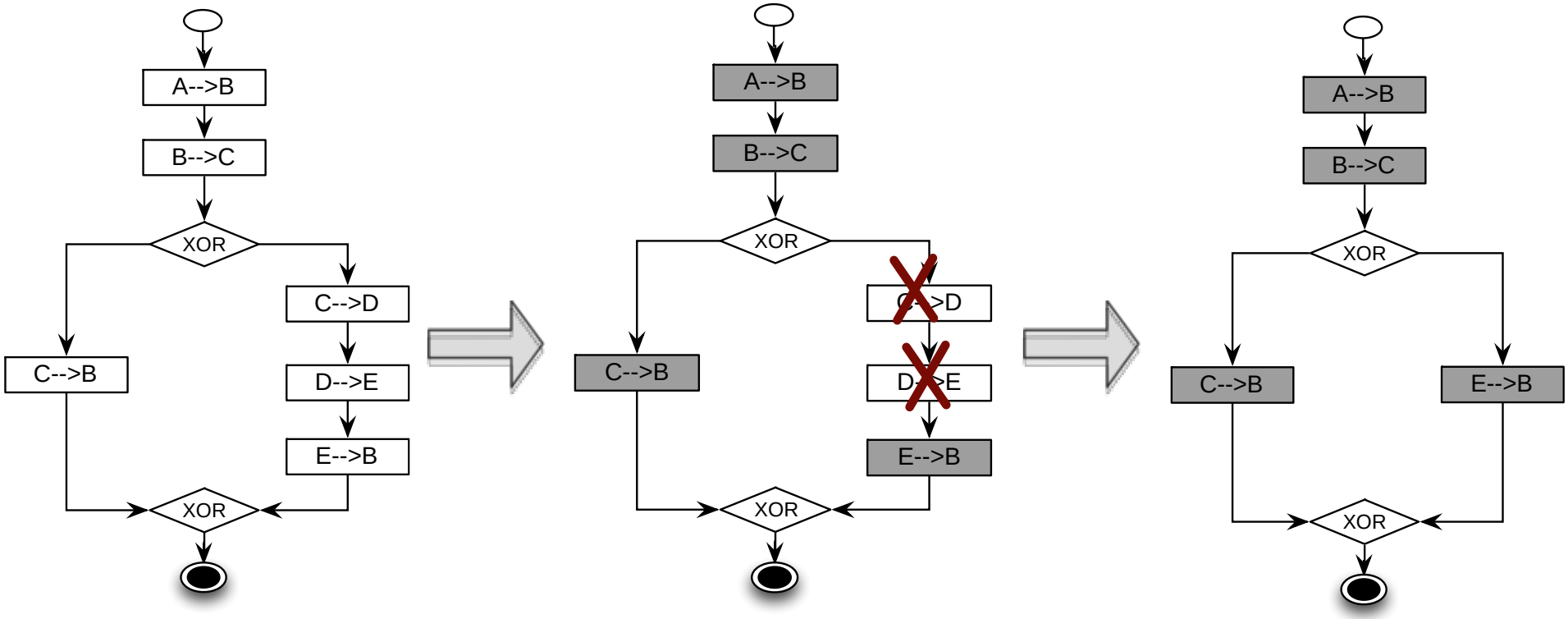
- Compliance monitoring and a-posteriori compliance checking for cross-organizational processes
- Preserving compliance of cross-organizational processes in the context of changes
- Deal with data-awareness in the context of cross-organizational compliance checking
- Modeling compliance rules that support multiple process perspectives? (see our ER 2013 paper)

D. Knuplesch, M. Reichert, T. Ly, A. Kumar, S. Rinderle-Ma (2013) *Visual Modeling of Business Process Compliance Rules with the Support of Multiple Perspectives.* In: 32nd Int'l Conference on Conceptual Modeling (ER 2013), Hong Kong, 2013

Enabling Change of Cross-Organizational Processes

W. Fdhila, S. Rinderle-Ma, M. Reichert (2012) *Change Propagation in Collaborative Processes Scenarios.* In: 8th IEEE International Conference on Collaborative Computing: Networking, Applications and Worksharing (CollaborateCom'12), Pittsburgh, 2012

Basics

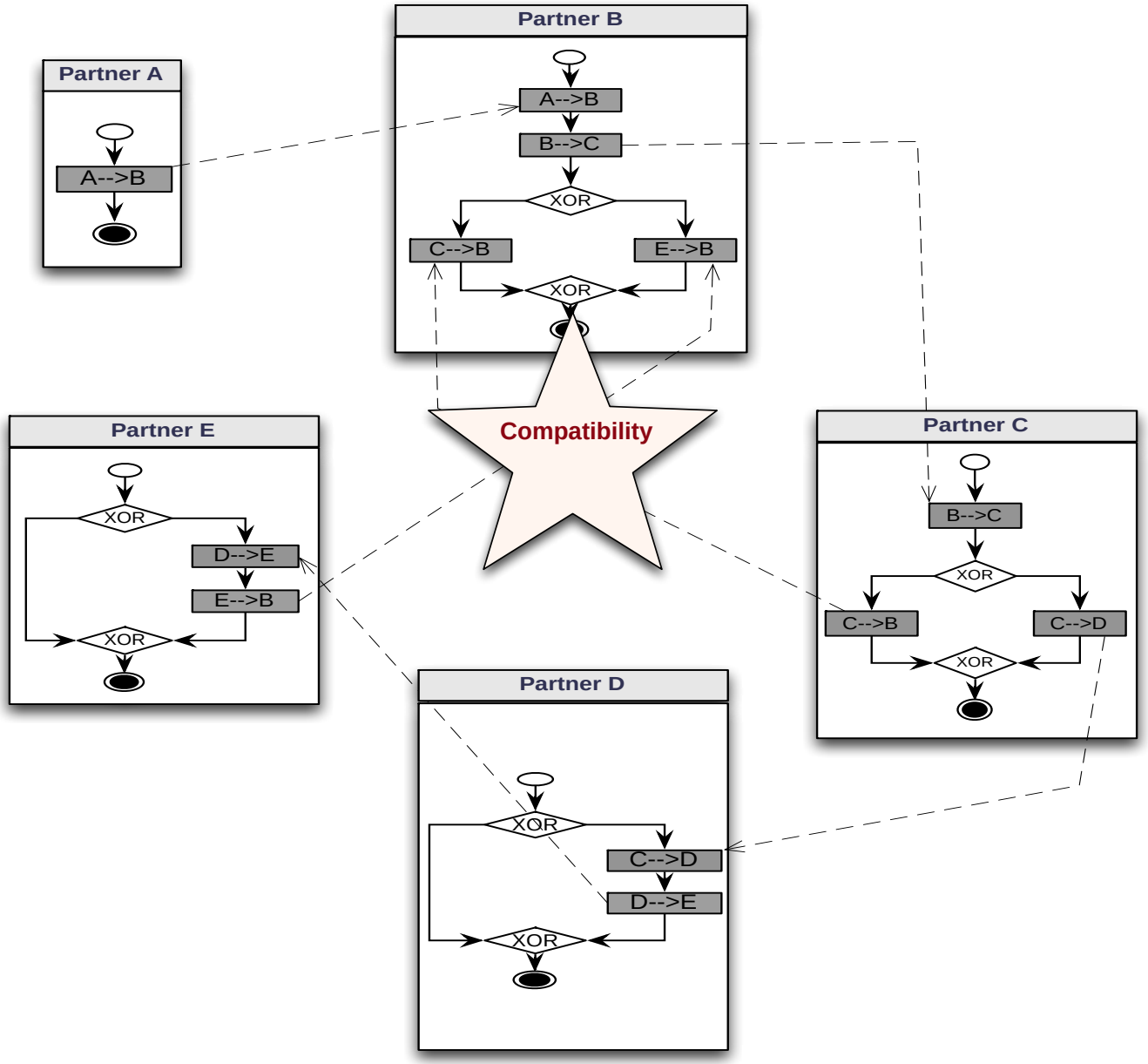


Global Choreography Model (Interaction Model)

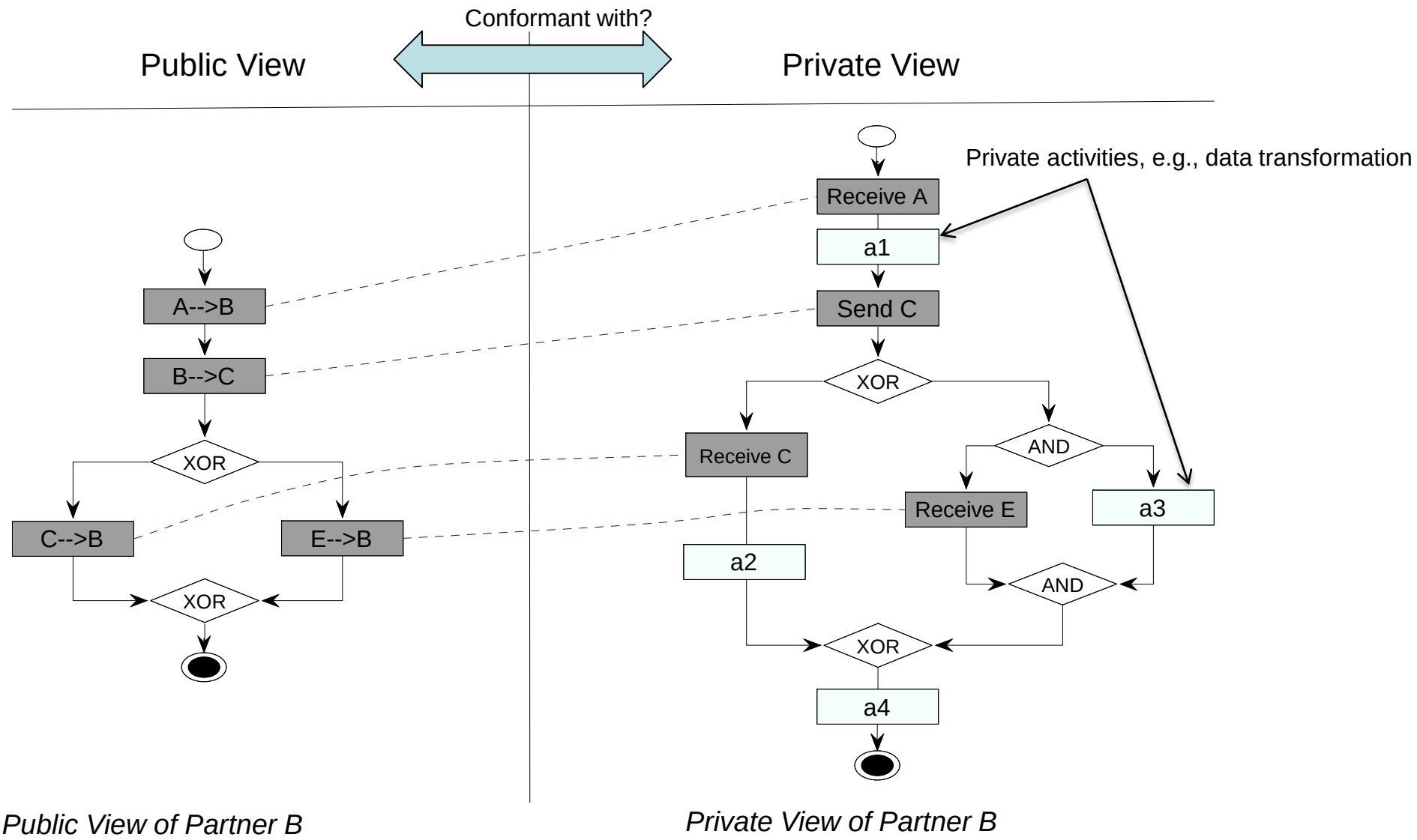
Model Abstraction

Public View of Partner B

Basics


Partner A
A-->B
Partner B
A-->B
B-->C
XOR
C-->B
E-->B
XOR
Compatibility
Partner E
XOR
D-->E
E-->B
XOR
Partner C
B-->C
XOR
C-->B
C-->D
XOR
Partner D
XOR
C-->D
D-->E
XOR

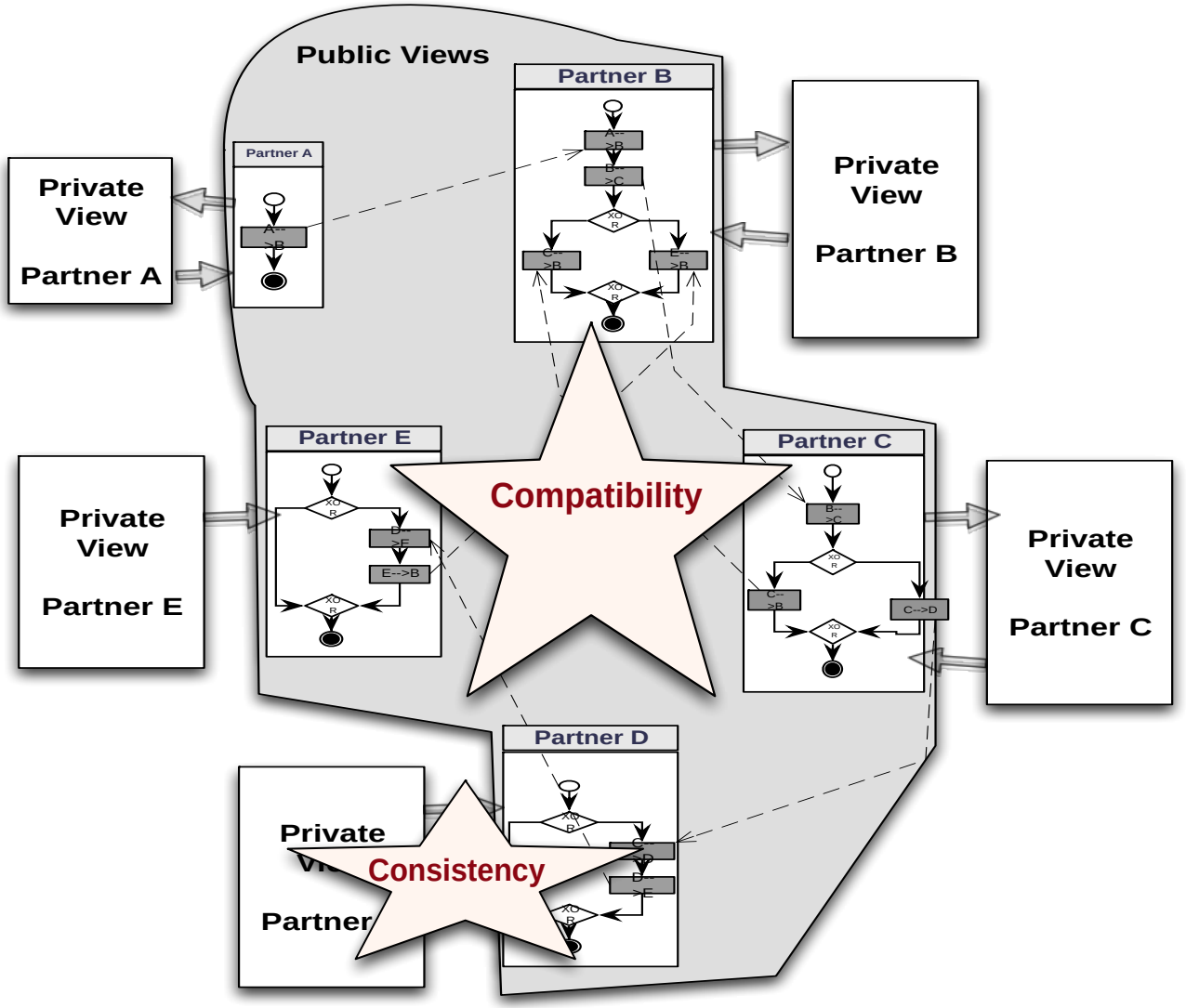
Basics



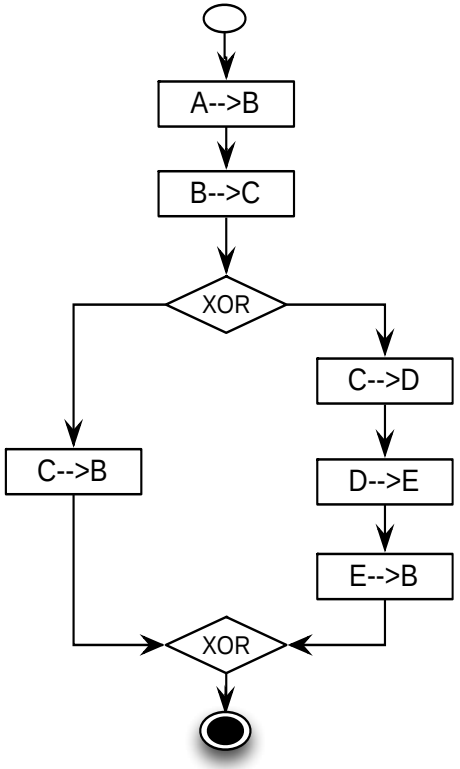
Public View of Partner B

Private View of Partner B

Basics



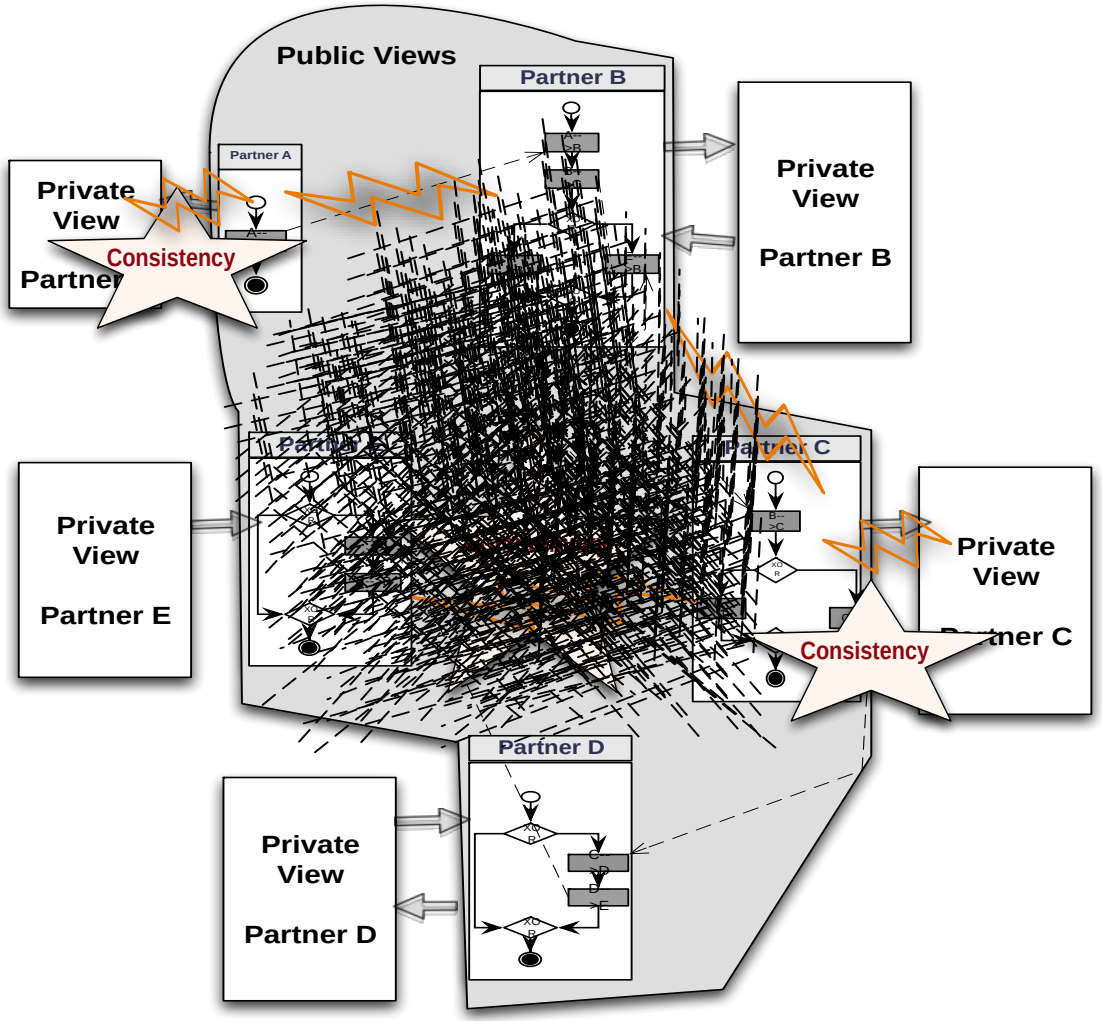
Global Schema



Global Choreography Model

Basics

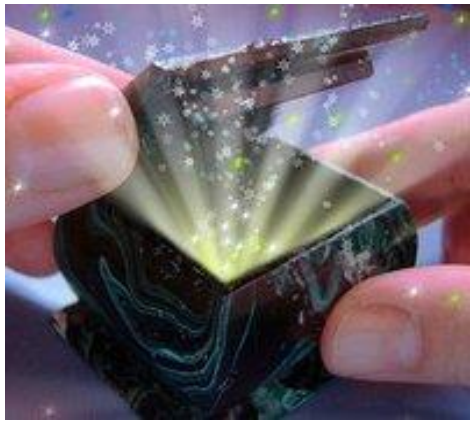
- Ok! and what is the problem then?



- ❑ Conformance (Consistency)
- ❑ Behavioral Compatibility
  - Waiting for a message which will never arrive
  - Sending message which will not be consumed
- ❑ Structural compatibility
- ❑ Transitivity effects
- ❑ Negotiation

Change Propagation

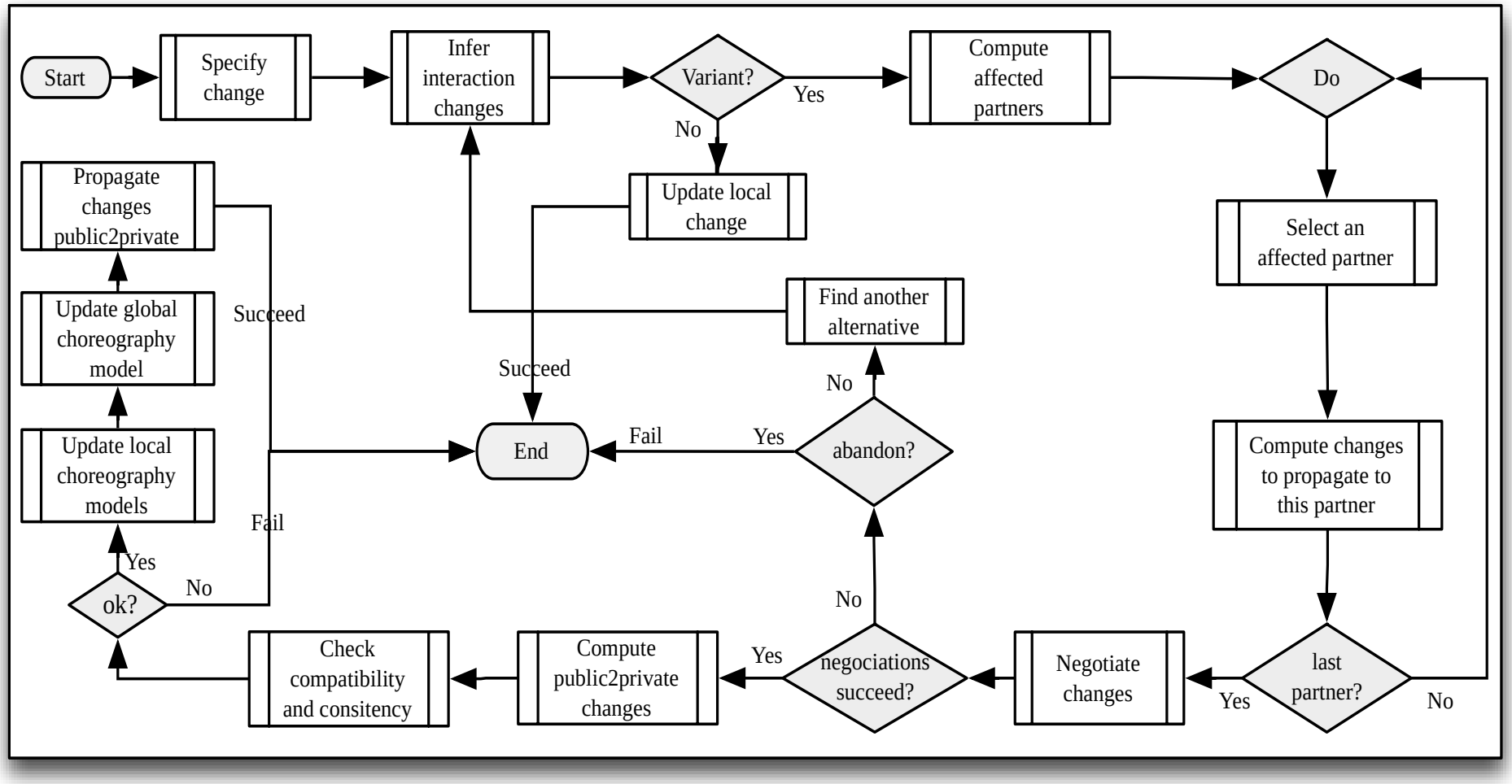
Choreography Model
+
Public views
+
Change Specification



Partners affected by the change
+
Changes to be propagated

- Preserve Conformance
- Preserve Compatibility
- Transitive effects
- Negotiation

Change Propagation: Negotiation



Change Propagation: Change Patterns

INSERT(fragment, how, in, out)

- inserts a new fragment in a process model.

DELETE(fragment)

- Deletes an existing fragment from a process model.

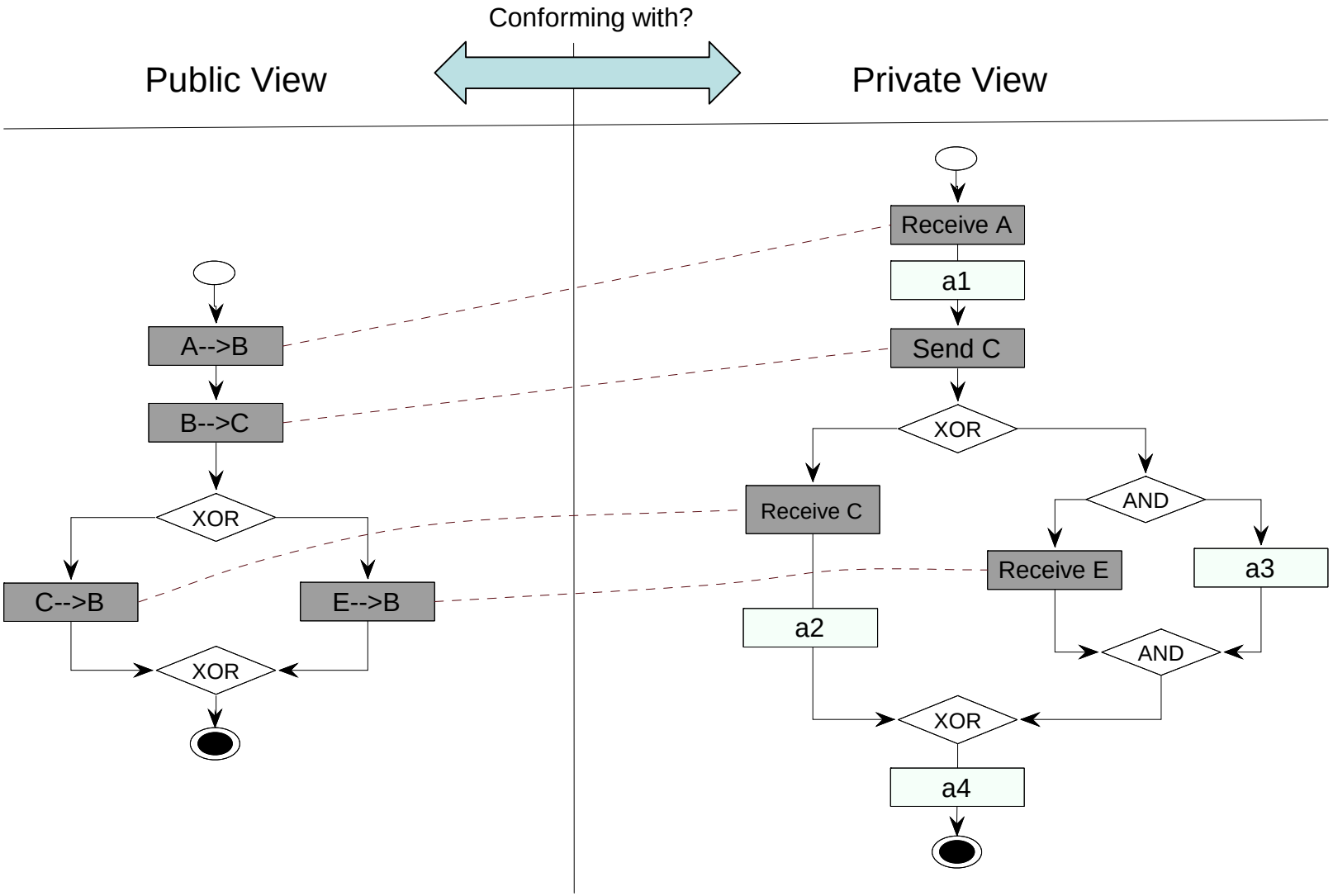
REPLACE(oldFragment, newFragment)

- Replaces an existing fragment by a new one in the process model.

UPDATE(activity, attribute, newValue)

- Updates the attributes of a single activity of a process model.
- *Attribute could be: partner, role, input, output, etc.*

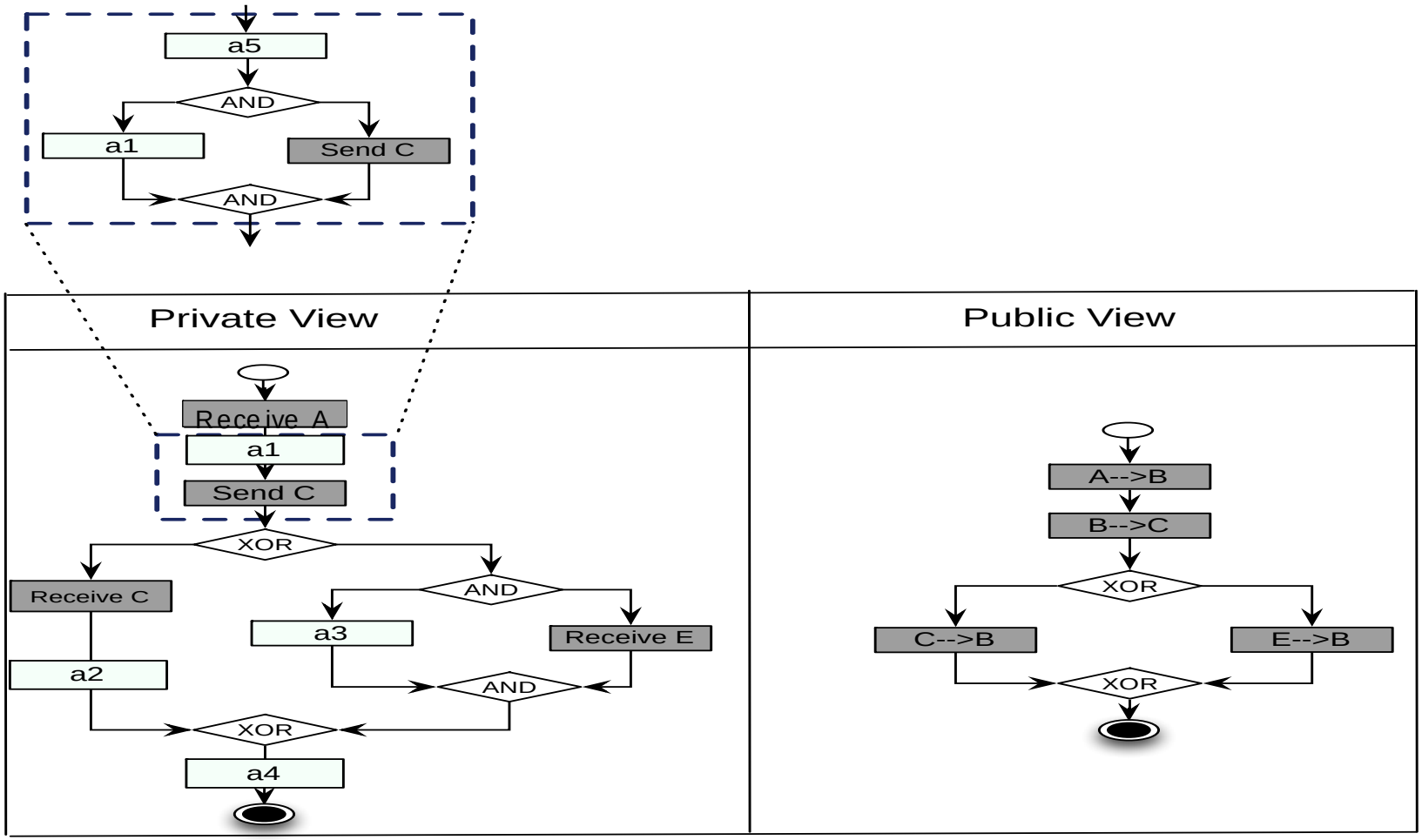
Change Propagation: Replace Pattern



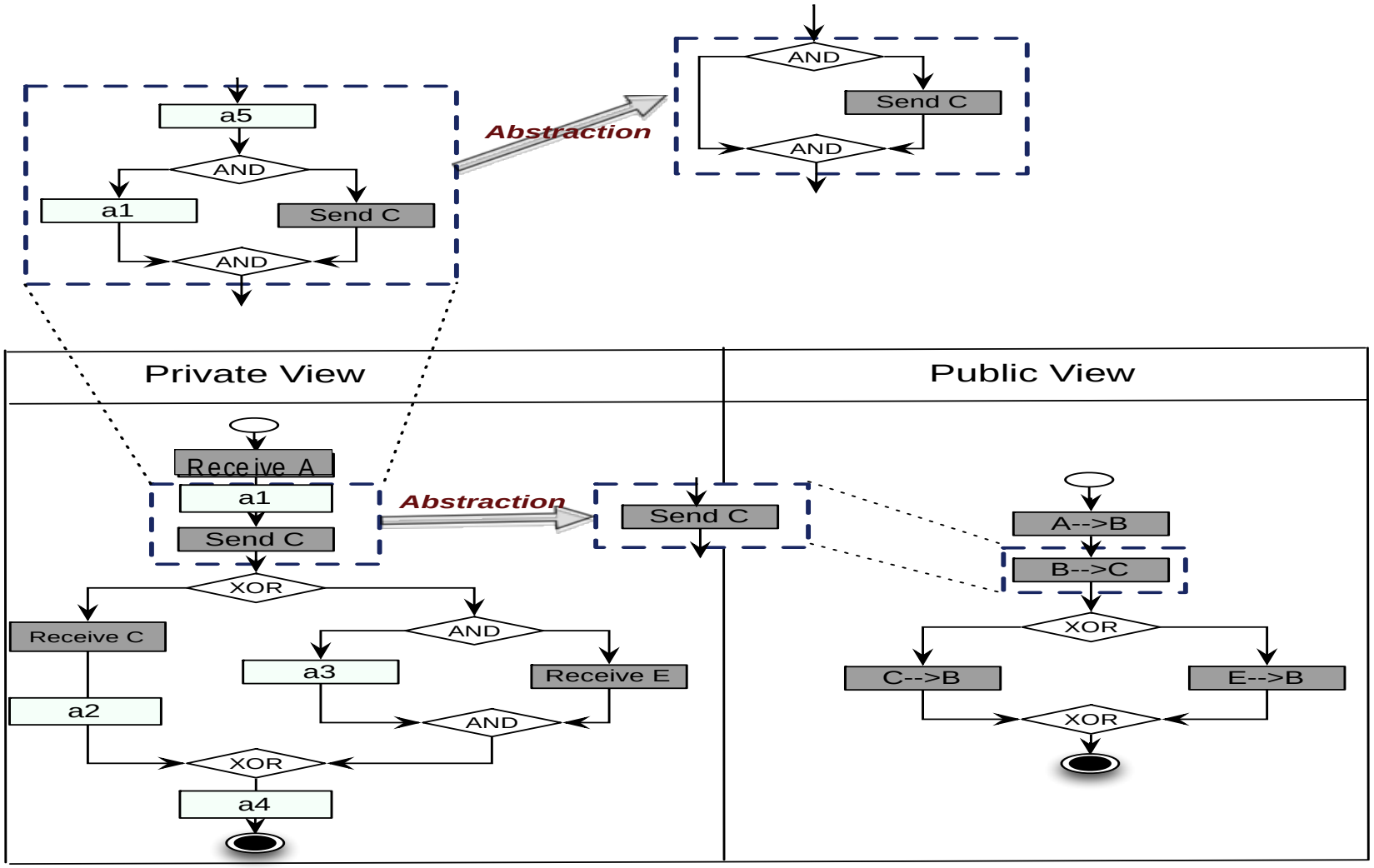
Public View of Partner B

Private View of Partner B

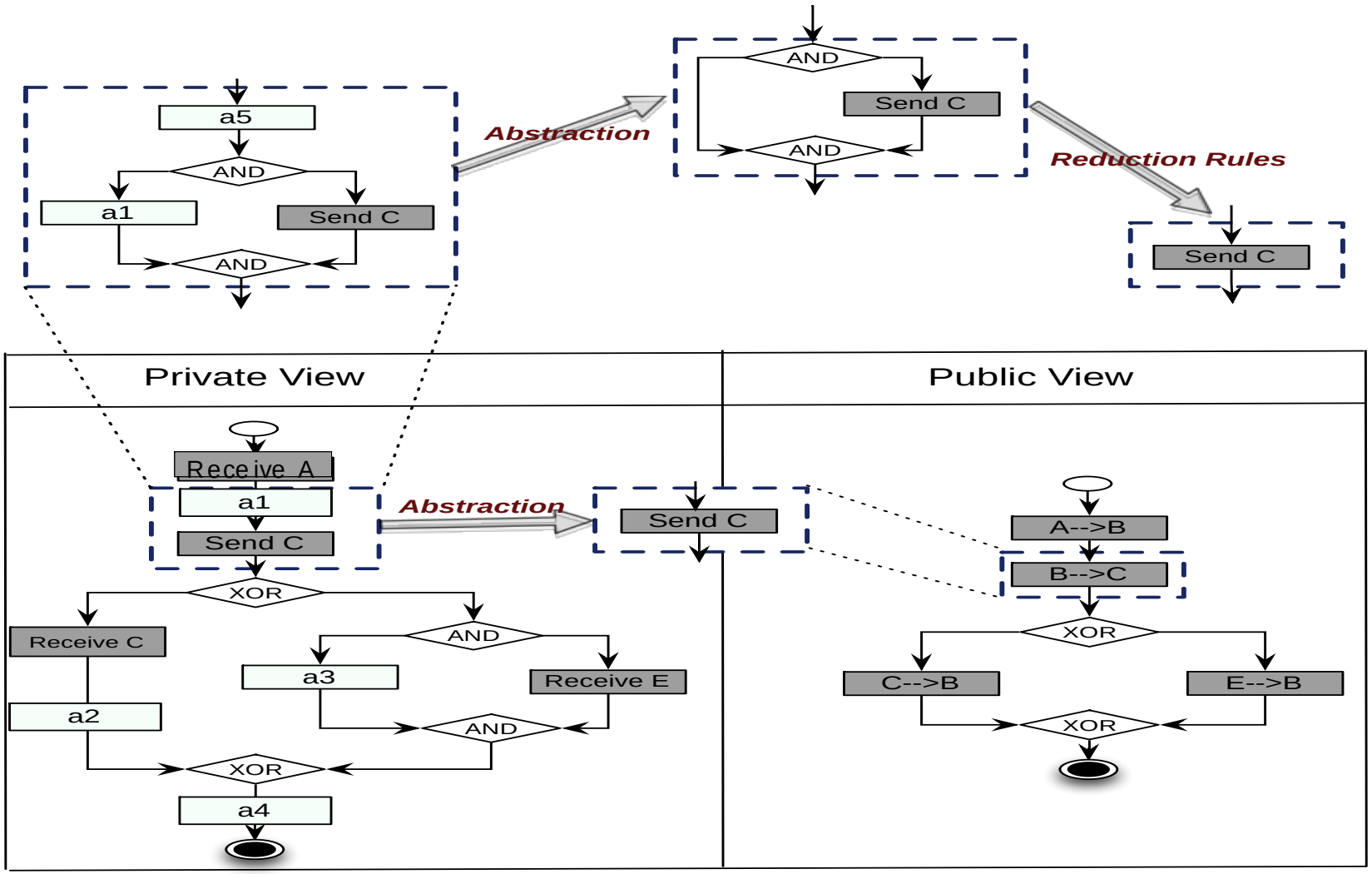
Change Propagation: Replace Pattern



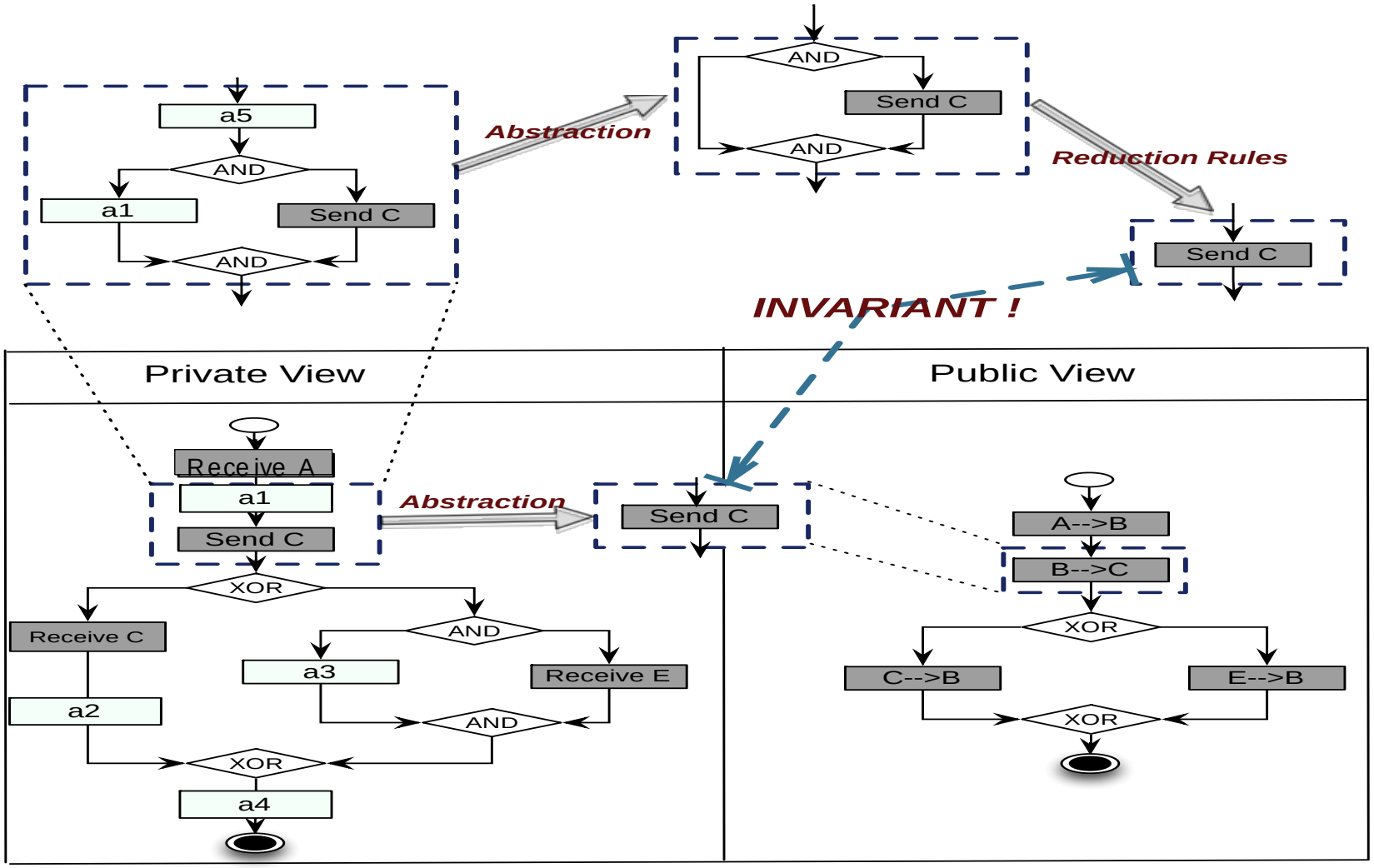
Change Propagation: Replace Pattern



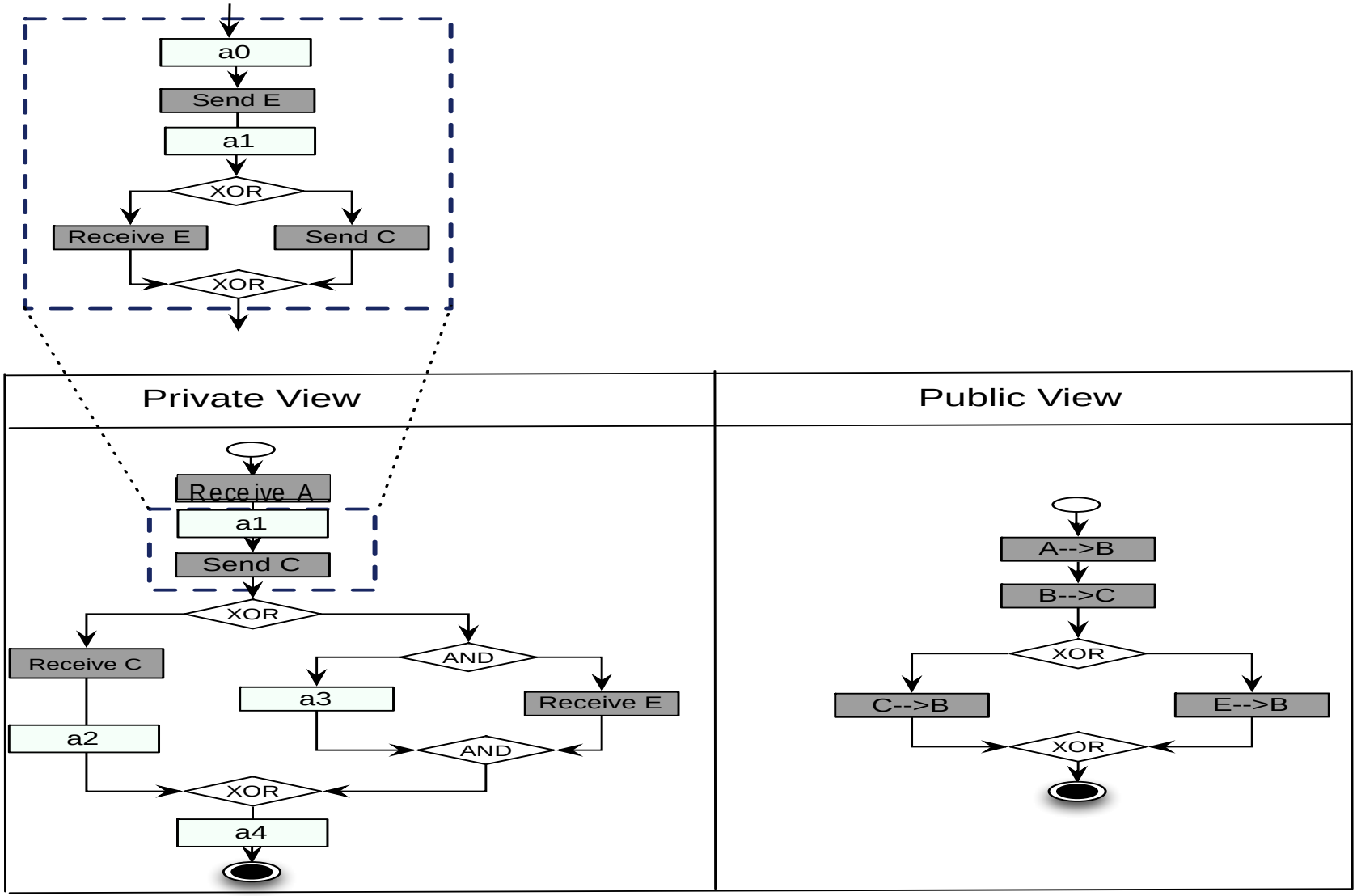
Change Propagation: Replace Pattern



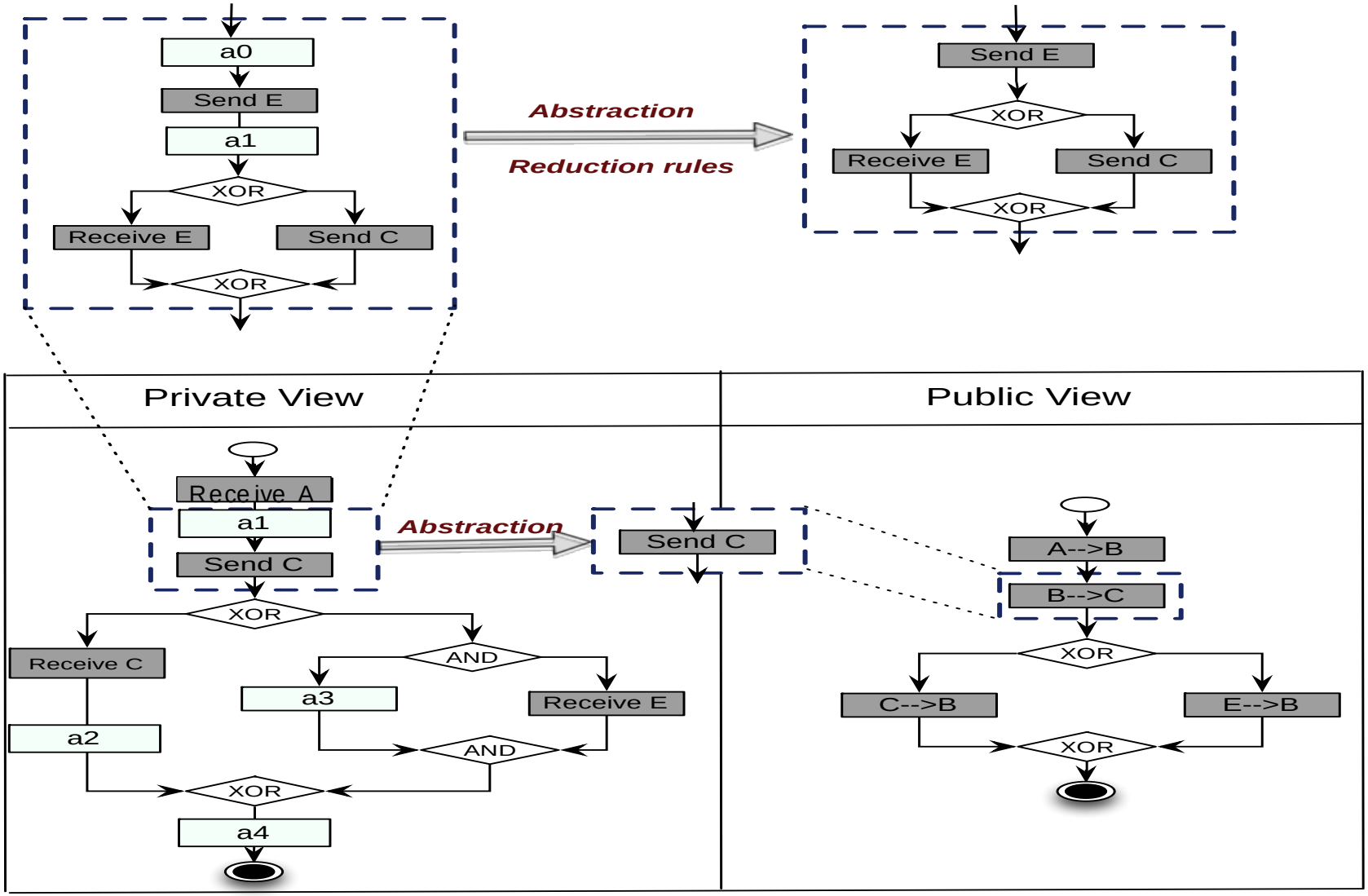
Change Propagation: Replace Pattern



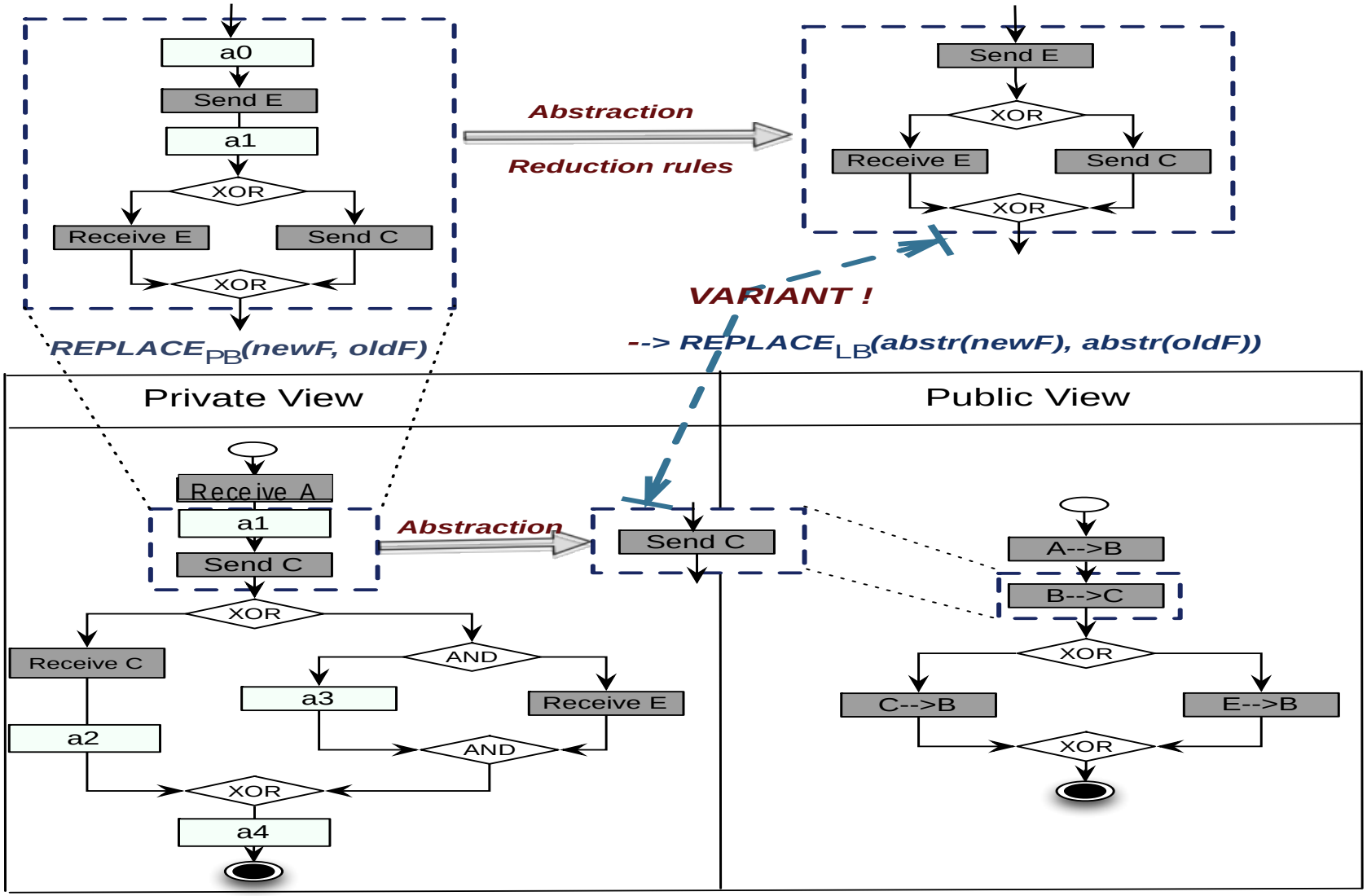
Change Propagation: Replace Pattern



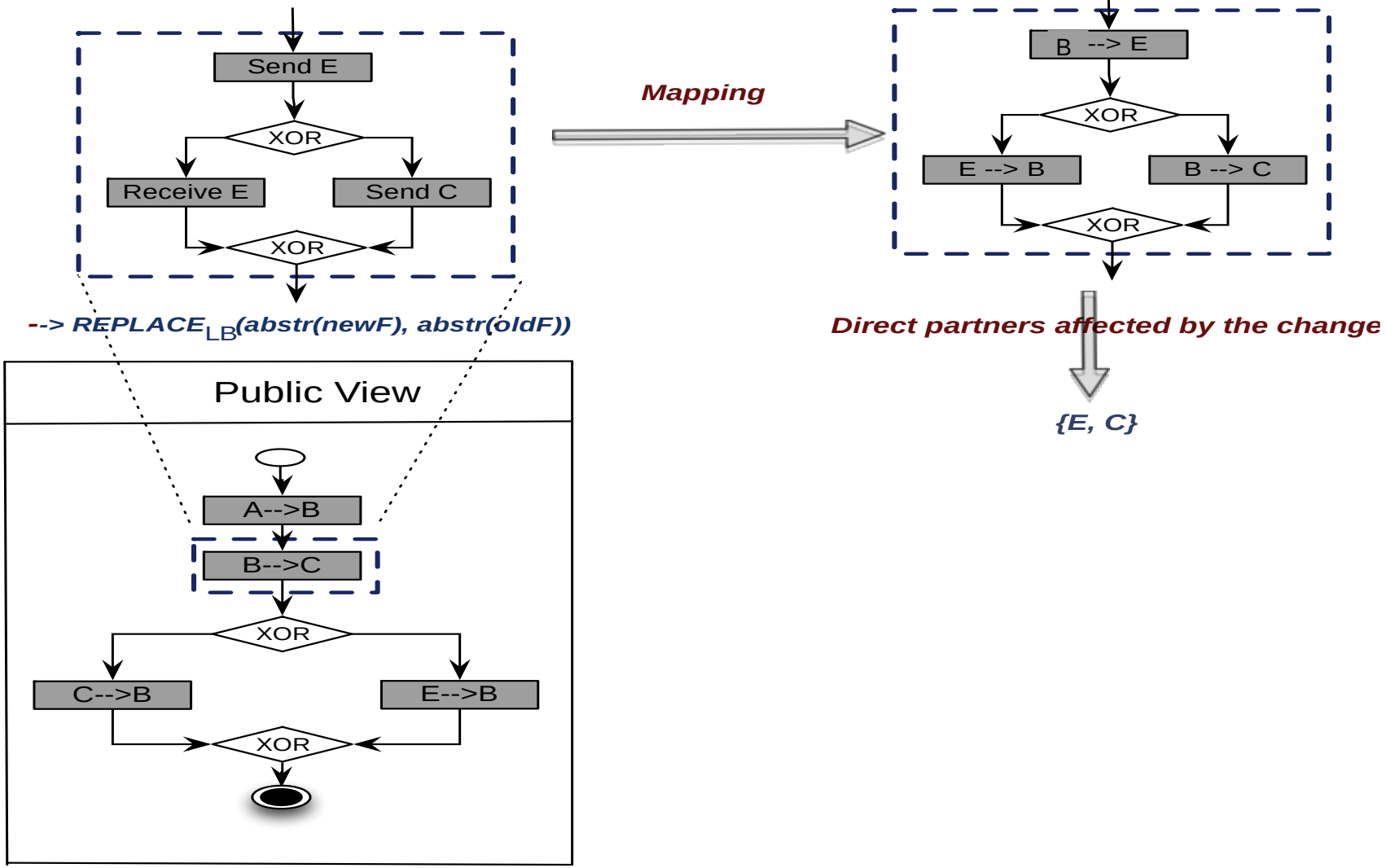
Change Propagation: Replace Pattern



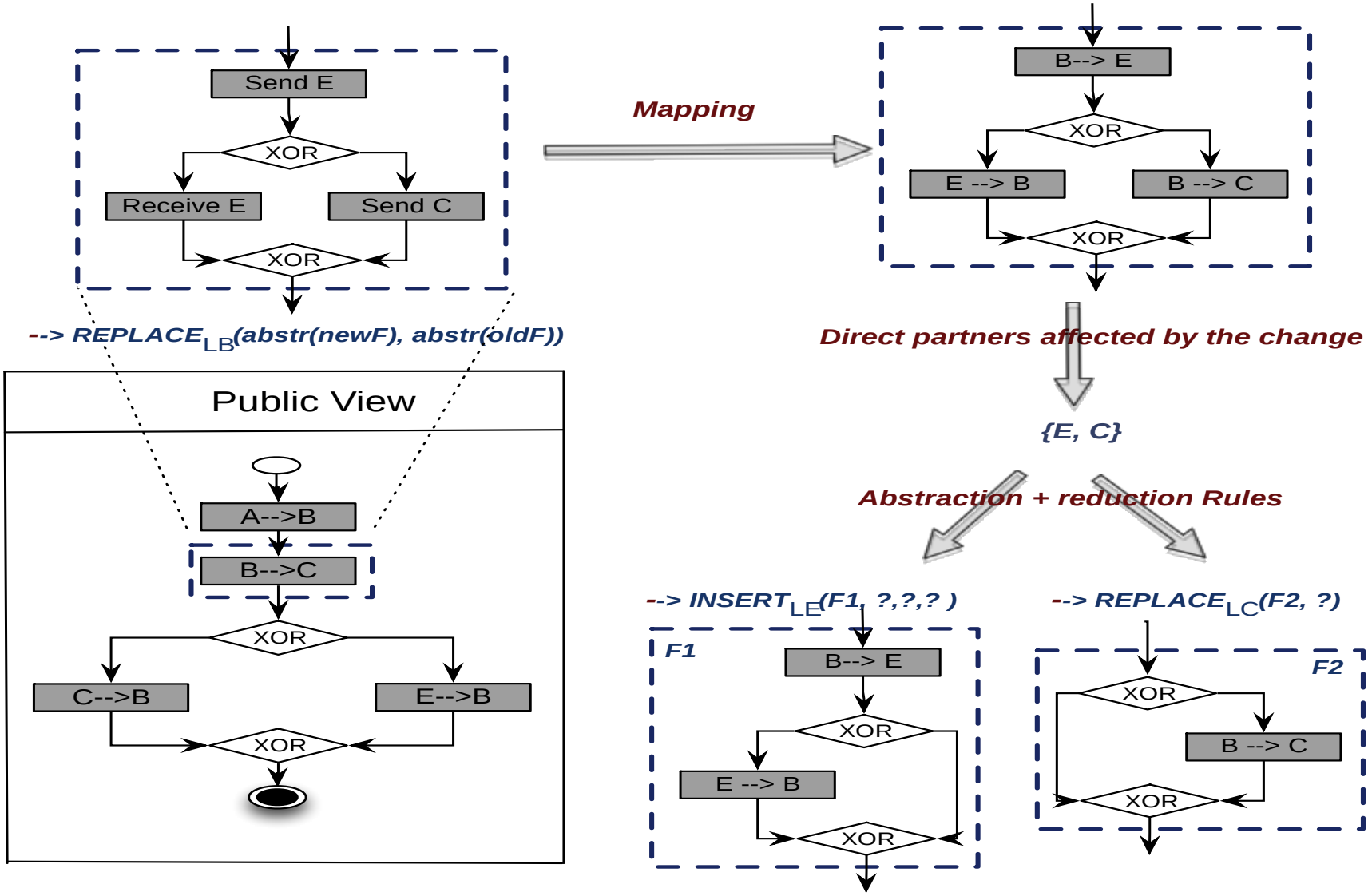
Change Propagation: Replace Pattern



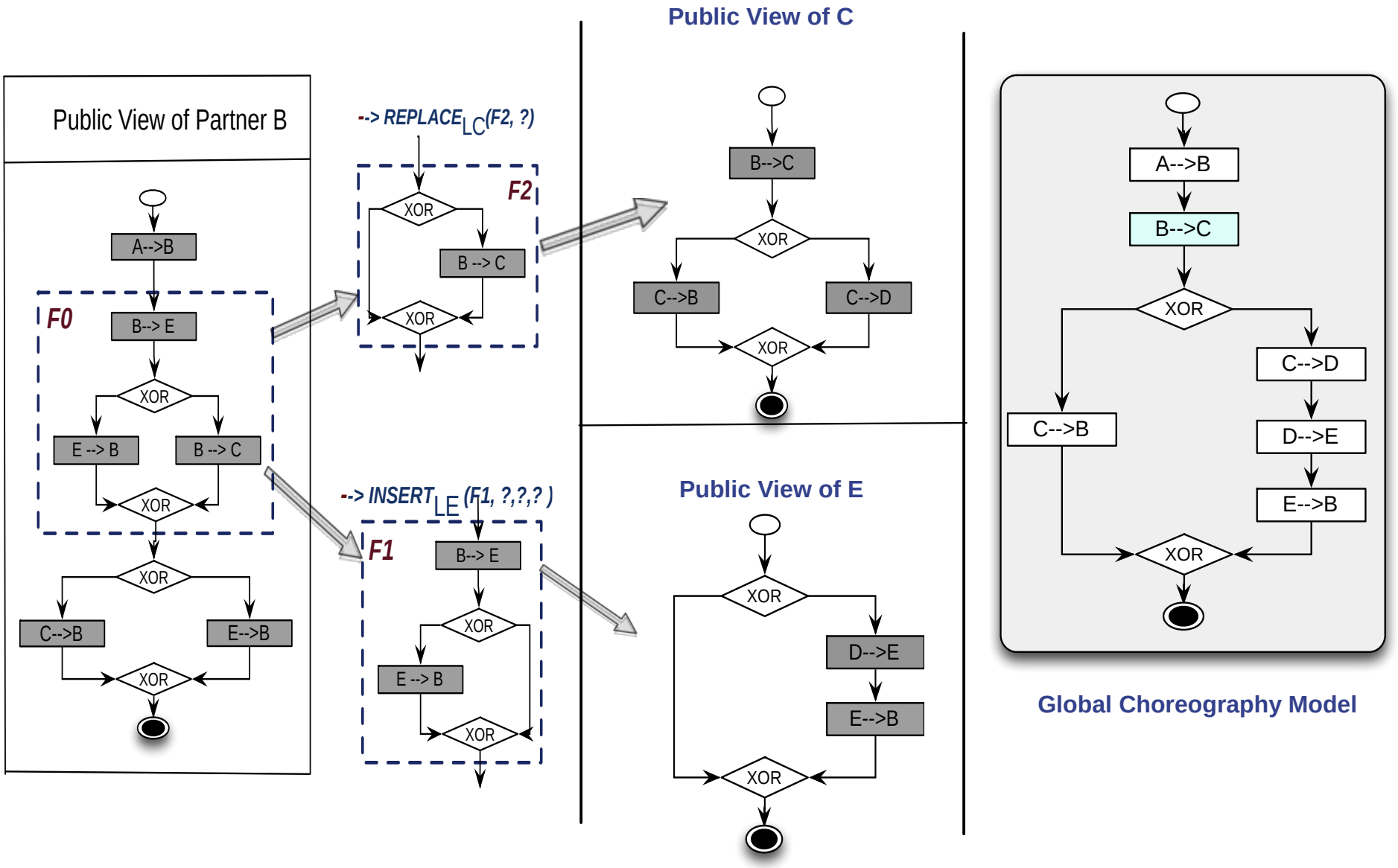
Change Propagation: Replace Pattern



Change Propagation: Replace Pattern

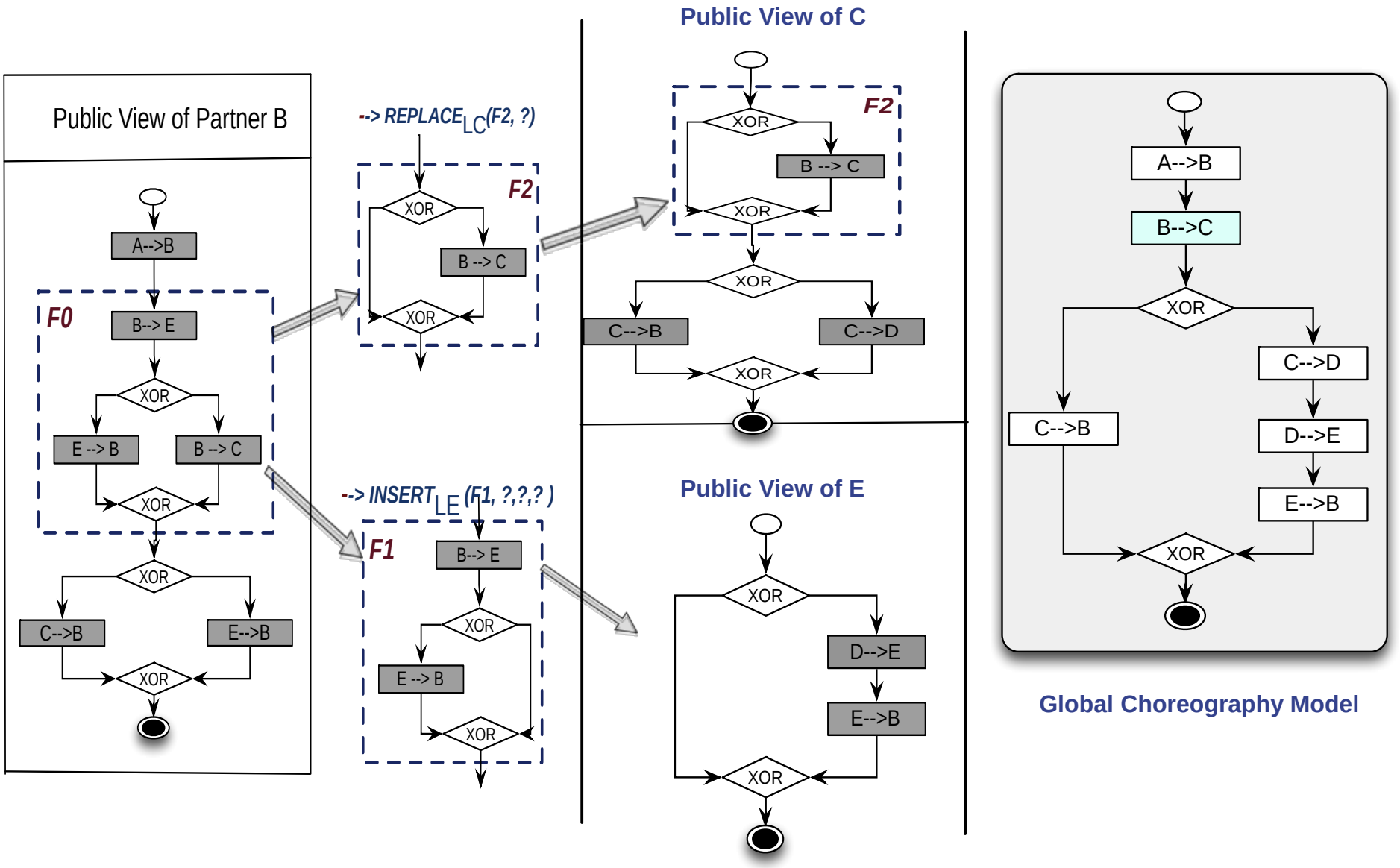


Change Propagation: Replace Pattern



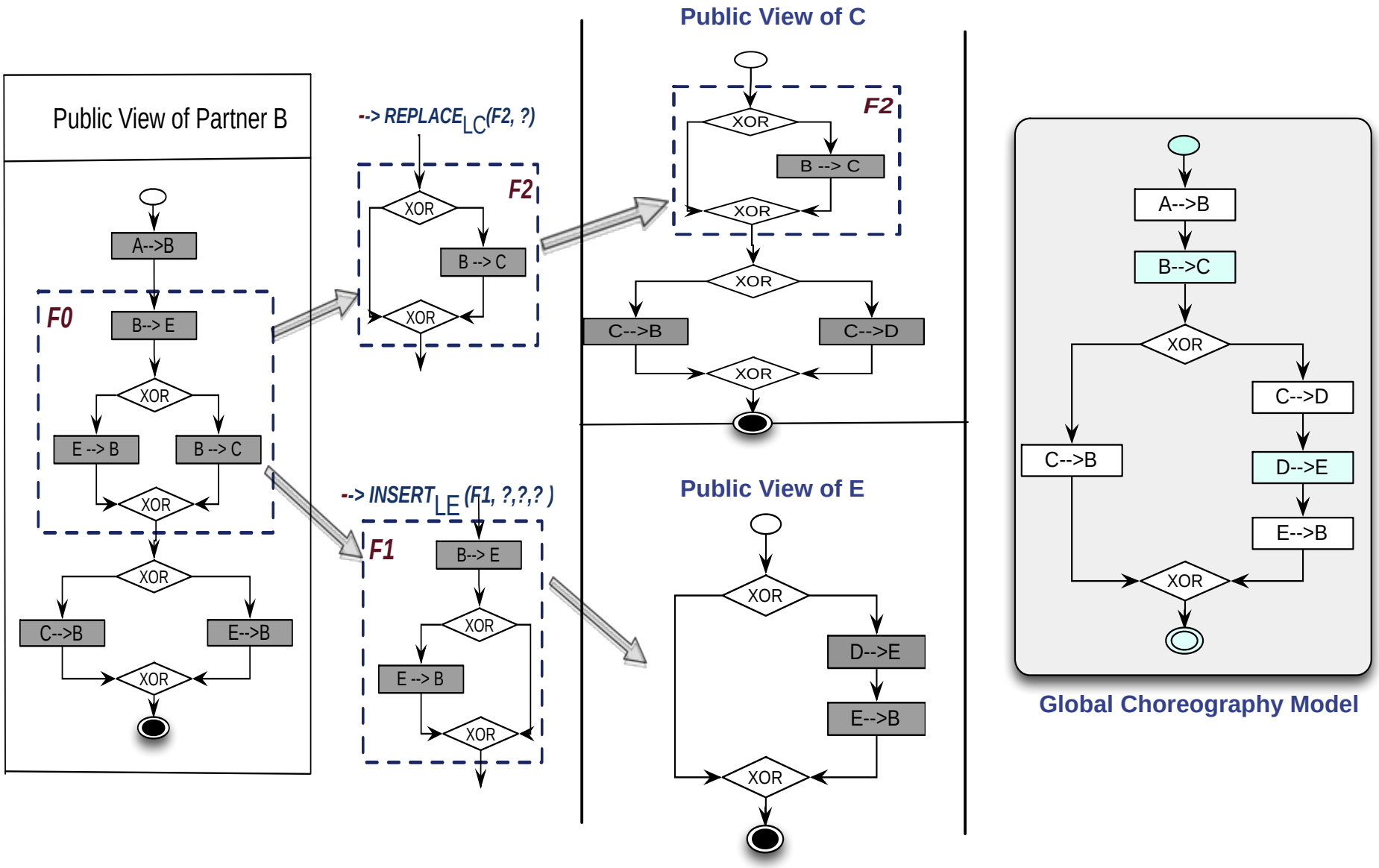
Global Choreography Model

Change Propagation: Replace Pattern

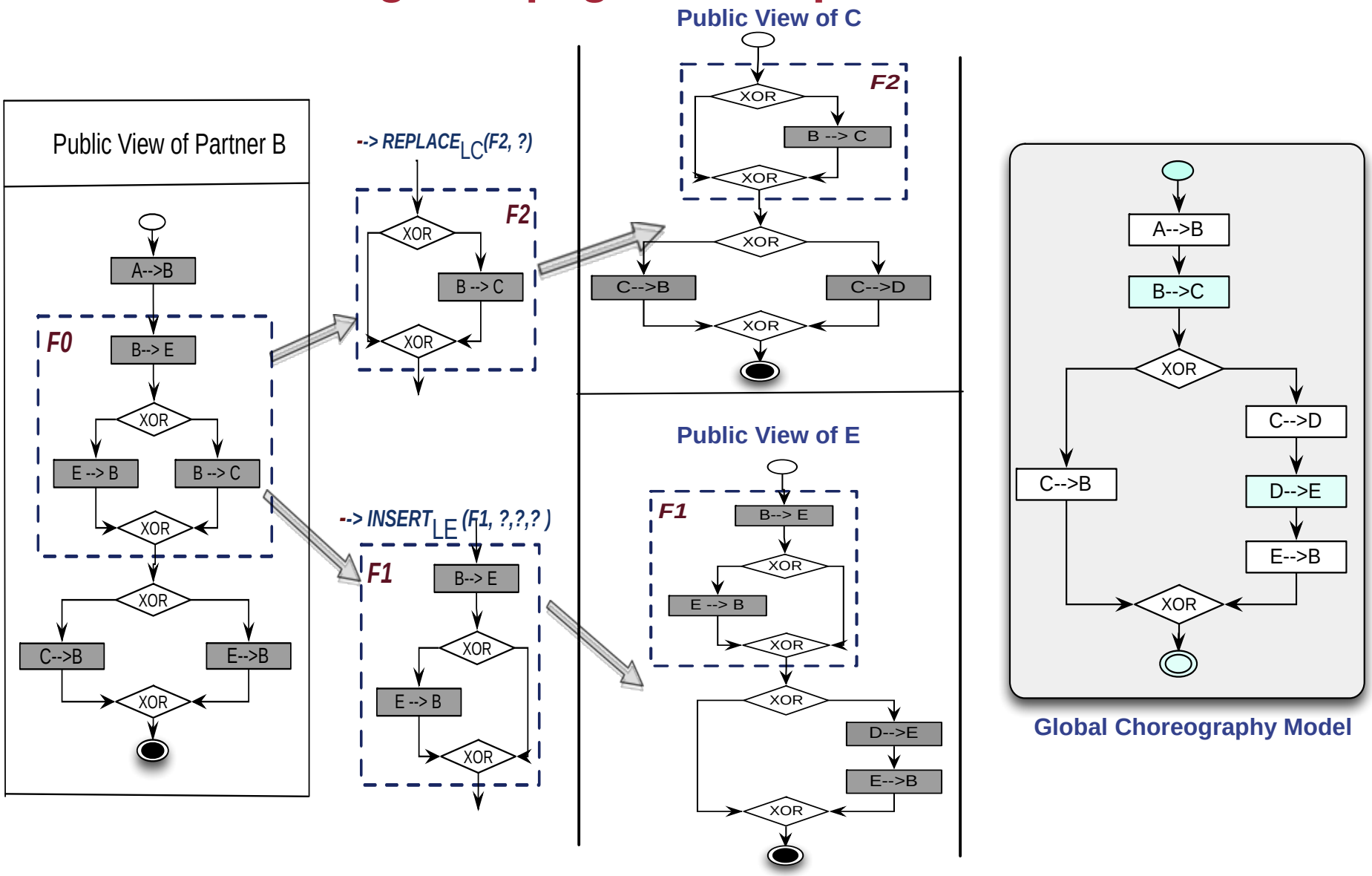


Global Choreography Model

Change Propagation: Replace Pattern



Change Propagation: Replace Pattern



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