The Challenges of Modeling and Evolving Cross-Organizational Processes

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Introduction

Cross-Organizational Processes

Business Process Compliance

Change

Process-aware Information System

Running Instances / Process Engine

Process Models

Process Logs
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

\[
A ::= BA \quad \text{(basic activities)} \\
| \quad A; A \quad \text{(sequential composition)} \\
| \quad A \sqcap A \quad \text{(choice)} \\
| \quad A \parallel A \quad \text{(parallel composition)}
\]

\[
BA ::= \text{skip} \quad \text{(no action)} \\
| \quad a^i \quad \text{(activity in role } R^i\text{)} \\
| \quad c^{[i,j]} \quad \text{(communication)}
\]

Basic:
- \([\text{skip}] \triangleq \{\} \]
- \([a] \triangleq \{a\}\]
- \([c^{[i,j]}] \triangleq \{c^{[i,j]}\}\]

Sequential:
- \([A_1; A_2] \triangleq [A_1] \cap [A_2]\]

Choice:
- \([A_1 \sqcap A_2] \triangleq [A_1] \cup [A_2]\]

Parallel:
- \([A_1 \parallel A_2] \triangleq \text{interlv}([A_1], [A_2])\]

Qiu Zongyan, Zhao Xiangpeng, Cai Chao, and Yang Hongli: Towards the Theoretical Foundation of Choreography, WWW'07, 2007.
Interaction Modeling: Languages, Notations, Standards

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Gero Decker, Mathias Weske:
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Languages, Notations, Standards

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

<!-- Coordinated CreditAuthorization Choreography without finalizedBlocks-->
<choreography name="CreditAuthorization" root="false" coordination="true">
  <relationship type="tns:CreditReqCreditResp"/>
  <variableDefinitions>
    <variable name="CreditExtended" informationType="xsd:int" silent="true"
      roleType="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>
  </interaction>
</choreography>
```

W3C: Web services choreography description language 1.0, 2005.
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- Chor
- Conversation protocols
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What about Data?
Interaction Modeling:
Languages, Notations, Standards

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Existing approaches do not adequately support the data perspective

inhibit parallelism

lack of proper correctness criteria

What about Data?
Data-Aware Interaction Modeling:
DAChor – A Data-Aware Interaction Modeling Language

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

Mapping → Data-Aware Interaction Nets
Data-Aware Interaction Modeling:
DACChor Semantics - Data-Aware Interaction Nets

Workflow Nets with Data

Interaction Nets


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

Traces $T$:

$\sigma_1 = < (M1, s1), ST-1, (M2, \epsilon), ST-2 >$

$\sigma_2 = < (M1, s2), ST-3, (M3, \epsilon), ST-4 >$

Conversations $C$:

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

$\eta_2 = < (M1, s2), (M3, \epsilon) >$

Options:

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

$mo(< (M1, s1) >) = \{(M2, \epsilon)\}$

Views:

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

$vc_A(\eta_2) = < (M1, s2) >$
(Data-aware) Interaction Modeling: Correctness Issues
(Data-Aware) Interaction Modeling:

Correctness Issues

Violation of soundness
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

Which Message may I send?
May I terminate my process?

No clear termination!
Definition 11 (Determinism and Soundness).

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

(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., \( \forall u \in \mathcal{T}_\# \exists \tau \in \mathcal{T}^c_\# : u \preceq \tau \).
- The set of reachable markings is finite, i.e.,
  \[ |\{m \in M_\#|\exists \tau \in \mathcal{T}_\#: \text{last}(\tau) = m\}| \in \mathbb{N} \]

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.,

  \[ \forall R \in \mathcal{R} : \forall \eta, \kappa \in C_\#: \text{vc}_\#^R(\eta) = \text{vc}_\#^R(\kappa) \Rightarrow \text{vo}_\#^{R \rightarrow} (\text{mo}_\#(\eta)) = \text{vo}_\#^{R \rightarrow} (\text{mo}_\#(\kappa)) \]

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

  \[ \forall R \in \mathcal{R} : \forall \eta \in C^c_\# \exists \kappa \in C_\#: \text{vc}_\#^R(\eta) \preceq \text{vc}_\#^R(\kappa) \]
(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


Cross-Organizational Process Compliance

Business Process Compliance

Cross-Organizational Processes

Change / Flexibility

Interaction Modeling

Analysis

Execution

Change

Modeling
Scenario: Electronic Change Request

**Interaction Model**
- inform about ECR
- request comments
- engineers
- comments on ECR
- change team
- request change details
- analyst
- change details
- change team
- request approval
- decision team
- approval
- change team
- engineers

**Local Views**
- e.g. local view of engineering team

**Public Process Models**
- request approval
- decide on approval
- approval

**Scenario: Electronic Change Request**
- initial request
- process initial request
- inform about ECR
- specify ECR
- request comments
- comments on ECR
- review & include comments
- request change details
- analyst
- detail change
- change details
- prepare final ECR
- request approval
- approval
- document ECR

**Solution**
- inform about ECR
- suspend affected development tasks
- request comments
- analyse ECR
- determine side effects
- write comments
- comments on ECR
- change details
- approval
- implement change & continue development tasks
The Process of Interaction Modeling

specify interaction model → check realizability → revise interaction model

specify public process models → compute local views

realizable?

specify private process models
Relevant Layers and Compliance Rules

**Public**

**Private**

**interaction model**

- Change team: inform about ECR
- Change team: request comments
- Engineers: comments on ECR
- Change team: request change details
- Analyst: change details
- Change team, engineers: request approval
- Decision team: approval

**local views**

- Change team: inform about ECR
- Change team: request comments
- Comments on ECR
- Analyst: change details
- Decision team: approval

**public process models**

- Inform about ECR
- Request comments
- Write comments
- Change details
- Approval
- Implement change

**private process models**

- Inform about ECR
- Suspend affected development tasks
- Analyse ECR
- Determine side effects
- Write comments
- Approval
- Implement change & continue develop, tasks
Relevant Layers and Compliance Rules

Interaction Model

Public

- Change team
  - Inform about ECR
  - Engineers

- Change team
  - Request comments
  - Engineers

- Engineers
  - Request change details on ECR
  - Change team

- Change team
  - Request approval
  - Change team

- Decision team
  - Approval

Local Views

- Change team
  - Inform about ECR
  - Engineers

- Change team
  - Request comments
  - Engineers

Public Process Models

- Inform about ECR
  - Request comments

Private Process Models

- Inform about ECR
  - Suspend affected development tasks
    - Request comments

- Analyse ECR
- Determine side effects
- Write comments
- Change details
- Approval
- Implement change & continue develop. tasks

Affected development tasks must be suspended before implementing changes.

Local Compliance Rules
The engineers must determine side effects before the decision team decides on the change.
Relevant Layers and Compliance Rules

Side effects must be determined before sending comments on the ECR to the change team.
The Process of Interaction Modeling

1. Select/specify compliance rules
2. Specify interaction models
3. Check realizability
4. Revise interaction models
5. Specify public process models & assertions
6. Compute local views
7. Realizable?
8. Check global compliance
9. Compliant?
10. Revise public process models & assertions
11. Specify private process models
12. Ensure local & asserted compliance
Comments on the ECR must not be requested before change details are sent to the engineers.
The Process of Interaction Modeling

1. Select/specify compliance rules
2. Specify public process models & assertions
3. Specify private process models
4. Compute local views
5. Specify interaction model
6. Check realizability
7. Realizable?
8. Revise interaction model
9. Revise public process models & assertions
10. Ensure local & asserted compliance
11. Check global compliance
12. Compliant?
13. Release
Relevant Layers and Compliance Rules

Public

interaction model

local views

public process models

private process models

Local compliance rules incl. assertions

Global compliance rules

Local compliance

Global compliance?

Compliance rules

Assertions
Compliance Checking

compliance rule CR

process model $M$

$\forall t \in \text{Traces}_M : t \models CR$

LTL-model checker

ture  false + counter example
How to Check Compliability?

LTL-model checker

false  true + compliant trace

How to Construct the Extended Interaction Model?

For each task its possible performers and interaction model:

Tasks: $T_1, T_2, \ldots, T_m$

Interaction model: IM

Extended interaction model: EIM
negation of conjunction of compliance rules $\text{CR}_i$

$$\psi := \neg \bigwedge_{i=1..n} \text{CR}_i$$

How to Check Compliability?

extended interaction model $\text{EIM}$

interaction model $\text{IM}$

$LTL$-model checker

false  true + compliant trace
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

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)

Enabling Change of Cross-Organizational Processes

**Basics**

**Global Choreography Model** (Interaction Model)

**Model Abstraction**

**Public View of Partner B**
Basics

Partner A

A --> B

Partner B

A --> B
B --> C
C --> B
E --> B

XOR

Partner C

B --> C
C --> D
C --> E

XOR

Partner D

C --> D
D --> E

XOR

Partner E

D --> E
E --> B

XOR

Compatibility
Public View of Partner B

Private View of Partner B

Private activities, e.g., data transformation

Conformant with?

Basics
- Ok! and what is the problem then?

- Conformance (Consistency)
  - Waiting for a message which will never arrive
  - Sending message which will not be consumed

- Behavioral Compatibility

- Structural compatibility

- Transitivity effects

- Negotiation
## Change Propagation

<table>
<thead>
<tr>
<th>Choreography Model</th>
<th>Partners affected by the change</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Public views</td>
<td>+ Changes to be propagated</td>
</tr>
<tr>
<td>+ Change Specification</td>
<td></td>
</tr>
</tbody>
</table>

- Preserve Conformance
- Preserve Compatibility
- Transitive effects
- Negotiation 🙋‍♂️ 😞
Change Propagation: Negotiation

Start

Specify change

Infer interaction changes

Variant?

Yes

Compute affected partners

Do

Select an affected partner

Compute changes to propagate to this partner

Fail

Succeed

End

Fail

Yes

abandon?

No

Yes

negociations succeed?

Negotiate changes

Yes

last partner?

No

Check compatibility and consistency

Compute public2private changes

Yes

negociations succeed?

Negotiate changes

Yes

negociations succeed?

Negotiate changes

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negociations succeed?

Negotiate changes

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Negotiate changes

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negociations succeed?
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

Private View

Conforming with?

Public View of Partner B

Private View of Partner B

A->B

B-->C

C-->B

E-->B

Receive A

Send C

Receive C

Receive E

a1

a3

a2

a4

XOR

AND

XOR

AND

XOR

Reconcile

Reconcile
Change Propagation: Replace Pattern

Private View
- Receive A
- a1
- Send C
- XOR
- Receive C
- a2
- XOR
- a4
- XOR
- a3
- AND
- Receive E

Public View
- A→B
- B→C
- XOR
- C→B
- E→B
- XOR
Change Propagation: Replace Pattern

Private View

Public View

Abstraction

a5
AND
a1
Send C
AND

Receive A
a1
Send C
XOR
Receive C
a2
XOR
a4

A-->B
C-->B
XOR
B-->C
XOR
E-->B
Receive B
Receive C
XOR
Send C
XOR
Send C

AND
Send C
AND

AND

Abstraction

AN
AND

Send C
AND

Send C
AND

Send C
AND

Abstraction

AND

Abstraction
Change Propagation: Replace Pattern

Private View

Public View

Abstraction

Reduction Rules
Change Propagation: Replace Pattern
Change Propagation: Replace Pattern

Private View

Public View

Change Propagation: Replace Pattern
Change Propagation: Replace Pattern

Private View

Public View

Abstraction
Reduction rules
Change Propagation: Replace Pattern

Private View

Public View

Abstraction

Reduction rules

VARIANT!
Change Propagation: Replace Pattern

Public View

- \( \text{A} \rightarrow \text{B} \)
- \( \text{B} \rightarrow \text{C} \)
- \( \text{C} \rightarrow \text{B} \)
- \( \text{E} \rightarrow \text{B} \)

\( \text{REPLACE}_{\text{LB}}(\text{abstr(newF)}, \text{abstr(oldF)}) \)

Mapping

- \( \text{B} \rightarrow \text{E} \)
- \( \text{E} \rightarrow \text{B} \)
- \( \text{B} \rightarrow \text{C} \)

Direct partners affected by the change
- \{E, C\}
Change Propagation: Replace Pattern

Mapping

Direct partners affected by the change

Abstraction + reduction Rules

-> REPLACE\textsubscript{LB}(\textit{abstr}(\textit{newF}), \textit{abstr}(\textit{oldF}))

Public View

-> INSERT\textsubscript{LE}(\textit{F1}, ?, ?, ?)

-> REPLACE\textsubscript{LC}(\textit{F2}, ?)
Change Propagation: Replace Pattern

Public View of Partner B

Public View of C

Public View of E

Global Choreography Model

Change Propagation: Replace Pattern

Public View of Partner B

Public View of C

Public View of E

Global Choreography Model
Change Propagation: Replace Pattern

Public View of Partner B

Public View of C

Public View of E

Global Choreography Model

F0

A→B

B→E

E→B

B→C

C→B

XOR

F2

→ REPLACE_{LC}(F2, ?)

F1

→ INSERT_{LE}(F1, ?, ?, ?)

F0

F2

Global Choreography Model
Change Propagation: Replace Pattern

Public View of Partner B

Public View of C

Public View of E

Global Choreography Model

\[ \text{Replace}_{LC}(F_2, ?) \]

\[ \text{Insert}_{EL}(F_1, ?, ?, ?) \]
Change Propagation: Replace Pattern

Public View of Partner B

**F0**
- A → B
- B → E

**F1**
- E → B
- B → C
- C → D
- D → E
- E → B

**F2**
- B → C
- C → B
- B → E
- E → B
- B → C

Public View of C

**F2**
- B → C
- C → D
- D → E
- E → B

Public View of E

**F1**
- B → E
- E → B

Global Choreography Model
Any Questions

Change
and Compliance
for Collaborative Processes