A Methodology to Define QoS and SLA Requirements in Service Choreographies

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Agenda

1. Introduction
2. Problem
3. Methodology
4. Performance Evaluation
5. Conclusions and Future Works

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SOC

SOC (Service Oriented Computing)

It is a new computing paradigm that utilizes services as the basic constructs to support the development of rapid, low-cost and easy composition of distributed applications even in heterogeneous environments. [Papazoglou et al., 2006].

Key elements:

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Service Orchestration

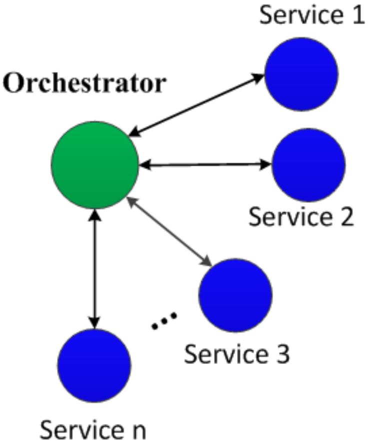


Figure: Service Orchestration

Service Choreography

- Allows service composition in a **collaborative** manner.
- Describes the **P2P interactions** of the externally **observable behavior of its participants**.
- Don't have a single point of control or coordination.

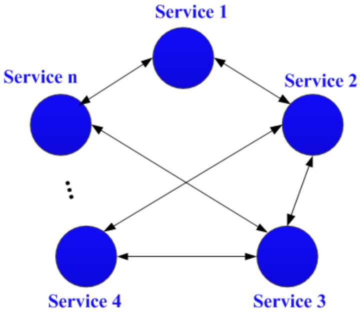
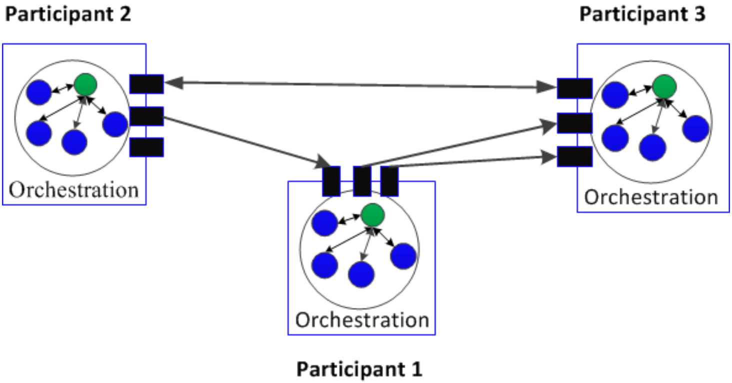


Figure: Service Choreography

Service Choreography



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BPMN and Choreography

- A Choreography is a type of process.
    - Differs in purpose and behavior from a standard BPMN Process (Process Orchestration).
    - Formalizes the way business **Participants** **coordinate** their **interactions**.

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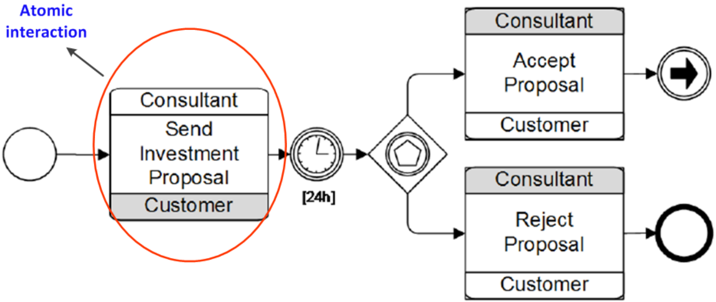
- Focus on the exchange of information (**Messages**) between these Participants.
- Two approaches:
  - Interconnection Model : With collaborations diagrams.
  - Interaction Model : BPMN Choreographies. using special activities (*Choreography Activity*).

Interaction Model

- Interactions **globally captured**.
- Basic building block: **atomic interaction** between two parties.
- "Choreography" in BPMN 2.0.



BPMN Choreography

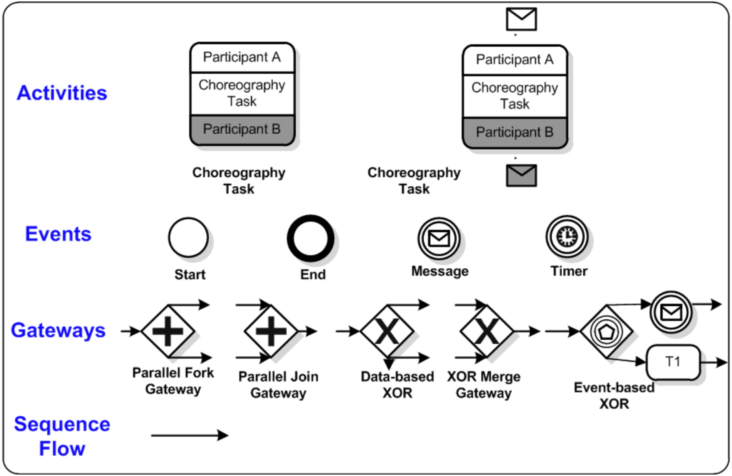


Figure: BPMN elements for modeling choreographies (BPMN 2.0).

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- Planning of resources before/during development of choreography.
- Little approaches don't evaluate choreographies:
  - focusing on **QoS** or
  - in earlier stages of development.
- To guarantee QoS about communications (network) is important.

Objectives

- To assess the **impact of QoS** attributes in a **choreography interaction model**.
- To propose a novel methodology to establish **requirements for QoS and SLA** in **early stages of development**.
- To plan the capacity of the network elements in choreographies.
- To convert a interaction model to a GSPN including a QoS model.

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Description

1. **Mapping** of a choreography to a GSPN.
    - The choreography is specified according “interaction model”.
    - The choreography is specified in BPMN 2.0.
    - The resulting GSPN include a QoS model.

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2. **Configurations** of the resulting GSPN.
3. **Simulations** of scenarios.

QoS Model

- Defining the QoS attributes involved in **service**, **network** and **message** aspects.
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  - In network : delay and **communication errors**.
  - In message : **message format**.

Mapping BPMN to GSPN (I)

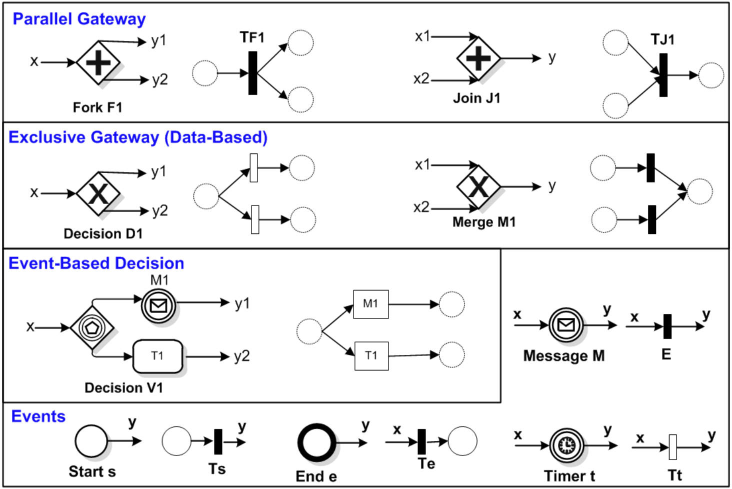
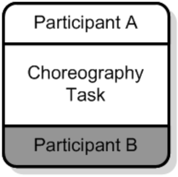
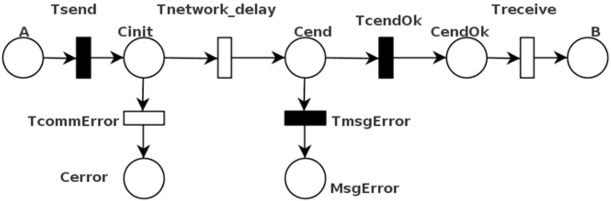


Figure: Mapping of events and gateways elements to modules of Petri nets

Mapping BPMN to GSPN (II)

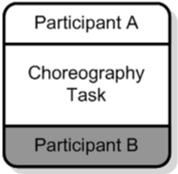


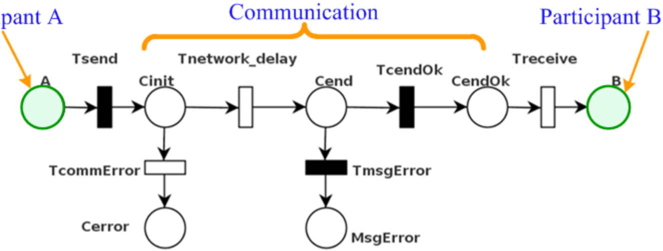
A) Interaction in BPMN 2



B) GSPN Mapping with QoS

Mapping BPMN to GSPN (II)





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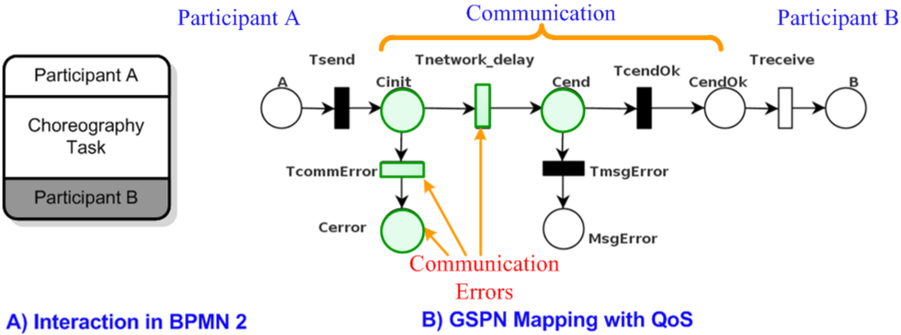

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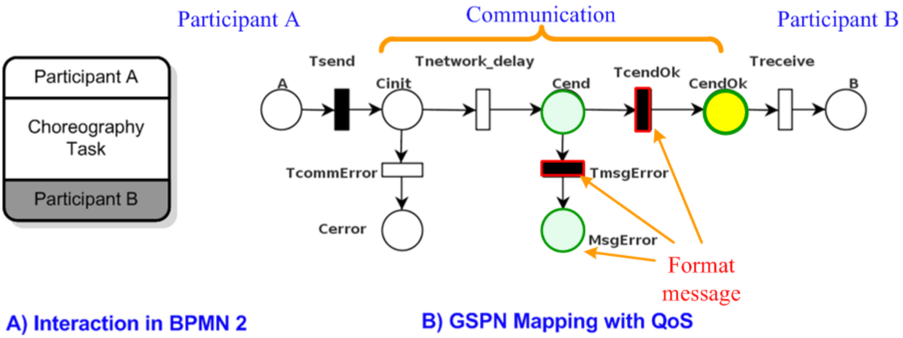

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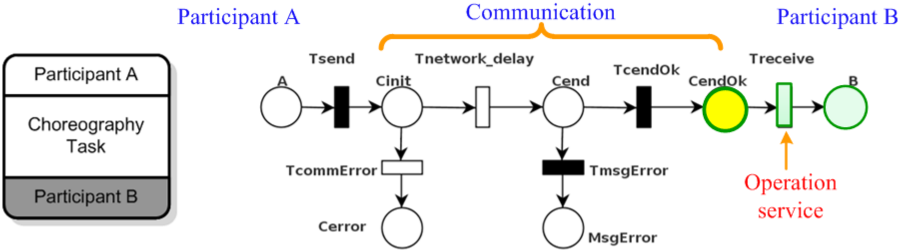

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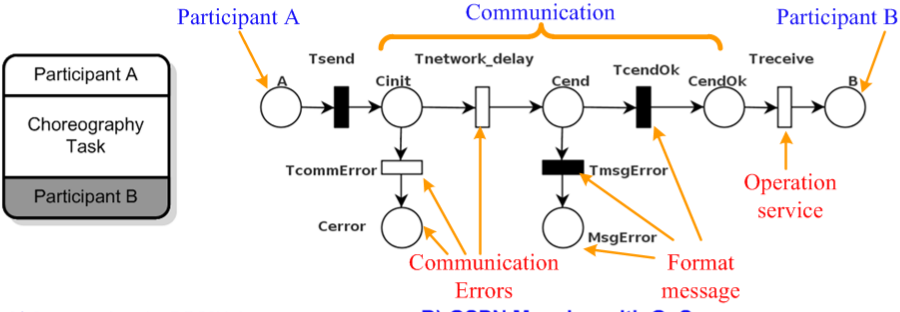

A) Interaction in BPMN 2

B) GSPN Mapping with QoS

Mapping Algorithm

Mapping of choreography in BPMN 2.0 to GSPN with QoS model

Input: **Process Choreography** $PC = (\mathcal{O}, \mathcal{A}, \mathcal{E}, \mathcal{G}, \mathcal{T}, \{e^S\}, \mathcal{E}^I, \{e^E\}, \mathcal{E}^{I_M}, \mathcal{E}^{I_T}, \mathcal{G}^F, \mathcal{G}^J, \mathcal{G}^X, \mathcal{G}^M, \mathcal{G}^V, \mathcal{F})$ in BPMN 2.0.

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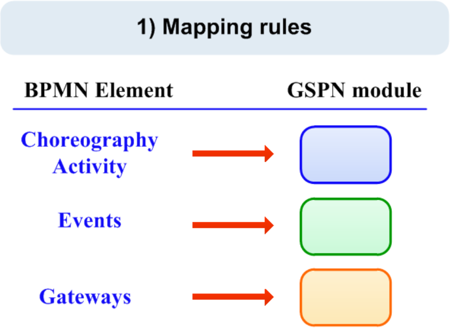
Output: Generalized Stochastic Petri Net $GSPN_{QoS}$.

$CT_i \in \mathcal{T}$, $G_j \in \mathcal{G}$ and $E_k \in \mathcal{E}$. where $i, j, k \in \mathbb{N}$.
$PNQoS(CT_i)$, $PNQoS(G_j)$, $PNQoS(E_k)$ are functions return a GSPN according to mapping rules.
$\bigoplus$ as the operator composition that returns other GSPN.

```
$GSPN_{QoS} \leftarrow Empty\ Petri\ Net$
For $CT_i \in \mathcal{T}$ Do
    $GSPN_{QoS} \leftarrow GSPN_{QoS} \oplus PNQoS(CT_i)$
    Add a arrival timed Transition at beginning of the $GSPN_{QoS}$.
End
For $G_j \in \mathcal{G}$ Do
    $GSPN_{QoS} \leftarrow GSPN_{QoS} \oplus PN(G_j)$
End
For $E_k \in \mathcal{E}$ Do
    $GSPN_{QoS} \leftarrow GSPN_{QoS} \oplus PN(E_k)$
End
Add a starting Place and immediate Transition at the beginning of the $GSPN_{QoS}$.
Add a ending Place and immediate Transition at the end of the $GSPN_{QoS}$.

Return $GSPN_{QoS}$
```

Mapping Algorithm (II)



1) Mapping rules

BPMN Element

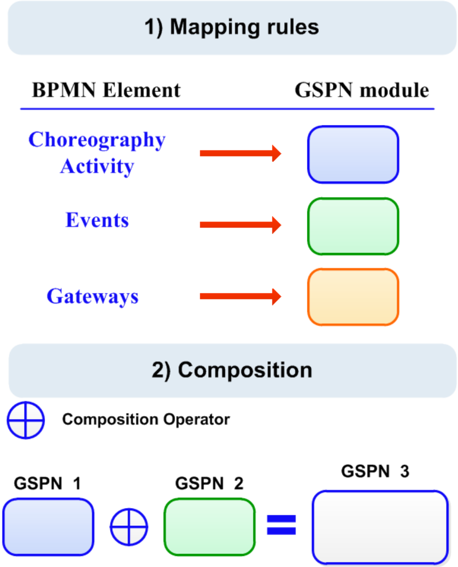
GSPN module

Choreography Activity

Events

Gateways

Mapping Algorithm (II)



1) Mapping rules

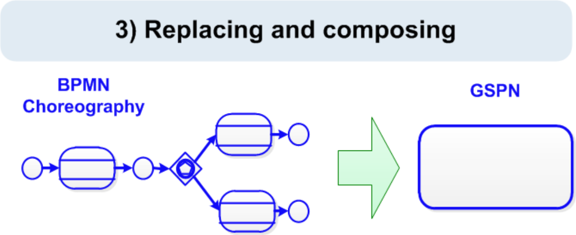
BPMN Element		GSPN module
Choreography Activity	→	🟦
Events	→	🟩
Gateways	→	🟧

2) Composition

⊕ Composition Operator

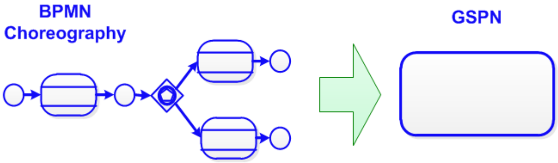
GSPN 1 ⊕ GSPN 2 = GSPN 3

Mapping Algorithm (II)

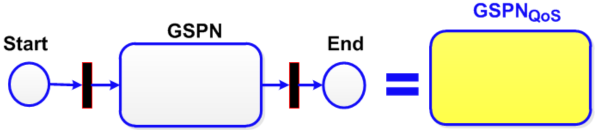


Mapping Algorithm (II)

3) Replacing and composing



4) Reducing and adding final elements



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Scenario

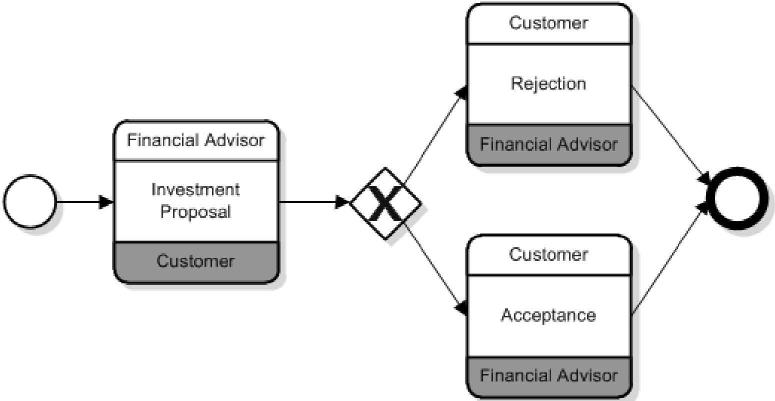
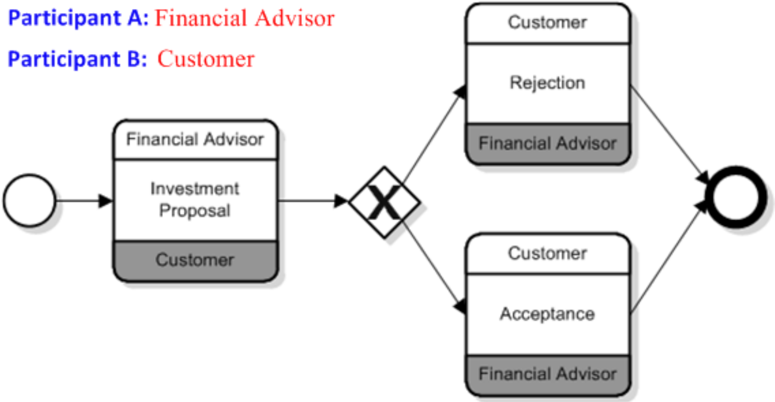


Figure: Choreography example using BPMN2 elements.

Scenario

Participant A: Financial Advisor

Participant B: Customer



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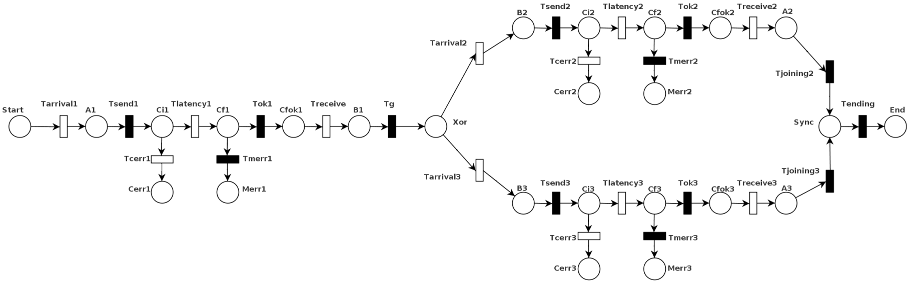


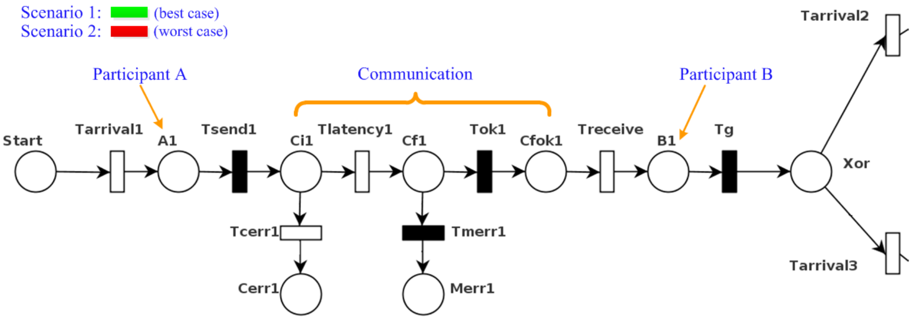
Figure: GSPN obtained from the choreography.

Configuration (I)

Table: Weights of Scenario 1 and Scenario 2

	Weights	
Transition	Scenario 1	Scenario 2
$T_{latency1}$, $T_{latency2}$, $T_{latency3}$	0.99	0.94
T_{cerr1}, T_{cerr2}, T_{cerr3}	0.01	0.06
$T_{receive}$, $T_{receive2}$, $T_{receive3}$	99	97
T_{merr1}, T_{merr2}, T_{merr3}	1	3
$T_{arrival2}$, $T_{arrival3}$	0.5	0.5

Configuration (II)



Scenario 1: 🟩 (best case)
Scenario 2: 🟥 (worst case)

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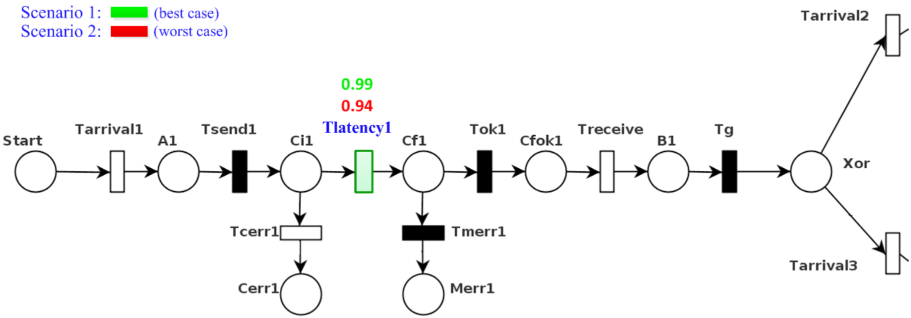

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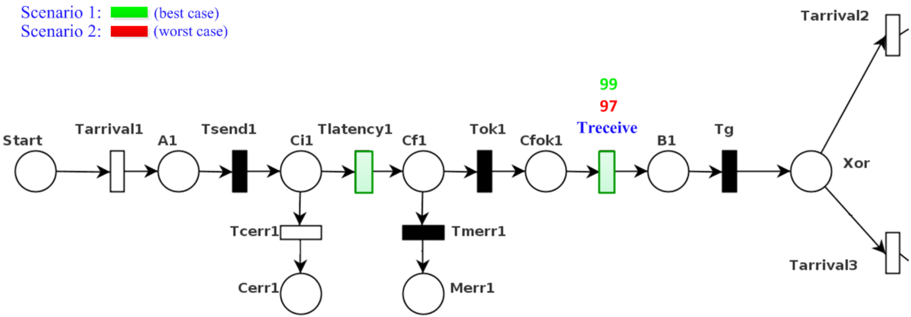

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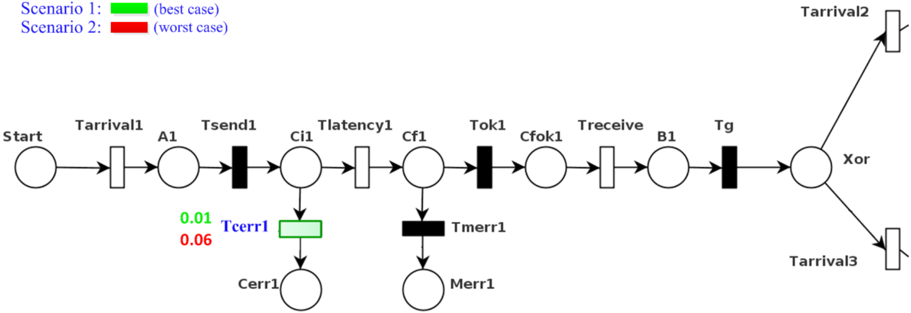

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- The **Pipe2** tool was used to **model** and **simulate** the **GSPN**.
- 1500 fires and 10 replications.
- Confidence level of 95%.

Results (I)

Table: Simulation results

	Average number of tokens (%)		95% Confidence interval (+/- %)	
Place	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Start	35.28	40.15	5.83	6.23
End	41.95	38.78	2.53	3.82
M_{err1}	0.39	0.91	0.95	1.92
M_{err2}	0.00	0.93	0.63	0.64
M_{err3}	0.00	0.66	0.87	0.74
C_{err1}	0.74	2.94	0.82	2.02
C_{err2}	0.00	0.00	0.67	1.75
C_{err3}	0.78	0.16	0.92	1.52
C_{i1}	8.32	8.90	5.33	7.48
C_{i2}	0.63	0.69	0.23	0.52
C_{i3}	0.75	8.90	0.39	0.21

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C_{i1}	8.32	8.90	5.33	7.48
C_{i2}	0.63	0.69	0.23	0.52
C_{i3}	0.75	8.90	0.39	0.21

Results (II)

- **Communication errors**: An average of $C_{err1} + C_{err2} + C_{err3}$ of instances **didn't finish the process**.
  - Scenario 1: 1.52%.
  - Scenario 2: 3.10% (more errors).

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  - Scenario 1: 0.39%.
  - Scenario 2: 2.50% (more invalid messages).
- **Bottleneck**: It was found a communication bottleneck in the first interaction (C_i place).
  - Scenario 1: 8.32%.
  - Scenario 2: 8.90%.

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- The GSPN is good to model and analyze several aspects involved into service choreography.
- The simulation is needed for supporting analysis of complex process (e.g. process choreography).
- The simulation results can be used to establish early QoS and SLA constraints.
  - Integration is expensive, then early detections are needed.
  - Establishing SLAs according to resources.
  - Planning in order to reduce failures.

Future Works

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- To expand our methodology to support generic probability distributions in the decision points. Use of Colored Petri Nets (CPNs) can be a alternative.
- To make more analysis and to use complex scenarios, where correlation problems could happen.

Future Works

- To extend the mapping to support more choreography BPMN elements.
- To expand our methodology to support generic probability distributions in the decision points. Use of Colored Petri Nets (CPNs) can be a alternative.
- To make more analysis and to use complex scenarios, where correlation problems could happen.
- To include more QoS attributes.

CHOReOS
Large Scale Choreographies for the Future Internet

SEVENTH FRAMEWORK PROGRAMME

hp

Baile Project
Enabling Scalable Cloud Service Choreographies

Thanks!