ObsGraph : a Tool for Modular Verification of Inter-enterprise Business Processes

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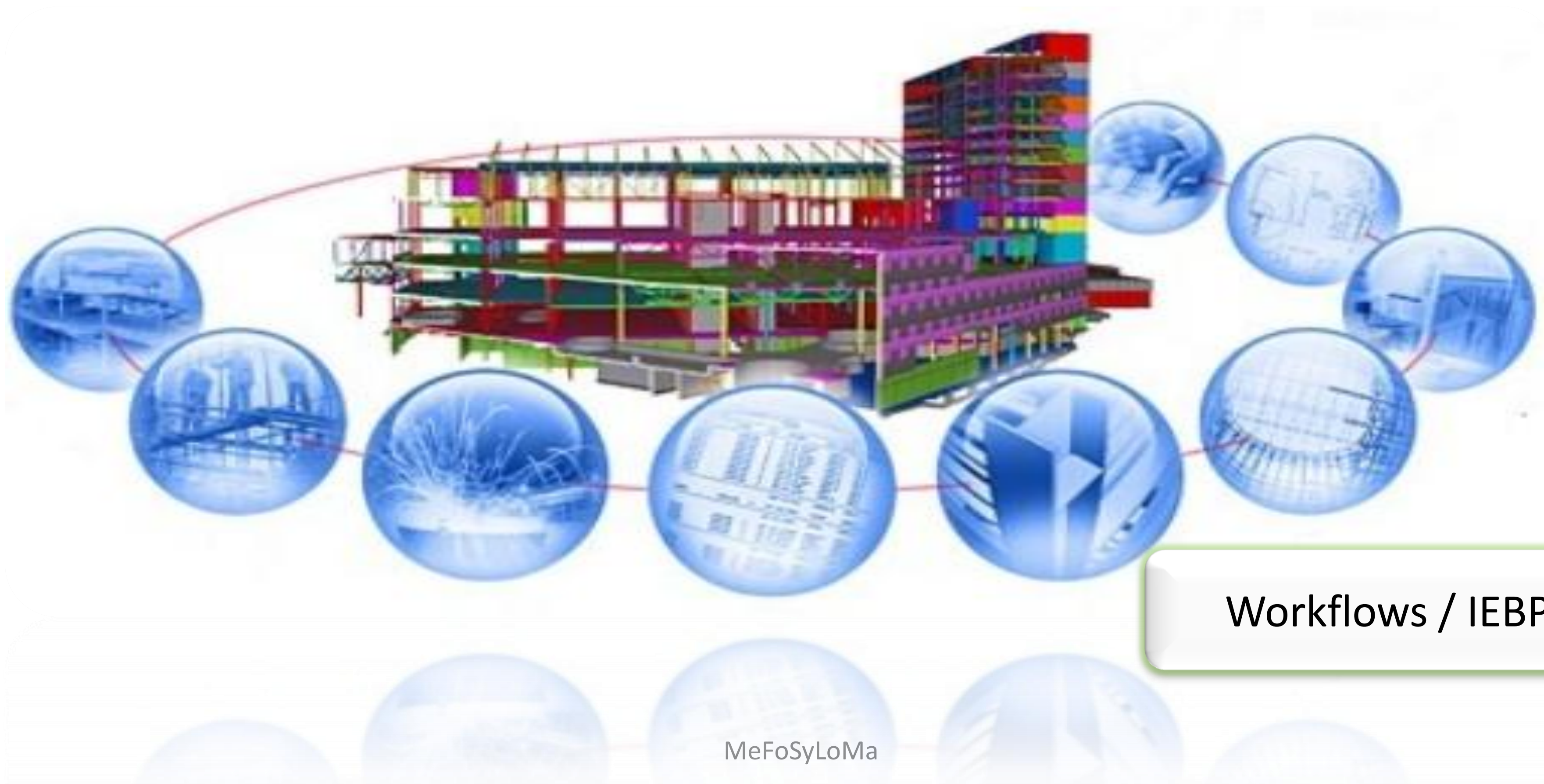
LIPN – MeFoSyLoMa - Juin 2012

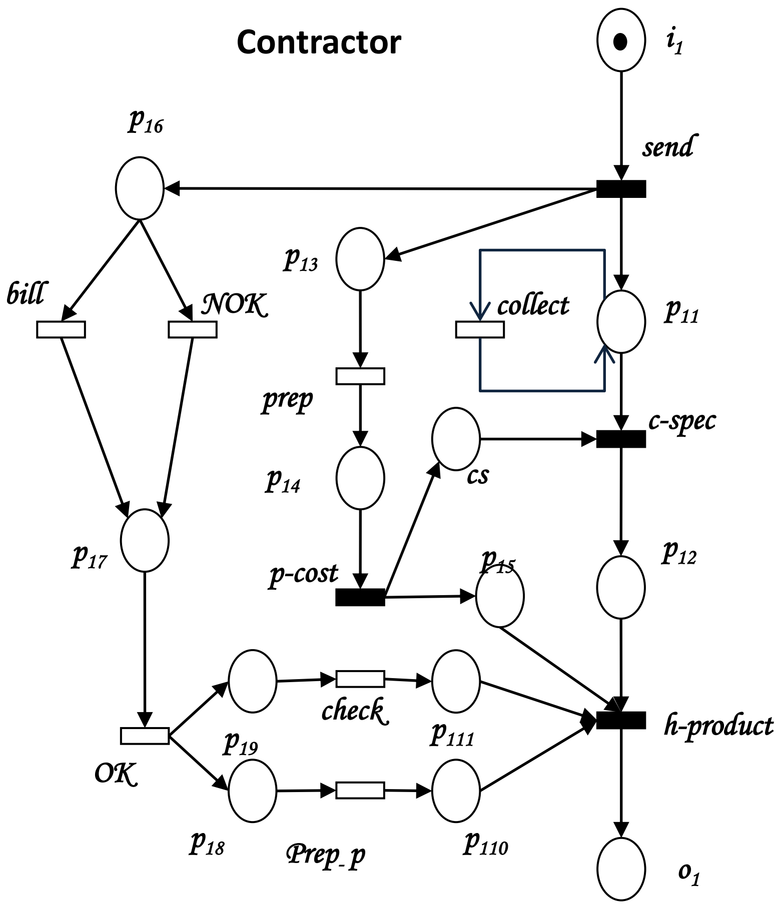
- Introduction
- Related work
- Abstraction and Verification of Inter-enterprise Business Processes (IEBP)
- Experimental results
- Conclusion

Motivation



Workflows / IEBP

Motivation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c-spec
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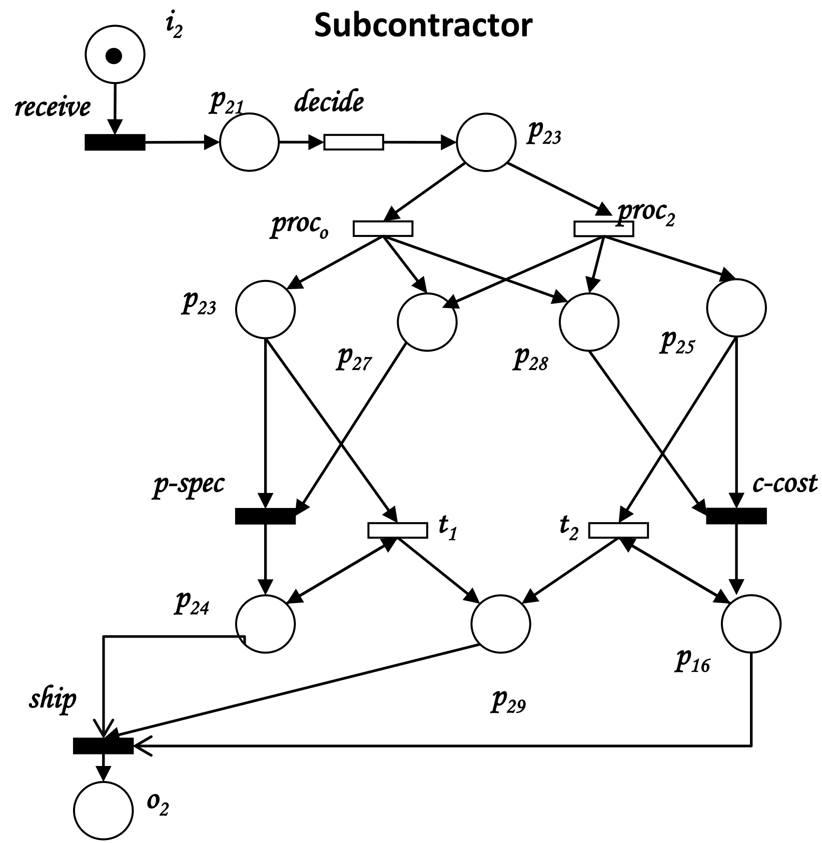
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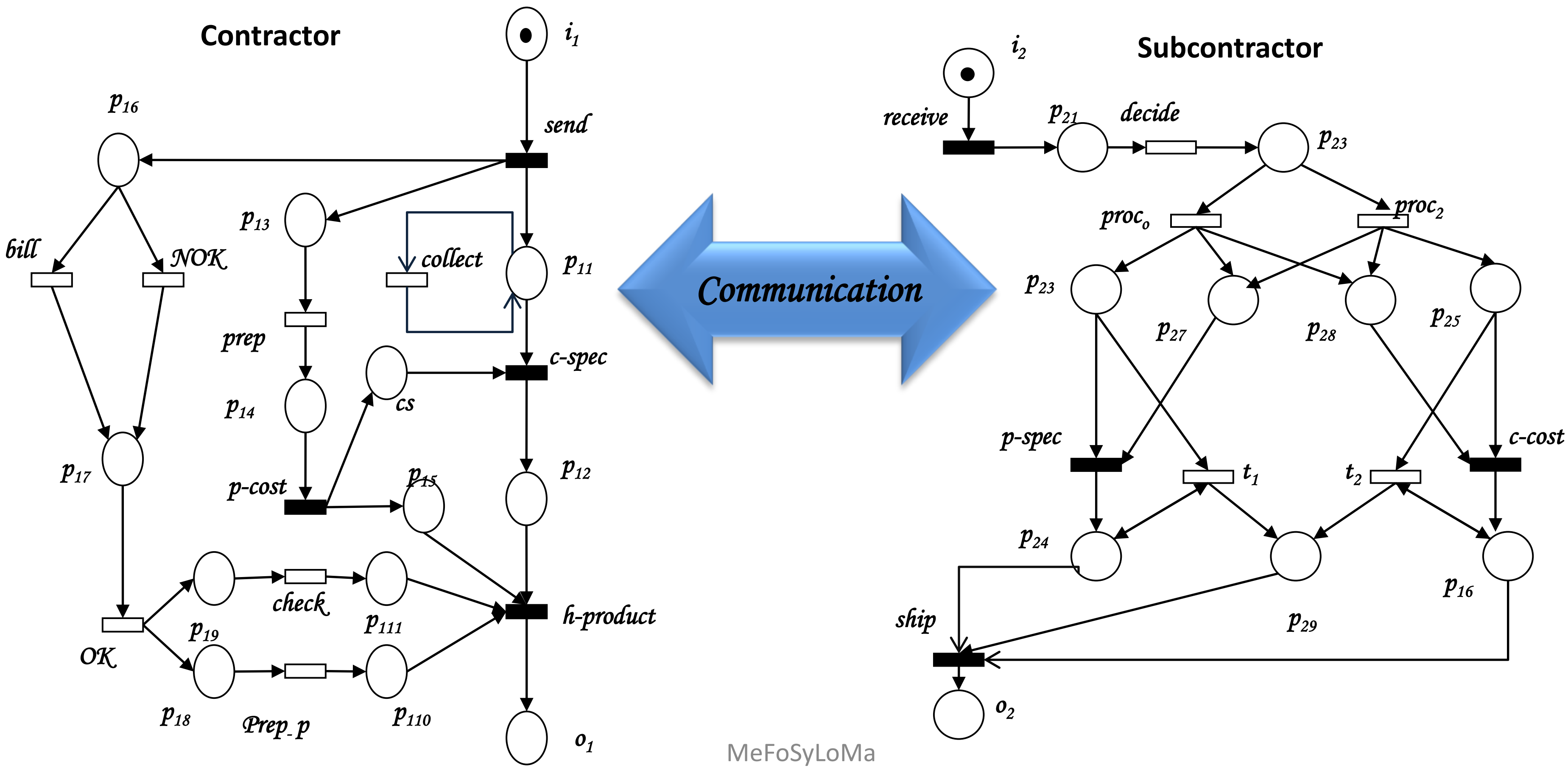
ship
p29
o2

Motivation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Motivation

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Related work

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Explicit approaches:

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<u>*Abstraction :*</u> States are represented by the graph's nodes

Symbolic approaches :
<u>*Abstraction :*</u> States are represented by BDD techniques

Hybrid approaches:
<u>*Abstraction :*</u> Graph's nodes representing a set of states are encoded using BDD techniques + the graph is represented explicitly

Verification of IEBP: Explicit approaches

- **Operating Guideline**
  - ✓ Abstraction used on SOA for services
  - ✓ Annotated automata
  - ✓ Verification of constraints represented as nodes' annotations

- **Communication graph**
  - ✓ Abstraction used for web services
  - ✓ A bi-part graph: visible nodes + hidden nodes
  - ✓ Verification of graph's paths

Hybrid approaches:

- **Symbolic Observation Graph SOG**
  - ✓ Abstraction of the reachability graph
  - ✓ Model checking
  - ✓ Events occurring in the formula: ***Obs***
  - ✓ Events not occurring in the formula: ***UnObs***
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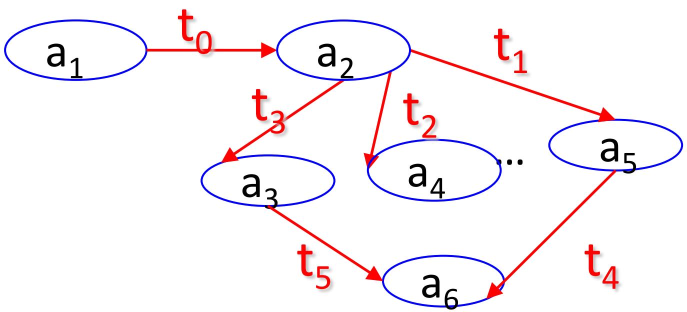

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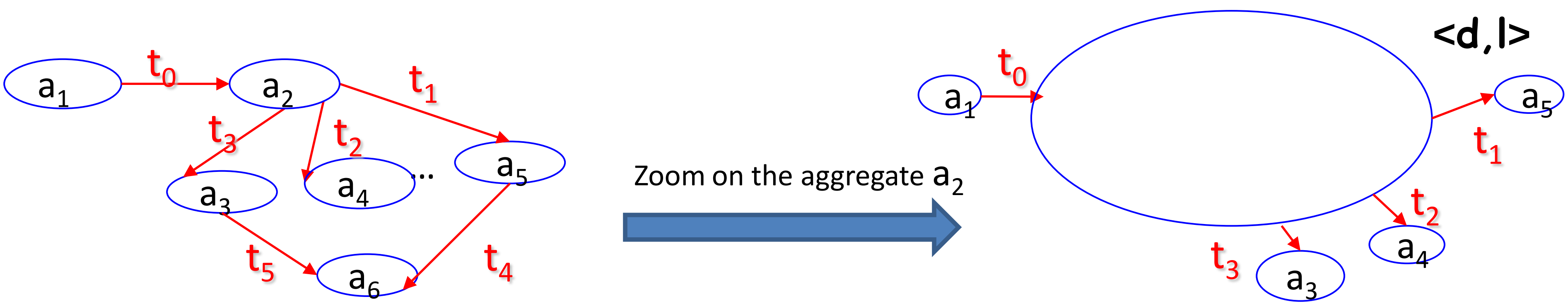

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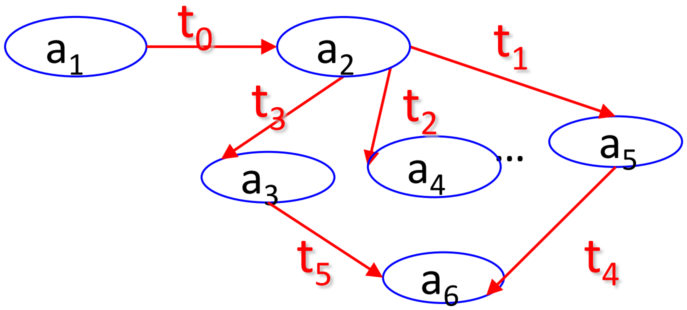
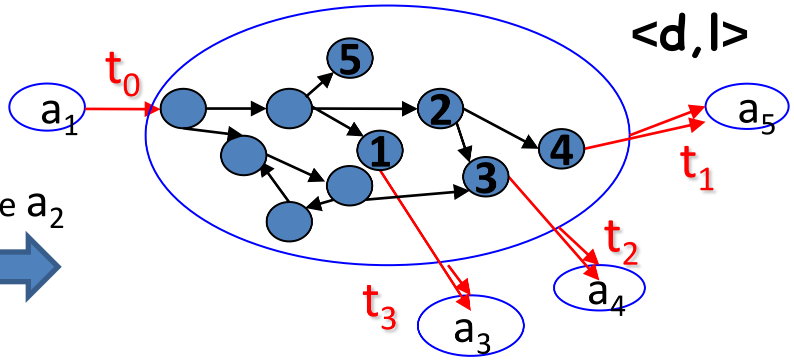
    Node : Set of states linked by *unobserved* actions



Zoom on the aggregate a_2



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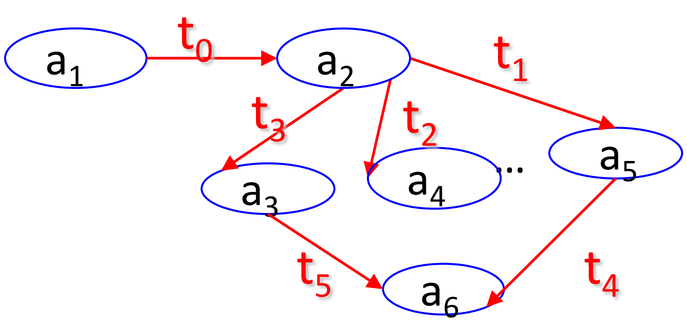
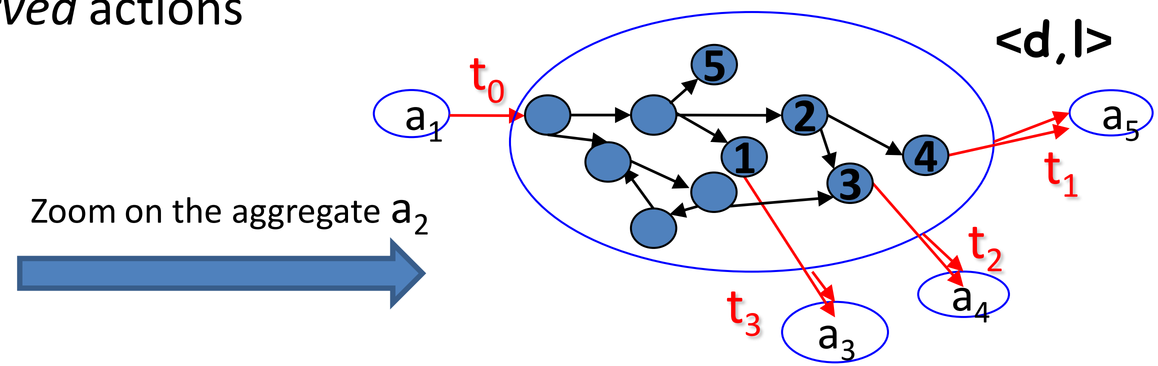




Abstraction

- **New version of Symbolic Observation Graph (SOG) for a workflow** :

  ✓Observation of only collaborative actions

  ✓Adding {*term*} : additional virtual observed action for proper termination
  (Act=Obs U UnObs U {*term*})

  ✓ Terminal circuit ⇔ deadlock state

  ✓ Observed behavor : λ

  => Nodes : Aggregates <S, λ>

Abstraction

•Comportement Observé <λ>

Définitions

1. $\lambda_{\mathcal{T}} : \mathcal{T} \rightarrow 2^{Obs}$

$$\lambda_{\mathcal{T}}(s) = (Enable(Sat(s)) \cap Obs) \cup \{term\} \text{ si } F \cap Sat(s) \neq \emptyset$$
$$(Enable(Sat(s)) \cap Obs) \cup \{term\} \text{ sinon}$$

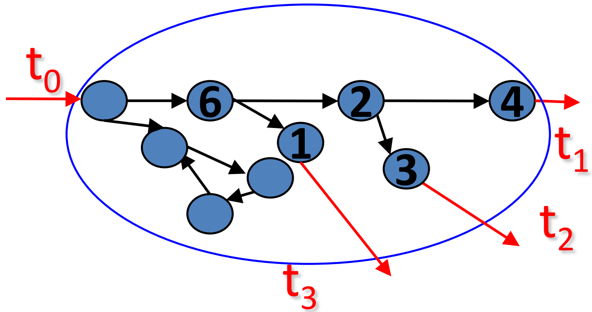
2 . $\lambda_{\mathcal{T}} : 2 \rightarrow 2^{Obs}$

$$\lambda_{\mathcal{T}}(S) = \{\lambda_{\mathcal{T}}(m) \mid m \in S\}$$

3. $\lambda_{min} : 2 \rightarrow 2^{2Obs}$

$$\lambda_{min}(S) = \{X \in \lambda_{\mathcal{T}}(S) \mid \nexists Y \in \lambda_{\mathcal{T}}(S) : Y \subset (X \setminus \{term\})\}$$

Observed behavior



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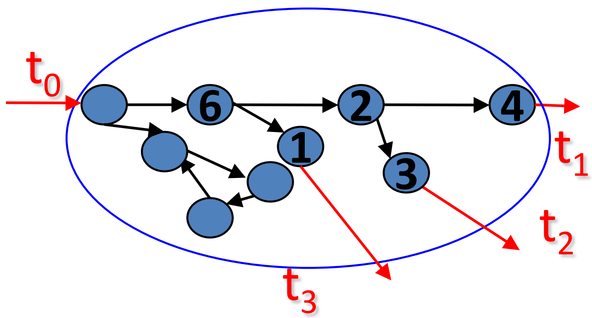
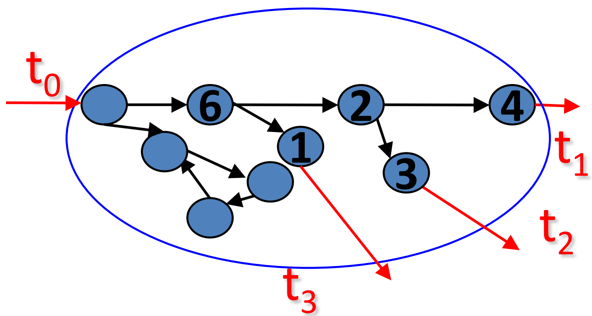


$\lambda = \{\{t_1\},\{t_2\},\{t_3\},\{t_1, t_2\},\{t_1, t_2, t_3\},\{\emptyset\}\}$

Observed behavior



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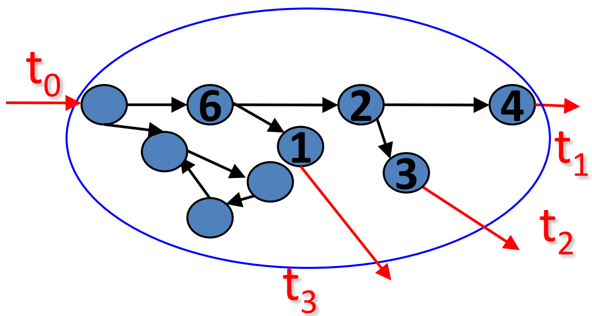

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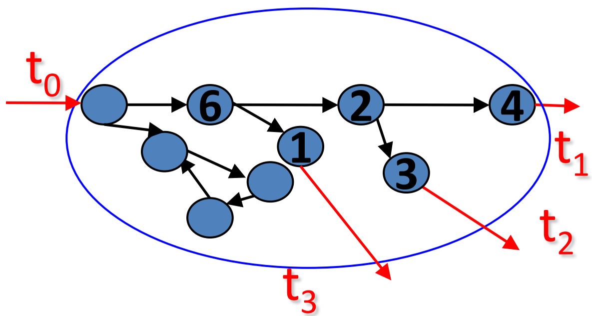

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- **Theorem** : Deadlock freeness

  A SOG $\mathcal{G}$ is said to be deadlock free $\Leftrightarrow \nexists\, a \in \mathcal{G} \mid \emptyset \in a.\lambda$

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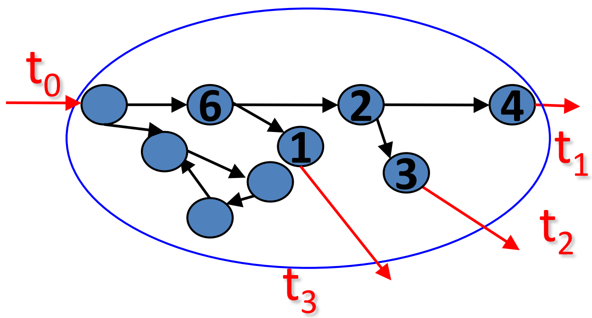

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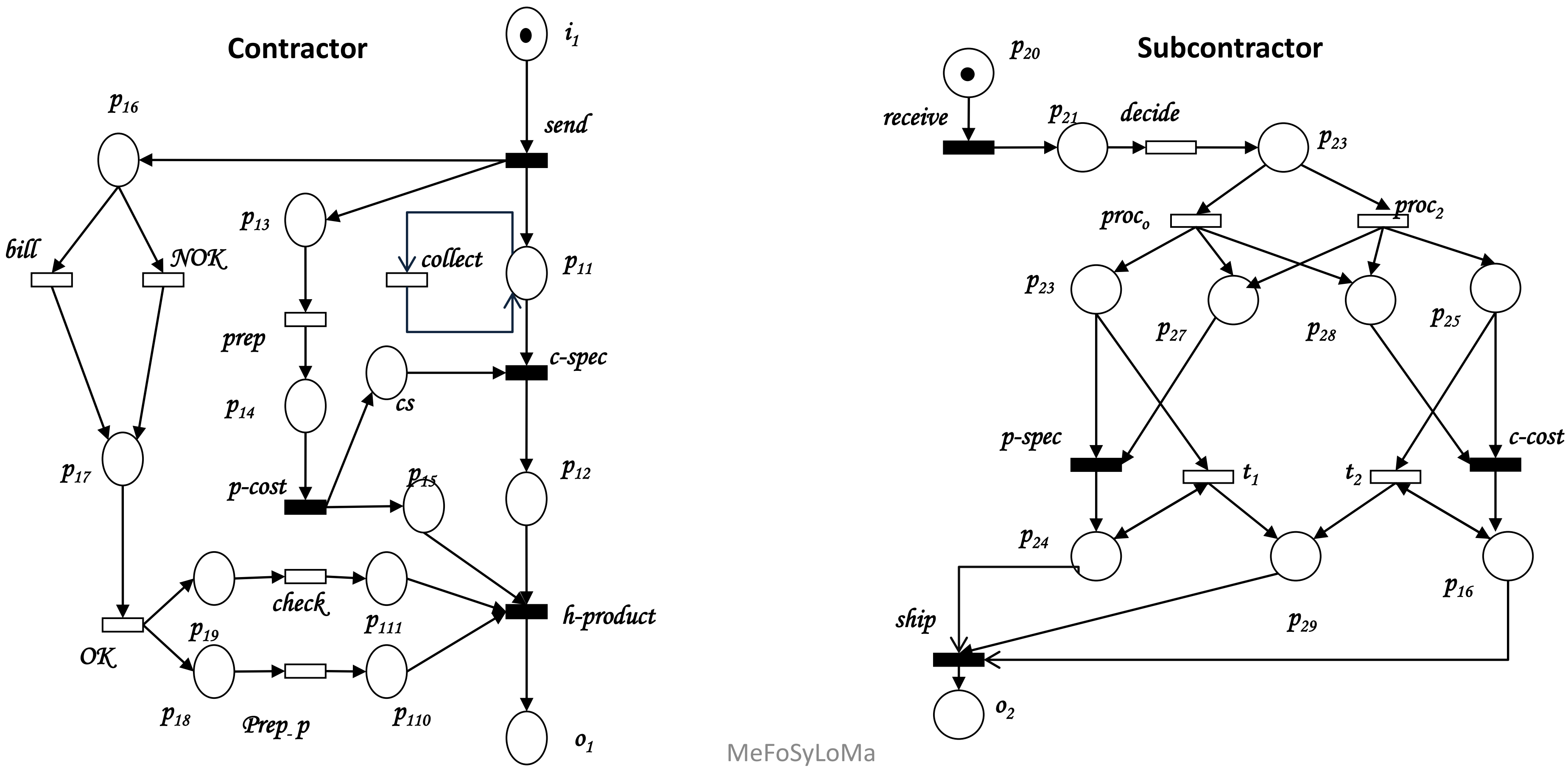
- **Proposition** :

  Let $\mathcal{WF}$ a BP and let $\mathcal{G}$ the asociated SOG

  $\mathcal{WF}$ has a deadlock state $\Leftrightarrow \exists\, a \in \mathcal{G} \mid \emptyset \in a.\lambda$

Example



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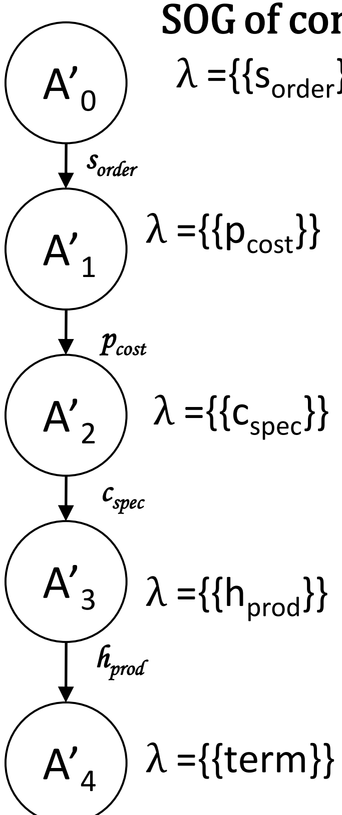
Example (SOGs)

SOG of contractor



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Reachability graph : 26 nodes + 66 edges

Reachability graph : 21 nodes + 22 edges

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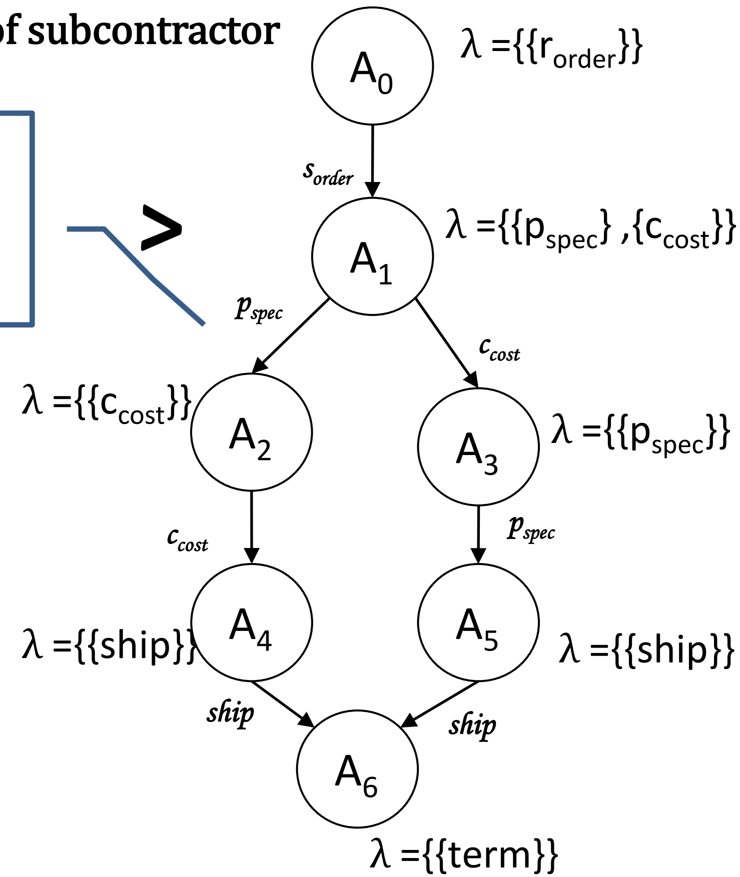
SOG of subcontractor



Composition of SOGs

- Locally $a = \langle S, \lambda \rangle$

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- Locally $a = <S, \lambda>$ **For composition** $\Rightarrow$ $a = <\lambda>$

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  Compute the observed behavior of $a = a1 \times a2$

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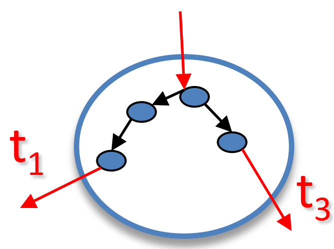
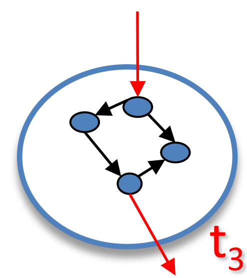


$\lambda_1 = \{\{t_1\}, \{t_3\}\}$



$\lambda_2 = \{\{t_3\}\}$

Composition of SOGs

- Locally $a = <S, \lambda>$ **For composition** ⇒ $a = <\lambda>$

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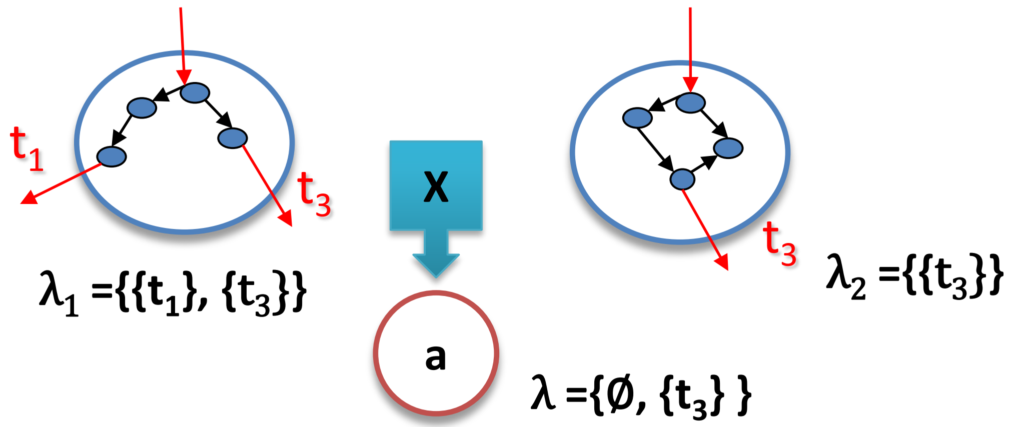

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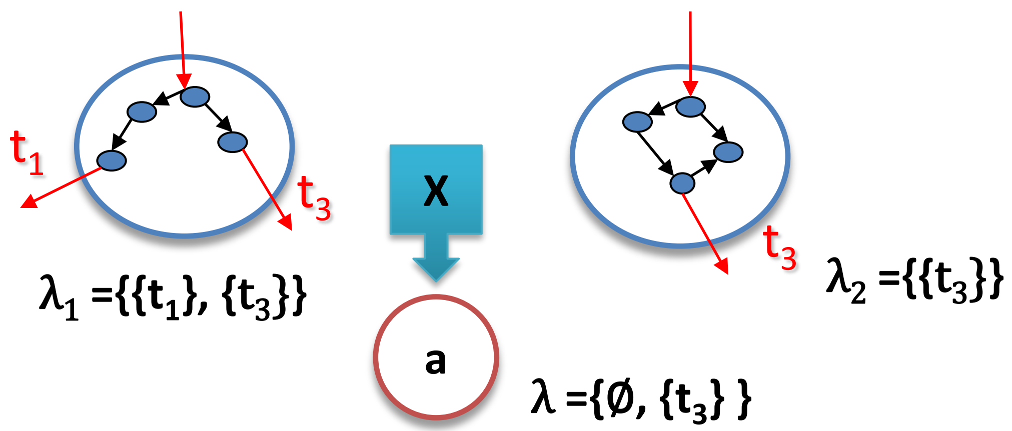
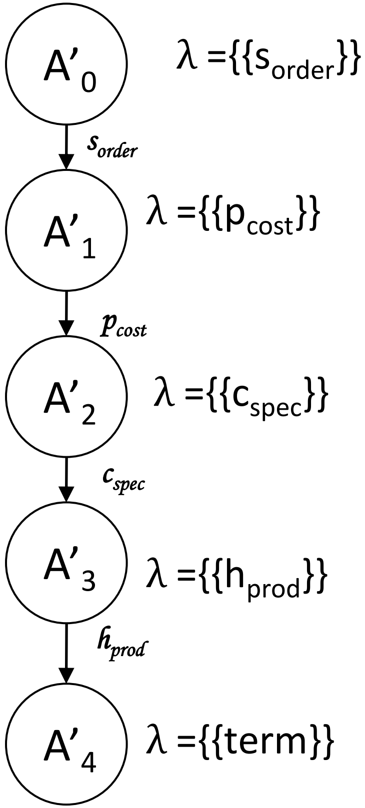


Theorem :
The composition of two SOGs $(\mathcal{G}_1, Obs_1)$ and $(\mathcal{G}_2, Obs_2)$ is a SOG $(\mathcal{G}, Obs_1 \cup Obs_2)$

Composition



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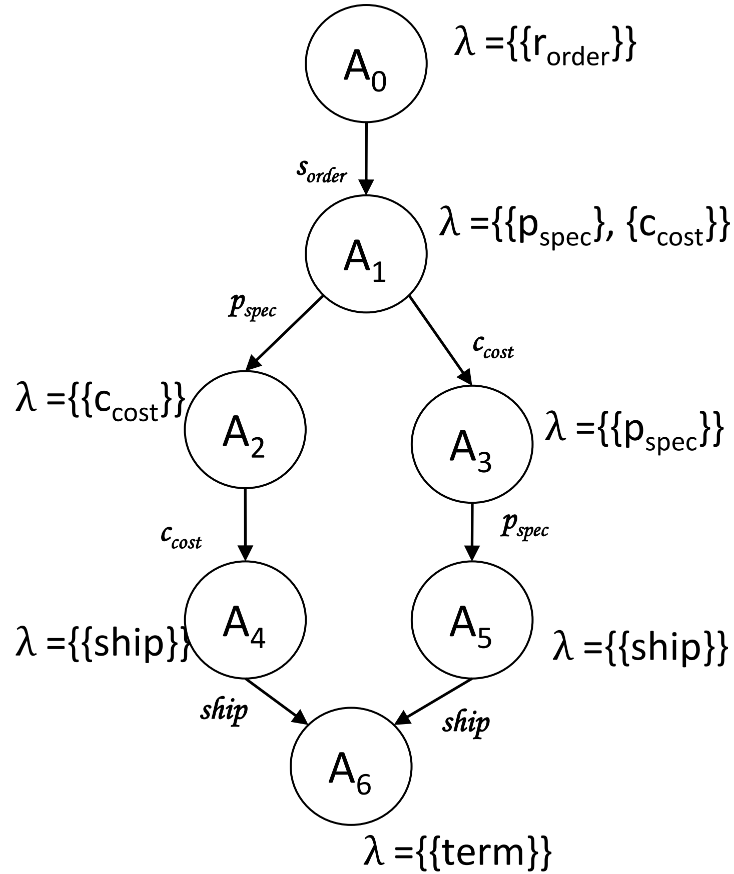

SOG of subcontractor

Composition

Reachability graph : 99 nodes + 320 edges

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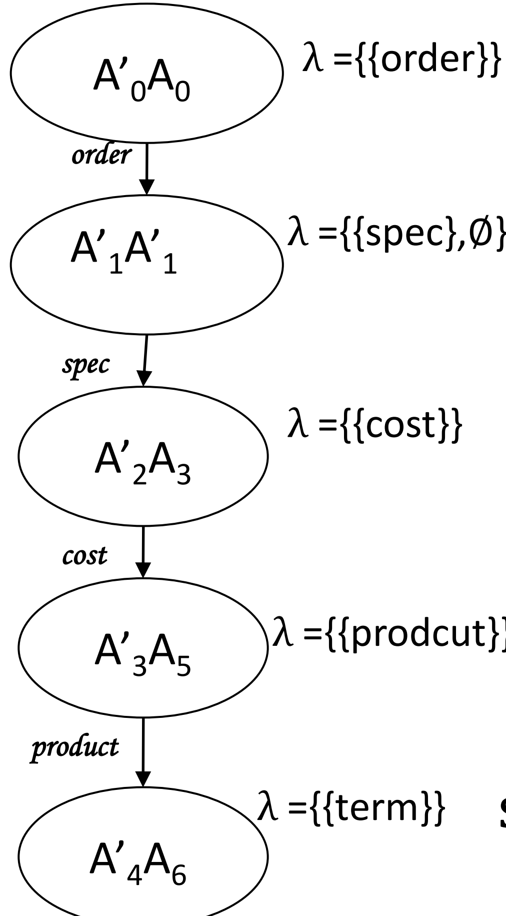

Synchronized product

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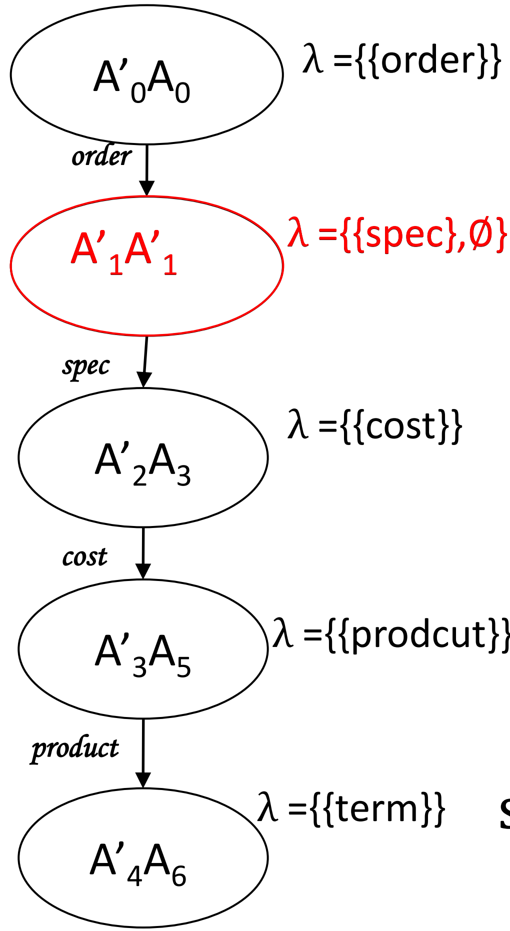


Synchronized product

Application on web services

✓Web service : $<(P, T, F,W), m_0, I, O, \Omega>$

- **Definition (Soundness)** : $N= <(P, T, F,W), m_0, I, O, \Omega>$ is sound if :
  - ✓*option to complete:* $\forall m \in R(N^*, m_0), \exists\, m_f \in \Omega$ s.t. $m_f \in R(N^*, m_0)$
  - ✓*proper completion*: if $\exists\, m \in R(N^*, m_0)$ and $m_f \in \Omega$ s.t. $m > m_f$ then $m = m_f$;
  - ✓*no dead transitions*: $\forall\, t \in T, \exists\, m \in R(N^*, m_0)$ s.t. $m \rightarrow^t$;

- **Soundness on SOG** : $\mathcal{G}= <\mathcal{A}, Act, \rightarrow a_0, \Omega'), m_0, I, O, \Omega>$ is sound if :
  - ✓*option to complete:* $\forall a \in \mathcal{A}, \emptyset \notin a.\lambda \wedge \exists\, a_f \in \Omega'$ s.t. $a_f \in R(a)$
  - ✓*proper completion*: if $\exists\, a \in \mathcal{A}, m \in a.S, m_f \in \Omega'$ s.t. $m > m_f$ then $m = m_f$;
  - ✓*no dead transitions*: $\bigcup_{a \in \mathcal{A}} Enable(a.S):T$;

Application on web services

- **Checking Soundness on the composition of SOGs** :

Let N_1 and N_2 be two oWF-nets locally sound and let $\mathcal{G}_1$ and $\mathcal{G}_2$ be the corresponding SOGs respectively.

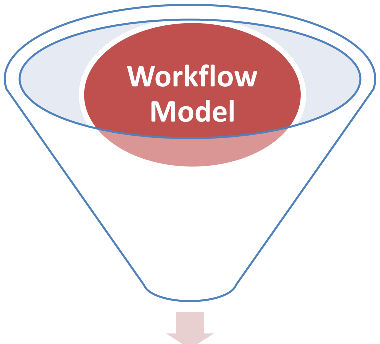
$N_1 \oplus N_2$ is sound **iff :**

✓ none $\nexists$a aggregate in $\mathcal{G}_1 \oplus \mathcal{G}_2$ s.t $\emptyset \in a.\lambda$

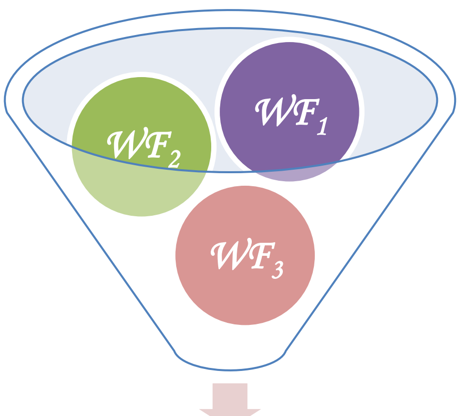
AND

✓ $\forall t \in Obs_1 \cup Obs_2$, $\exists$a, a' two aggregates in $\mathcal{G}_1 \oplus \mathcal{G}_2$ s.t. $a \rightarrow_t a'$.

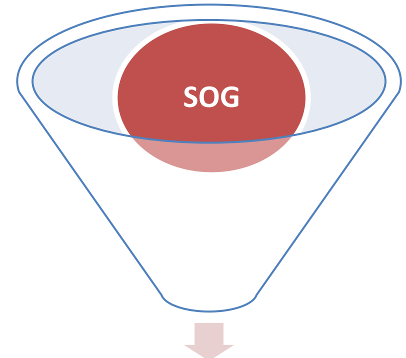
Implementation



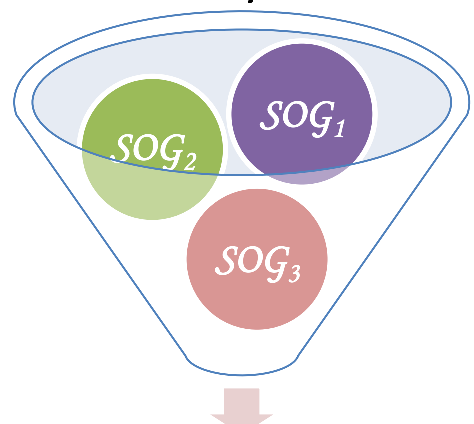
Assoiated SOG + Verification on the fly



Synchronized product of SOGs + Verification on the fly



Verification on the fly



Synchronized product of SOGs + Verification on the fly

Experimental results

Model	Places	Trans	Obs	RG		OG			SOG		
				States	Edges	States	Edges	Time(s)	States	Edges	Time(s)
C	18	11	4	26	66	12	20	<1	5	4	<1
SC	15	9	4	11	11	9	11	<1	7	7	<1
OS	15	8	8	10	10	12	17	<1	10	10	<1
R	38	33	17	28	33	369	14 E^2	<1	17	17	<1
Ph5	36	16	10	417	10 E^2	14 E^2	34 E^2	16	297	721	8
Ph6	43	19	12	14 E^2	46 E^2	61 E^2	17 E^3	245	991	28 E^2	42
Ph7	50	22	14	52 E^2	19 E^3	26 E^2	88 E^3	42 E^2	33 E^2	11 E^3	162
Ph10	71	31	20	23 E^5	23 E^4	-	-	-	12 E^4	58 E^4	15 E^2
2xPh5	71	31	4	23 E^5	23 E^4	-	-	-	21	50	15

Table: Experimental results: OG vs. SOG

-*RG:* Reachability Graph -*OG:* Operating Guideline -*SOG*: Symbolic Observation Graph

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Conclusion

-Study of some approaches for abstraction workflows

-New version of the graph of symbolic observation adapted to workflow

-Checking for deadlock freeness

-CosyVerif :

- ✓Online shared tools integration platform.
- ✓Integration of ObsGraphTool :
    - Local Verification on workflow models
    - Modular verification for composition of workflows

Demo

Further work

- **Modeling, Abstraction and Verification of Inter-Enterprise Processes**

  - Consider different types of properties

  - Consider shared resources

  - Consider time explicitly

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    - ✓ Specific properties : Expressed with temporal logic (LTL, CTL ..)
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Further work

- **Modeling, Abstraction and Verification of Inter-Enterprise Processes**

  - Consider different types of properties
    - ✓ Specific properties : Expressed with temporal logic (LTL, CTL ..)

  - Consider shared resources

  - Consider time explicitly
    - ✓ Model : e.g. timed Petri nets
    - ✓ Properties : e.g. TCTL

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Thank you for your attention