

# Timed Specification For Web Services Compatibility Analysis

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# Introduction (1): Web services

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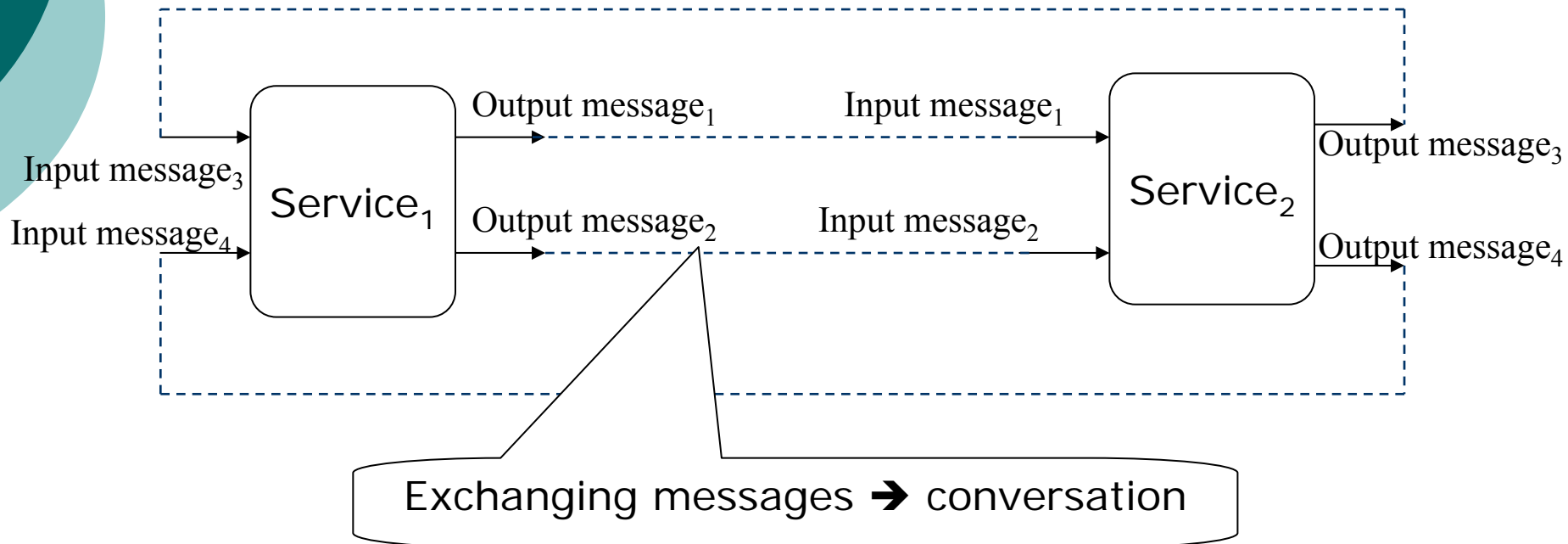
- Interoperability and integration of applications:
  - Based on standards: WSDL, SOAP,...
  - Design and build complex business applications:
    - Interaction of Web services

# Introduction (2): WS Compatibility

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- Successful interaction of Web services:
  - Compatibility of Web services
- Two services are compatible:
  - Can terminate correctly when interacting together
- Need for defining a formal compatibility checking framework

# Introduction (2): WS Compatibility



# Problem: WS Compatibility

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- Services conversation involves data:
  - Considering only the exchanged messages types is insufficient → need for considering data flow in the compatibility analysis.
- Web services can have temporal requirements:
  - Need for considering temporal constraints in the compatibility analysis

# Problem: WS Compatibility

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- A formal compatibility framework:
  - Exchanged messages
  - Data flow and constraints over data
  - Temporal constraints
- Basis for Web services composition

# Outline

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- Introduction
- Related work
- The model of Web services
- Compatibility checking
- Conclusion and perspectives

# Compatibility regarding the WS conversations

## [Bordeaux-TES04, Benatallah-ER04]

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- The framework considers only the supported sequences of messages.
- Do not consider the involved data flow
- Do not consider the requirements, such that:
  - Constraints over data
  - Temporal constraints

# Compatibility regarding the temporal constraints (1): [Benatallah-CAISE05]

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- Compatibility framework considers:
  - Sequences of exchanged messages
  - A particular form of temporal constraints:
    - An activation constraint over one transition

# Compatibility regarding the temporal constraints (2): [Ponge-Inforsid04, Ponge-ER07]

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- More expressiveness temporal constraints:
  - Period between exchanging messages
- The model does not consider:
  - Data flow and constraints over data
- Does not consider the possible dependencies between the temporal constraints

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# The model of Web services

## [D.Berardi-VLDB05]

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- Extended Web Service Timed Transition Systems EWSTTS:
  - Messages flow: WSDL
  - Operations: atomic process OWL-S
  - Data flow capabilities (parameters of messages, and input/output of operations)
  - Constraints over data
  - Temporal constraints
- Web services are modeled as deterministic finite state machines

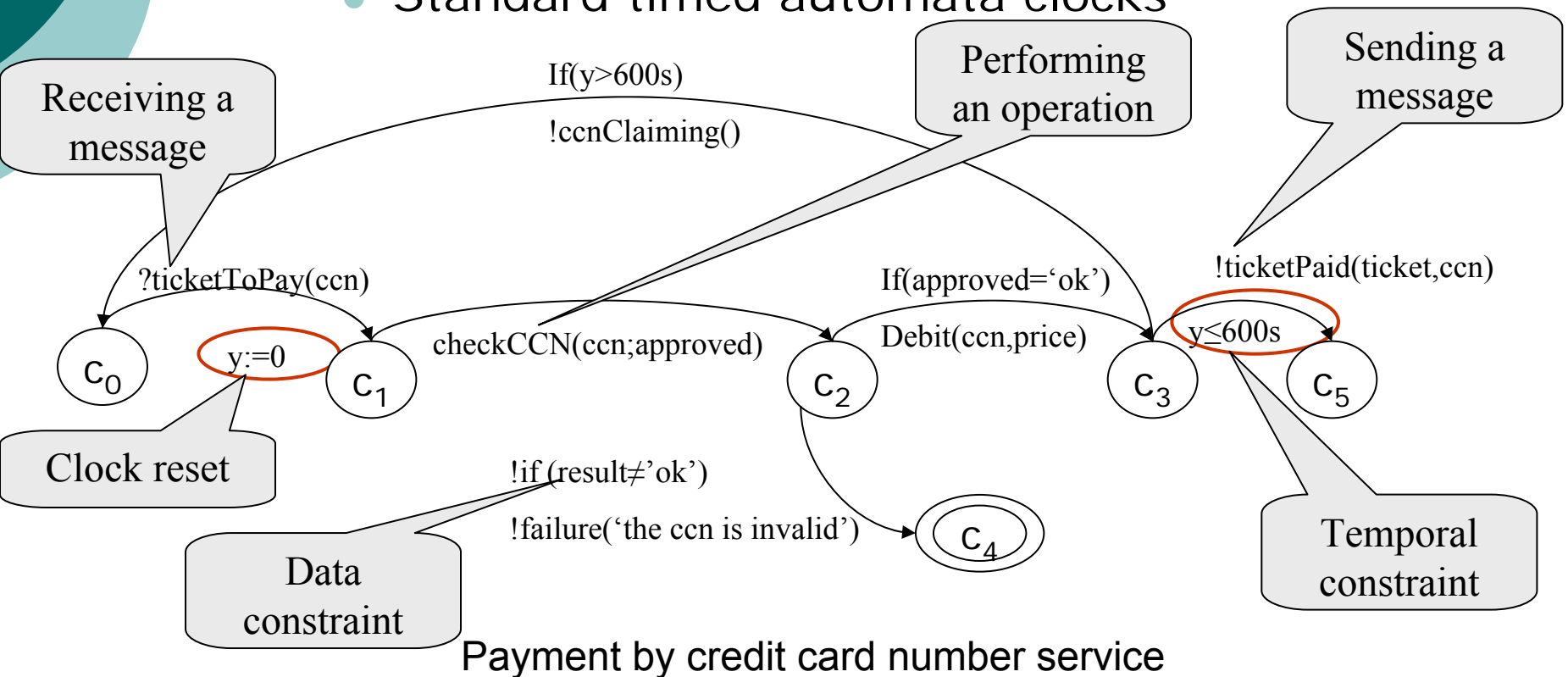
# The model

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- A Web service is a tuple  $Q = (S, s_0, F, M, A, C, X, T)$  such that:
  - $S$  is a set of states,  $s_0$  is the initial state and  $F \subseteq S$  is a set of final states
  - $A$  is a set of actions
  - $M$  is a set of messages
  - $C$  is a set of constraints over data
  - $X$  is a set of clocks
  - $T \subseteq S \times (M \cup A) \times C \times \psi(X) \times 2^X \times S$

# The model

- Specification of temporal constraints:
  - Standard timed automata clocks



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# Compatibility checking

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- Two web services are incompatible if:
  1. One service waits for a message that is not sent by the other service
  2. The constraints over data associated to the input and output messages are not consistent, i.e., disjoint set of solutions
  3. The corresponding temporal constraints are not consistent, i.e., disjoint set of solutions

# Compatibility checking

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- The compatibility checking relies on:
  - Consistency of pairs (input message, output message):
- Consistency classes of two transitions:
  - Absolute consistency
  - Likely consistency
  - Absolute inconsistency

# Compatibility checking

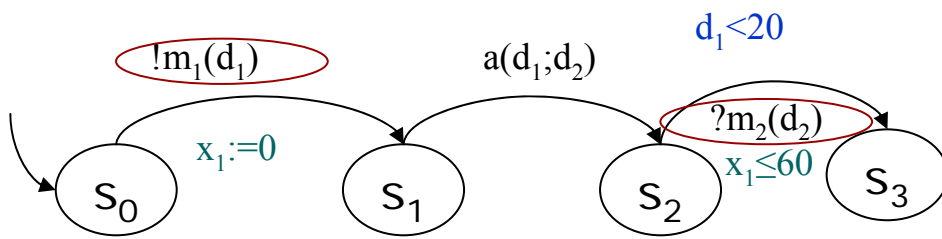
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## 1. Absolute consistency:

- An output transition  $t_1=(s,!m,c_1,\psi_{X_1},Y_1,s')$  is *absolutely consistent* with an input transition  $t_2=(q,?m,c_2,\psi_{X_2},Y_2,q')$  if:
  - $\text{Sol}(c_1) \subseteq \text{Sol}(c_2)$  and  $\text{Sol}(\psi_{X_1}) \subseteq \text{Sol}(\psi_{X_2})$

## 2. Likely consistency:

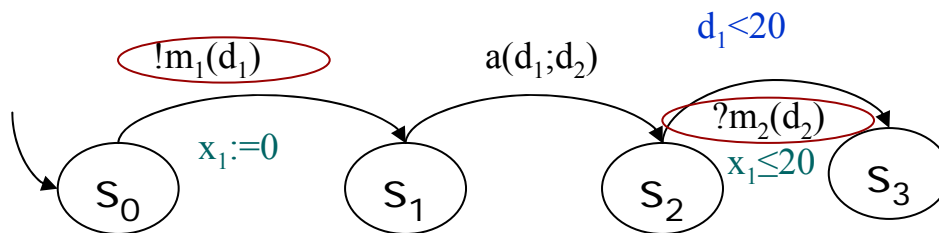
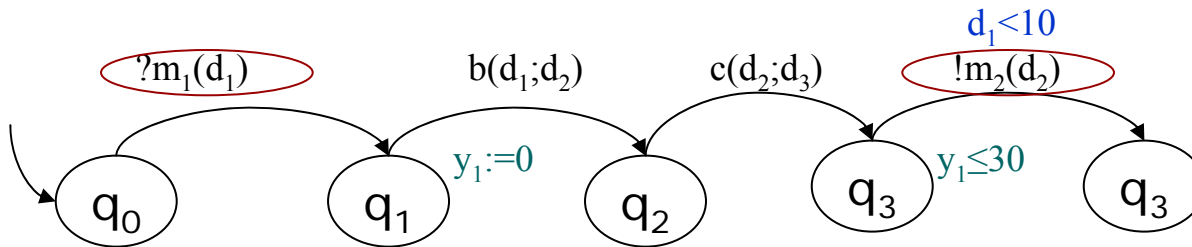
- The output transition  $t_1$  is *likely consistent* with the input transition  $t_2$  if:
  - $\text{Sol}(c_1) \cap \text{Sol}(c_2) \neq \emptyset$  and  $\text{Sol}(\psi_{X_1}) \cap \text{Sol}(\psi_{X_2}) \neq \emptyset$



$$\text{Sol}(d_1 < 10) \subseteq \text{Sol}(d_1 < 20)$$

$$\text{Sol}(y_1 \leq 30) \subseteq \text{Sol}(x_1 \leq 60)$$

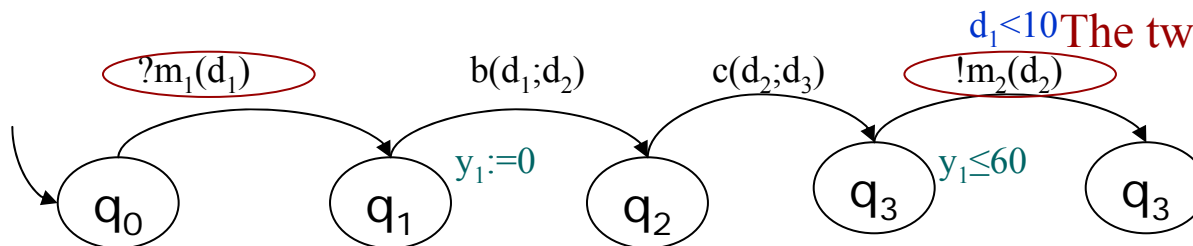
The two transitions are absolutely consistent



$$\text{Sol}(d_1 < 20) \cap \text{Sol}(d_1 < 10) \neq \emptyset$$

$$\text{Sol}(y_1 \leq 60) \cap \text{Sol}(x_1 \leq 20) \neq \emptyset$$

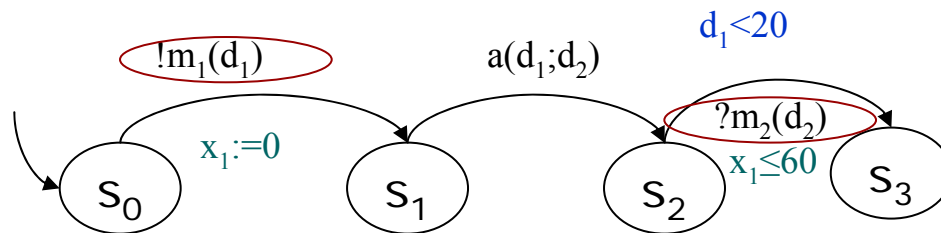
The two transitions are likely consistent



# Compatibility checking

## 1. Absolute inconsistency:

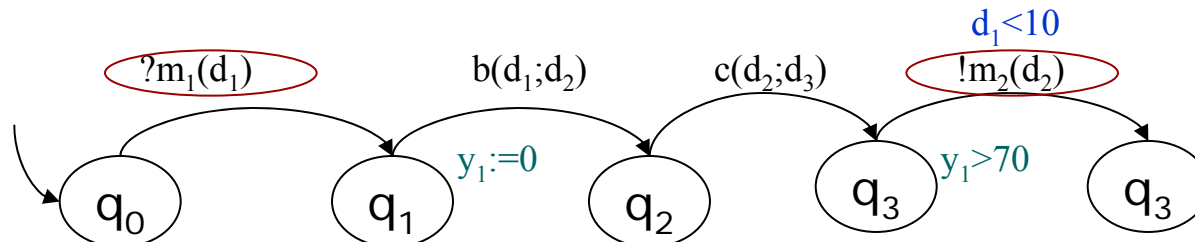
- The output transition  $t_1$  is *absolutely inconsistent* with the input transition  $t_2$  :
  - $\text{Sol}(c_1) \cap \text{Sol}(c_2) = \emptyset$  or  $\text{Sol}(\psi_{X_1}) \cap \text{Sol}(\psi_{X_2}) = \emptyset$



$$\text{Sol}(d_1 < 20) \cap \text{Sol}(d_1 < 10) \neq \emptyset$$

$$\text{Sol}(y_1 > 70) \cap \text{Sol}(x_1 \leq 60) = \emptyset$$

The two transitions are absolutely inconsistent

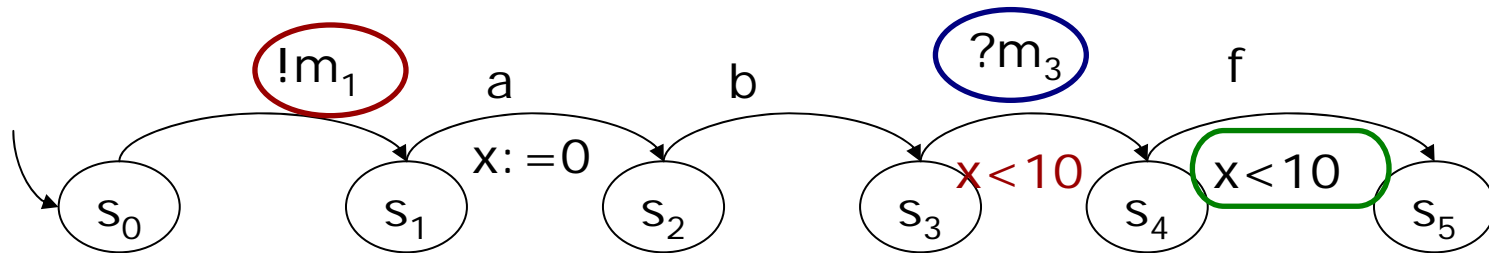


# Compatibility checking

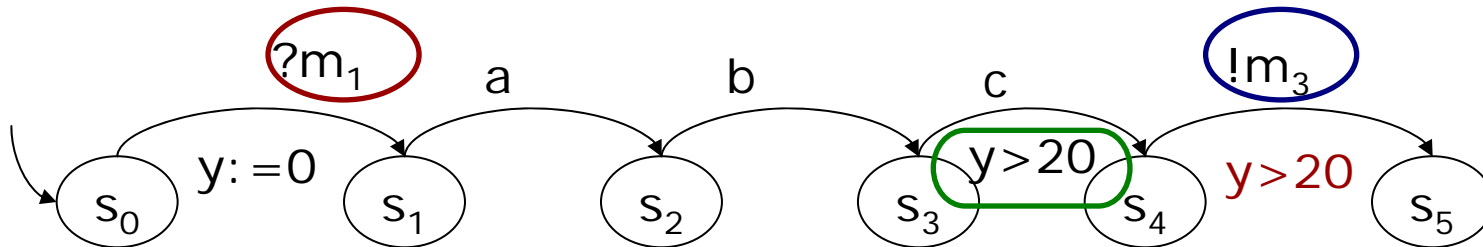
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- The temporal constraints of some transitions can have an impact on other transitions of the same service:
- The local consistency of transitions is not sufficient:
- Check the dependencies between the temporal constraints → *Inference of external constraints*

# Compatibility checking



The two services are compatible!



The two services are not compatible!

# Compatibility checking

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- Reduction of the compatibility checking into the reachability problem:
  - Cartesian product
- Compatibility analysis based on the inference is less expensive w.r.t the reachability analysis:
  - Do not deal with automata product

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# Conclusion

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- A compatibility framework:
  - Messages flow
  - Data flow
  - Operations
  - Constraints over data
  - Temporal constraints:
    - Implicit dependencies between the different temporal constraints



# Perspectives

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- Studying automatic tool for inferring external constraints
- Enhance the compatibility framework to build a composition.

# Reference

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1. [Bordeaux TES04]. L. Bordeaux, G. Salaün, D. Berardi, and M. Mecella. ***When are two web services compatible?*** TES 2004.
2. [Benatallah ER04]. B. Benatallah, F. Casati, J. Ponge, and F. Toumani. ***Analysis and management of web service protocols.*** ER 2004.
3. [Benatallah CAISE05]. B. Benatallah, F. Casati, J. Ponge, and F. Toumani. ***On temporal abstractions of web service protocols.*** CAISE 2005.
4. [Ponge Inforsid04]. J. Ponge. ***A new model for web services timed business protocols.*** SIWS-Inforsid 2006.
5. [Ponge ER07]. J. Ponge, B. Benatallah, F. Casati, and F. Toumani. ***Fine-Grained Compatibility and Reachability Analysis of Timed Service Protocols.*** ER 2007.
6. [kazhamiakin ARES06]. R. Kazhamiakin, P. K. Pandya, and M. Pistore. ***Timed modelling and analysis in web services compositions.*** ARES 2006.
7. [D. Berardi VLDB05]. D. Berardi, D. Calvanese, G. D. Giacomo, R. Hull, and M. Mecella. ***Automatic composition of transition-based semantic web services with messaging.*** VLDB 2005



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*Thank you!*  
*Questions??*