



Service Composition and Planning

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- Part I: Introduction to Software Services
- Part II: The Automated Composition Problem
- Part III: An Approach to Service Composition
- Part IV: A New Vision for the Internet of Services

- Services

- business model from products to services ..
- services are used, they are not owned



- Services
 - business model from products to services ...
 - services are used, they are not owned
- Software services
 - software components that can be used ...
 - ... but are not owned
- Service-oriented applications
 - constructed by composing and configuring software services...
 - ... most often provided by “third parties”
 - ... software that is not under control

- Service Level Agreements:
 - to describe services to the rest of the world
- Service Composition:
 - to construct new services
- Service Monitoring & Adaptation:
 - to trigger the evolution of services and make them evolve

Service Level Agreements (SLA)

SLA

a description of the
access/authorization
permissions (e.g., in *SAML*)

a description of the non-functional
properties of the service
(e.g., with *WS-Agreement*)

QoS

Security

Behaviour

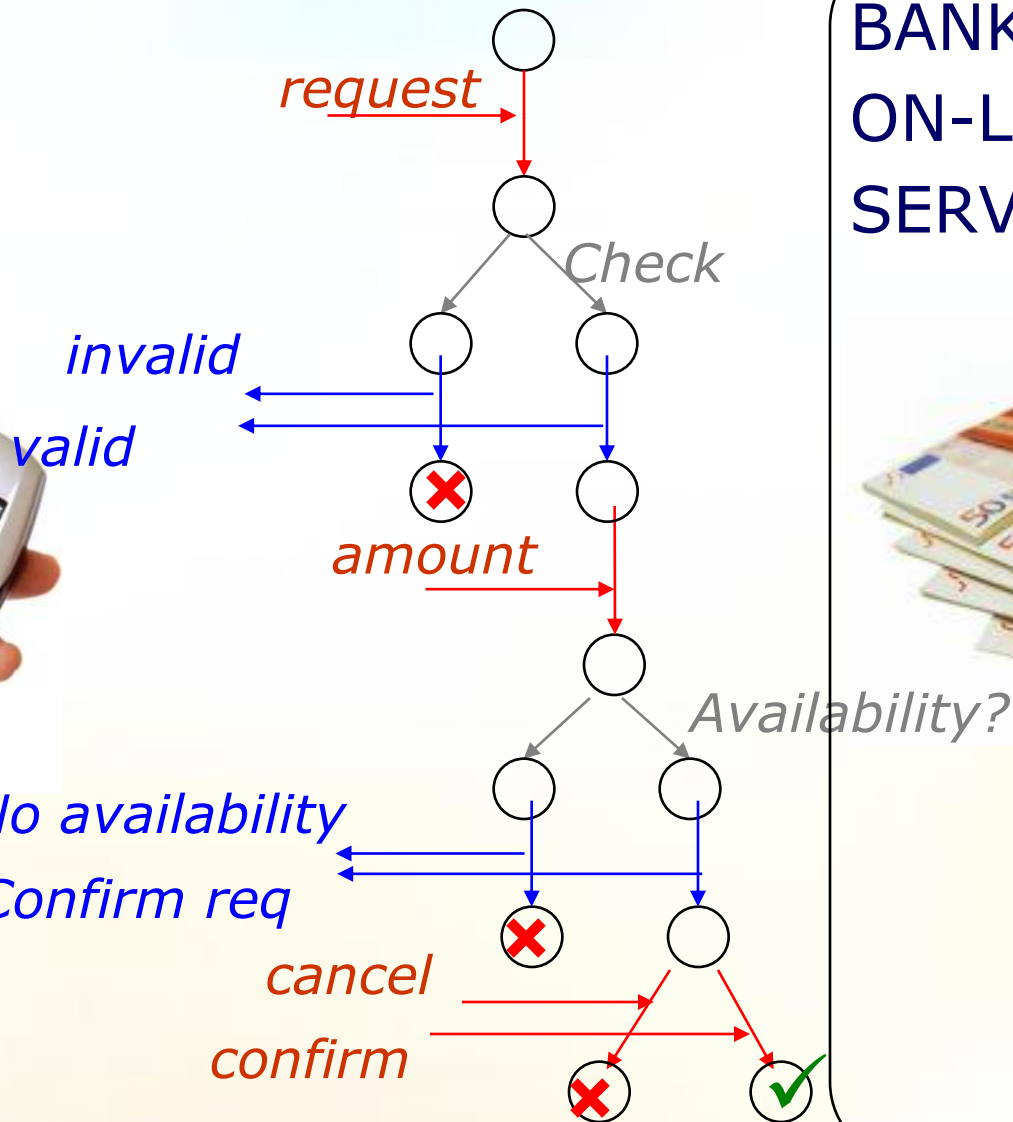
Interface

a description of the interaction flow
that is required to interact with
the service (e.g., in *BPEL*)

a description of messages and data
that are exchanged (e.g., in *WSDL*)

Example: Behaviour SLA

The interaction flow for an on-line bank payment (e.g. in BPEL)



**BANK
ON-LINE
SERVICE**



1. Service Level Agreements:

- to describe services to the rest of the world

2. Service Composition:

- to construct new services

3. Service Monitoring & Adaptation:

- to trigger the evolution of services and make them evolve

Automata-based e-service coordination:

- Formal framework for composing e-services from behavioral descriptions given in terms of automata.

Hull, Benedikt, Christophides. PODS 2003

Satisfiability-based e-service coordination:

- decision procedures for satisfiability are used to address the problem of e-coordination

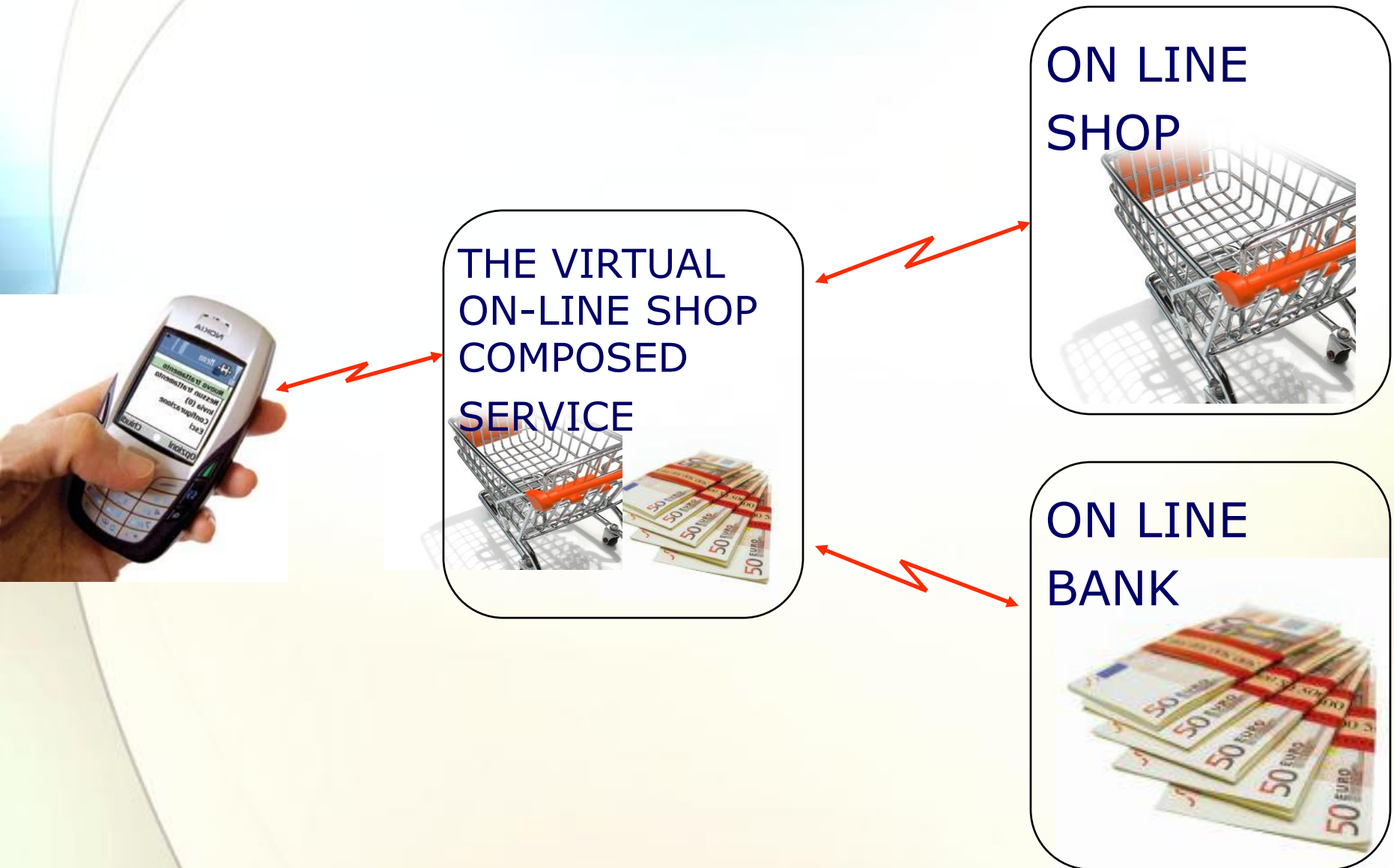
Berardi, Degiacomo, Mecella, Lenzerini. ICSOC 2004, 2005

QoS-aware service composition:

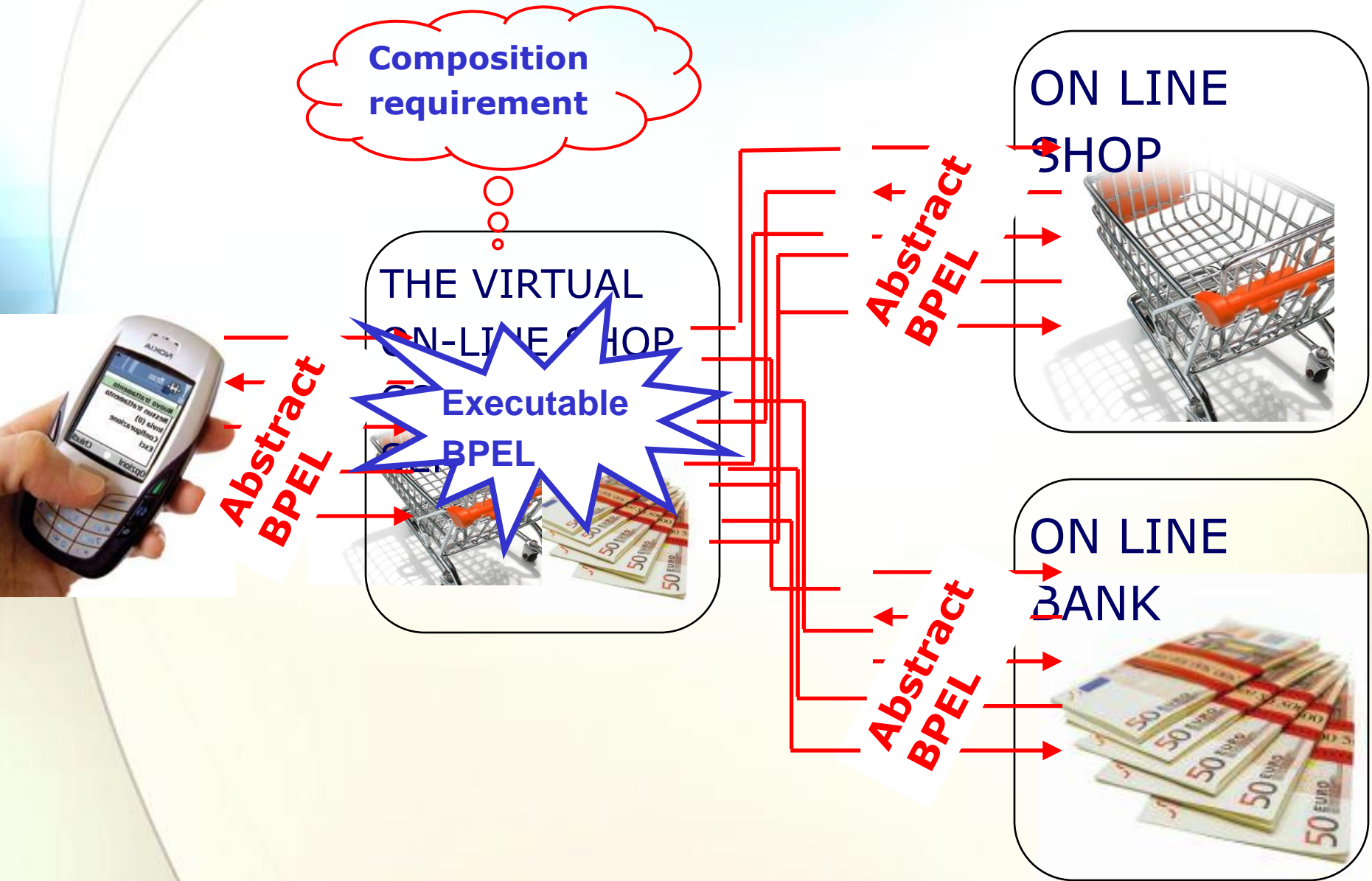
- genetic algorithms for the optimal QoS estimation

Canfora, Di Penta et al. ICSOC 2004, ICWS 2005

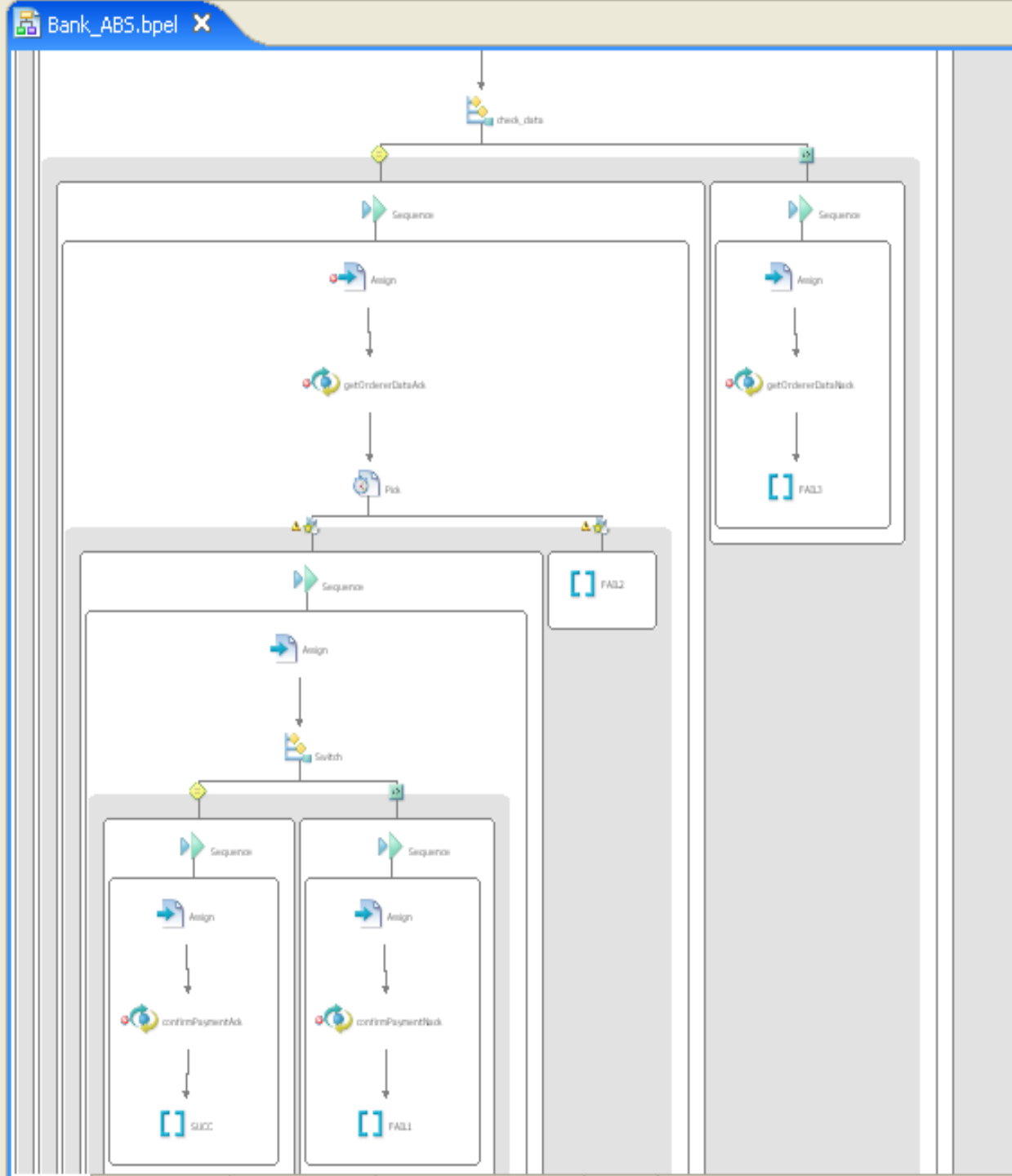
The Automated Composition Problem



The Automated Composition Problem



Abstract BPEL



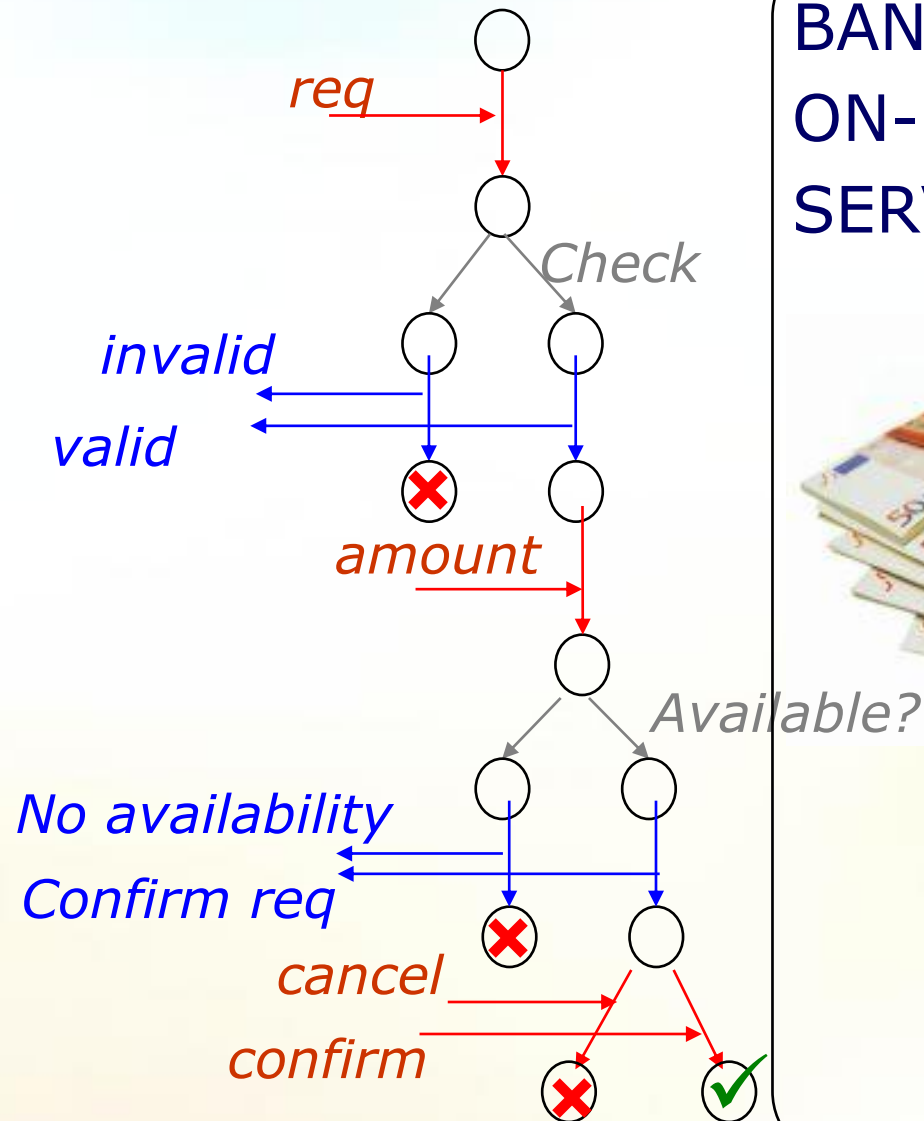
From Abstract BPEL to State Transition Systems

Abstract BPEL ->
State Transition
Systems

Input actions I
(reception of
messages)

Output actions O
(message sent)

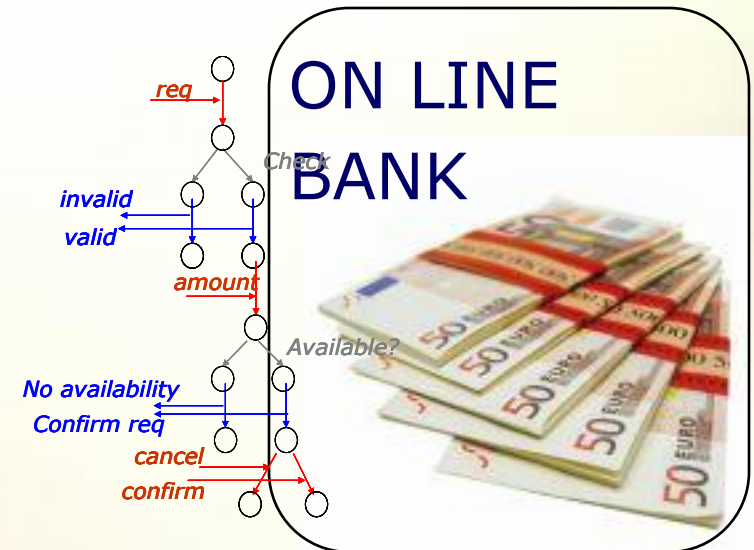
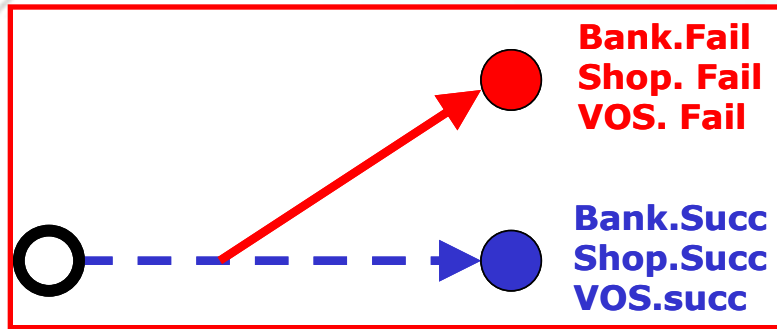
Internal action τ
(internal
evolutions that
are not visible to
external
services)



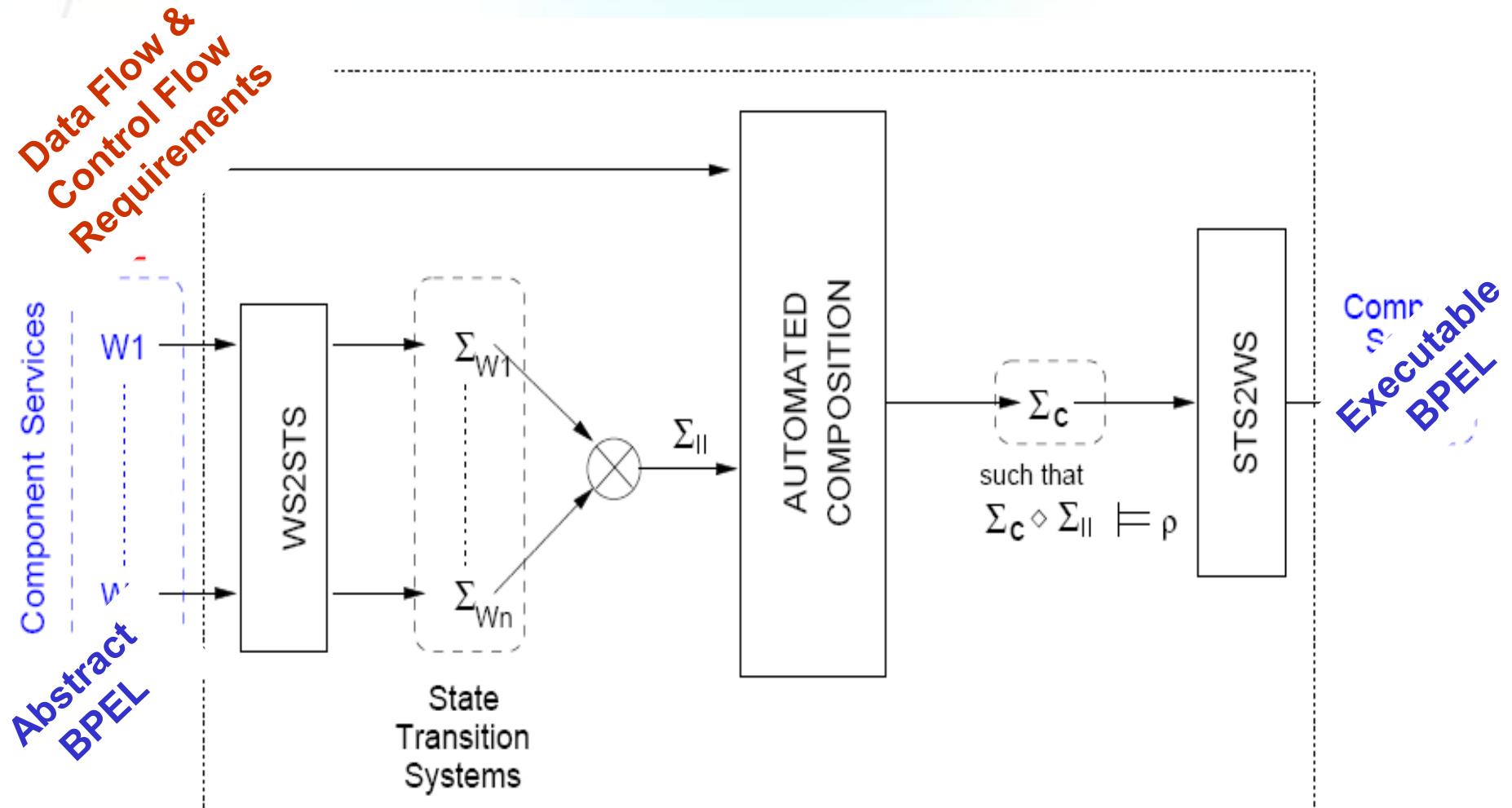
BANK
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The Automated Composition Problem



The Approach



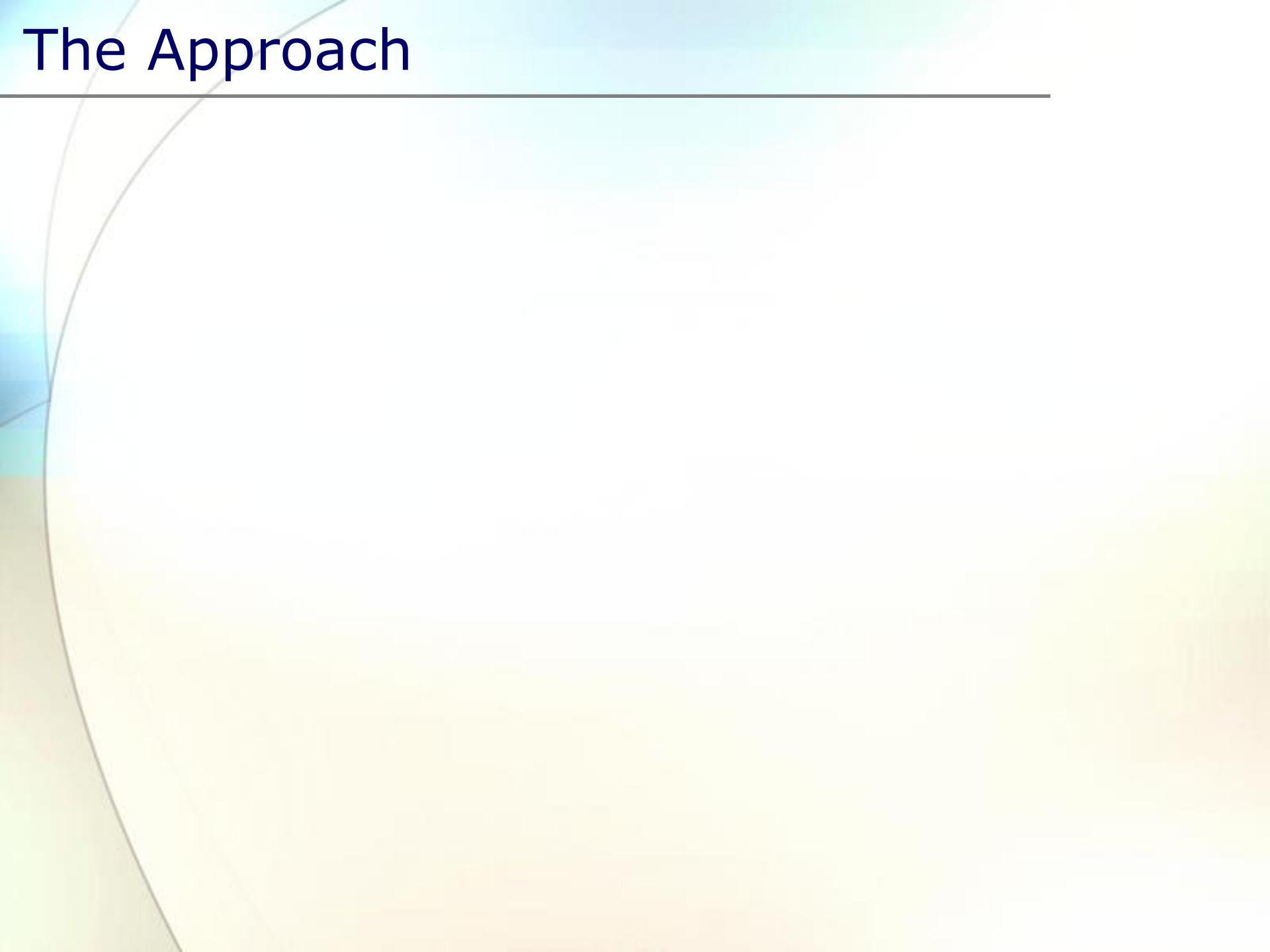
The Approach

Definition. Let $\Sigma_1 = \langle \mathcal{S}_1, \mathcal{S}_1^0, \mathcal{I}, \mathcal{O}, \mathcal{R}_1 \rangle$ and $\Sigma_2 = \langle \mathcal{S}_2, \mathcal{S}_2^0, \mathcal{O}, \mathcal{I}, \mathcal{R}_2 \rangle$ be two complementary state transition systems. The **controlled system** $\Sigma_1 \diamond \Sigma_2$ is the STS defined as:

$$\Sigma_1 \diamond \Sigma_2 = \langle \mathcal{S}_1 \times \mathcal{S}_2, \mathcal{S}_1^0 \times \mathcal{S}_2^0, \emptyset, \emptyset, \mathcal{R}_1 \diamond \mathcal{R}_2, \rangle$$

where $\langle (s_1, s_2), \tau, (s'_1, s'_2) \rangle \in (\mathcal{R}_1 \diamond \mathcal{R}_2)$ if

- $\langle s_1, \tau, s'_1 \rangle \in \mathcal{R}_1$ and $s_2 = s'_2$;
- $\langle s_2, \tau, s'_2 \rangle \in \mathcal{R}_2$ and $s_1 = s'_1$;
- $\langle s_1, a, s'_1 \rangle \in \mathcal{R}_1$ and $\langle s_2, a, s'_2 \rangle \in \mathcal{R}_2$ with $a \in \mathcal{I} \cup \mathcal{O}$.

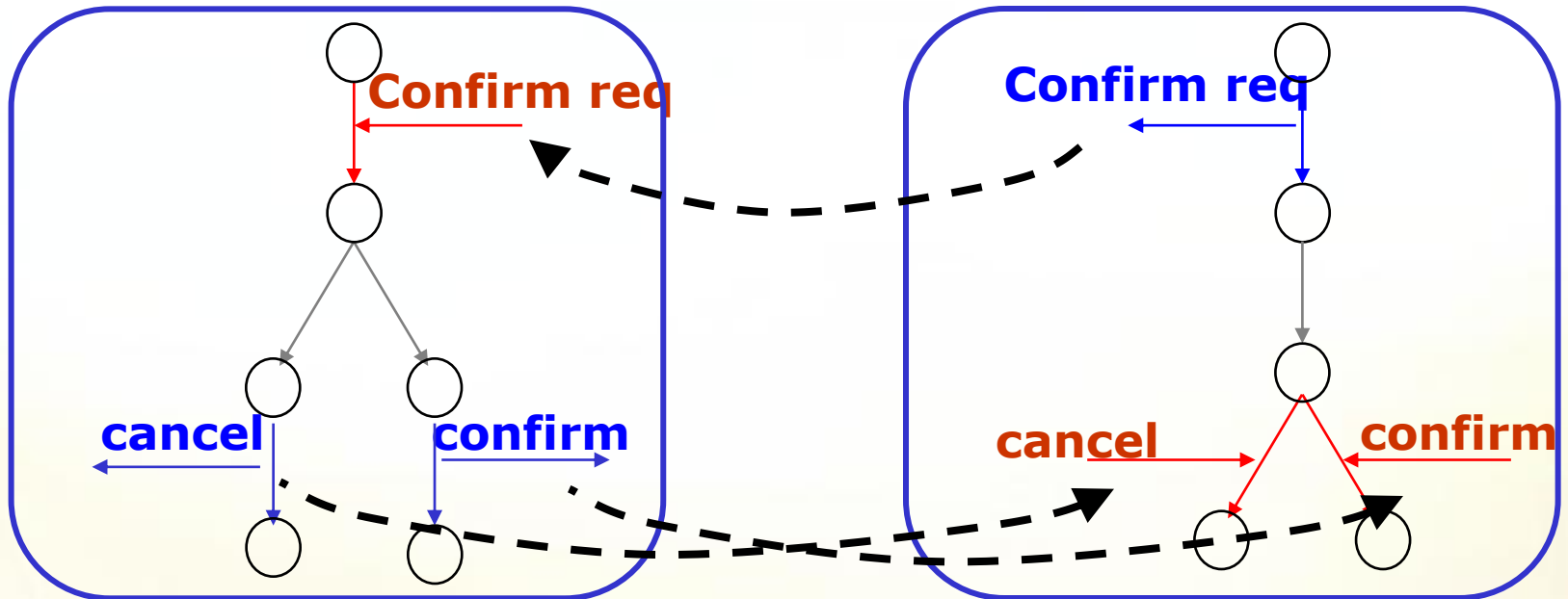


The Approach

The Approach: Controlled System

Supply & pay service

Bank



Deadlock free composition

Deadlock-free composition:

Definition. Let $\Sigma_1 = \langle S_1, S_1^0, \mathcal{I}, \mathcal{O}, \mathcal{R}_1 \rangle$ and $\Sigma_2 = \langle S_2, S_2^0, \mathcal{O}, \mathcal{I}, \mathcal{R}_2 \rangle$ be two STS.

The controlled system $\Sigma_1 \diamond \Sigma_2$ is said to be **deadlock free** if all states $(s_1, s_2) \in S_1 \times S_2$ satisfy the following conditions:

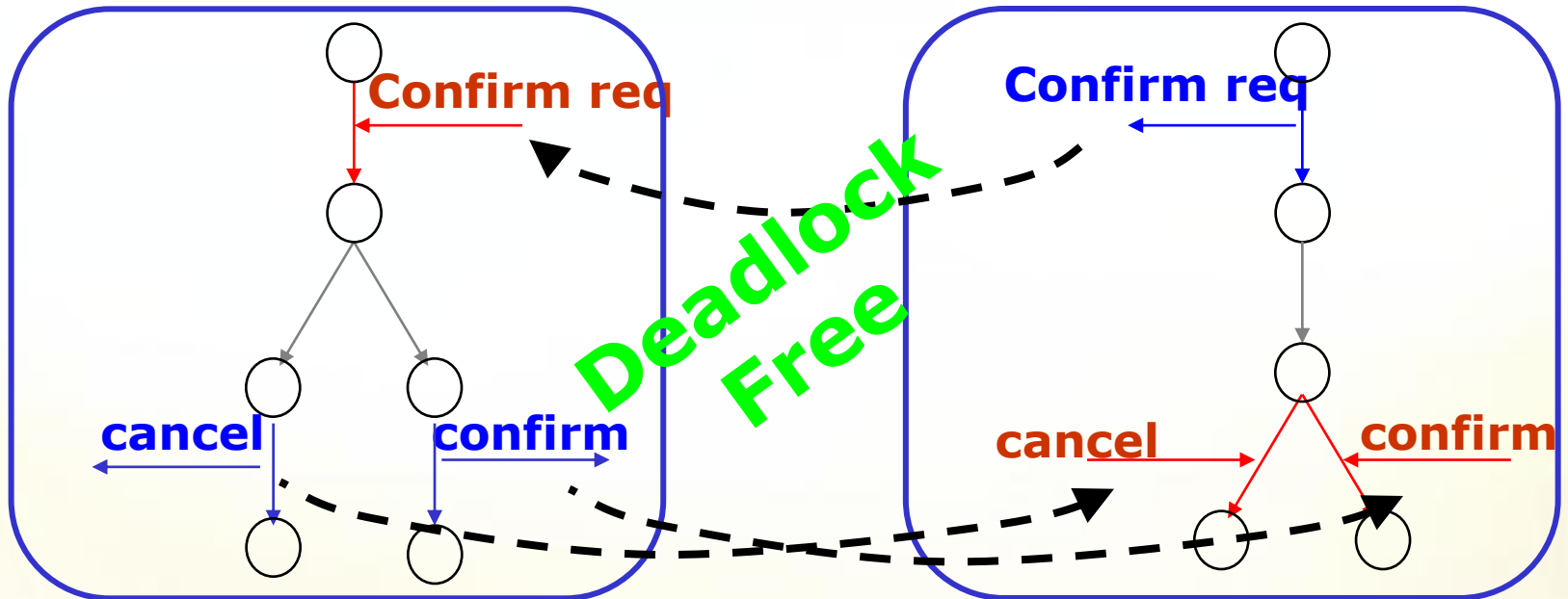
- if $\langle s_1, a, s'_1 \rangle \in \mathcal{R}_1$ with $a \in \mathcal{O}$ then there is some $s'_2 \in \tau\text{-closure}(s_2)$ such that $\langle s'_2, a, s''_2 \rangle \in \mathcal{R}_2$ for some $s''_2 \in S_2$;
- if $\langle s_2, a, s'_2 \rangle \in \mathcal{R}_2$ with $a \in \mathcal{I}$ then there is some $s'_1 \in \tau\text{-closure}(s_1)$ such that $\langle s'_1, a, s''_1 \rangle \in \mathcal{R}_1$ for some $s''_1 \in S_1$.

$\tau\text{-closure}(s)$ denotes the set of states reachable from s performing transitions labelled by τ .

Deadlock free composition

Supply & pay service

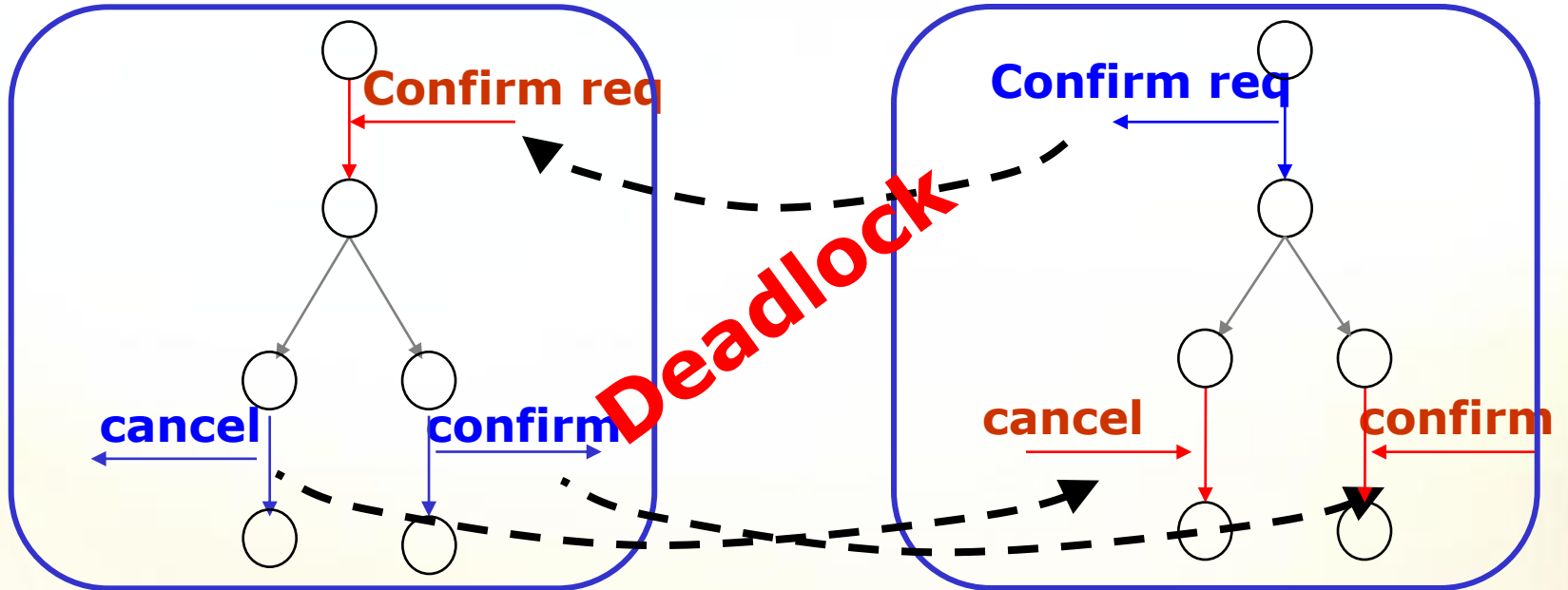
bank service



Deadlock free composition

supply & pay service

bank service



Synthesis: the automated composition problem

Composition of web services:

- Starting from $\Sigma_{\parallel} = \Sigma_1 \parallel \cdots \parallel \Sigma_n$ and composition requirement ρ , find a controller Σ_c such that:
 - requirement ρ is enforced:

$$\Sigma_c \diamond \Sigma_{\parallel} \models \rho$$

- the asynchronous interaction model is respected:

$$\Sigma_c \diamond \Sigma_{\parallel} \text{ is deadlock-free}$$

The Composition Algorithm: Intuitions

- The **Parallel Product** of the State Transitions Systems (STSs) of Available Interaction Flows (Components + Composed)
- Search the Product STS to satisfy the Composition Requirement
- Find a **subgraph of the Product** STS which satisfies the following conditions (example with **reachability conditions**):

1. All terminal states satisfy the condition

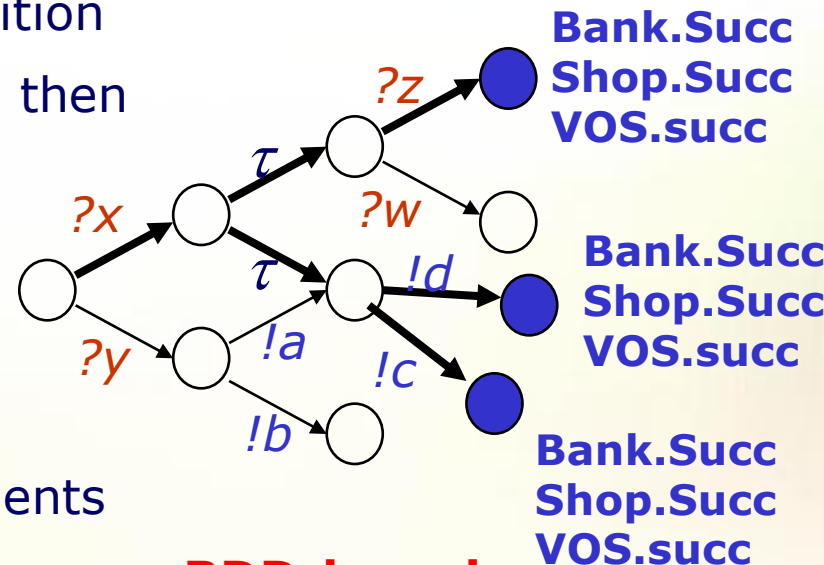
2. If a state belongs to the subgraph, then

- one outgoing input**
- all outgoing taus**
- all outgoing outputs**

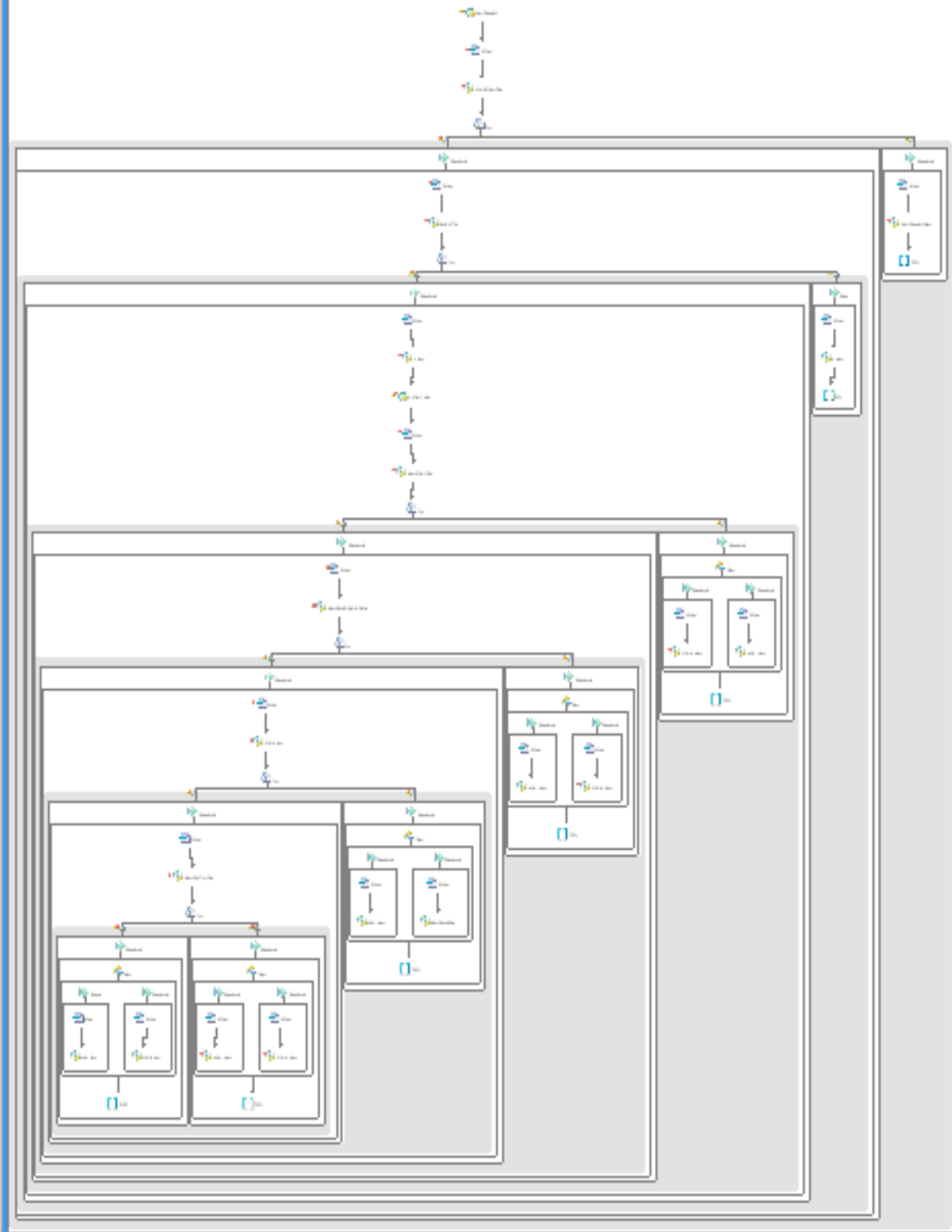
belong to the subgraph

3. remove non deadlock-free components

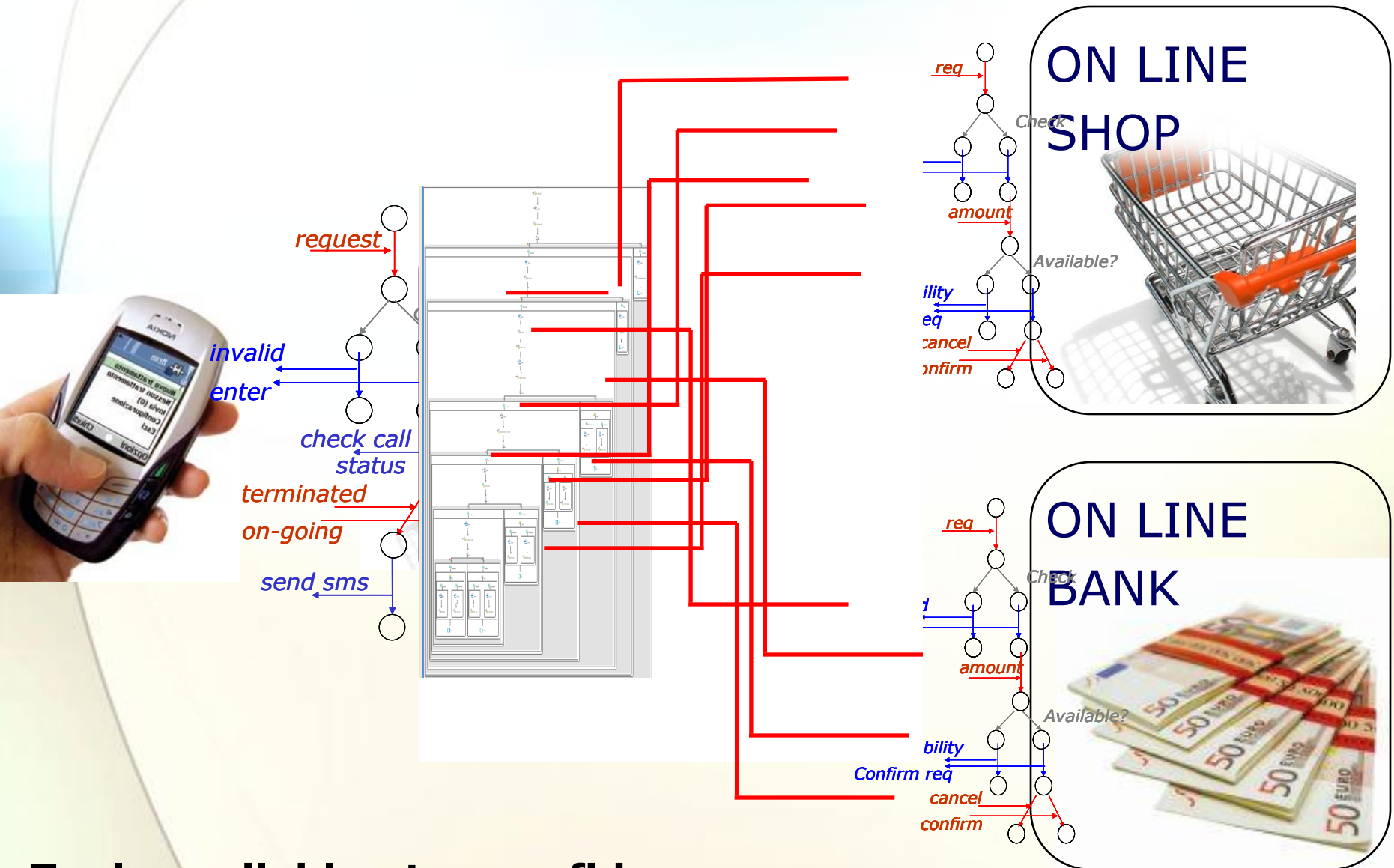
- Product STSs can be extremely large: we use **BDD-based exploration primitives** from the “**Planning as Model Checking**” framework



The Automatically C



Deployment of Executable BPEL




Tools available at www.fbk.eu

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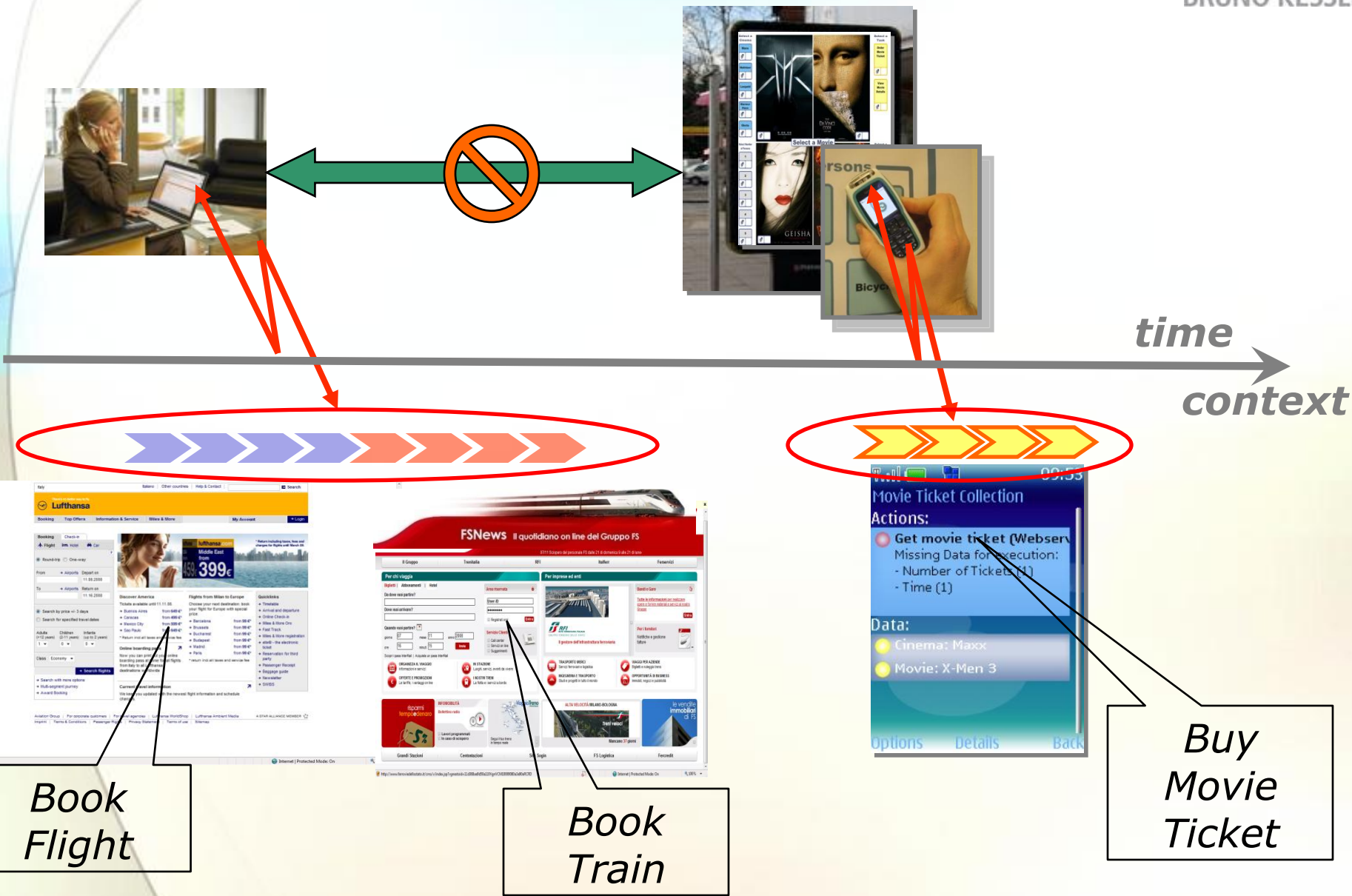
Current travel information

We keep you updated with the newest flight information and schedule.

Example: Flight Service



Example: Service Composition



The Vision (one step forward ...)

**Real Services are very different from Software Services,
for instance with respect to ...**

→ **... duration:** the time for booking a travel is limited
with respect to the duration of the actual travel.

→ **... dynamic:** software services are
static and accessible anywhere and anytime;
the real services are dynamic and context dependent.

→ **... coupling:** software services are
independent and loosely coupled;
the real services we use are strongly related.

The SOC concepts and approaches have to be re-thought:

- **... monitoring:** from monitoring the execution of software to monitoring the environment where the service operates
- **... adaptation:** from adaptation among software services to adaptation to service and environment changes and to user's reactions
- **... composition:** from task/goal driven composition of software to a composition based on how a service relates to core assets for the users

Conclusions

Thank you for your attention!

