Interaction safety in Web service orchestrations

Just sessionize it !

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6/11/2012

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I am going to present to you:

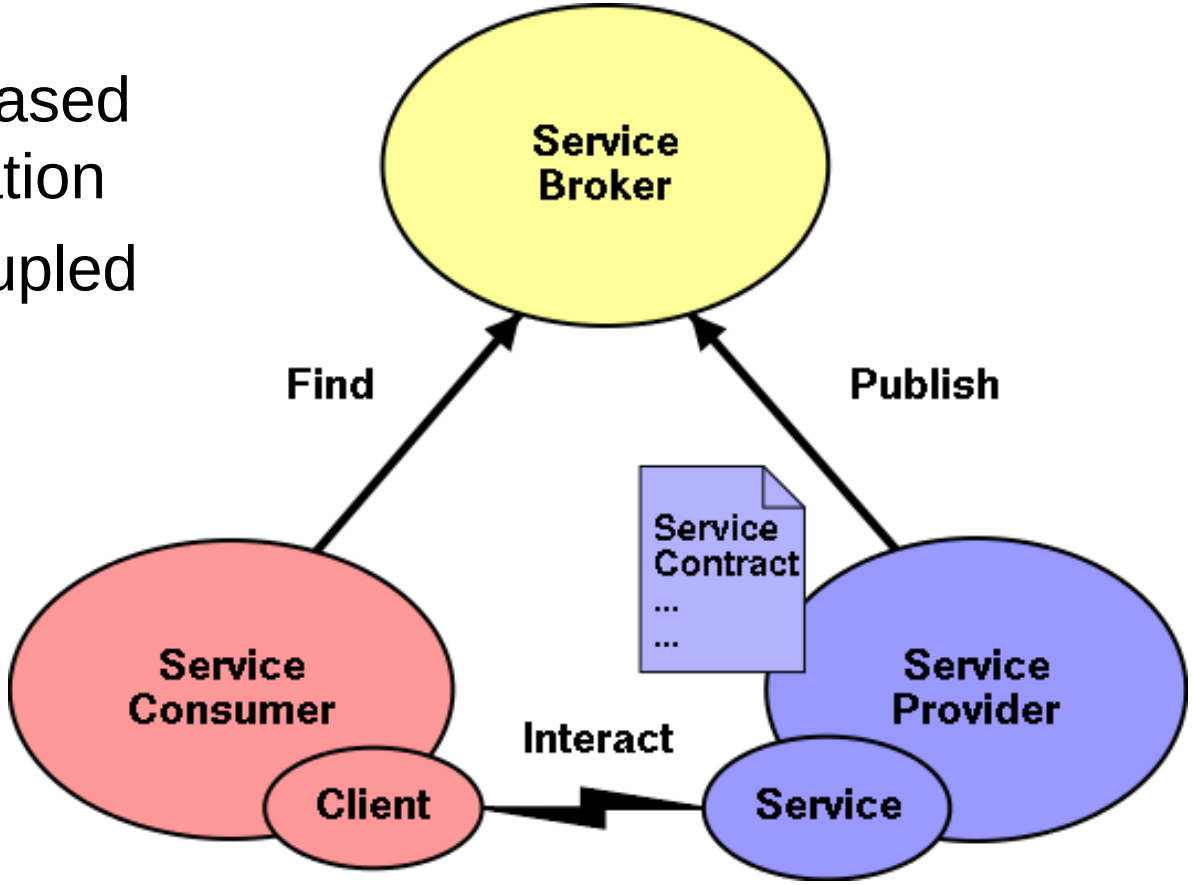
- The meaning and purpose of Web service orchestrations
- Runtime errors that we would like to be able to avoid
- A simple orchestration language
- A new approach to behavioural typing: session-based programming
- **How the approach helps us avoid the runtime errors *at compile-time***

To do so, I am going to:

- Introduce Web services, orchestration, and interaction errors
- Present a simple orchestration language with a promising new feature: **typed sessions** (a concurrent programming paradigm with lots of potential)
- Jump into an example of an orchestration
  - Implement the orchestration
  - Show that the implementation contains errors
  - Show how the errors are detected
  - Correct the code

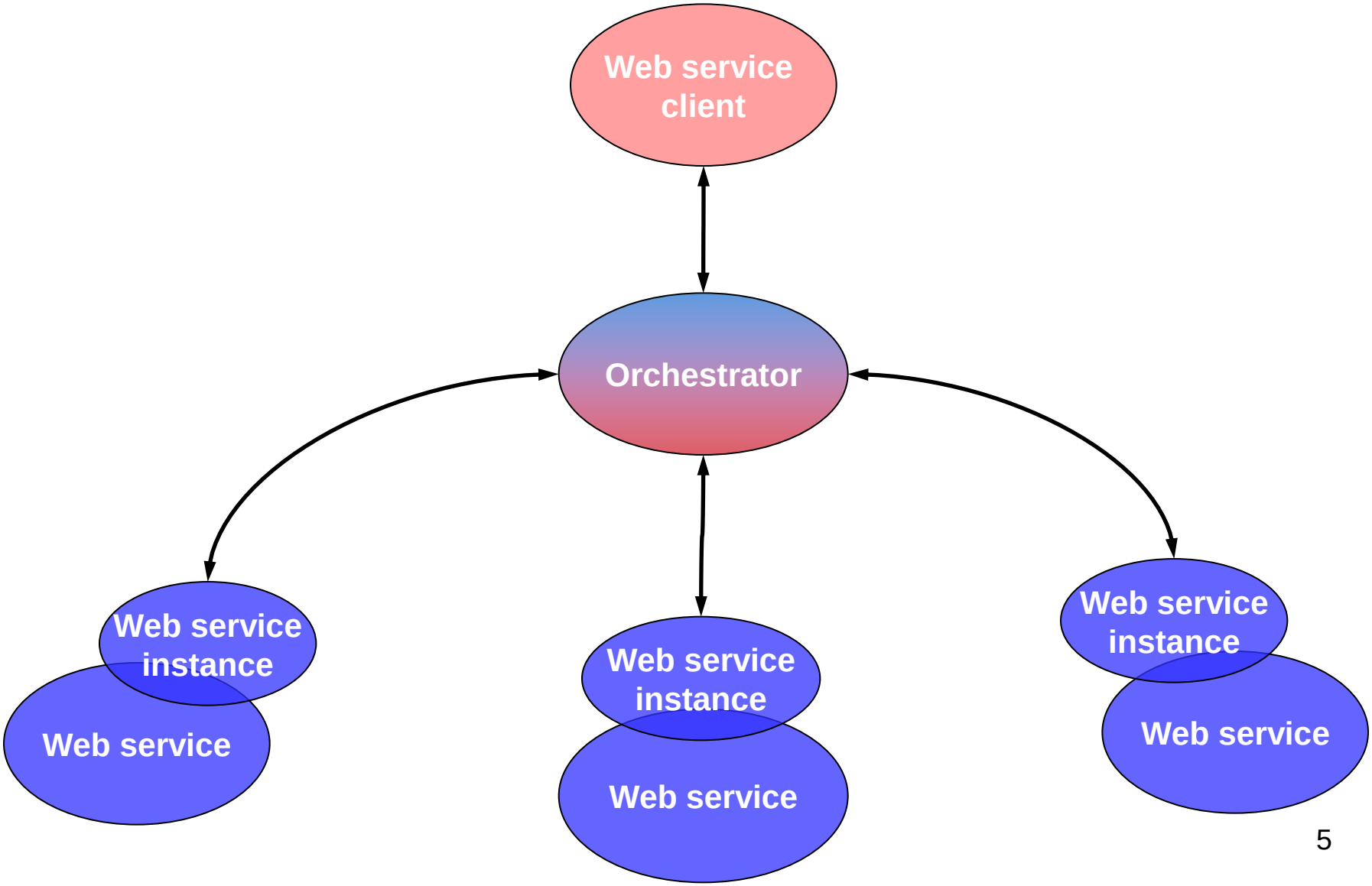
Service Oriented Architecture (SOA)

- Message-based communication
- Loosely coupled services



(w3c.org)

Web service orchestration

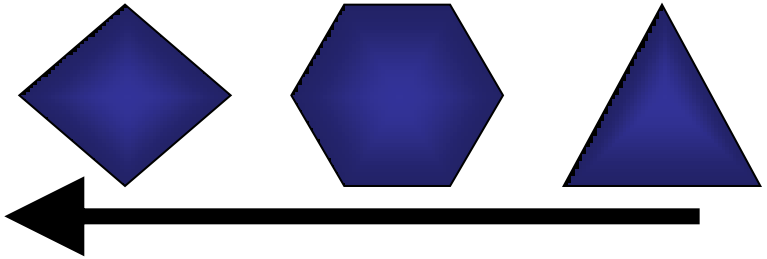


Interactions errors

A service client is awaiting message

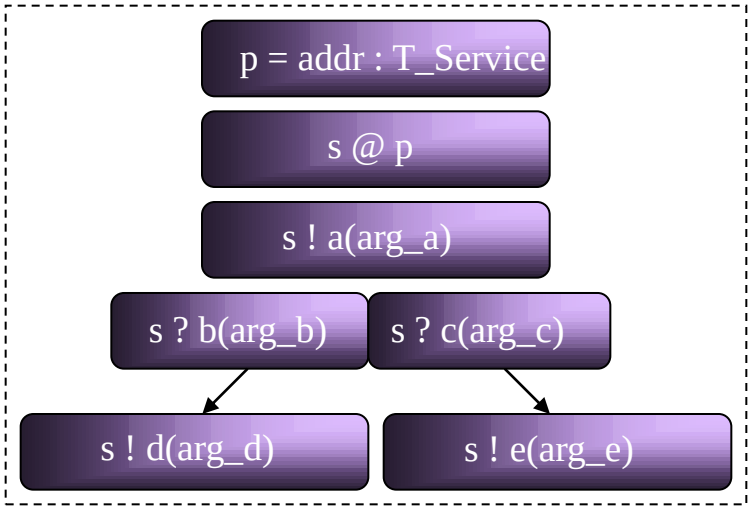
or

… but the message queue contains



A simple orchestration language with typed sessions

- **Atomic activities: Invocation, Reception, Session initiation**
- **Structured activities: Sequence, Parallel, Pick, Recursion…**
- **Control links: Synchronisation of parallel activities.**



Traditional **computation** tasks can be done externally.

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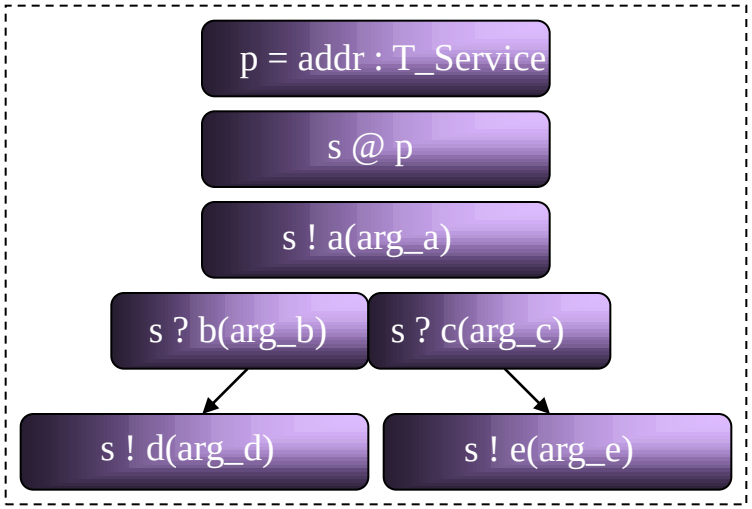
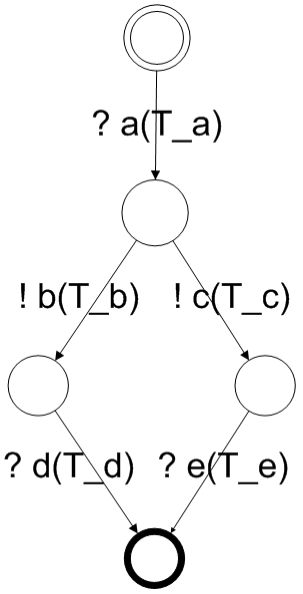


T_Service service type:



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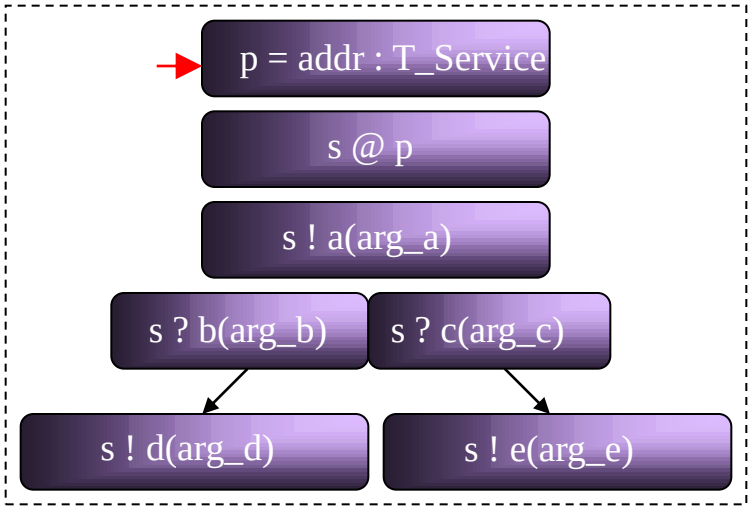

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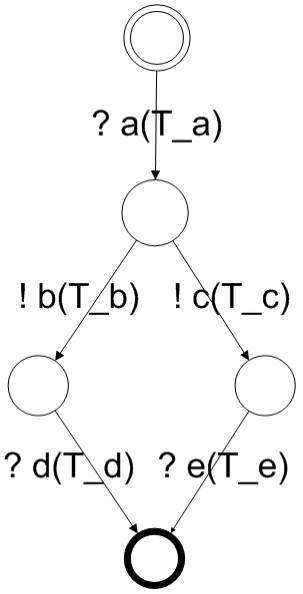

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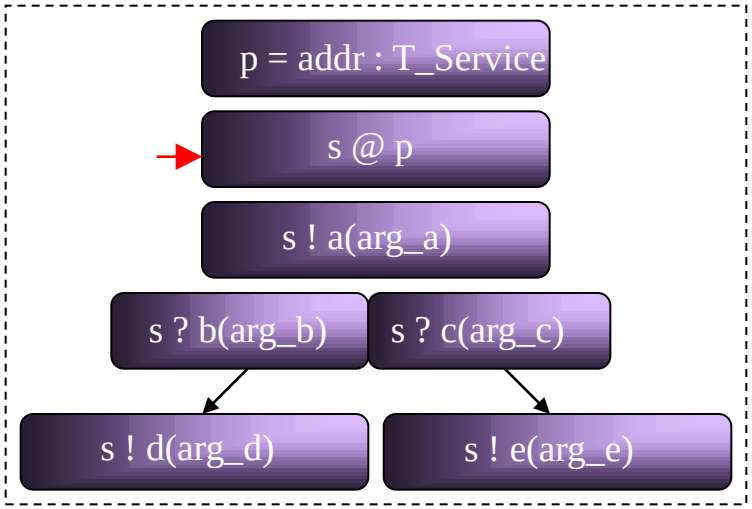

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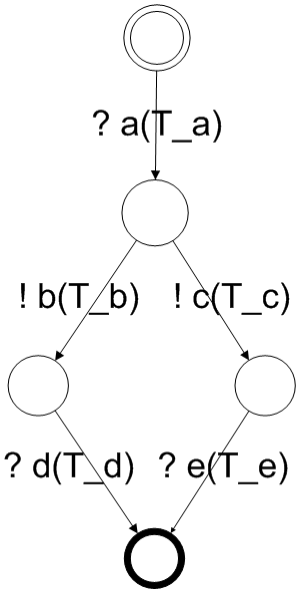

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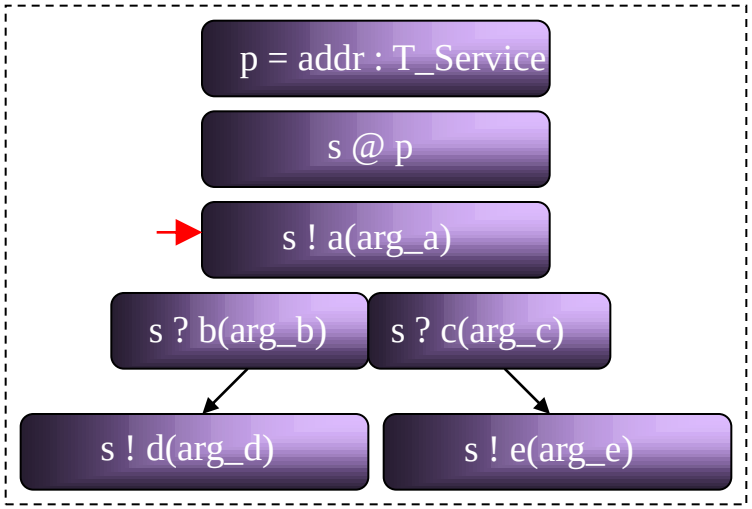

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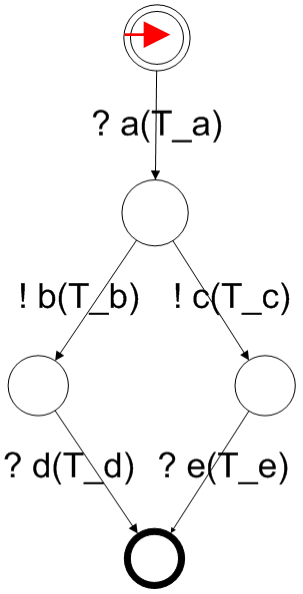

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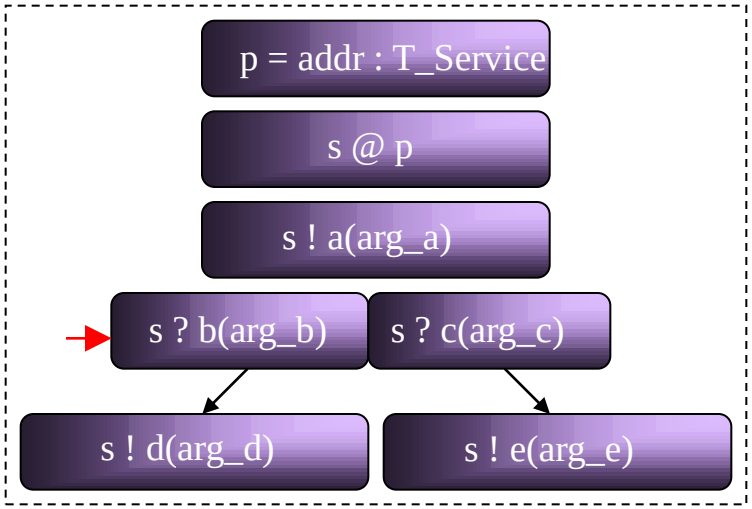

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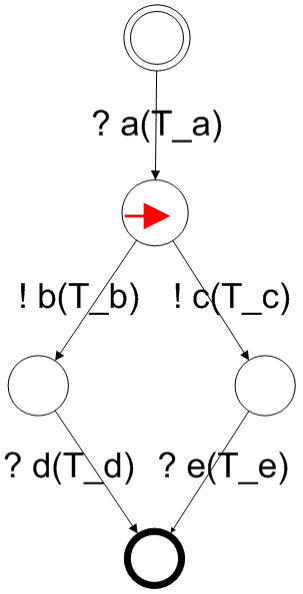

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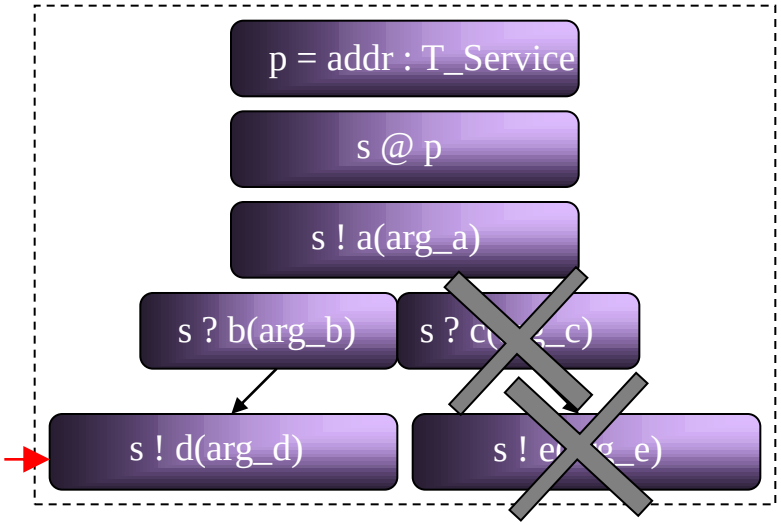

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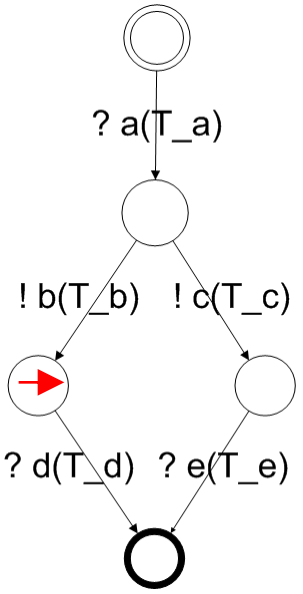

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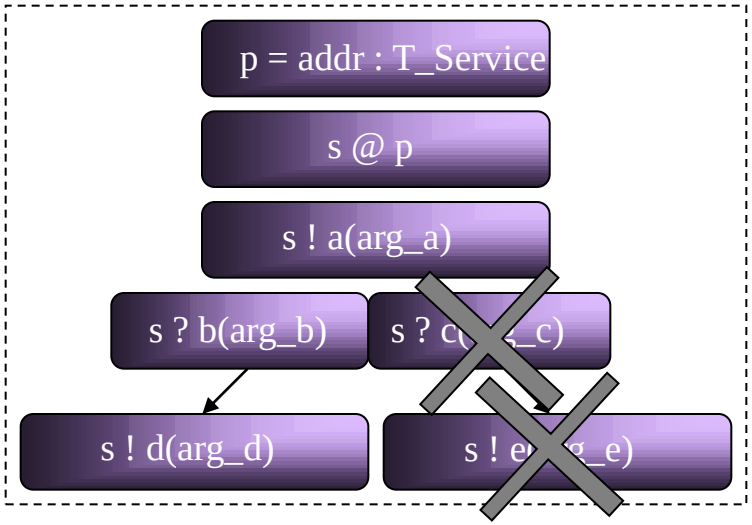

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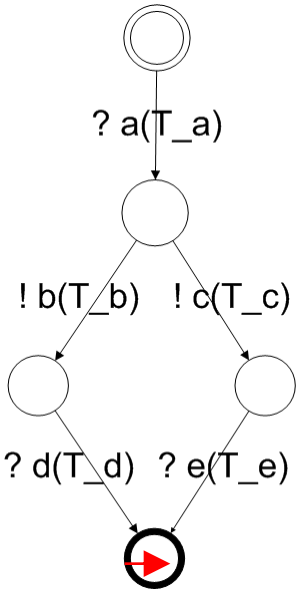

Example service orchestration: The Event Booking System

The Event Booking System chooses a date from a previously set up Doodle page and books a room by using EOLE and some equipment by using the DSI service.

Doodle®

Event Booking System

EOLE L'intranet

Division Systemes Information

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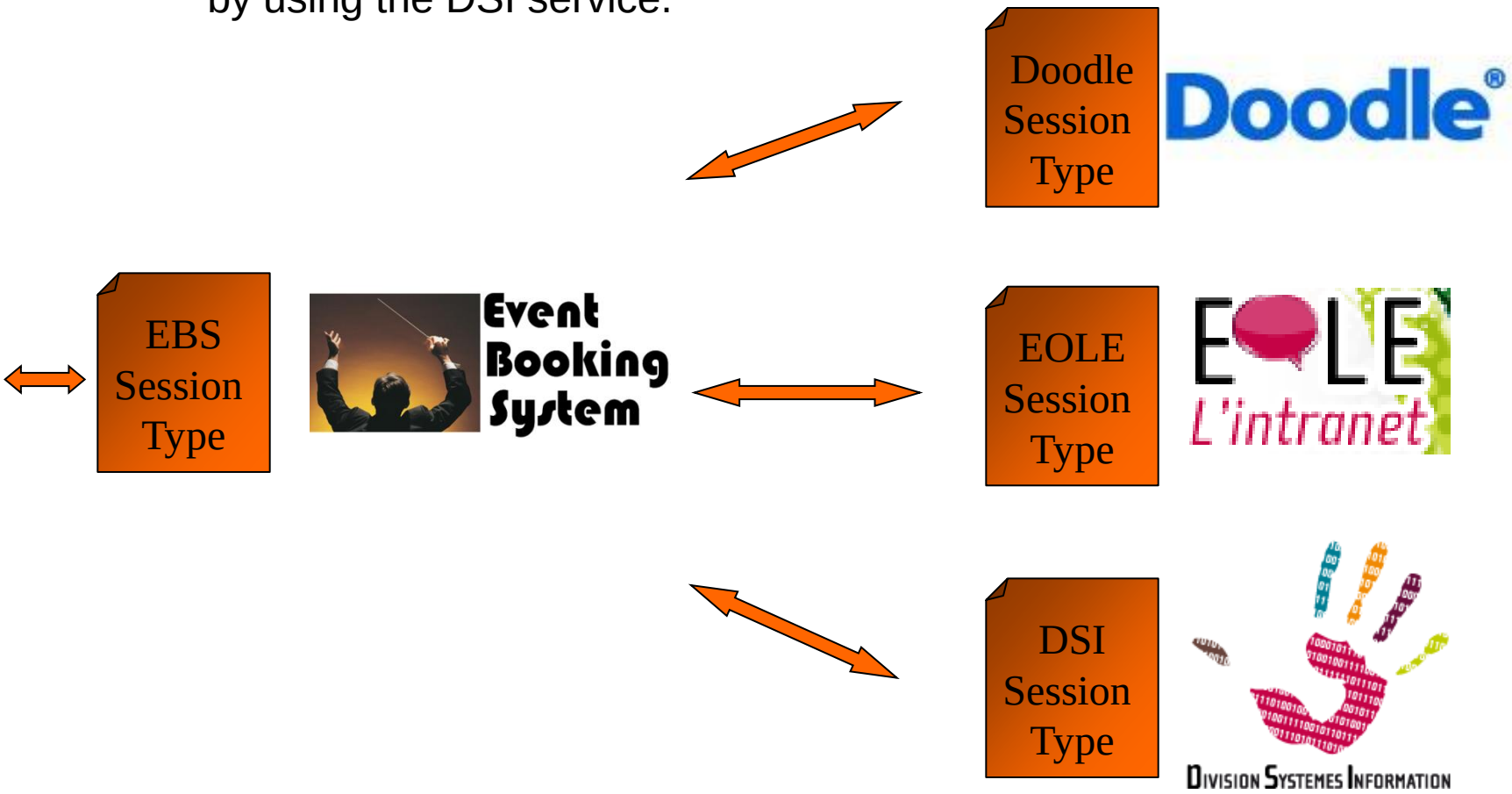
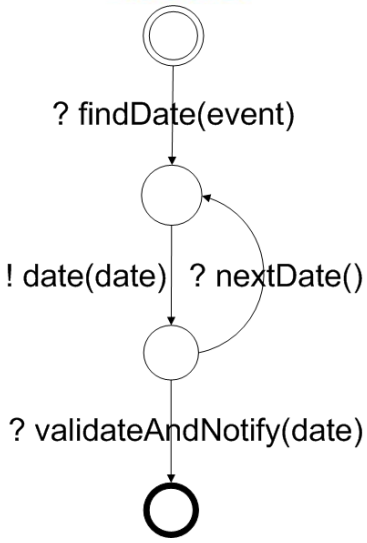
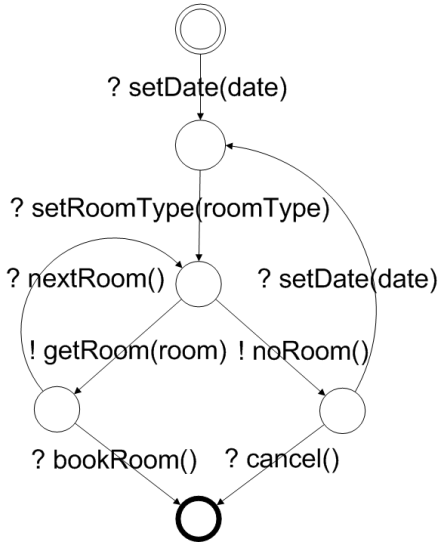


Event Booking System

Doodle

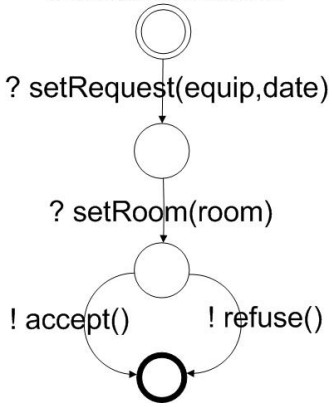


EOLE L'intranet



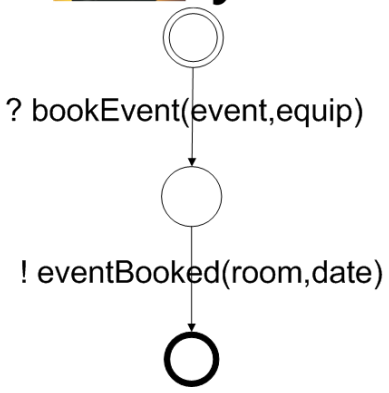
Required Session types

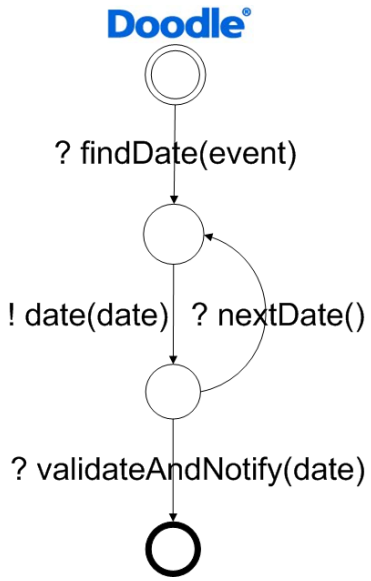
Division Systemes Information

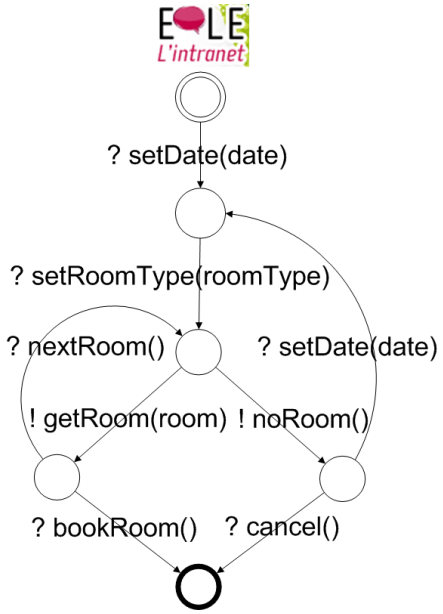


Event Booking System

Provided Session type







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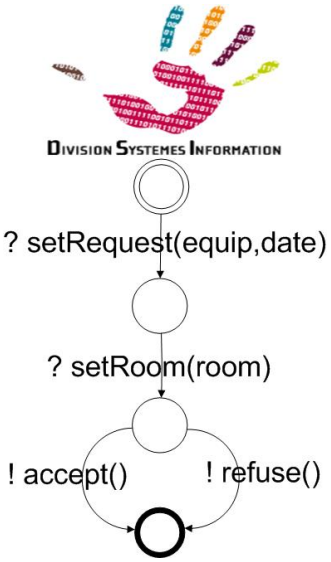
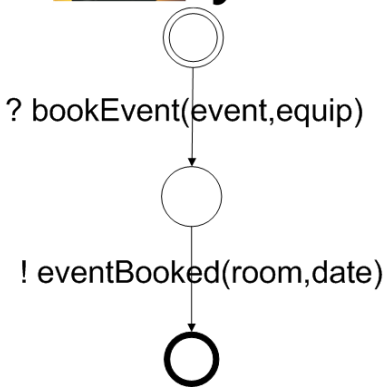


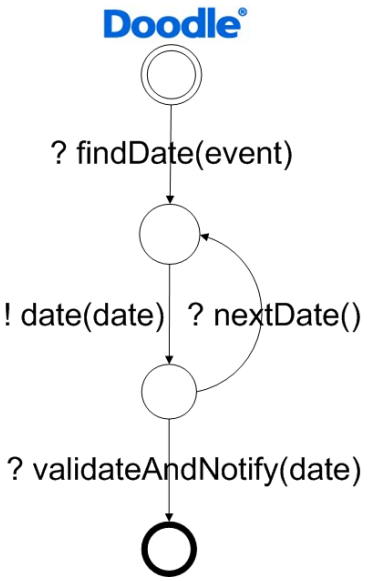
```
Doodle_t doodle = @1;   String date;
EOLE eole = @2;         String room;
DSI dsi = @3;           String event;
EBS_T s;                String equip;
```

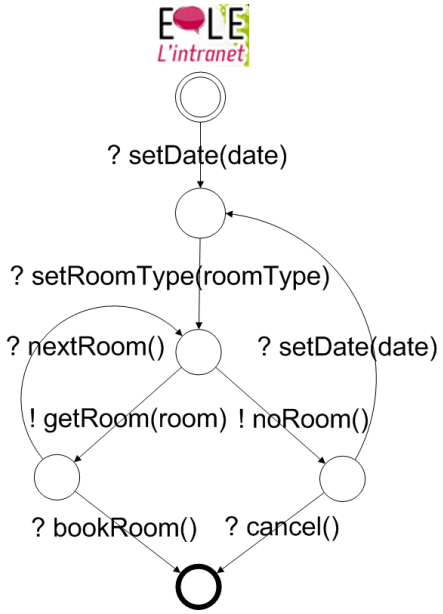
```
s ? bookEvent(event,equip)
```

Event Booking System

Provided Session type







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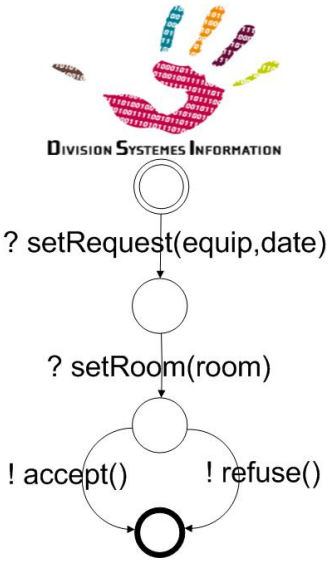

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EOLE eole = @2; String room;
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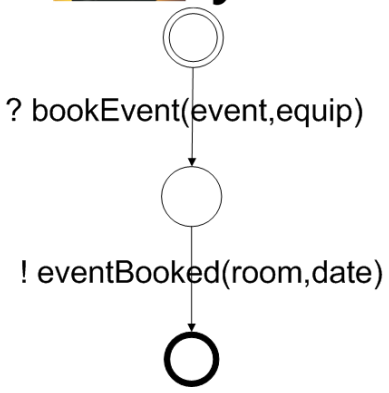
EBS_T s; String equip;

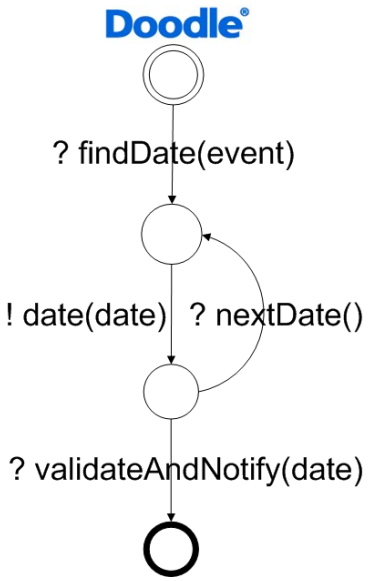
s ? bookEvent(event,equip)

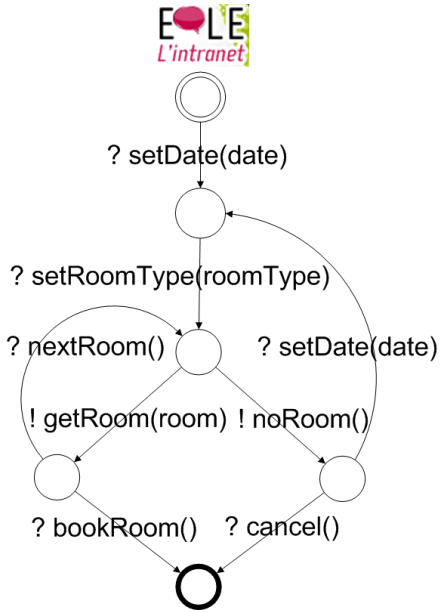
d @ doodle
e @ eole
i @ dsi

PARALLEL

Provided Session type







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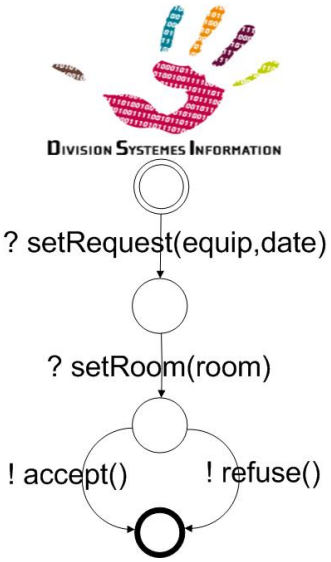

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String date;
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String equip;

s ? bookEvent(event,equip)

d @ doodle
e @ eole
i @ dsi

Event Booking System

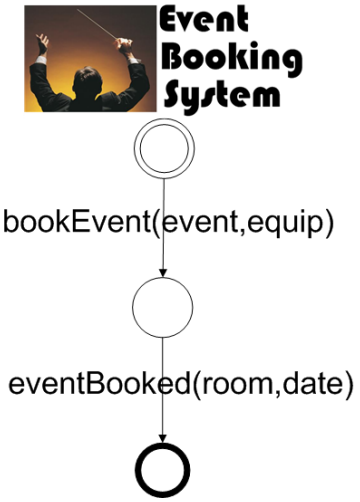
PARALLEL

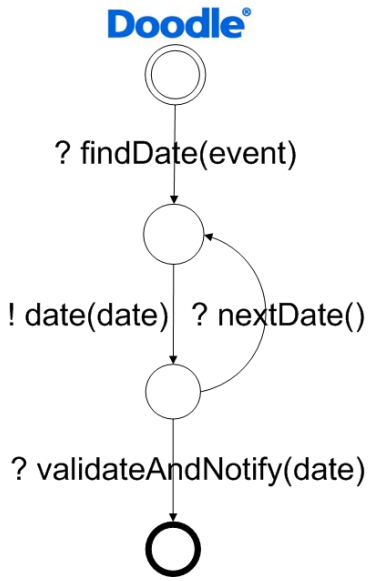
d ! findDate(event)

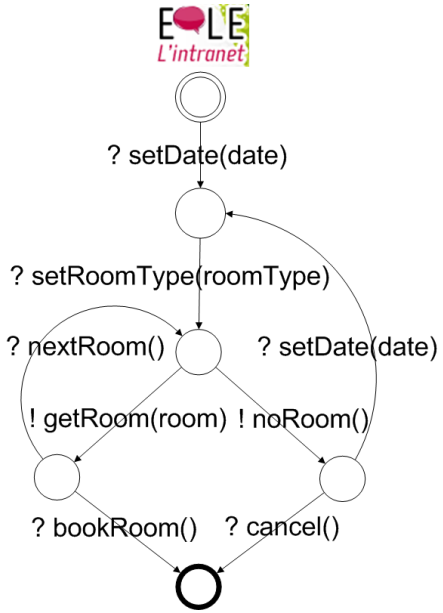
d ? date(date)

d ! validateAndNotify(date)

Provided Session type







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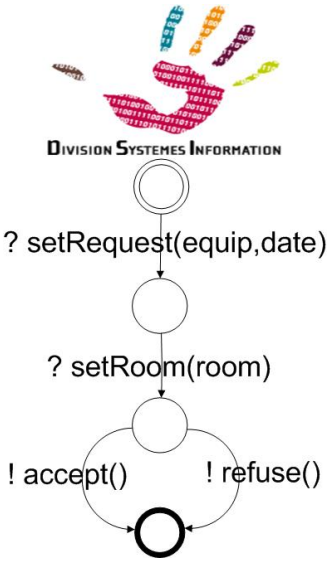

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d @ doodle
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i @ dsi

PARALLEL

d ! findDate(event)

d ? date(date)

d ! validateAndNotify(date)

e ! setDate(date)

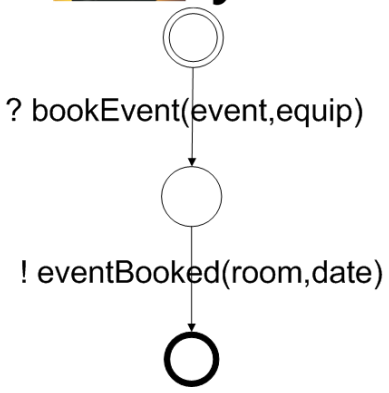
e ! setRoomType(« meeting »)

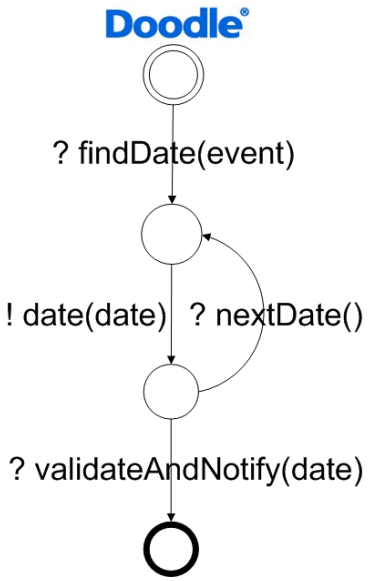
e ? getRoom(room)

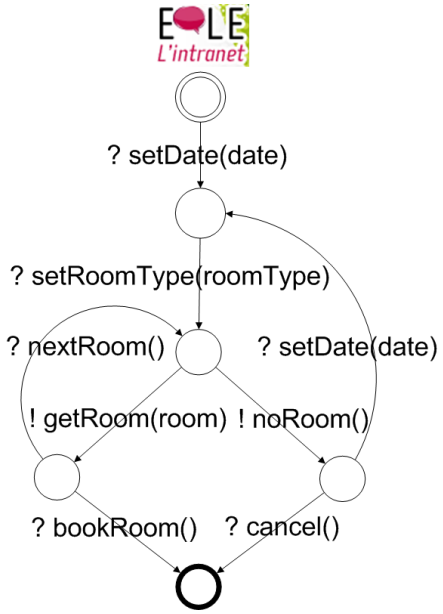
e ? noRoom()

e ! bookRoom()

Provided Session type







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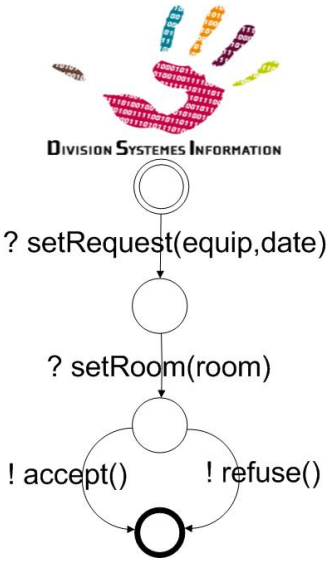

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i @ dsi

Event Booking System

PARALLEL

d ! findDate(event)

d ? date(date)

d ! validateAndNotify(date)

e ! setDate(date)

e ! setRoomType(« meeting »)

e ? getRoom(room)

e ? noRoom()

e ! bookRoom()

i ! setRequest(equip,date)

i ! setRoom(room)

i ? accept(room)

i ? refuse()

Provided Session type

? bookEvent(event,equip)

! eventBooked(room,date)

Doodle

? findDate(event)

! date(date)

? nextDate()

? validateAndNotify(date)

EOLE L'intranet

? setDate(date)

? setRoomType(roomType)

? nextRoom()

? setDate(date)

! getRoom(room)

! noRoom()

? bookRoom()

? cancel()

Required Session types

Division Systemes Information

? setRequest(equip,date)

? setRoom(room)

! accept()

! refuse()

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EBS_T s;

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e ? noRoom()

e ! bookRoom()

i ! setRequest(equip,date)

i ! setRoom(room)

i ? accept(room)

i ? refuse()

s ! eventBooked(date,room)

s ! eventFailed()

Provided Session type

? bookEvent(event,equip)

! eventBooked(room,date)

? findDate(event)

! date(date)

? nextDate()

? validateAndNotify(date)

? setDate(date)

? setRoomType(roomType)

? nextRoom()

? setDate(date)

! getRoom(room)

! noRoom()

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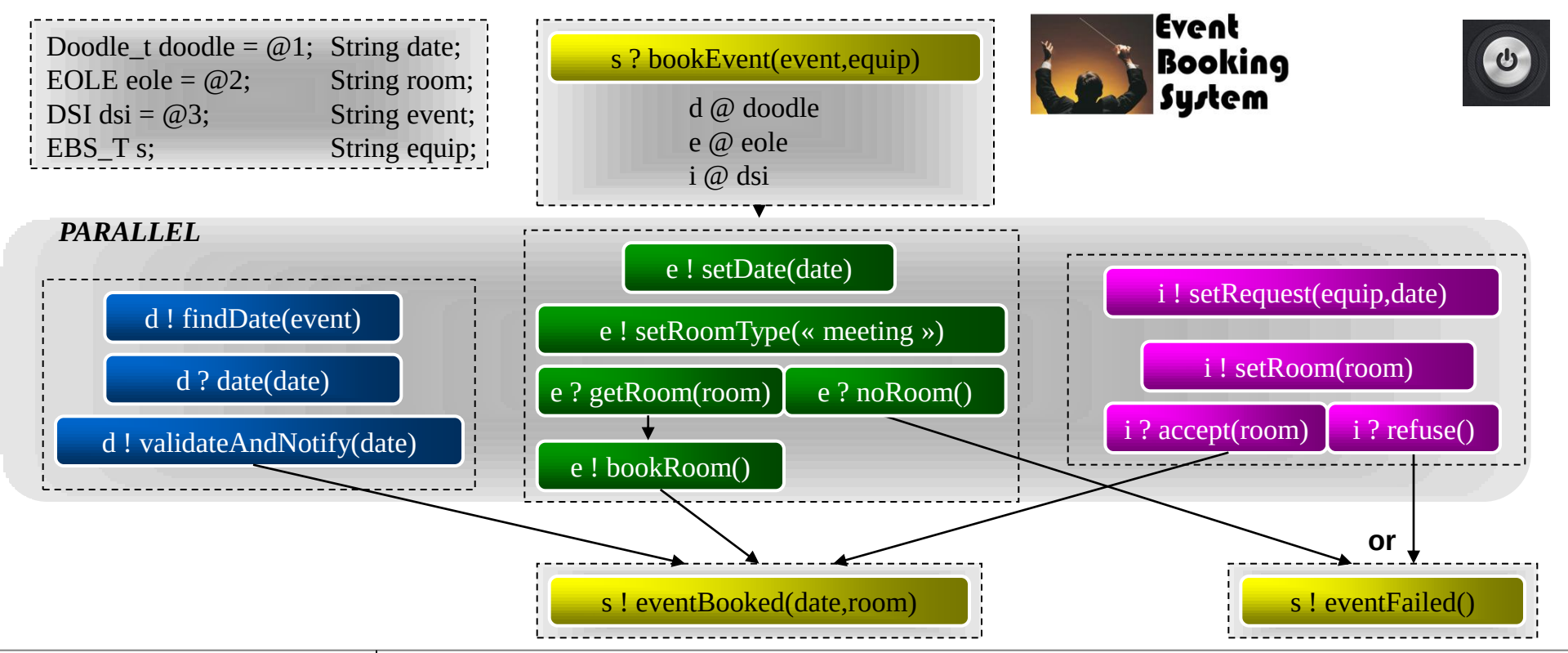

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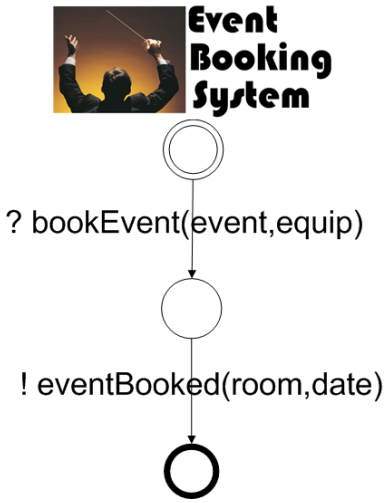
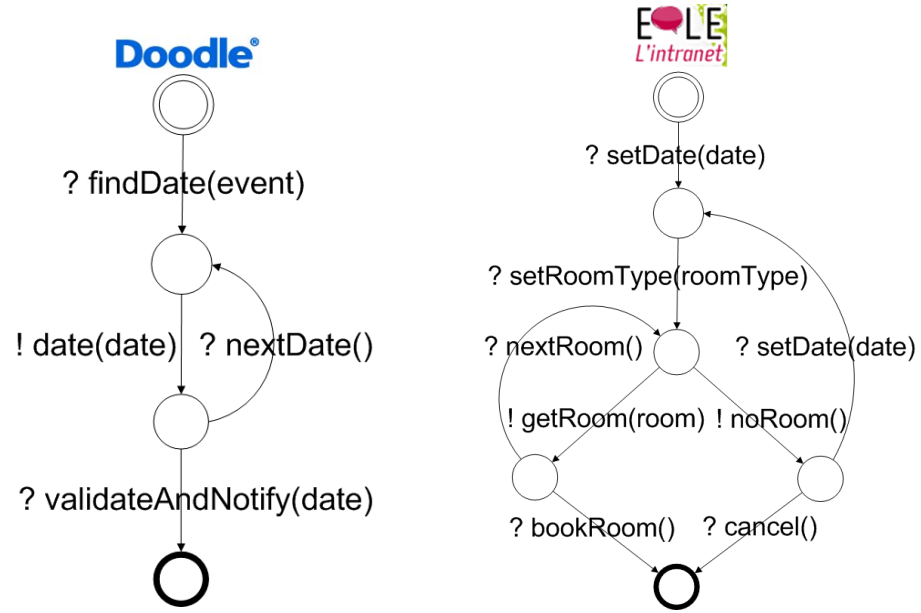


Required Session types



```
Doodle_t doodle = @1;   String date;
EOLE eole = @2;         String room;
DSI dsi = @3;           String event;
EBS_T s;                String equip;
```

s ? bookEvent(event,equip)

d @ doodle
e @ eole
i @ dsi

Event Booking System

What happens if we push the button ?

PARALLEL

d ! findDate(event)

d ? date(date)

d ! validateAndNotify(date)

e ! setDate(date)

e ! setRoomType(« meeting »)

e ? getRoom(room) e ? noRoom()

e ! bookRoom()

i ! setRequest(equip,date)

i ! setRoom(room)

i ? accept(room) i ? refuse()

or

s ! eventBooked(date,room)

s ! eventFailed()

Provided Session type

Event Booking System

? bookEvent(event,equip)

! eventBooked(room,date)

Required Session types

Doodle

? findDate(event)

! date(date) ? nextDate()

? validateAndNotify(date)

EOLE L'intranet

? setDate(date)

? setRoomType(roomType)

? nextRoom() ? setDate(date)

! getRoom(room) ! noRoom()

? bookRoom() ? cancel()

Division Systemes Information

? setRequest(equip,date)

? setRoom(room)

! accept() ! refuse()

Doodle_t doodle = @1; String date;
EOLE eole = @2; String room;
DSI dsi = @3; String event;
EBS_T s; String equip;

s ? bookEvent(event,equip)

d @ doodle
e @ eole
i @ dsi

4 errors detected

PARALLEL

d ! findDate(event)
d ? date(date)
d ! validateAndNotify(date)

e ! setDate(date)
e ! setRoomType(« meeting »)
e ? getRoom(room) | e ? noRoom()
e ! bookRoom()

i ! setRequest(equip,date)
i ! setRoom(room)
i ? accept(room) | i ? refuse()

or

s ! eventBooked(date,room)

s ! eventFailed()

Provided Session type

? bookEvent(event,equip)

! eventBooked(room,date)

Required Session types

Doodle

? findDate(event)

! date(date) ? nextDate()

? validateAndNotify(date)

EOLE L'intranet

? setDate(date)

? setRoomType(roomType)

? nextRoom() ? setDate(date)

! getRoom(room) ! noRoom()

? bookRoom() ? cancel()

Division Systemes Information

? setRequest(equip,date)

? setRoom(room)

! accept() ! refuse()

Event Booking System

3 variable errors

Doodle_t doodle = @1;
EOLE eole = @2;
DSI dsi = @3;
EBS_T s;

String date;
String room;
String event;
String equip;

s ? bookEvent(event,equip)

d @ doodle
e @ eole
i @ dsi

PARALLEL

d ! findDate(event)

d ? date(date)

d ! validateAndNotify(date)

e ! setDate(date)

e ! setRoomType(« meeting »)

e ? getRoom(room)

e ? noRoom()

e ! bookRoom()

i ! setRequest(equip,date)

i ! setRoom(room)

i ? accept(room)

i ? refuse()

or

s ! eventBooked(date,room)

s ! eventFailed()

Event Booking System

3 variable errors

```
Doodle_t doodle = @1;   String date;
EOLE eole = @2;         String room;
DSI dsi = @3;           String event;
EBS_T s;                String equip;
```

s ? bookEvent(event,equip)

d @ doodle
e @ eole
i @ dsi

PARALLEL

d ! findDate(event)

d ? date(date)

d ! validateAndNotify(date)

e ! setDate(date)

e ! setRoomType(« meeting »)

e ? getRoom(room)

e ? noRoom()

e ! bookRoom()

i ! setRequest(equip,date)

i ! setRoom(room)

i ? accept(room)

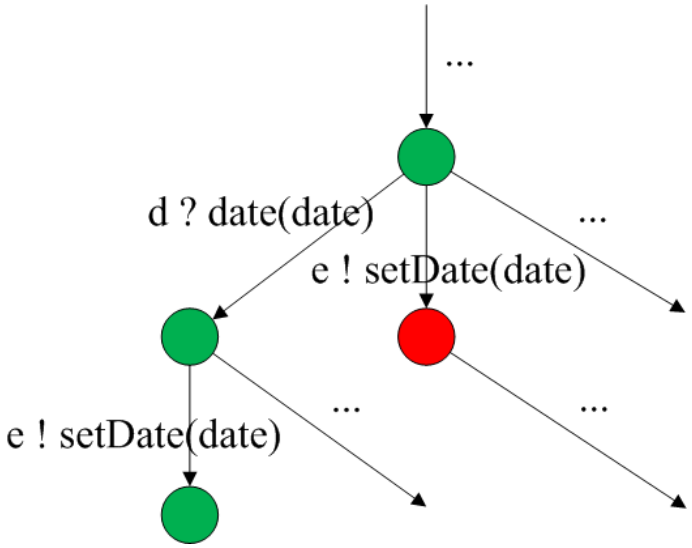
i ? refuse()

or

s ! eventBooked(date,room)

s ! eventFailed()

Part of the Event Booking System's ***control graph***.



= valid state

= error state

Event Booking System

1 error left

Doodle_t doodle = @1; String date;
EOLE eole = @2; String room;
DSI dsi = @3; String event;
EBS_T s; String equip;

s ? bookEvent(event,equip)

d @ doodle
e @ eole
i @ dsi

PARALLEL

d ! findDate(event)

d ? date(date)

d ! validateAndNotify(date)

e ! setDate(date)

e ! setRoomType(« meeting »)

e ? getRoom(room) | e ? noRoom()

e ! bookRoom()

i ! setRequest(equip,date)

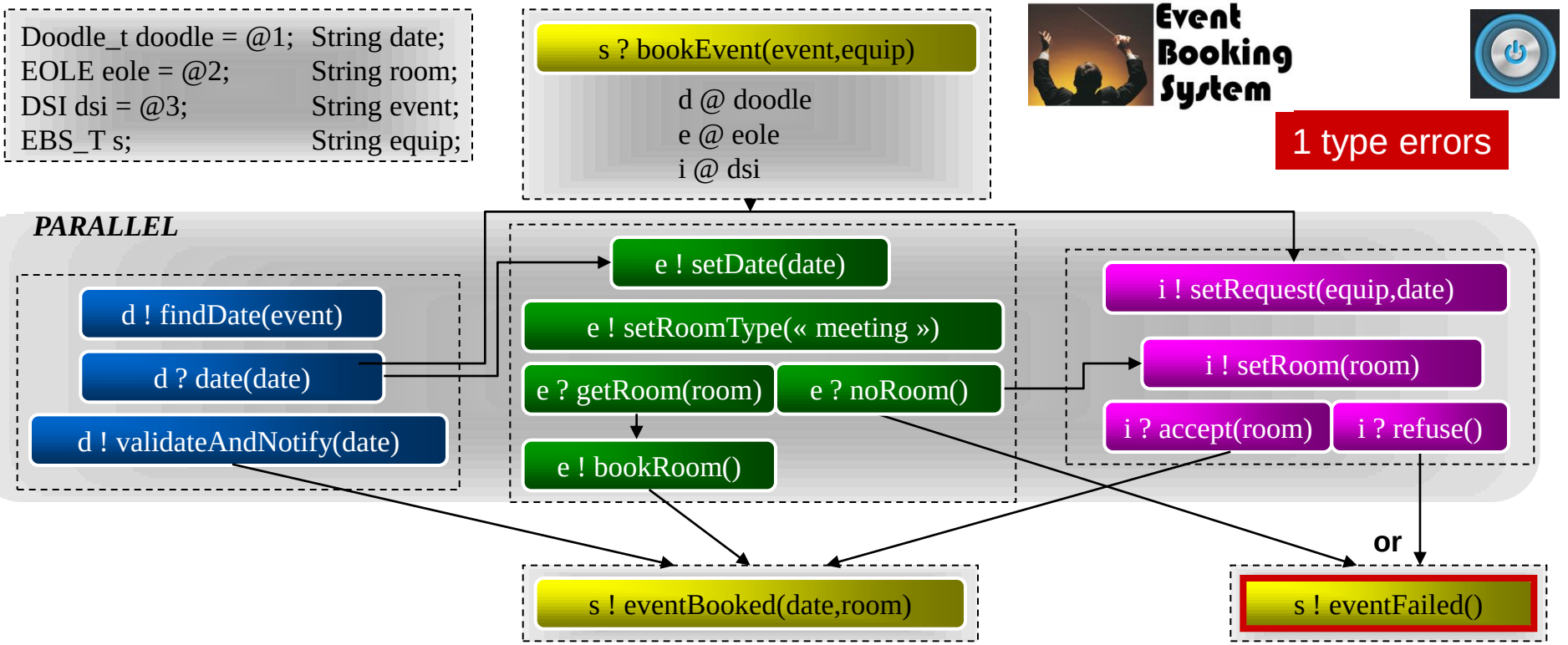
i ! setRoom(room)

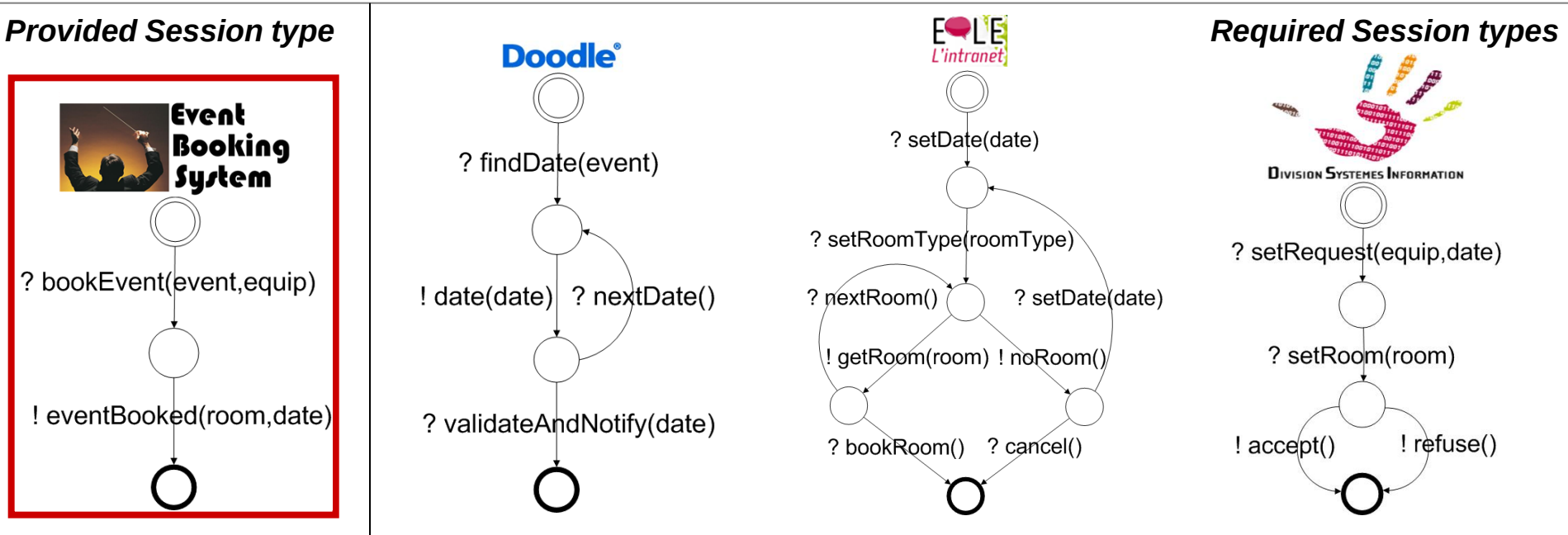
i ? accept(room) | i ? refuse()

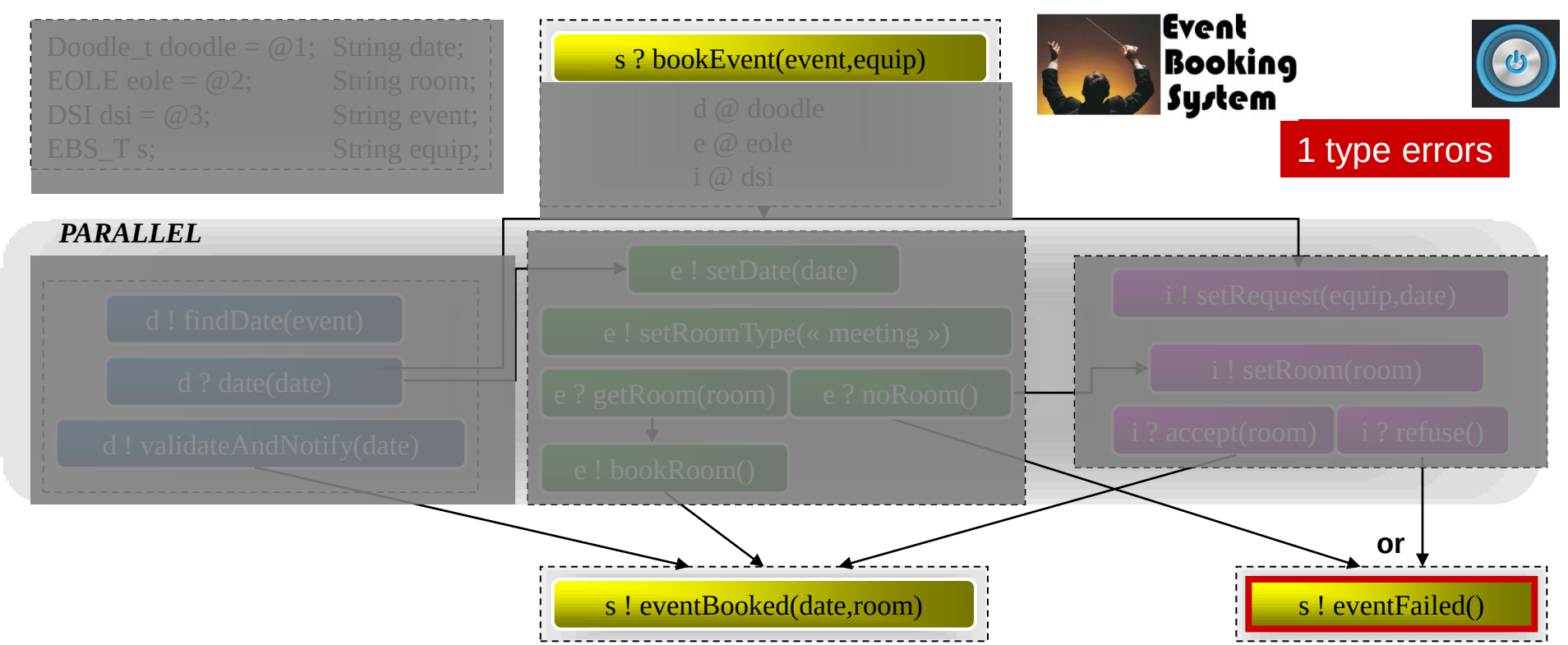
or

s ! eventBooked(date,room)

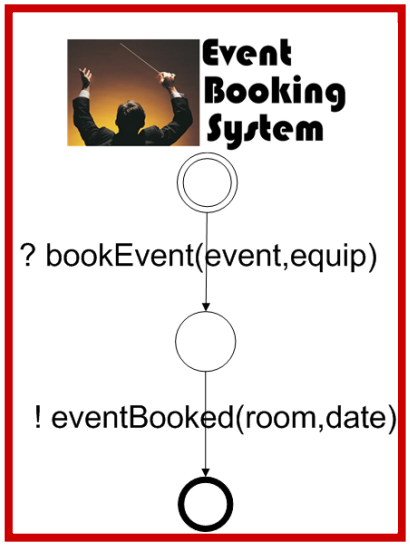
s ! eventFailed()


Doodle_t doodle = @1;
EOLE eole = @2;
DSI dsi = @3;
EBS_T s;
String date;
String room;
String event;
String equip;
s ? bookEvent(event,equip)
d @ doodle
e @ eole
i @ dsi
Event Booking System
1 type errors
PARALLEL
d ! findDate(event)
d ? date(date)
d ! validateAndNotify(date)
e ! setDate(date)
e ! setRoomType(« meeting »)
e ? getRoom(room)
e ? noRoom()
e ! bookRoom()
i ! setRequest(equip,date)
i ! setRoom(room)
i ? accept(room)
i ? refuse()
or
s ! eventBooked(date,room)
s ! eventFailed()


Provided Session type
Event Booking System
? bookEvent(event,equip)
! eventBooked(room,date)
Doodle
? findDate(event)
! date(date)
? nextDate()
? validateAndNotify(date)
EOLE L'intranet
? setDate(date)
? setRoomType(roomType)
? nextRoom()
? setDate(date)
! getRoom(room)
! noRoom()
? bookRoom()
? cancel()
Required Session types
Division Systemes Information
? setRequest(equip,date)
? setRoom(room)
! accept()
! refuse()

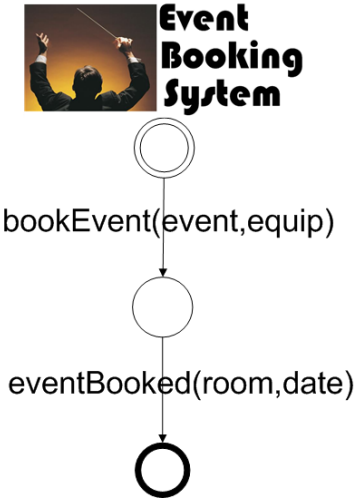


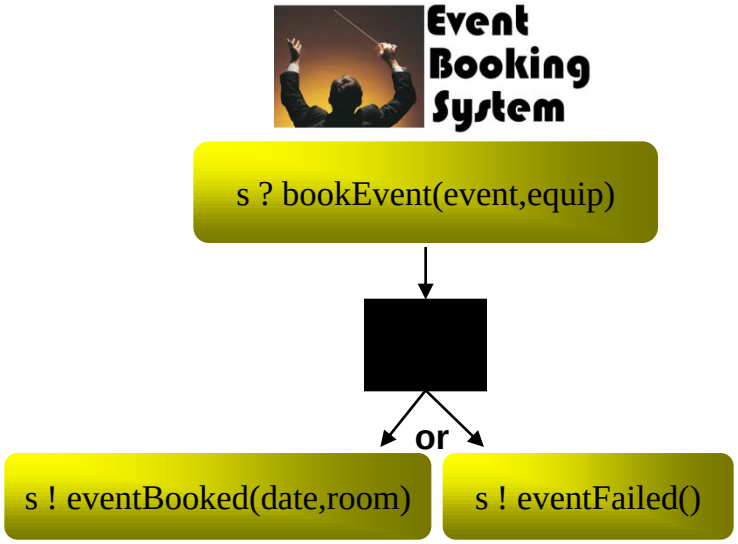
Provided Session type

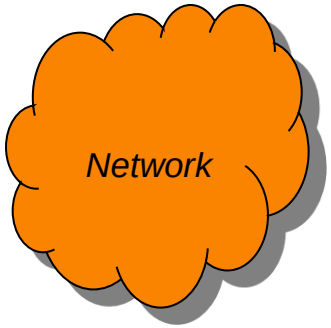


Web service client

b @ EBS
b ! bookEvent(« dbweb seminar », « laptop »)
b ? eventBooked(room,date)

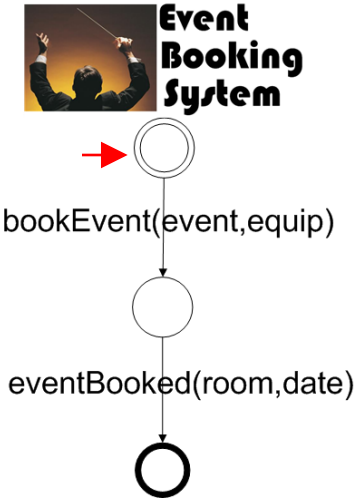


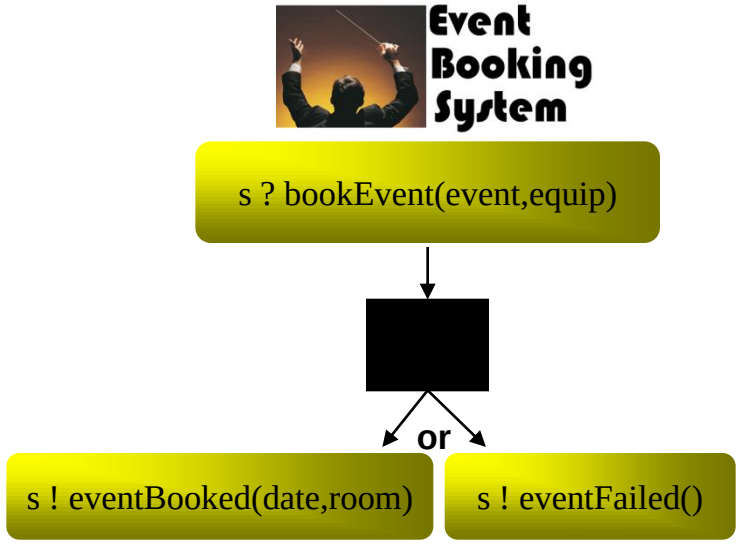




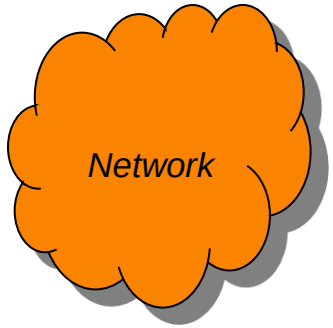
Web service client

b @ EBS
b ! bookEvent(« dbweb seminar », « laptop »)
b ? eventBooked(room,date)



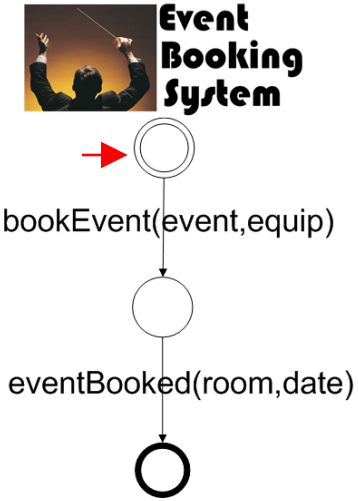


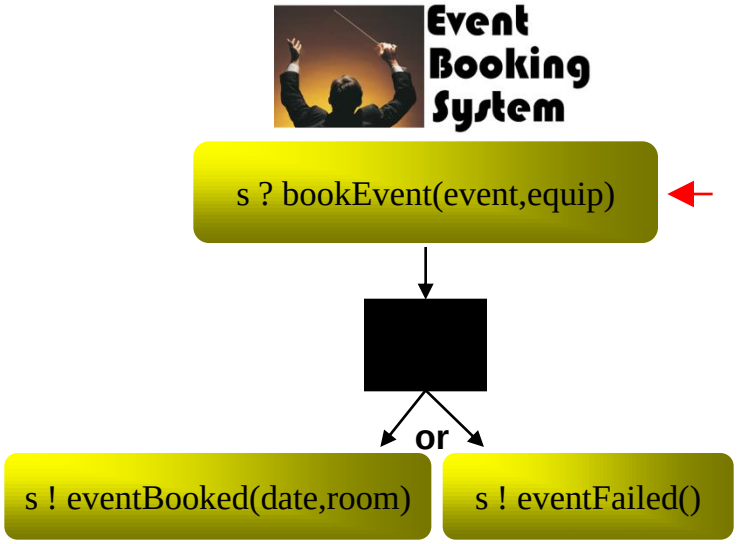
b @ EBS



Web service client

b @ EBS
b ! bookEvent(« dbweb seminar », « laptop »)
b ? eventBooked(room,date)





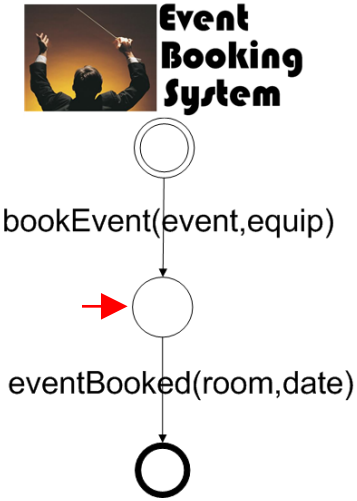
b @ EBS

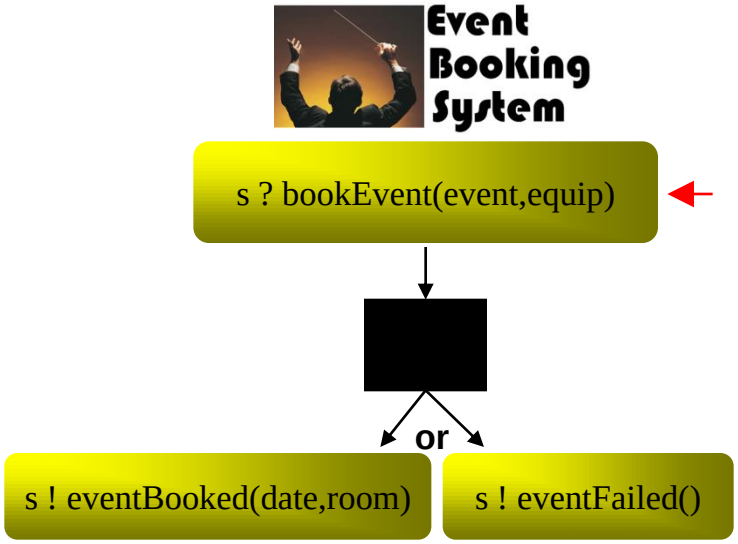
b @ EBS

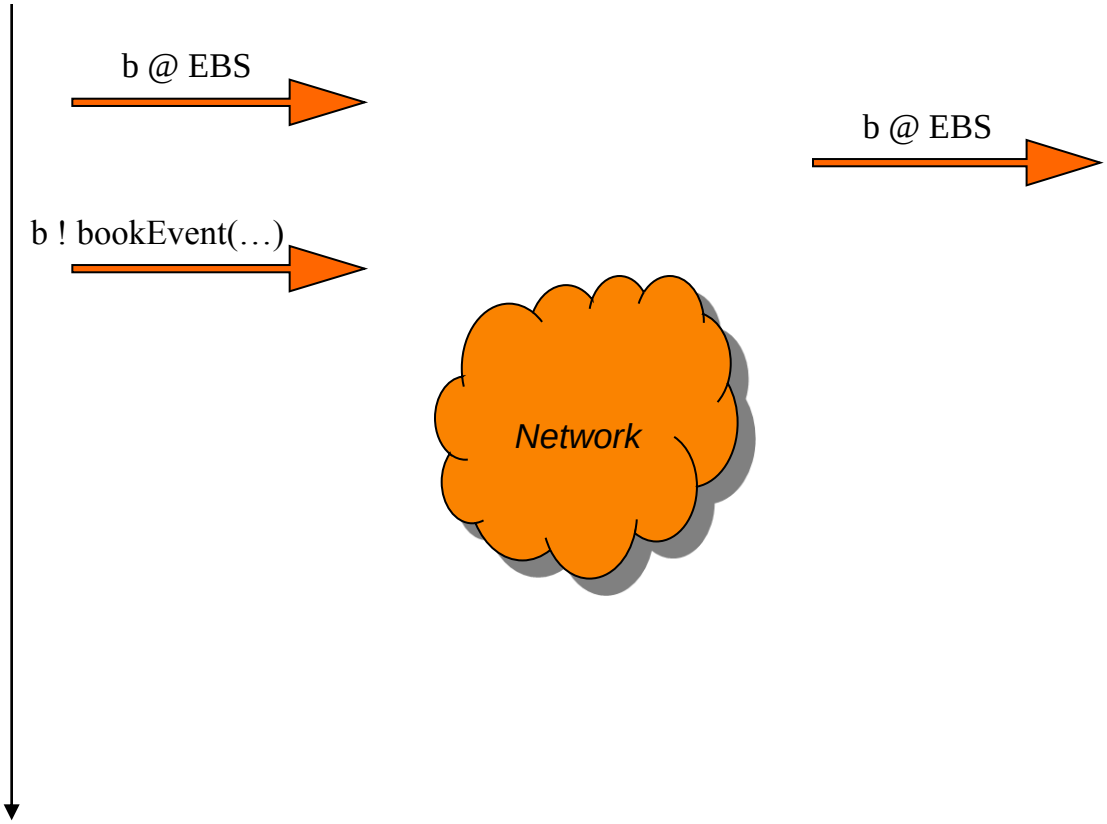
Network

Web service client

b @ EBS
b ! bookEvent(« dbweb seminar », « laptop »)
b ? eventBooked(room,date)

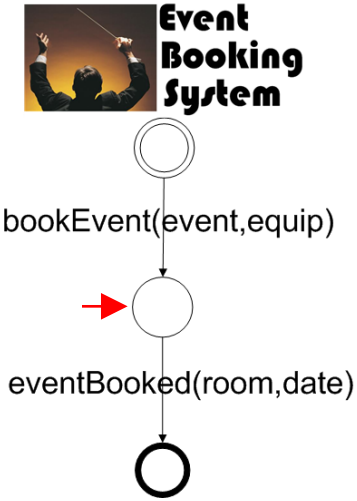


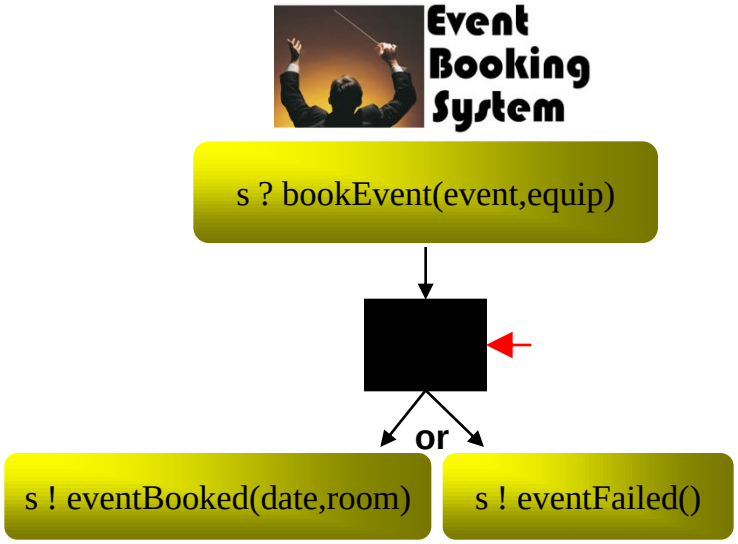


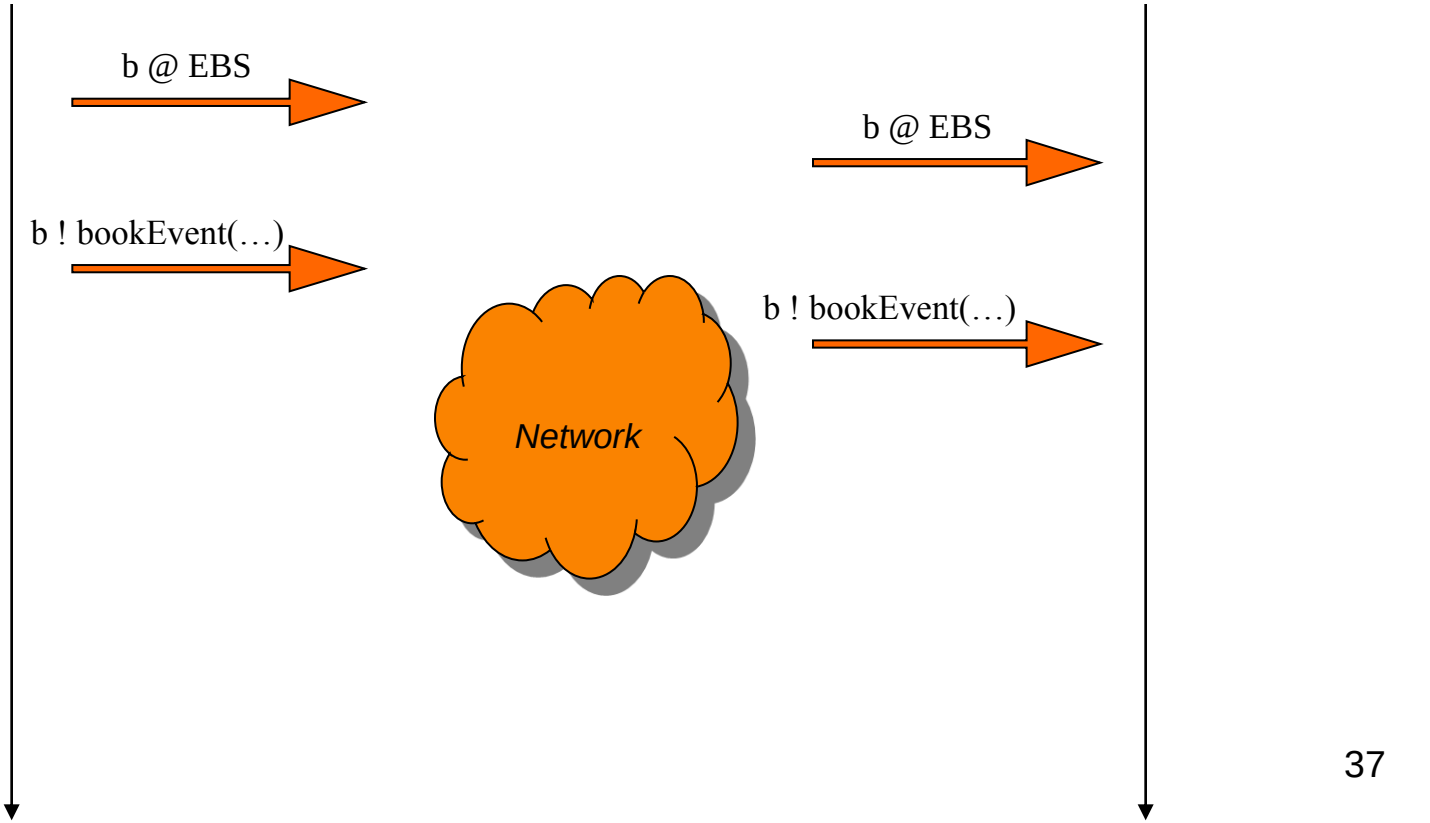


Web service client

b @ EBS
b ! bookEvent(« dbweb seminar », « laptop »)
b ? eventBooked(room,date)

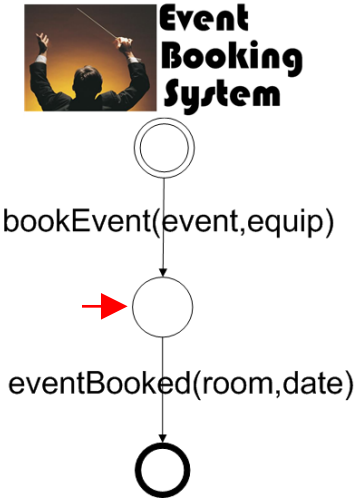


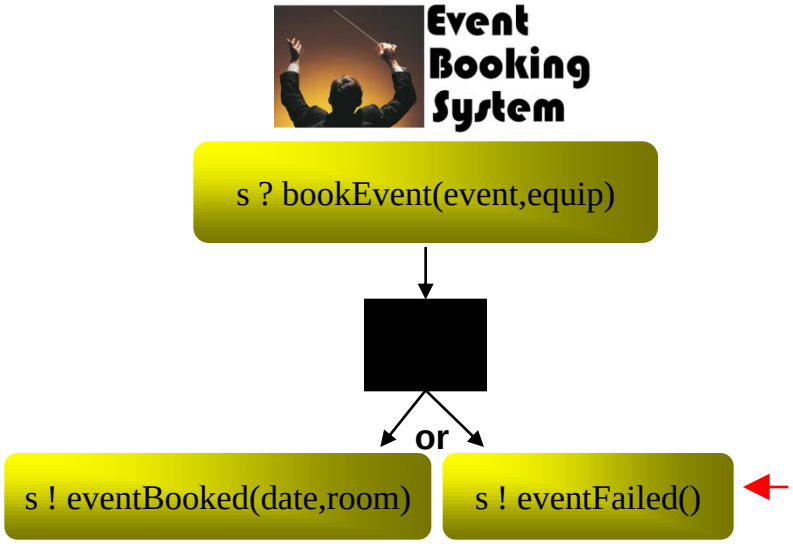


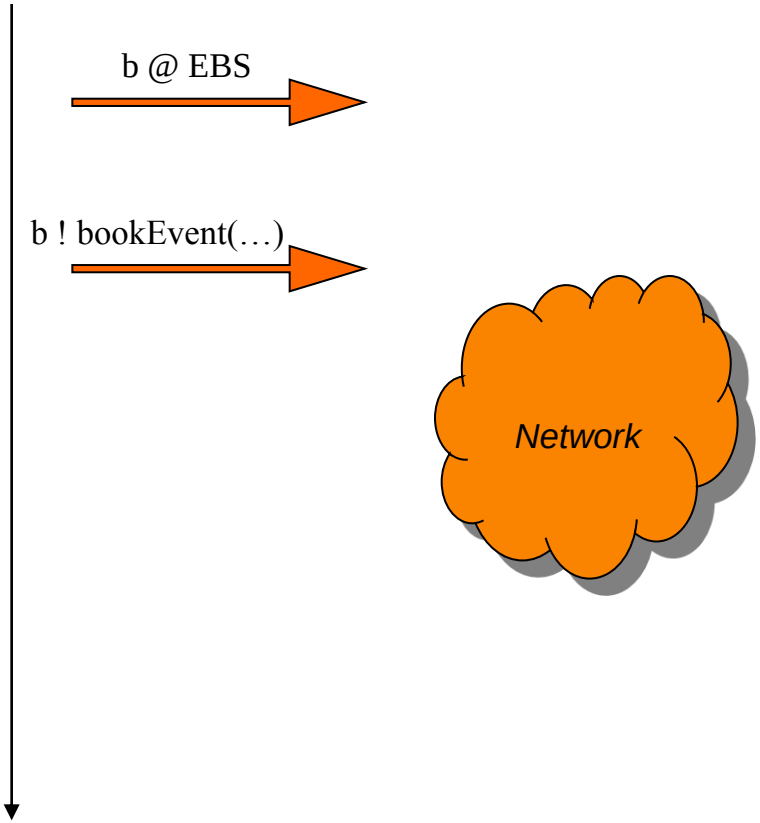


Web service client

b @ EBS
b ! bookEvent(« dbweb seminar », « laptop »)
b ? eventBooked(room,date)

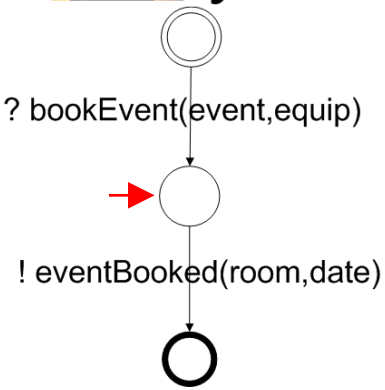


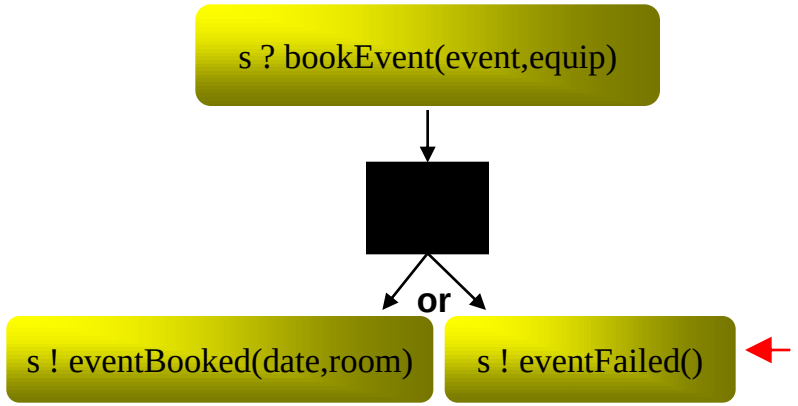


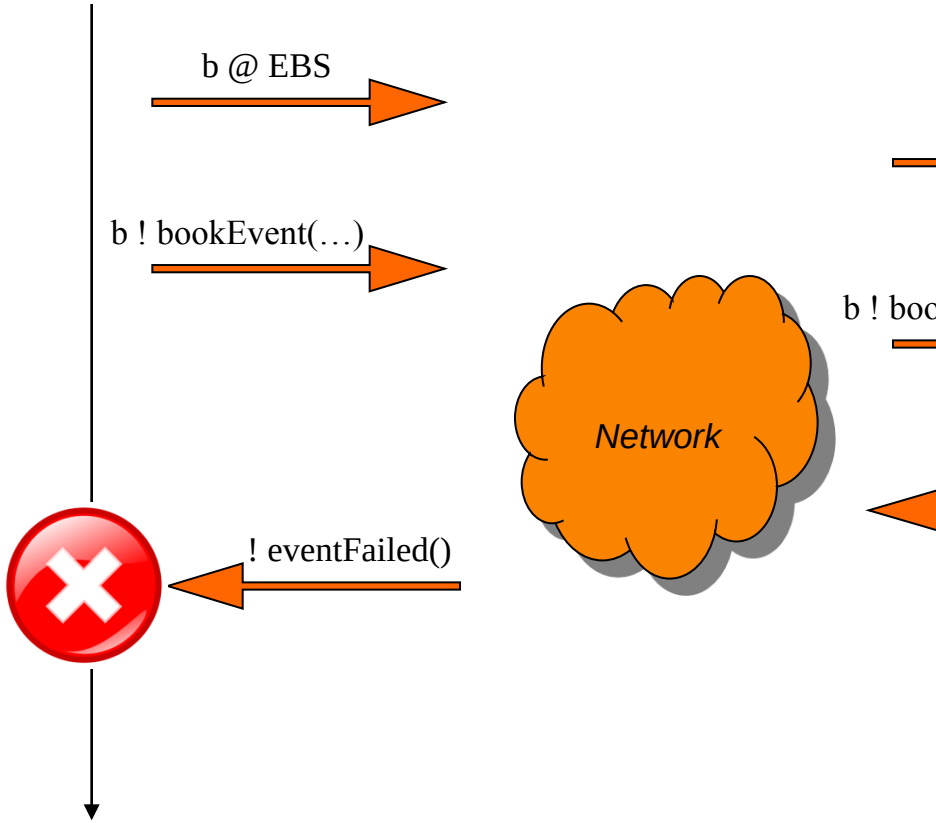


Web service client

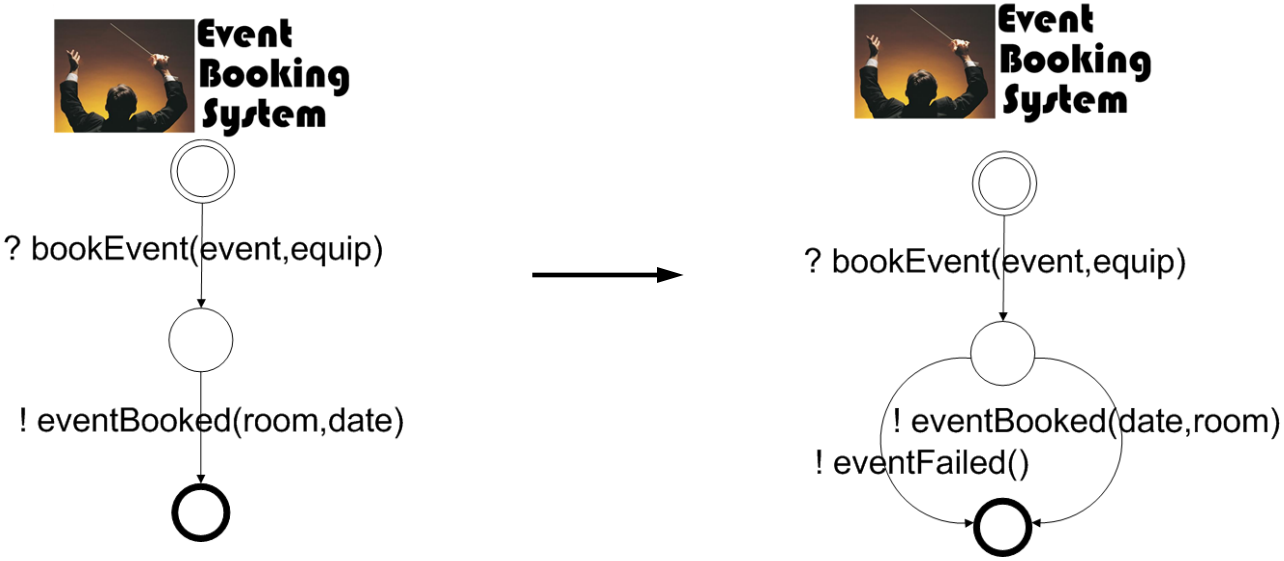
b @ EBS
b ! bookEvent(« dbweb seminar », « laptop »)
b ? eventBooked(room,date)

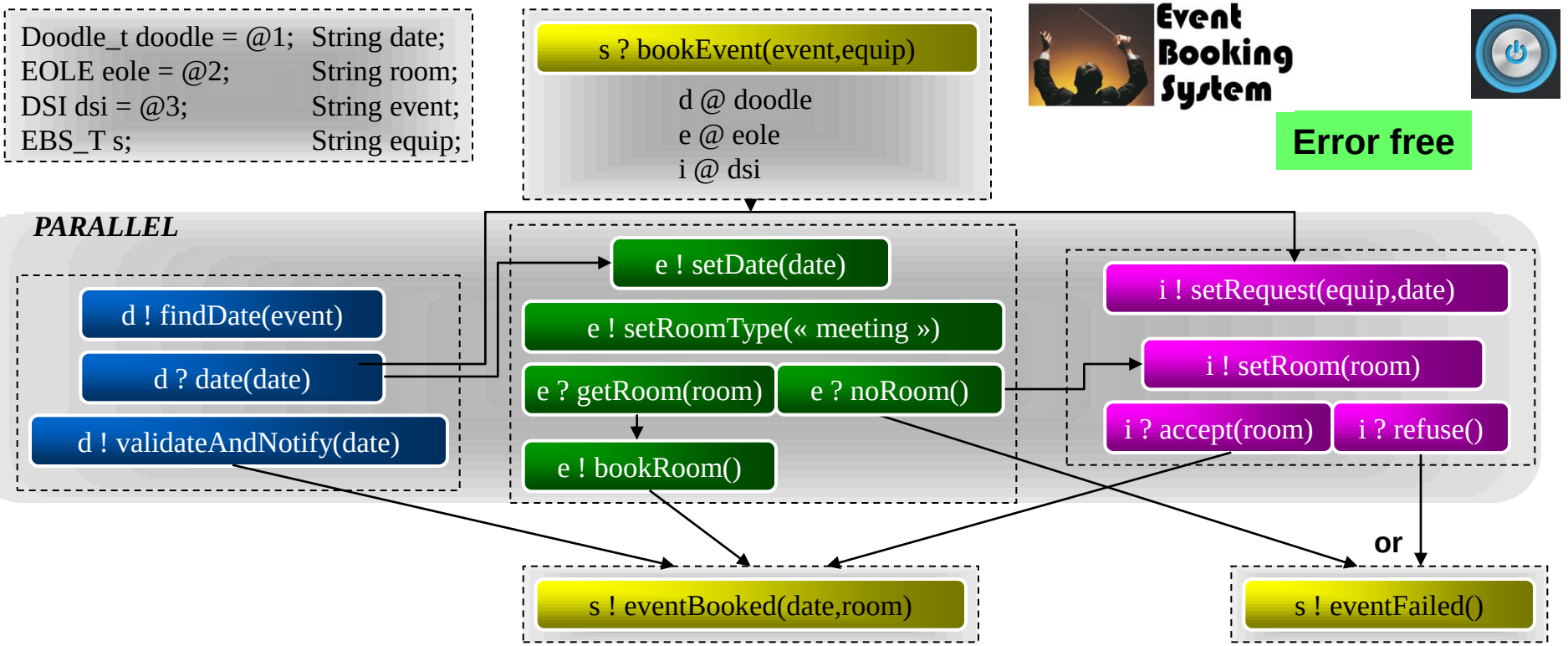




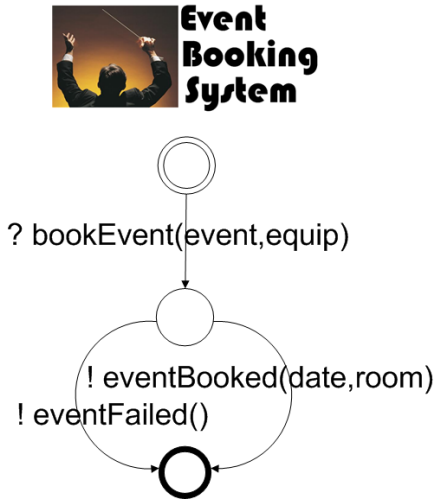


Solution:

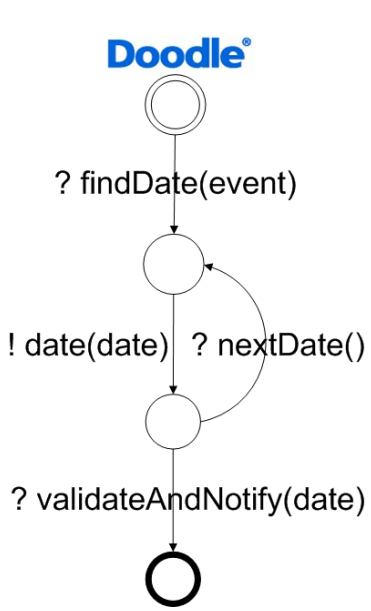

Event
Booking
System
? bookEvent(event,equip)
! eventBooked(room,date)
Event
Booking
System
? bookEvent(event,equip)
! eventBooked(date,room)
! eventFailed()

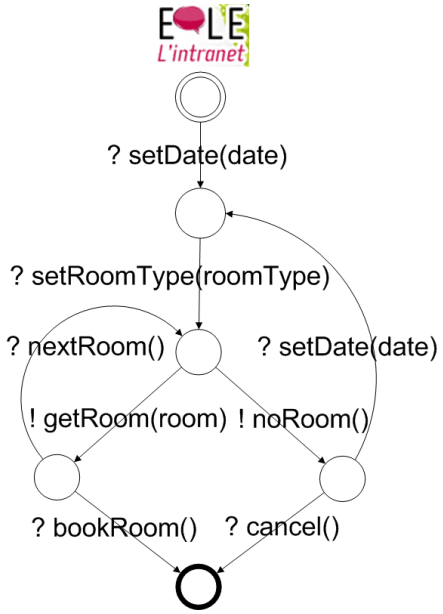


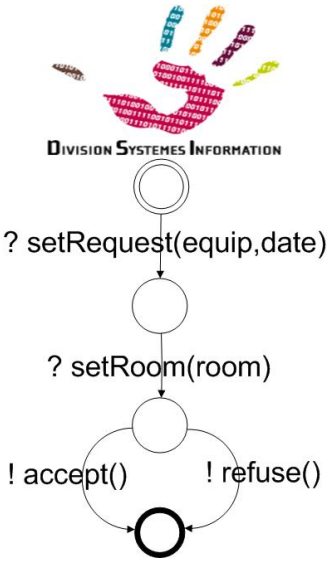
Provided Session type



Required Session types







Related work

- The language I presented is based on BPEL
  - Much work has gone into giving BPEL formal semantics, not an easy task
- The session paradigm is a vast topic that has warranted much attention recently
  - See “Language primitives and type discipline for structured communication-based programming” – Kohei Honda, Vasco T. Vasconcelos, Makoto Kubo.
  - Interesting extensions such as multiparty sessions

Main contributions

- A formal definition of an orchestration language
  - Based on BPEL
  - Novel semantics that capture important parts of BPEL compared to related work
- Behavioural typing extension
  - Session types are supported
- Main result: ***Theorem of interaction safety*** – *any well-typed configuration of services is interaction safe.*

Conclusion

- Web service orchestrations are value added compositions of existing services
- Orchestrations are prone to certain types of runtime errors
- Session-based programming is a new paradigm that can help to detect these errors before deployment
- **We can prove that if services correctly implement their session types, then the property of safe interaction is verified.**

Thank you for listening

Remember : ***Just sessionize it !***