Type-safe Communication in Java with Session Types

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Overview (1)

1. Background and Related Work.
2. Worked Example: Session Programming.
3. Runtime Support for Session Communication.
4. Conclusion and Future Work.

Session Types

- Type systems for process calculi:
  - Takeuchi et al. *An Interaction-based Language and its Typing System*. (1994)
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➢ Implementation of a practical, distributed language.

Implementation of Session Types

- Singularity OS:
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➢ Why use untyped sockets if we can use sessions?

Overview (2)

1. Background and Related Work.
2. Worked Example: Language Design.
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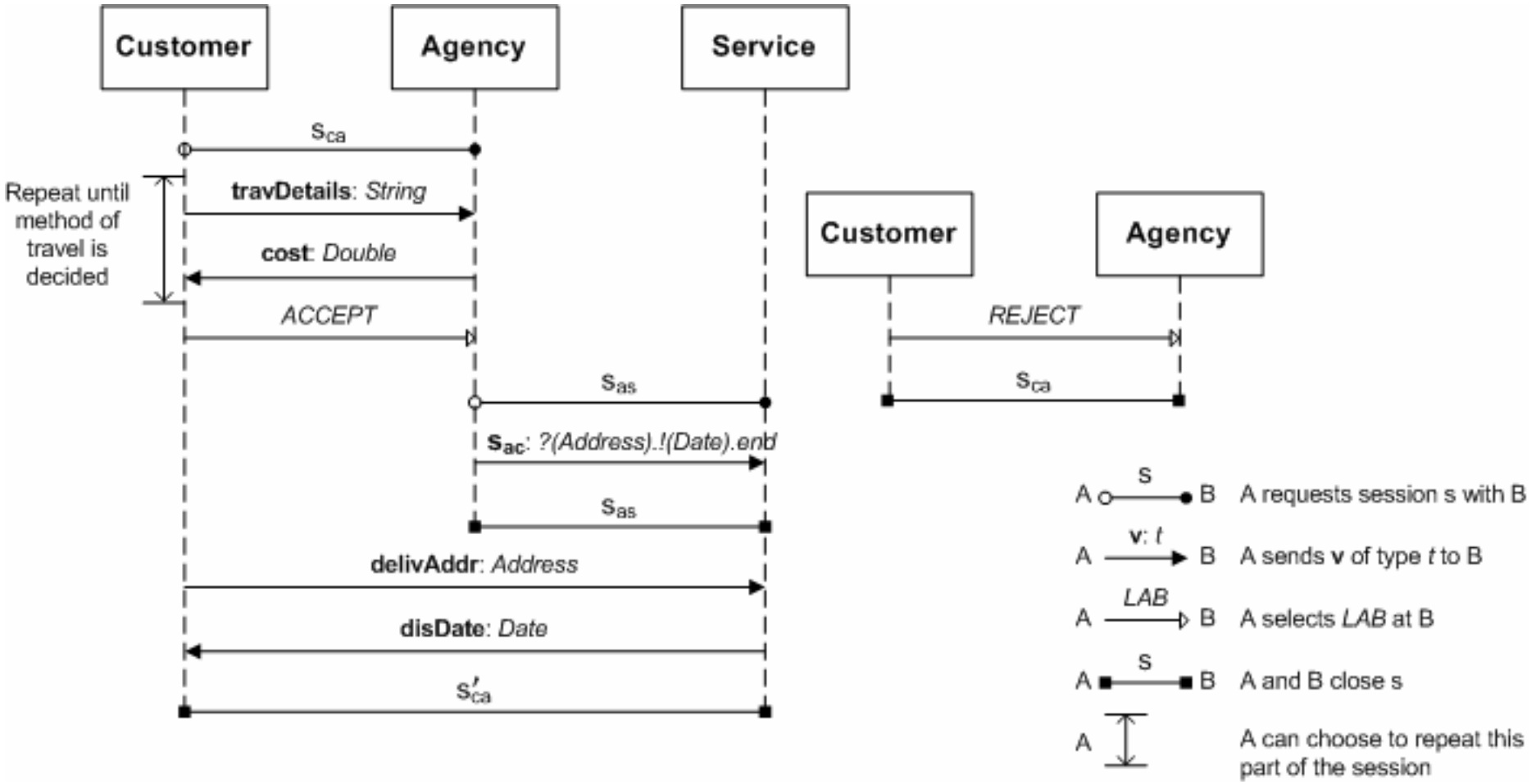
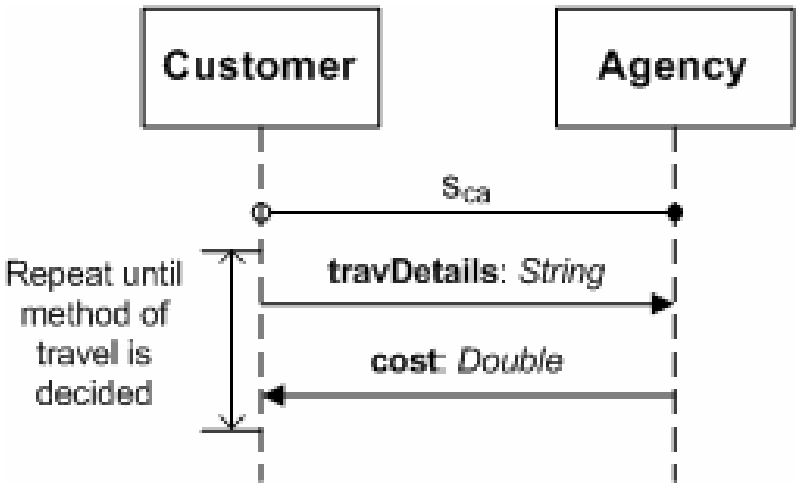
An Online Ticket Ordering System



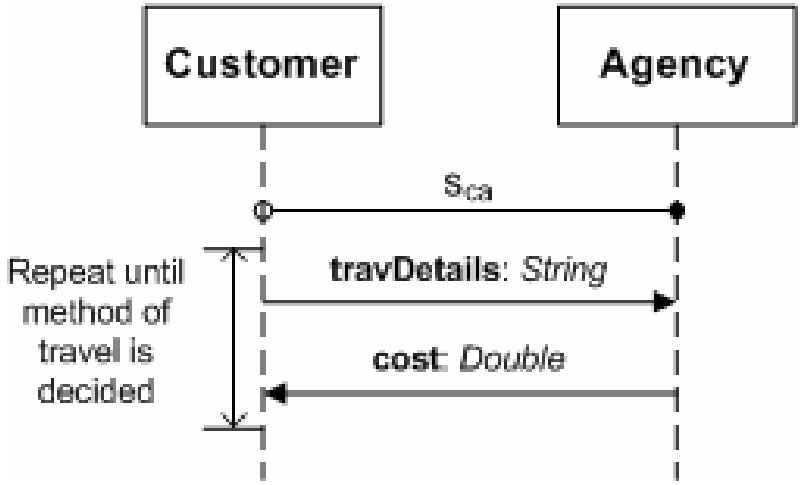
Protocol Specification (1)

```
begin
```



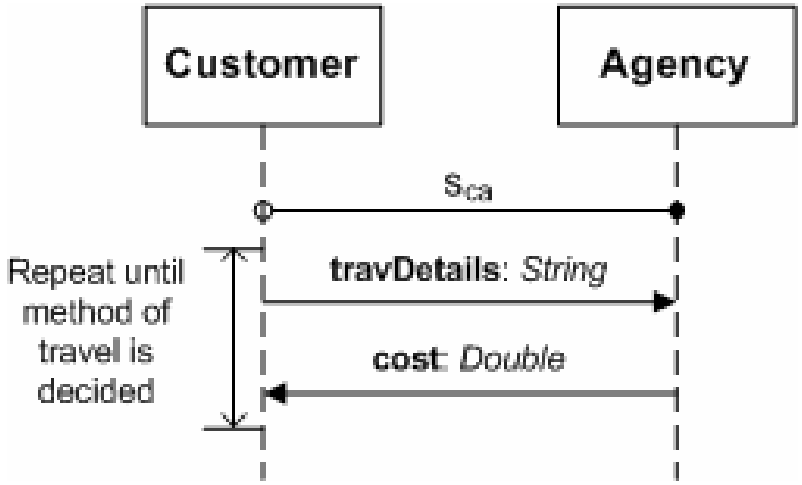
Protocol Specification (1)

```
begin.

  !(String)
```



Protocol Specification (1)

```
begin.

  !(String).
  ?(Double)
```



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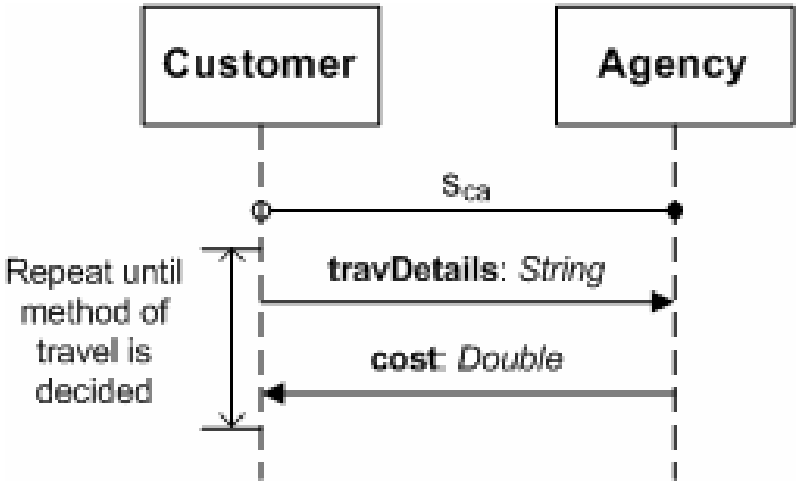

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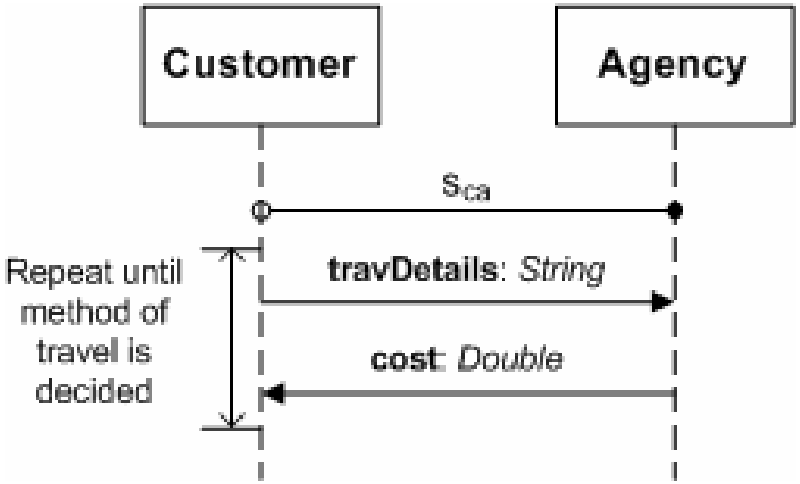


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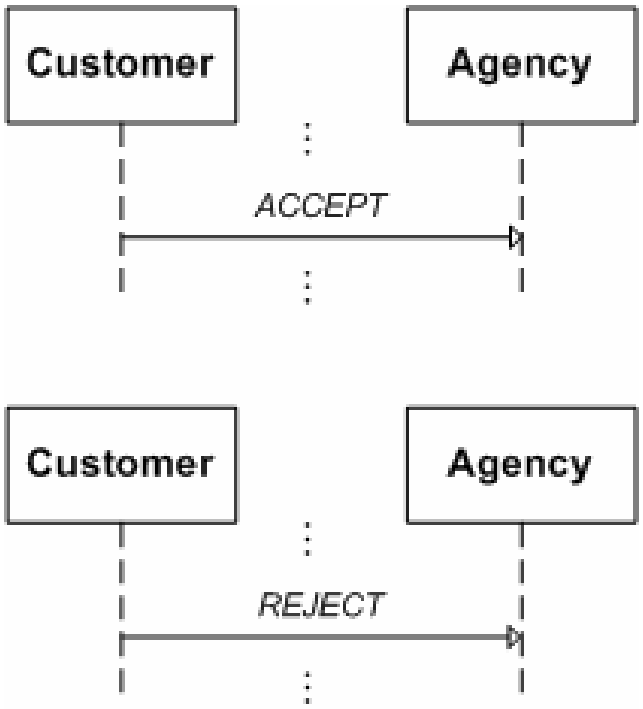
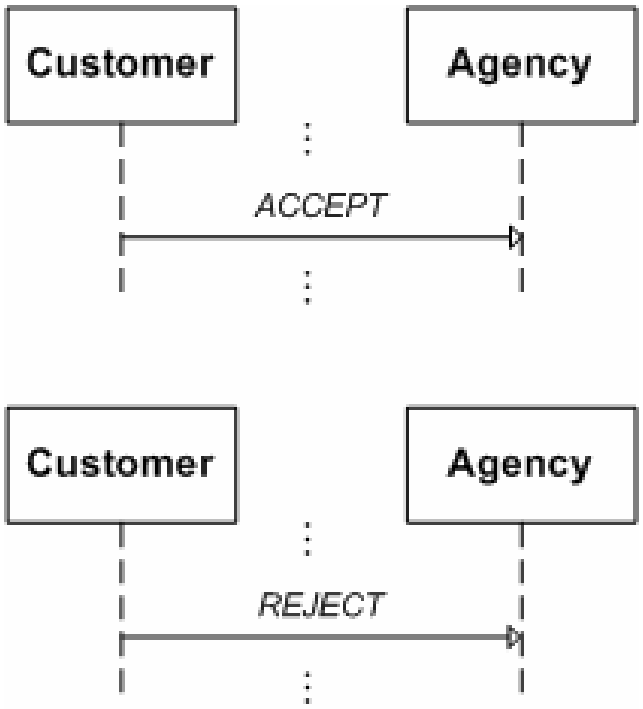
Protocol Specification (2)




```
...
?{

}.
...
```

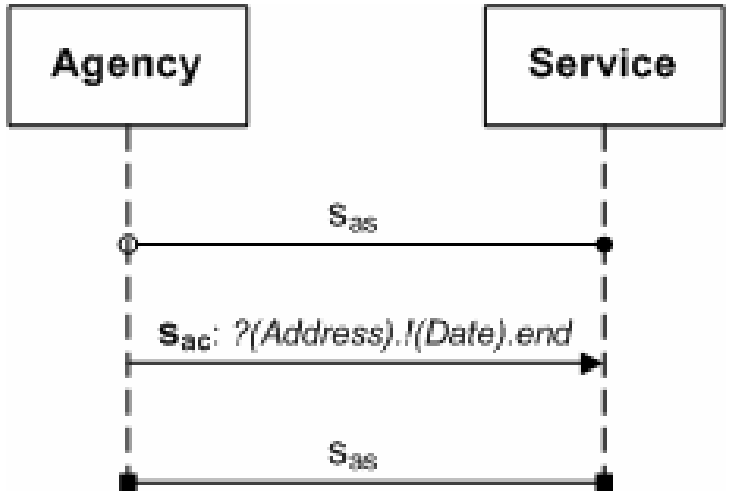
Protocol Specification (2)




```
…
?{
   ACCEPT:
         … ,

   REJECT:
         …
}.
…
```

Protocol Specification (3)

```
protocol p_as {



}
```



Protocol Specification (3)

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  begin.
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  end
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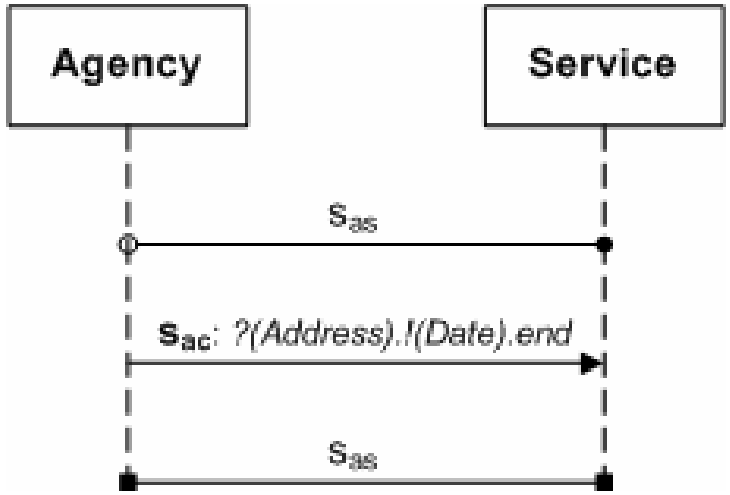
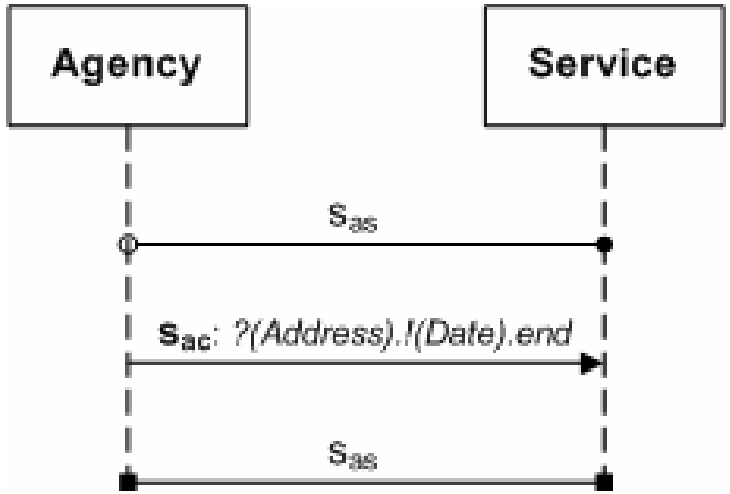


Protocol Specification (3)

```
protocol p_as {
  begin.
  !(
    ?(Address).!(Date).end
  ).
  end
}
```



Protocol Implementation (1)

```
protocol p_ca {
   begin.
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     ?(Double)
   ]*.
   …
```

```
// Customer
STSocket s_ca =
  STSocketImpl.create(p_ca);
```

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   ![
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```
// Customer
STSocket s_ca =
  STSocketImpl.create(p_ca);

s_ca.request(Agency, port);
```

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protocol p_ca {
   begin.
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   …
```

```
// Customer
STSocket s_ca =
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s_ca.request(Agency, port);
s_ca.outwhile(!decided) {




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// Customer
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  s_ca.send(travDetails);

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  cost =
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  decided = …;
}
```

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```

Protocol Implementation (2)

```
…
!{
  ACCEPT:
      … , // 1

  REJECT:
      … // 2
}
…
```

```
// Customer

  s_ca.select(ACCEPT) {
      … // 1
  }
```

Protocol Implementation (2)

```
…
!{
  ACCEPT:
      … , // 1

  REJECT:
      … // 2
}
…
```

```
// Customer
if(cost < 100.00) {
  s_ca.select(ACCEPT) {
      … // 1
  }
}
else {




}
```

Protocol Implementation (2)

```
…
!{
  ACCEPT:
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```

```
// Customer
if(cost < 100.00) {
  s_ca.select(ACCEPT) {
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}
else {
  s_ca.select(REJECT) {
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  }
}
```

Protocol Implementation (3)

```
…
?{
   ACCEPT:
        … , // 1'

   REJECT:
        … // 2'
}
…
```

```
// Agency

…
s_ac.branch() {




}
```

Protocol Implementation (3)

```
…
?{
  ACCEPT:
      … , // 1'

  REJECT:
      … // 2'
}
…
```

```
// Agency

…
s_ac.branch() {
  case ACCEPT: {
      … // 1'
  }
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  }
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```

Putting `Customer` Together

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finally {
   s_ca.close();
}
```

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Sessions over TCP

- Map session operations to `Socket` communications.
  - Preserve asynchrony.
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- Map session operations to `Socket` communications.
  - Preserve asynchrony.
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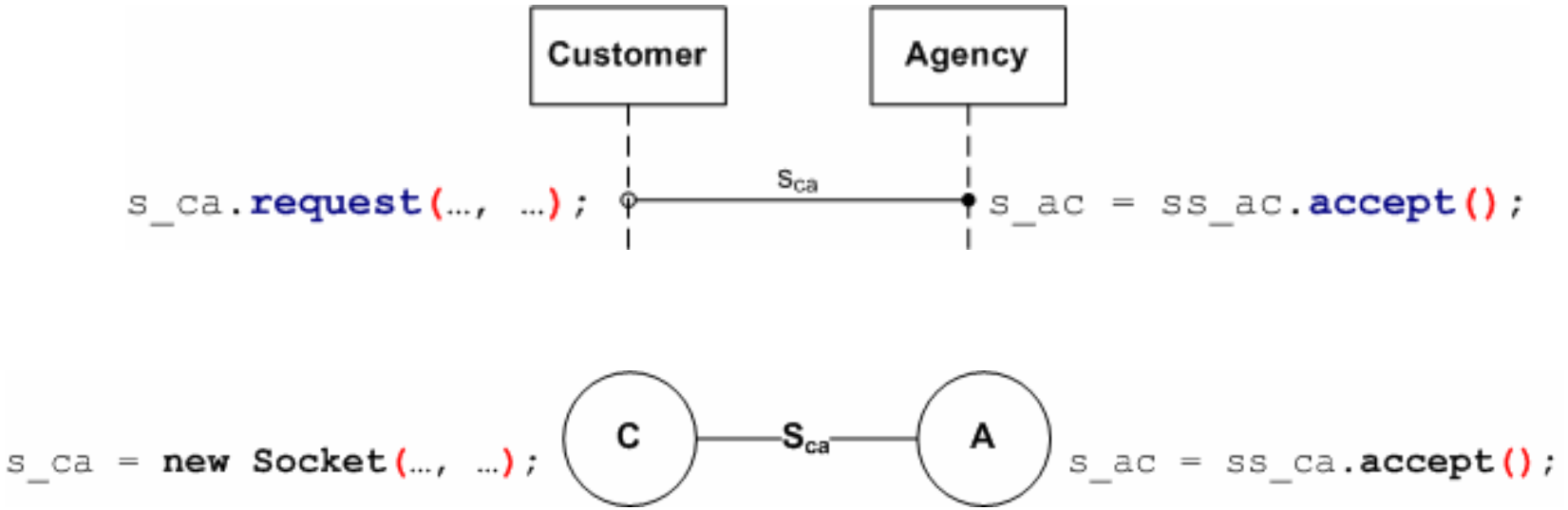
- Possible designs:
  - Proxy / Integrated runtime layer.
  - “Lost message” forwarding (cf. Mobile IP).
  - “Lost message” resending.

Session Initiation



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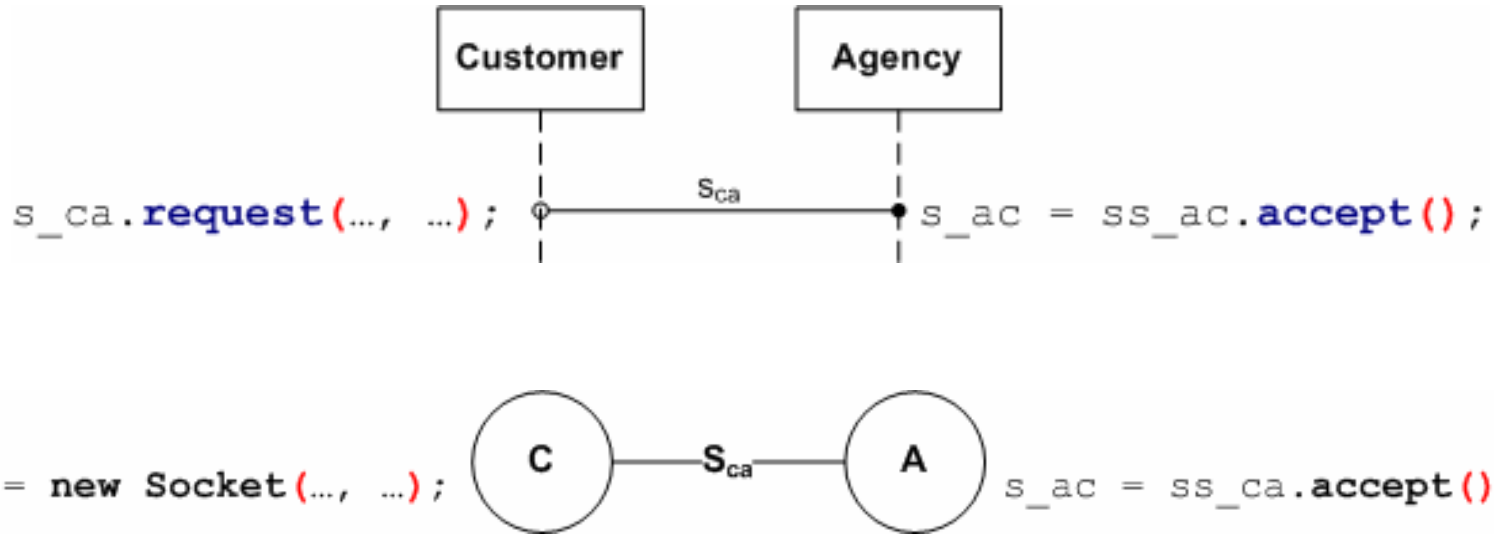
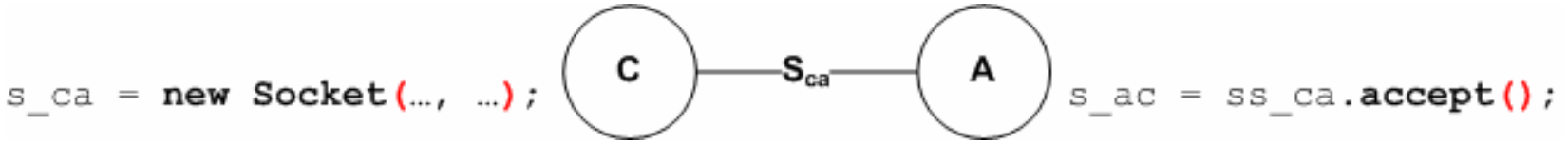


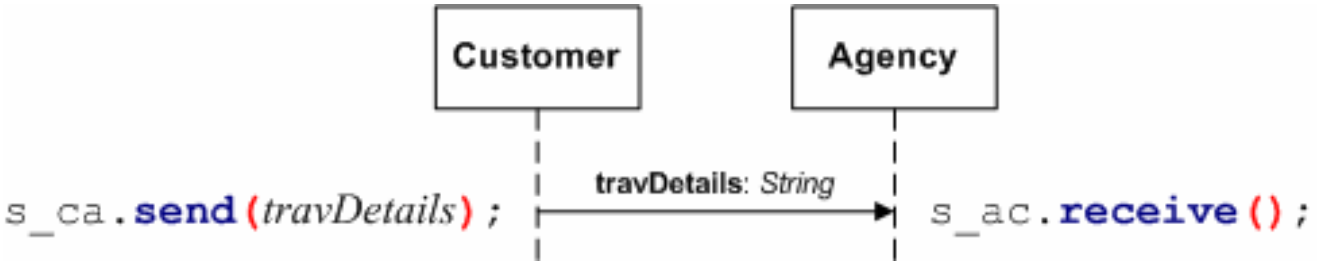
1. **C** → **A** : Type of intended session.

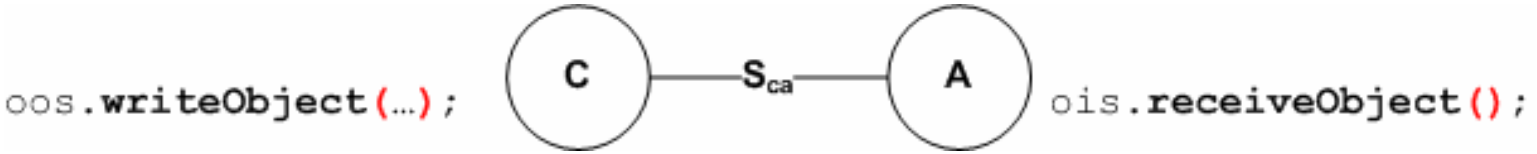
Session Initiation



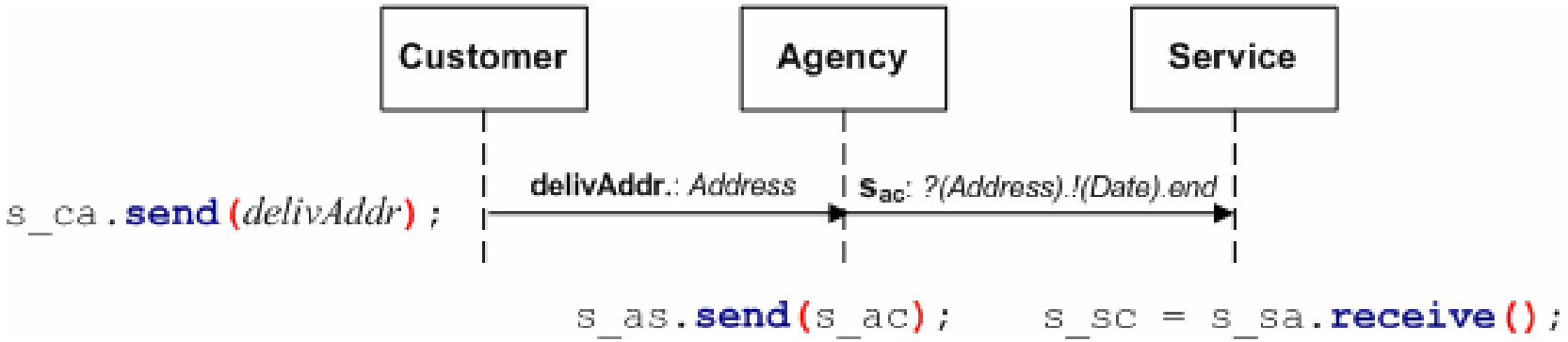
1. **C** → **A** : Type of intended session.
2. **A** → **C**: "YES" if types compatible, else "NO".

Session Communication

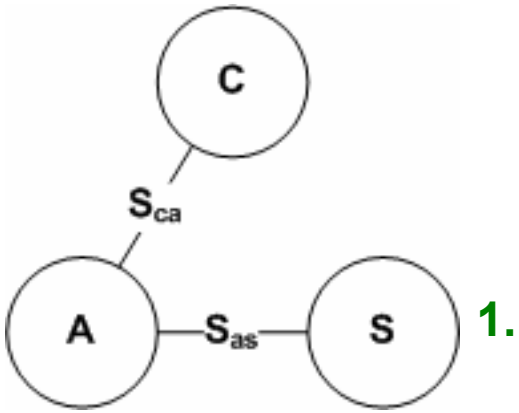




Session Delegation (1)

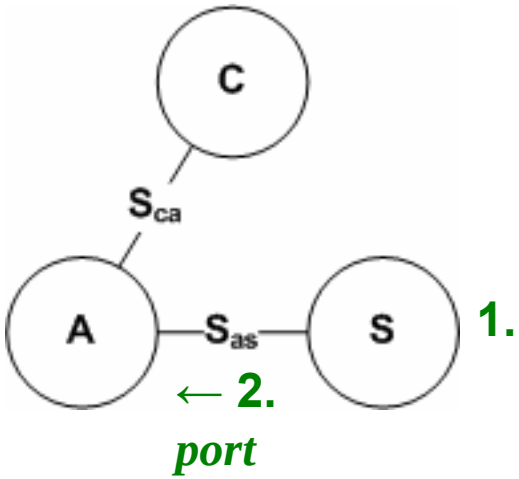


Session Delegation (2)



1. **S**: Create server socket on *port*.

Session Delegation (2)



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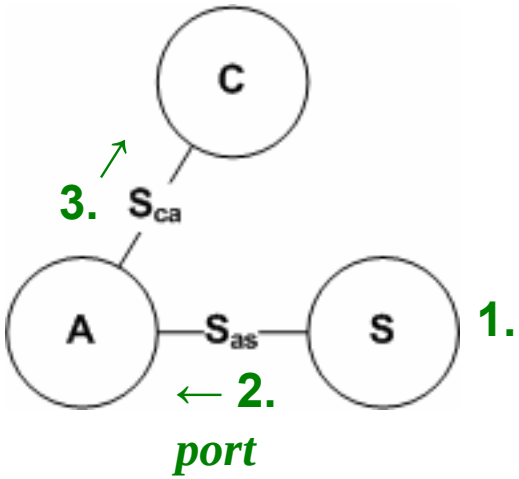
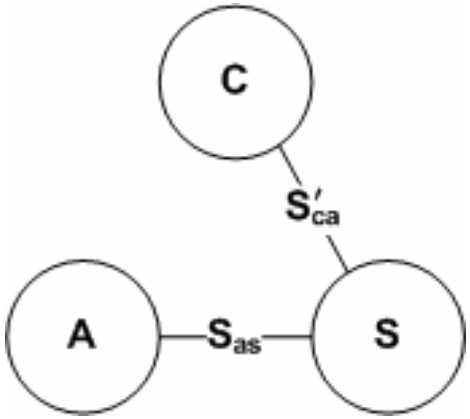


1.	**S**:	Create server socket on *port*.
2.	**S** → **A**:	*port*
3.	**A** → **C**:	IP_S, *port*, $\mathbf{ST_A(s_{ca})}$

Session Delegation (3)



4. **C**: Connect to IP_S: *port*.

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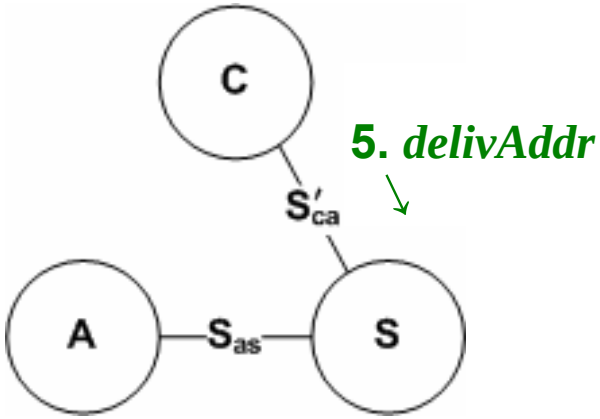

4. **C**: Connect to IP_S: *port*.
5. **C** → **S**: "Lost messages" according to $ST_A(s_{ca})$ - $ST_C(s_{ca})$.

Overview (4)

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Conclusion

- http://www/~rh105/sessiondj.html

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- Asynchrony and distribution.
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- Protocols for session initiation, delegation and close.
- Delegation protocol uses session type information.

Future Work

- Usability improvements (syntax, features, ...).
- Communication optimisations.

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- Performance evaluation.
- Associating session types to addresses.
- Class downloading and verification.
- Session exceptions.
- Alternative runtime designs.
- Sessions over alternative transports.

Session Exceptions (Poss. Design)

```
protocol p { begin.….end | X:….end | … }
STChannel c = new STChannel(…, p);
STSocket s = STSocketImpl.create(c);
try {
   try {
        s.request();
        …
   }
   catch(STIncompatibleSessionException ise) { }
   catch(s:X) { … }
   catch(…) { … }
}
catch(IOException ioe) { … }
finally { s.close(); }
```

Preliminary Results (1)

- For simple benchmark experiment, implemented:

```
begin . ![ ?( MyObject ) ]* . end
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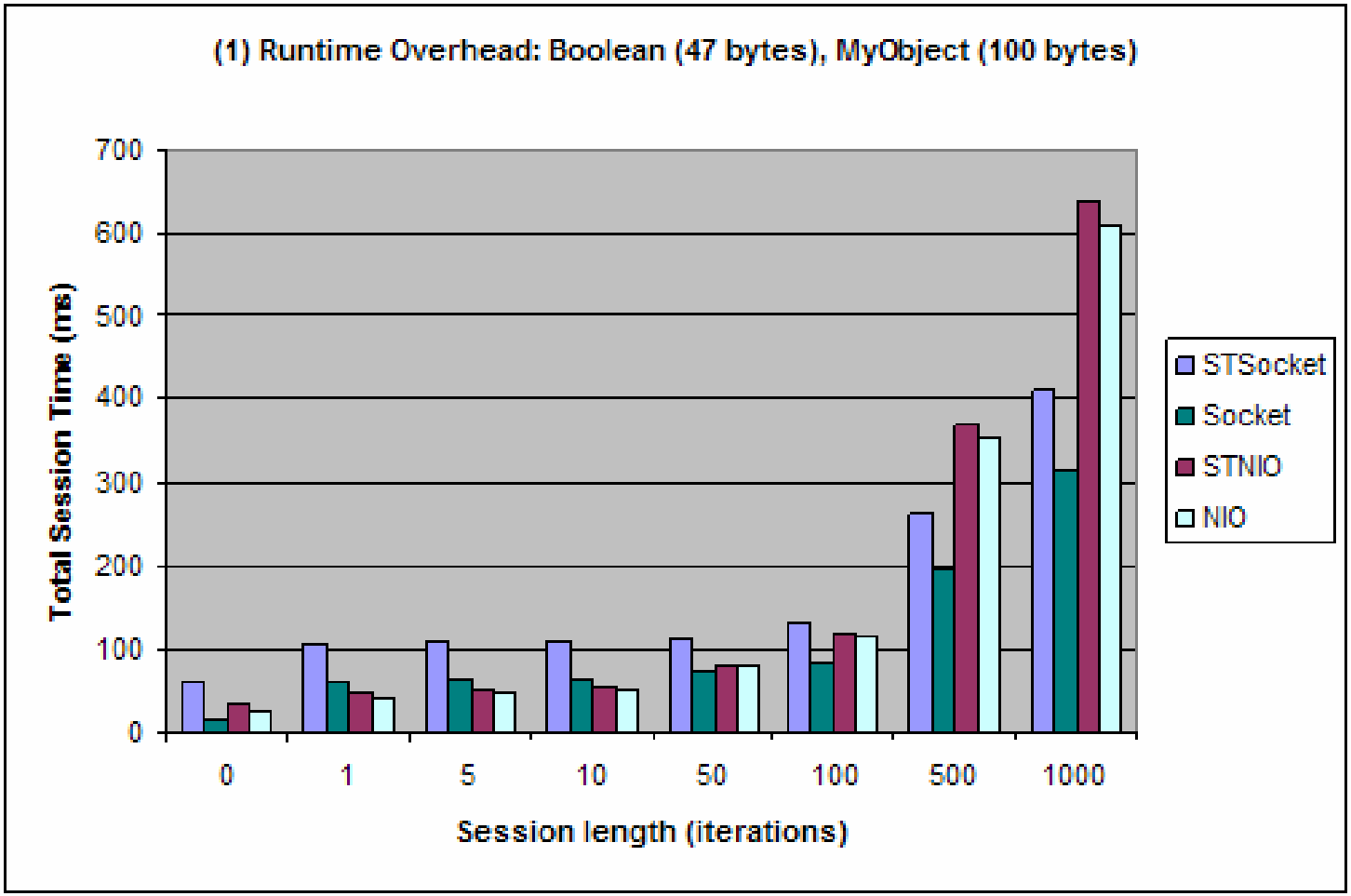
- Using:
  - STSocket and equivalent “Plain Socket”
  - STNIOSocket and equivalent “Plain SocketChannel”
  - RMI: `MyObject remoteMeth(Boolean bool)`

Preliminary Results (2)



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