Jolie Microservices and Choreographies for the Web

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Service-Oriented Programming

3 Commandments:

- Everything is a **service**;
- A service is an application that offers **operations**;
- A service can **invoke** another service by calling one of its operations.

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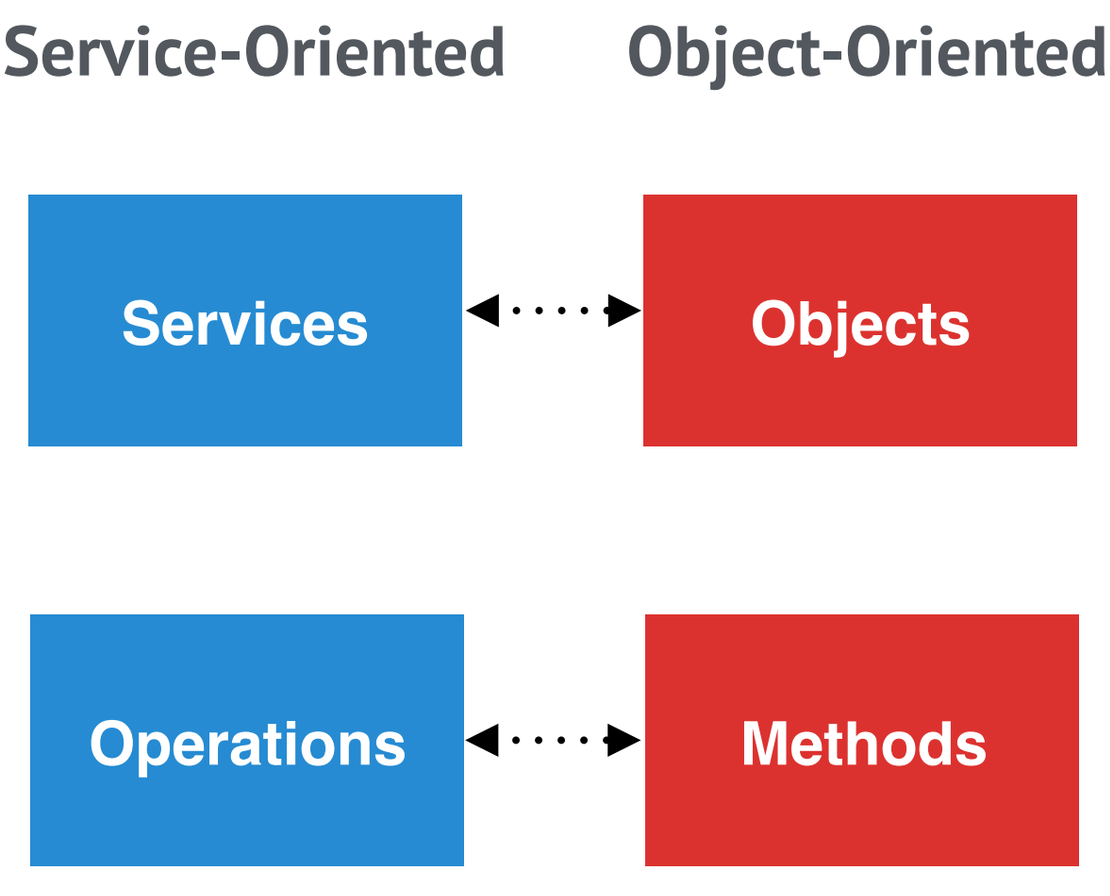
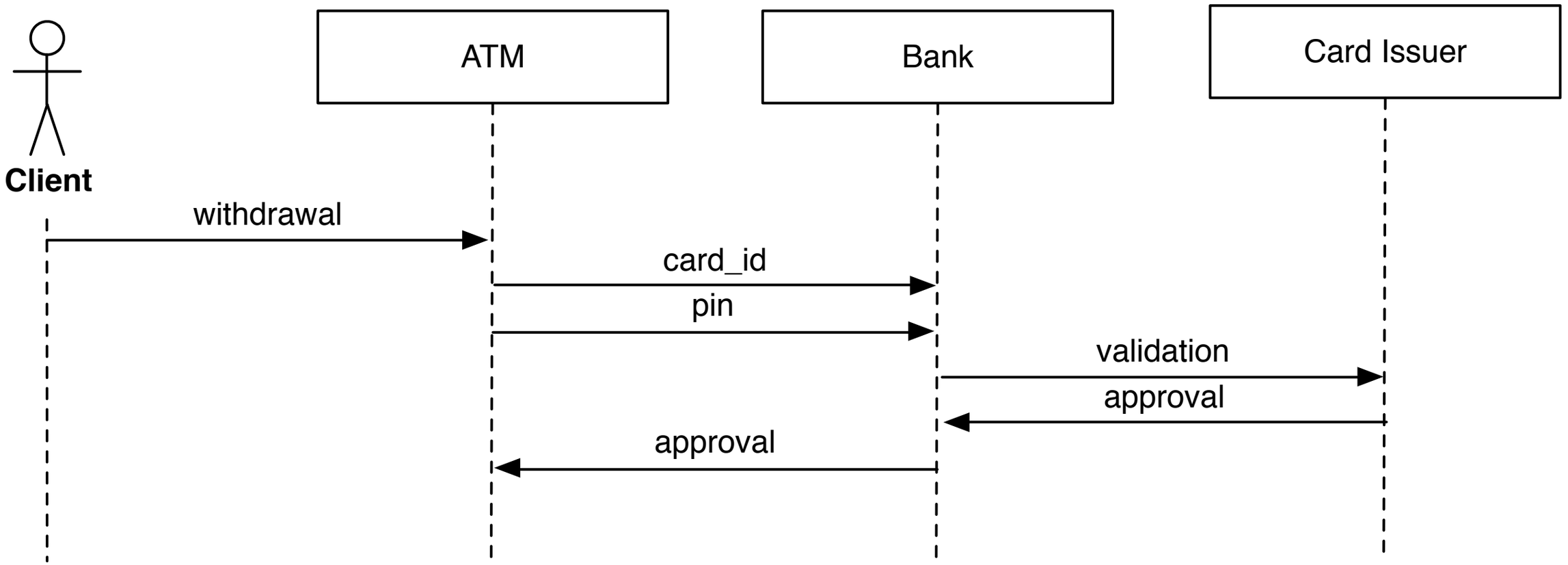
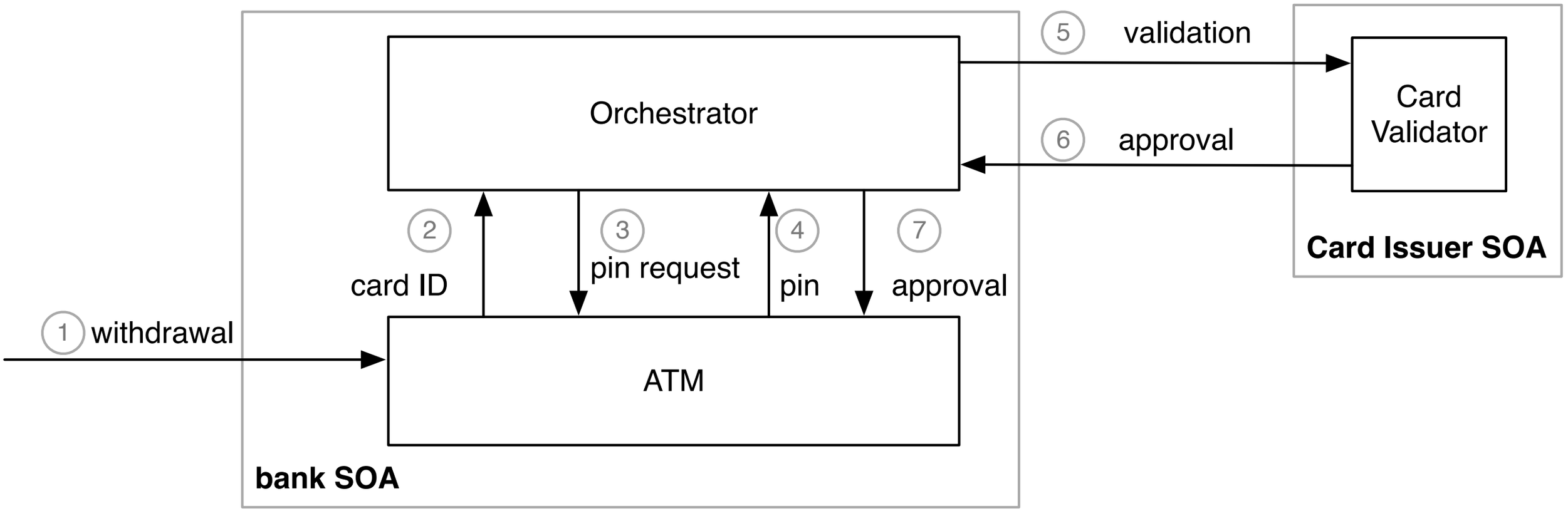
Recalling the Object-Oriented creed



A simple distributed system



Orchestration



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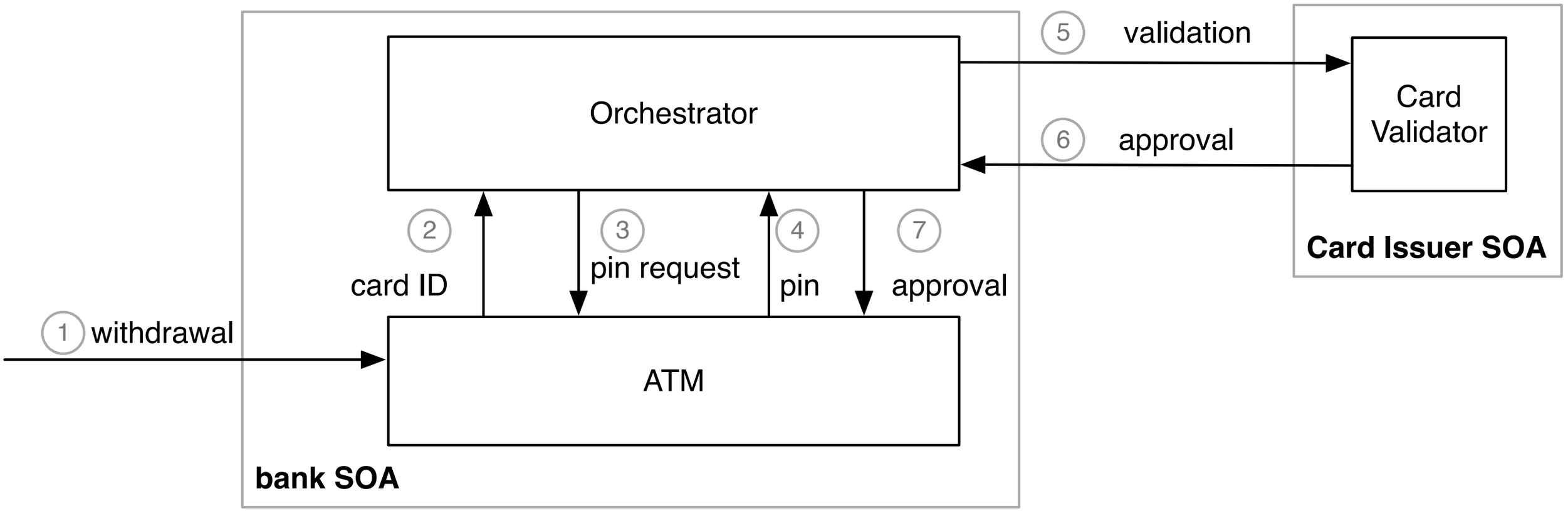

Process-Oriented

Why SOC and Jolie?

Need for languages that express complex compositions of services.

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Need for languages that express complex compositions of services.

But I already know Java!
Why shall I use Jolie?

Why SOC and Jolie?

```
SocketChannel socketChannel = SocketChannel.open();
  socketChannel.connect(
new InetSocketAddress("http://someurl.com", 80));
  Buffer buffer = . . .; // byte buffer
  while( buffer.hasRemaining() ) {
     channel.write( buffer );
}
```

Happy?

Why SOC and Jolie?

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SocketChannel socketChannel = SocketChannel.open();
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```

Happy?

Ok, but you did not even close the channel or handled exceptions

Why SOC and Jolie?

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  Buffer buffer = . . .; // byte buffer
  while( buffer.hasRemaining() ) {
    channel.write( buffer );
} }
catch( UnresolvedAddressException e ) { . . . }
catch( SecurityException e ) { . . . }
/* . . . many catches later . . . */
catch( IOException e ) { . . . }
finally { channel.close(); }
```

Happier now?

Why SOC and Jolie?

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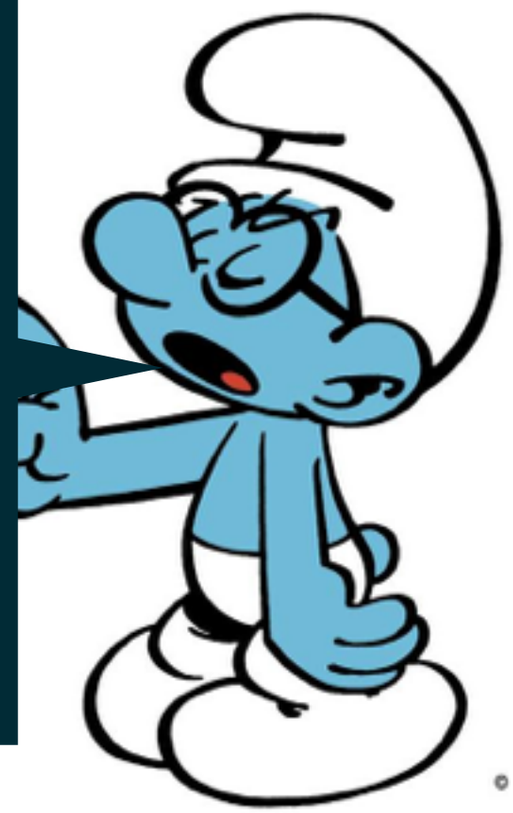
Happier now?

Yes, but what about the **server**?

Why SOC and Jolie?

```
Selector selector = Selector.open();
channel.configureBlocking(false);
SelectionKey key = channel.register(selector, SelectionKey.OP_READ);
while(true) {
  int readyChannels = selector.select();
  if(readyChannels == 0) continue;
  Set<SelectionKey> selectedKeys = selector.selectedKeys();
  Iterator<SelectionKey> keyIterator = selectedKeys.iterator();
  while(keyIterator.hasNext()) {
    SelectionKey key = keyIterator.next();
    if(key.isAcceptable()) {
        // a connection was accepted by a ServerSocketChannel.
    } else if (key.isConnectable()) {
        // a connection was established with a remote server.
    } else if (key.isReadable()) {
        // a channel is ready for reading
    } else if (key.isWritable()) {
        // a channel is ready for writing
    }
    keyIterator.remove();
  }
}
```

Here you are



Why SOC and Jolie?

Well, ok, but again, you are not **handling exceptions**.
And what about if **different operations** use the **same channel**?
And if we wanted to use **RMIs** instead of **Sockets**?
In what **format** are you transmitting data? And if we need to **change** the **format** after we wrote the application? Do you **check** the **type of data** you receive/send?

Why SOC and Jolie?

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Why SOC and Jolie?

Programming distributed systems is usually harder than programming non distributed ones.

Concerns of **concurrent** programming.

Plus (not exhaustive):

- handling **communications**;
- handling **heterogeneity**;
- handling **faults**;
- handling the **evolution** of systems.


Jolie

A **Service-Oriented Orchestration** Programming Language

Resources | **Online**

- Official Website:
  - **http://www.jolie-lang.org**
- Official Docs:
  - **http://docs.jolie-lang.org**
- Official Codebase:
  - **https://github.com/jolie/jolie**

Hello World! in Jolie

"Hello World!" is enough to let you see some of the main features of Jolie and Service-Oriented Programming.

```
include "console.iol"

main
{
  println@Console( "Hello, world!" )()
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program entry point

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Include a service

program entry point

operation

service

A more interesting example

```
interface MyInterface {
  OneWay: sendNumber( int )
}
```

A

B

```
include "MyInterface.iol"
outputPort  B  {
Location:
   "socket://localhost:8000"
Protocol: sodep
Interfaces: MyInterface
}

main
{
   sendNumber @ B ( 5 )
}
```

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include "MyInterface.iol"
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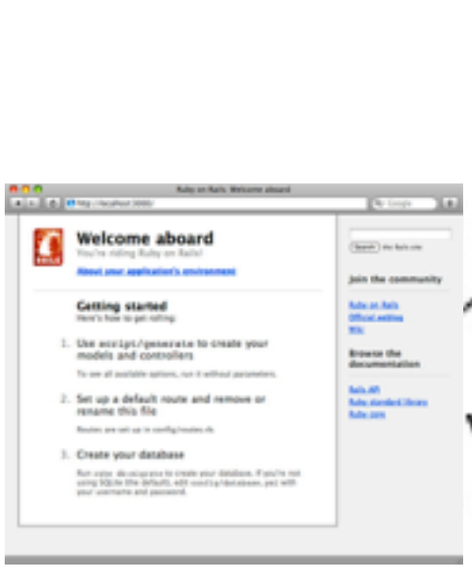
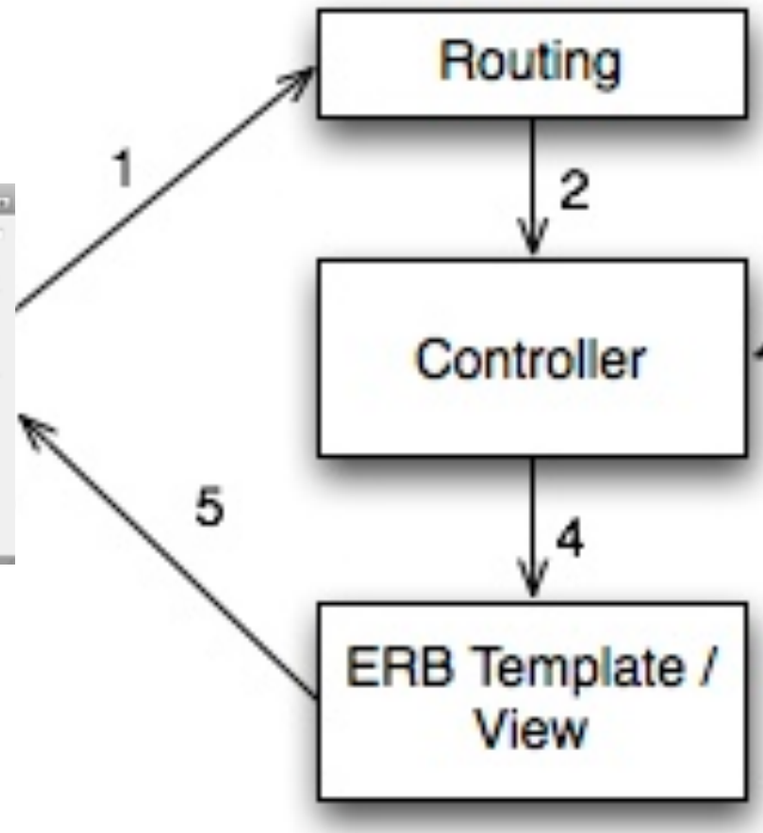
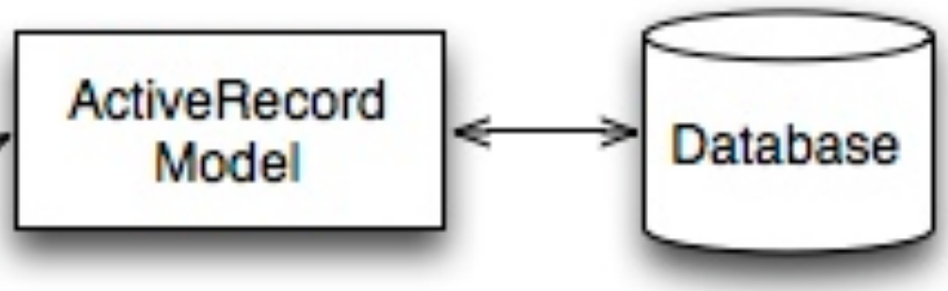
Can service-orientation aid web programming?

SOC already snuck into web programming

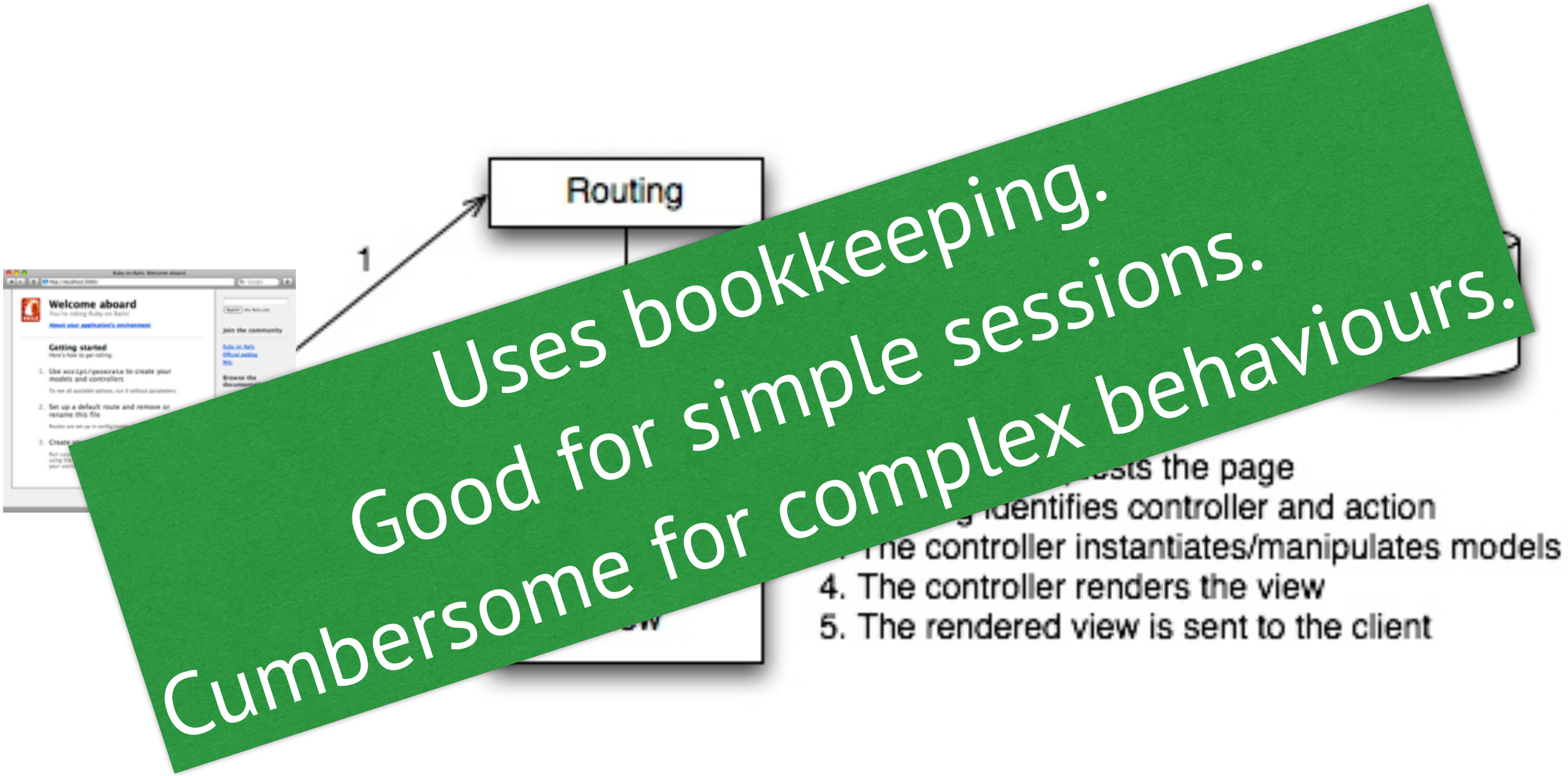






1. The Client requests the page
2. Routing identifies controller and action
3. The controller instantiates/manipulates models
4. The controller renders the view
5. The rendered view is sent to the client

SOC already snuck into web programming



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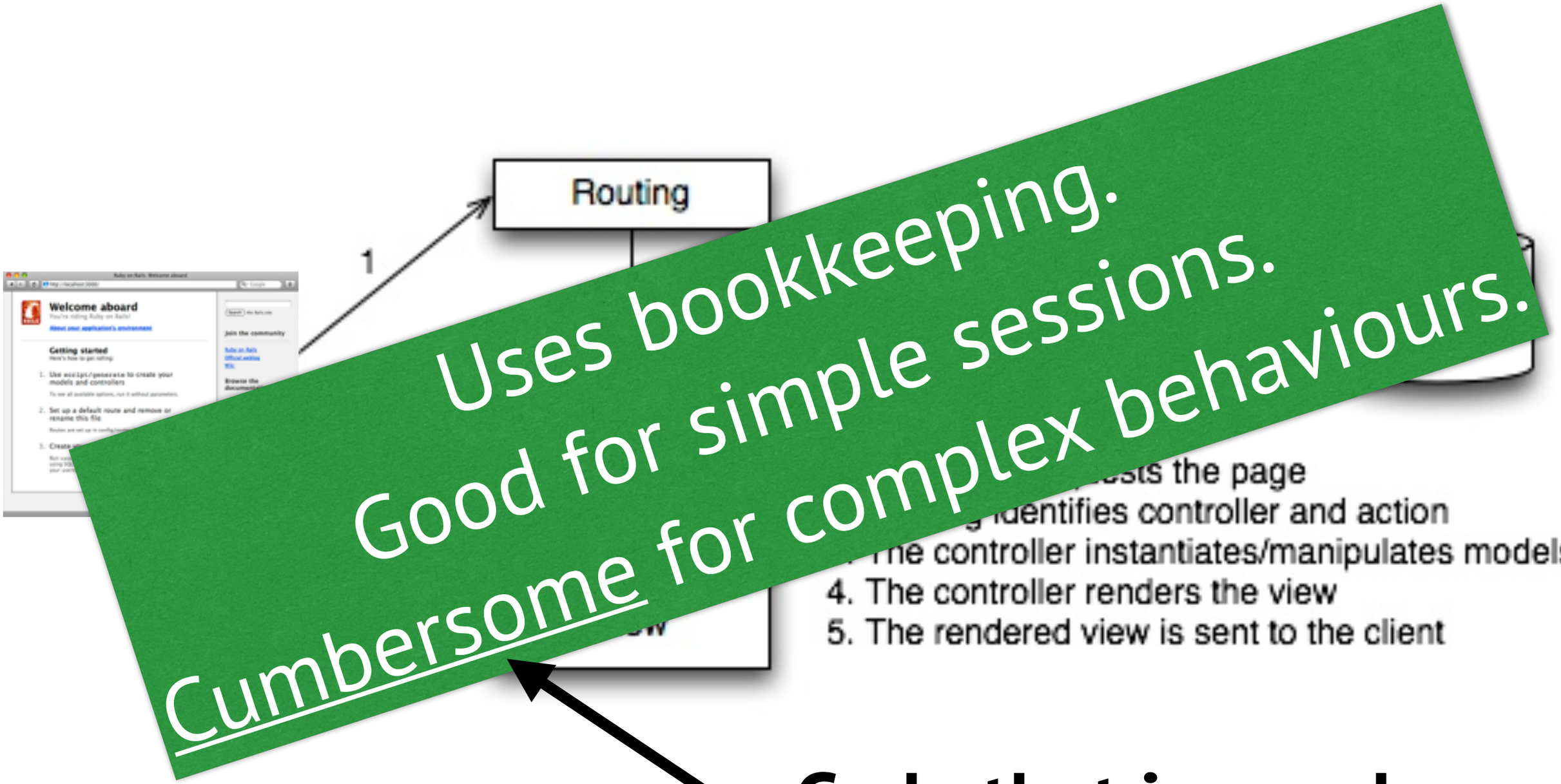
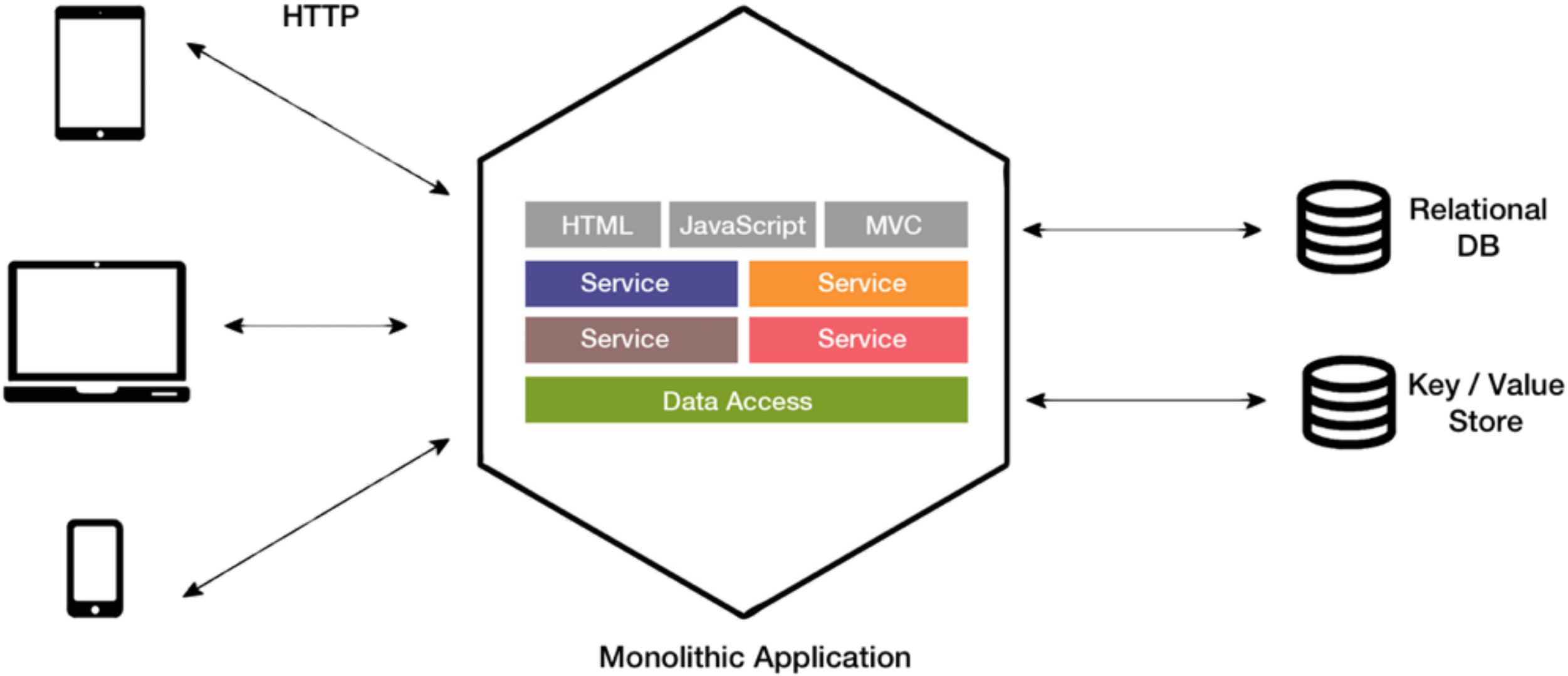


Code that is poorly readable and hard to maintain

SOC already snuck into web programming



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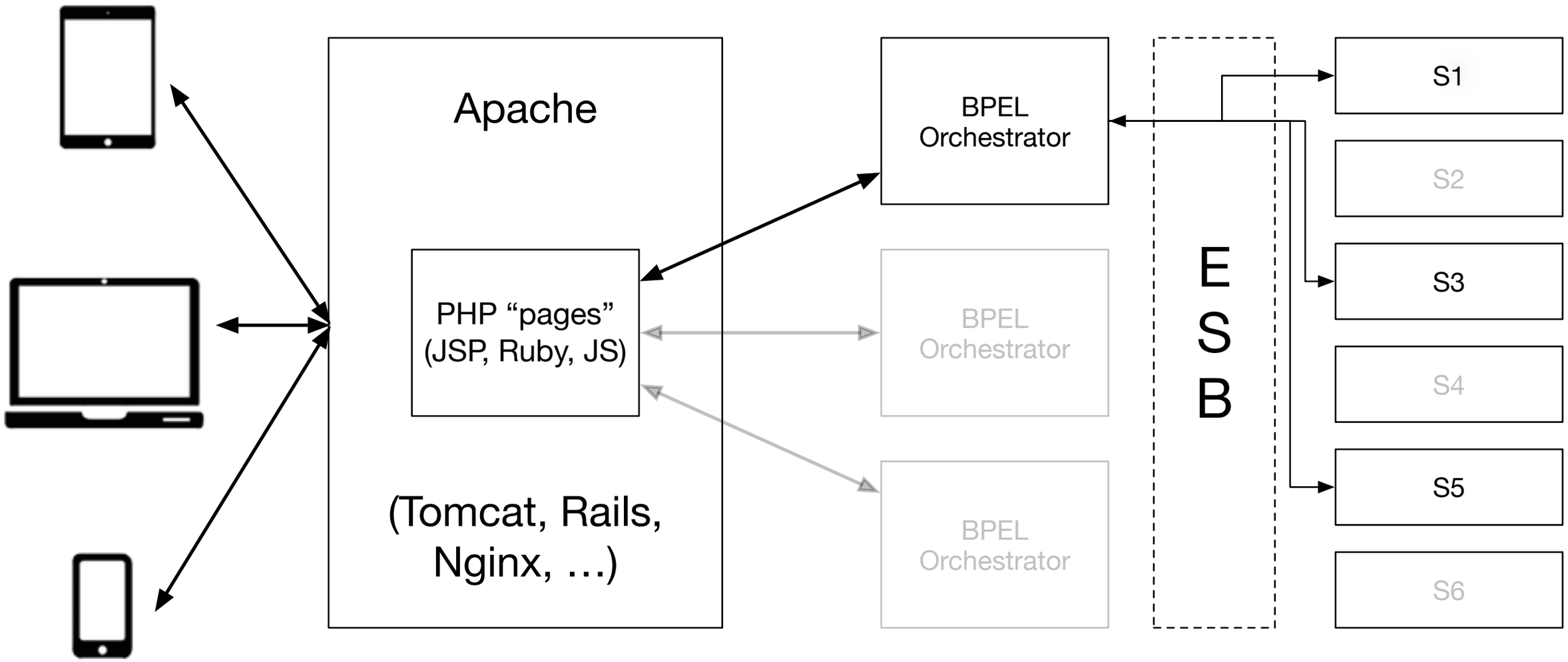
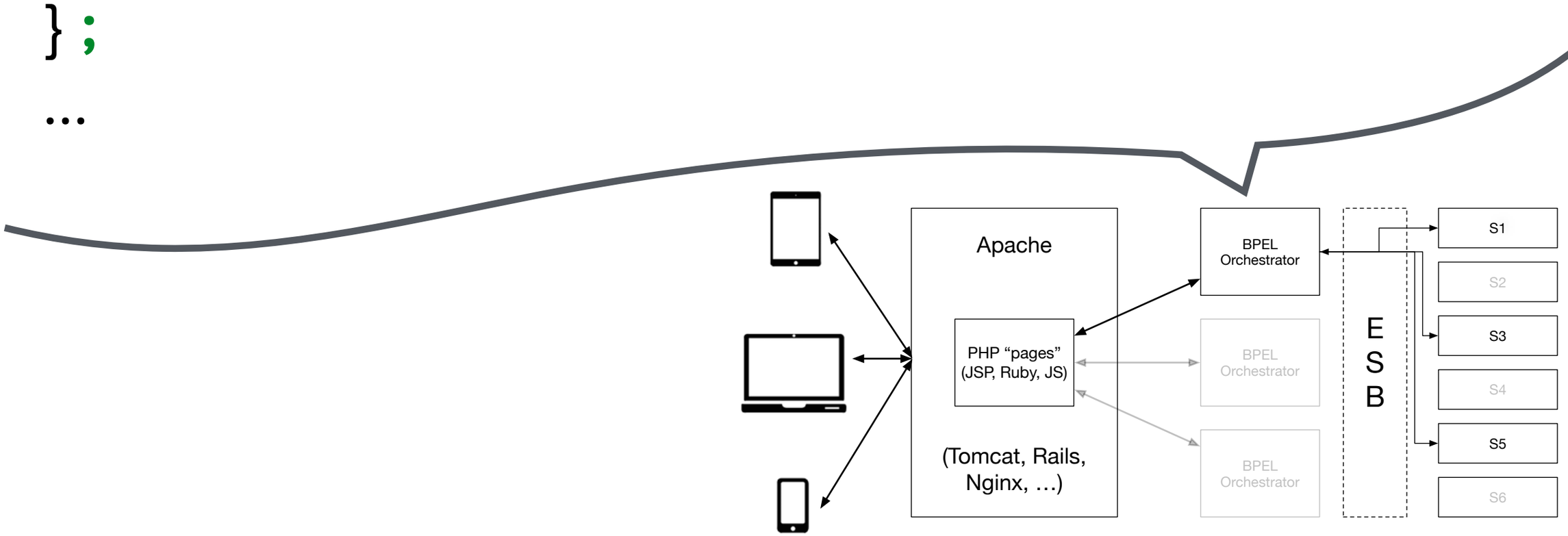


Multi-layered architecture

SOC already snuck into web programming

```
startSession( req )( sid ) { login@S1( req )( sid ) };
 {
    userApproval( u )( ru ){   userApproval@S3( u )( ru )   }
    |
    adminApproval( a )( ra ){   adminApproval@S5( a )( ra )   }
 };
...
```



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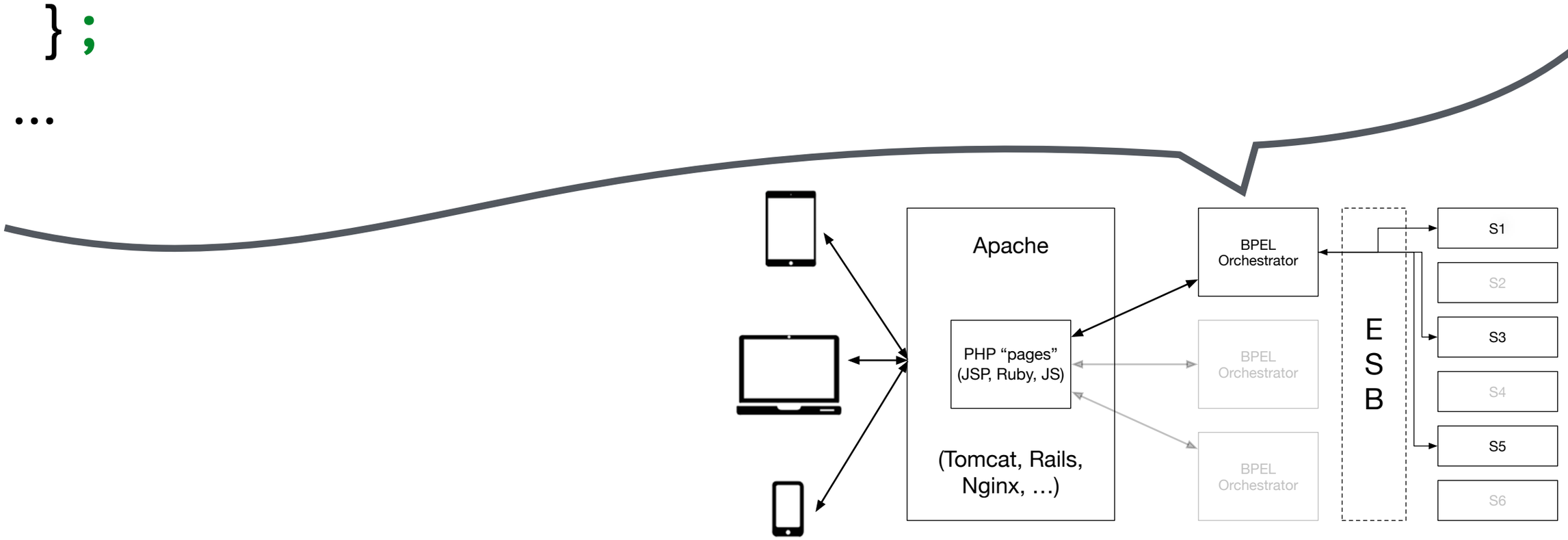

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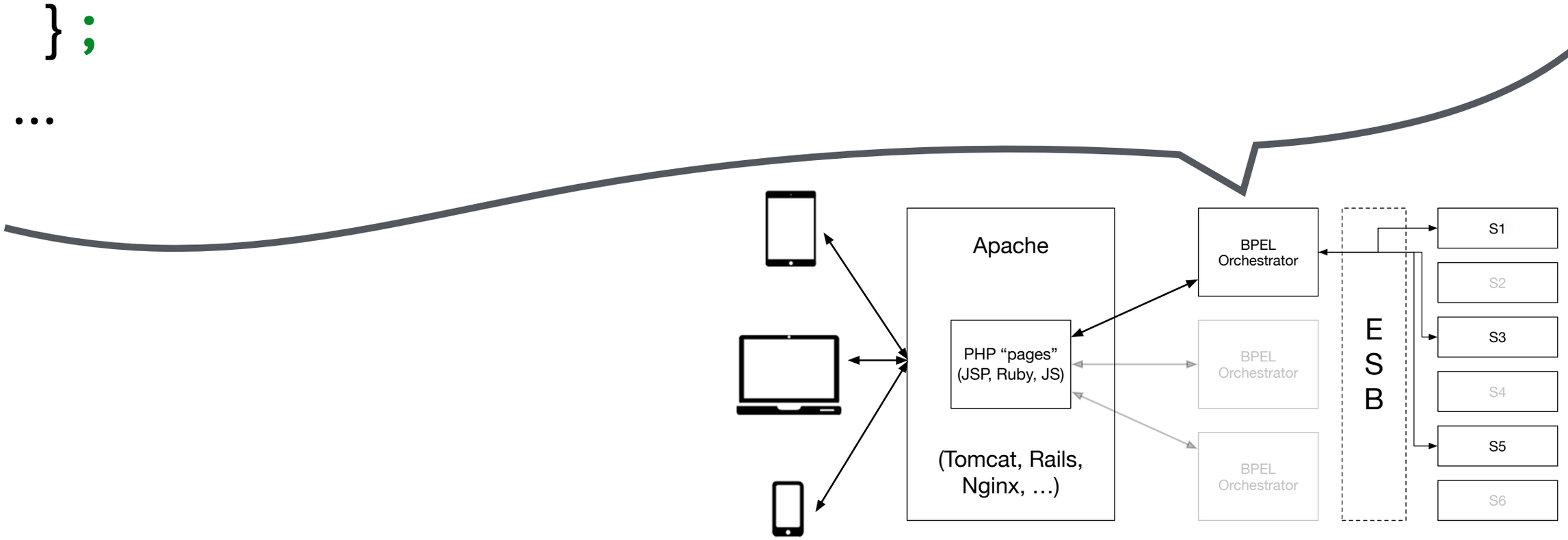
Sequence



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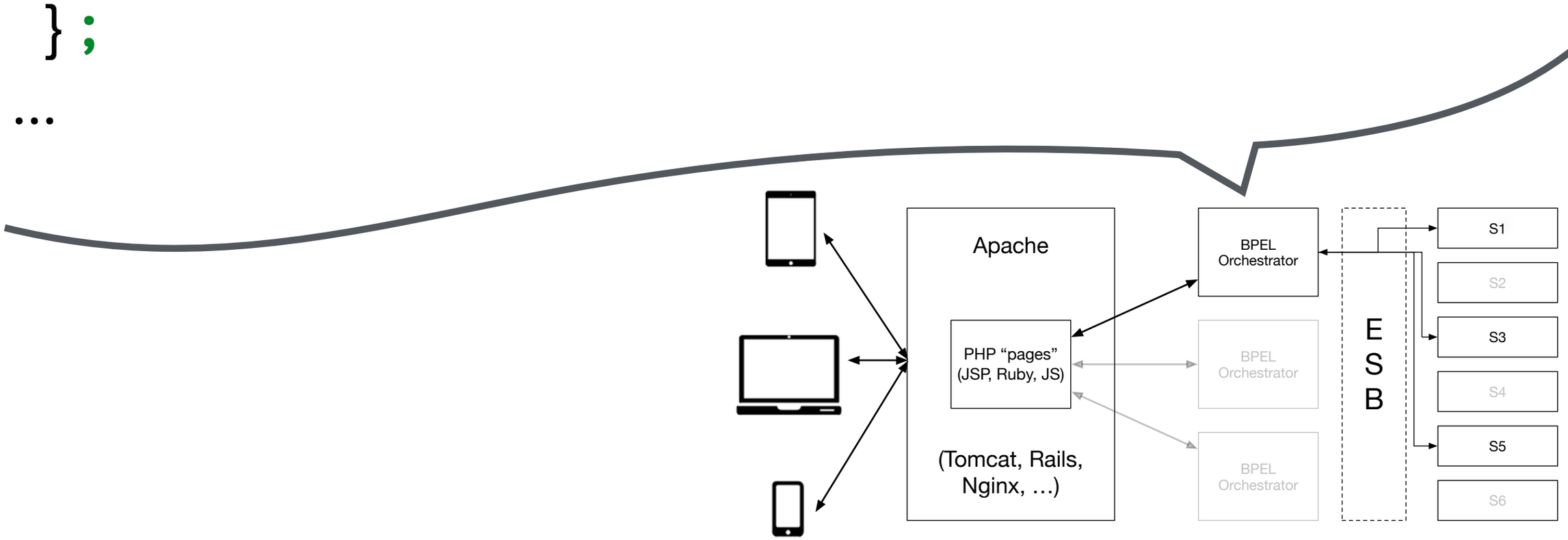
Sequence →

| ← Parallel



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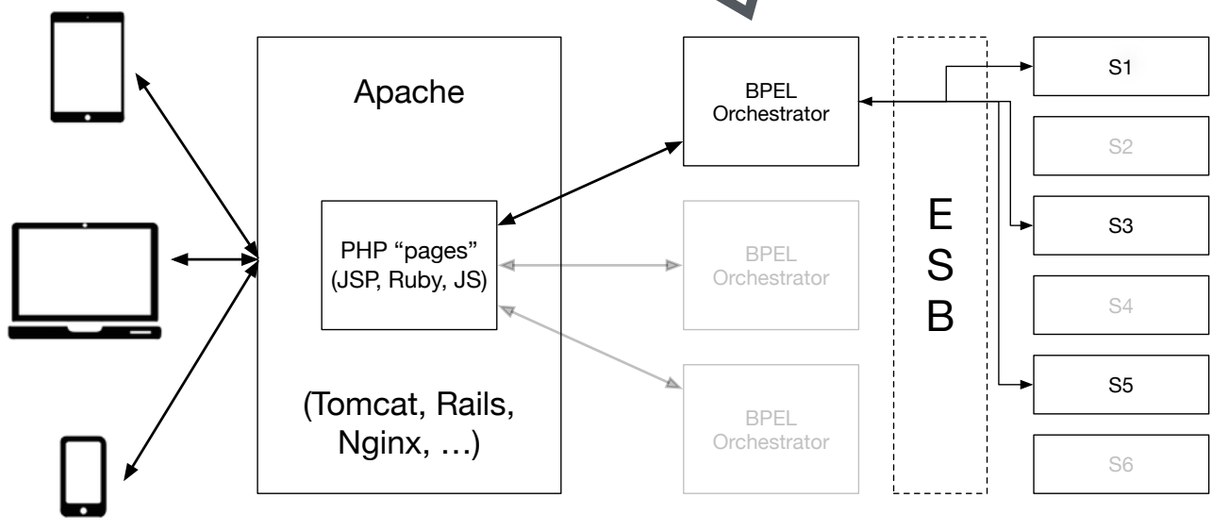
 } ;
...
```

Sequence

Parallel

Same instance (session) subsequent requests

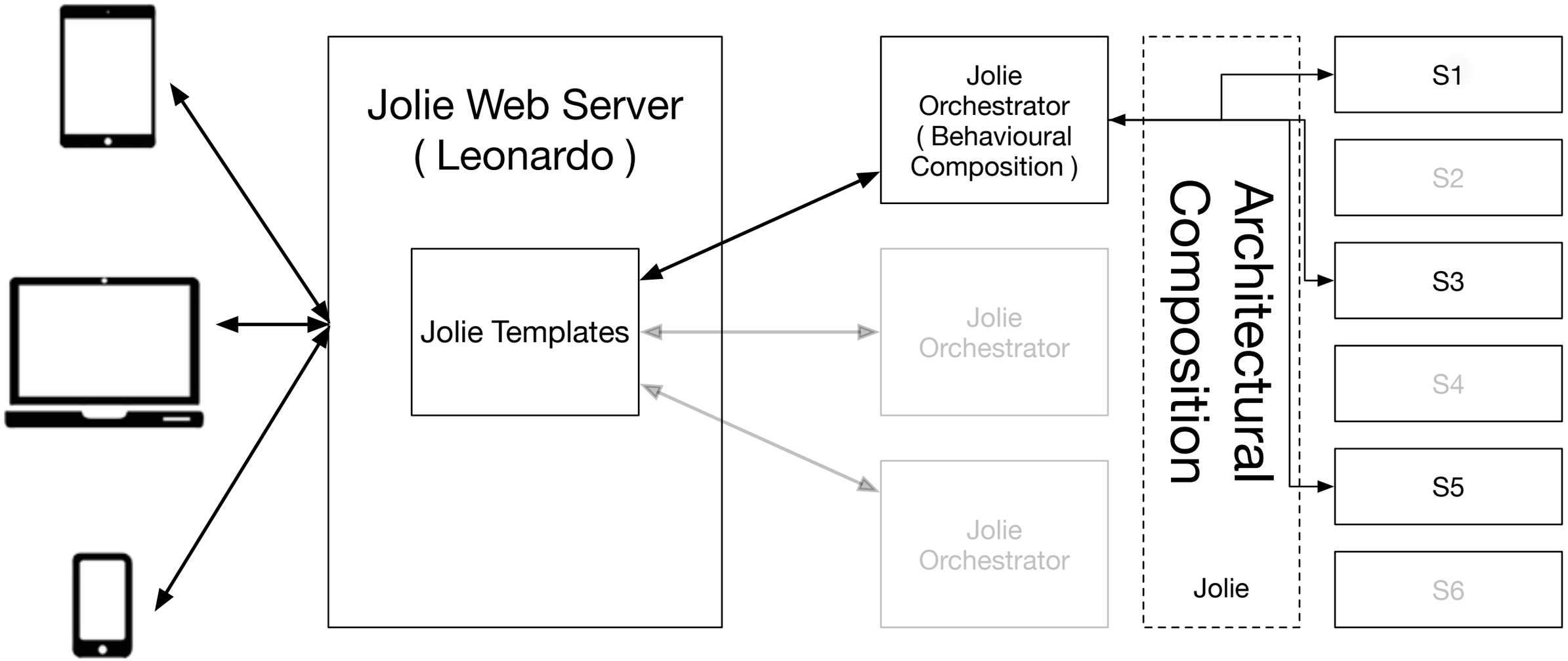


SOC already snuck into web programming

However:

- many “moving parts”;
- heterogeneous (specific know-how);
- hard to maintain;
- prone to breakage with modifications (upgrades, patches, etc).

Can Jolie aid web programming?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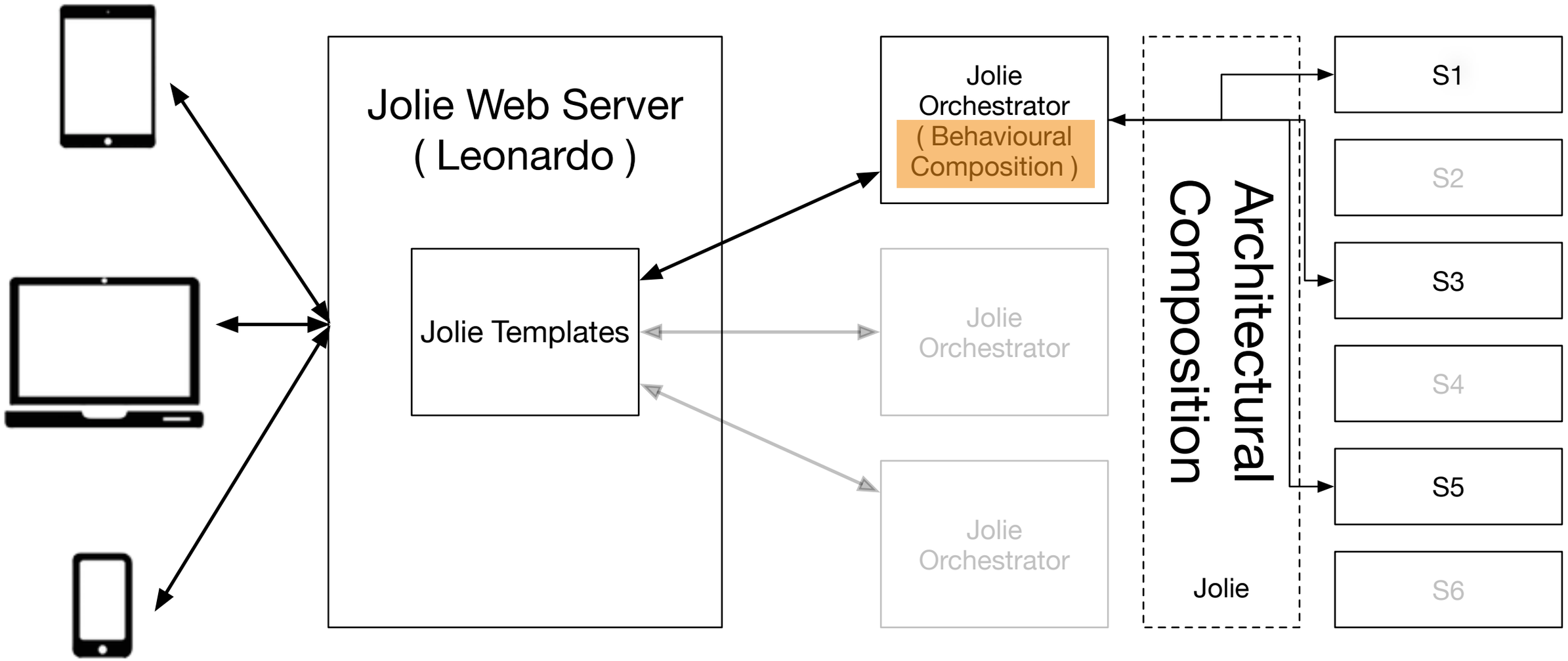
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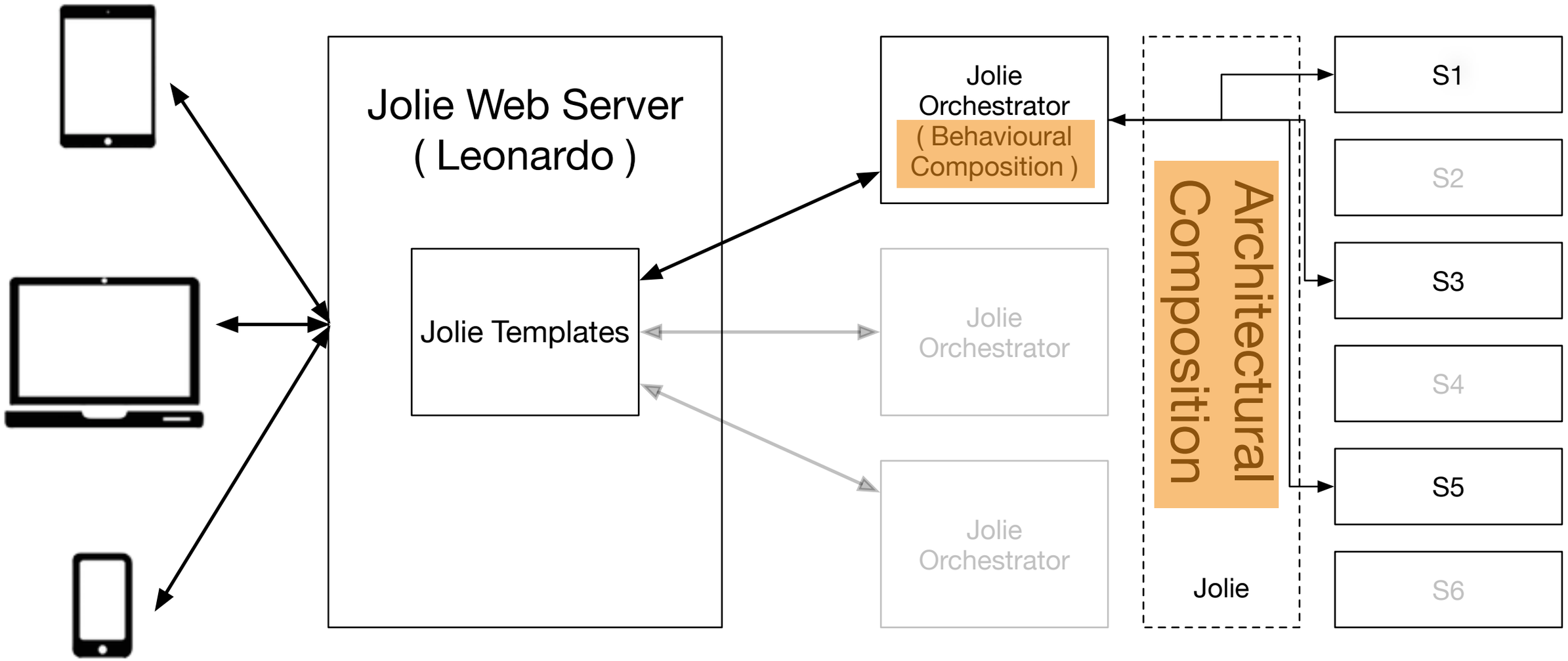
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S3
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S5
S6

Behavioural Composition

B	::=	η	*(input)*
	|	$\overline{\eta}$	*(output)*
	|	`[` η_1 `]` `{` B_1 `}` ... `[` η_n `]` `{` B_n `}`	*(input choice)*
	|	**`if`**`(` e `)` B_1 **`else`** B_2	*(cond)*
	|	**`while`**`(` e `)` B	*(while)*
	|	B **`;`** B'	*(seq)*
	|	B **`|`** B'	*(par)*
	|	**`throw`**`(f)`	*(throw)*
	|	`x =` e	*(assign)*
	|	`x -> y`	*(alias)*
	|	**`nullProcess`**	*(inact)*

η	::=	`o(x)`	*(one-way)*
	|	`o(x)` `(`e`)` `{` B `}`	*(request-response)*
$\overline{\eta}$	::=	`o@OP(`e`)`	*(notification)*
	|	`o@OP(`e`)(y)`	*(solicit-response)*

Architectural Composition (Deployment)

IP ::= **inputPort** $Port$ OP ::= **outputPort** $Port$

$Port$ ::= id {
Location: Loc
Protocol: $Proto$
Interfaces: $\text{iface}_1, \ldots, \text{iface}_n$
}

+ **Aggregation**
+ **Redirection**

Jolie HTTP Protocol

Jolie can support web applications with the **http** protocol.

Jolie HTTP Protocol

```
interface SumIface { RequestResponse: sum(SumT)(int) }

inputPort SumInput {
Location: "socket://localhost:8000"
Protocol: soap
Interfaces: SumIface
}

main
{
   sum( req )( resp ) {
      resp = req.x + req.y
   }
}
```

Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

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just change “soap” to “http”

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types are automatically casted (otherwise TypeMismatch with 403)

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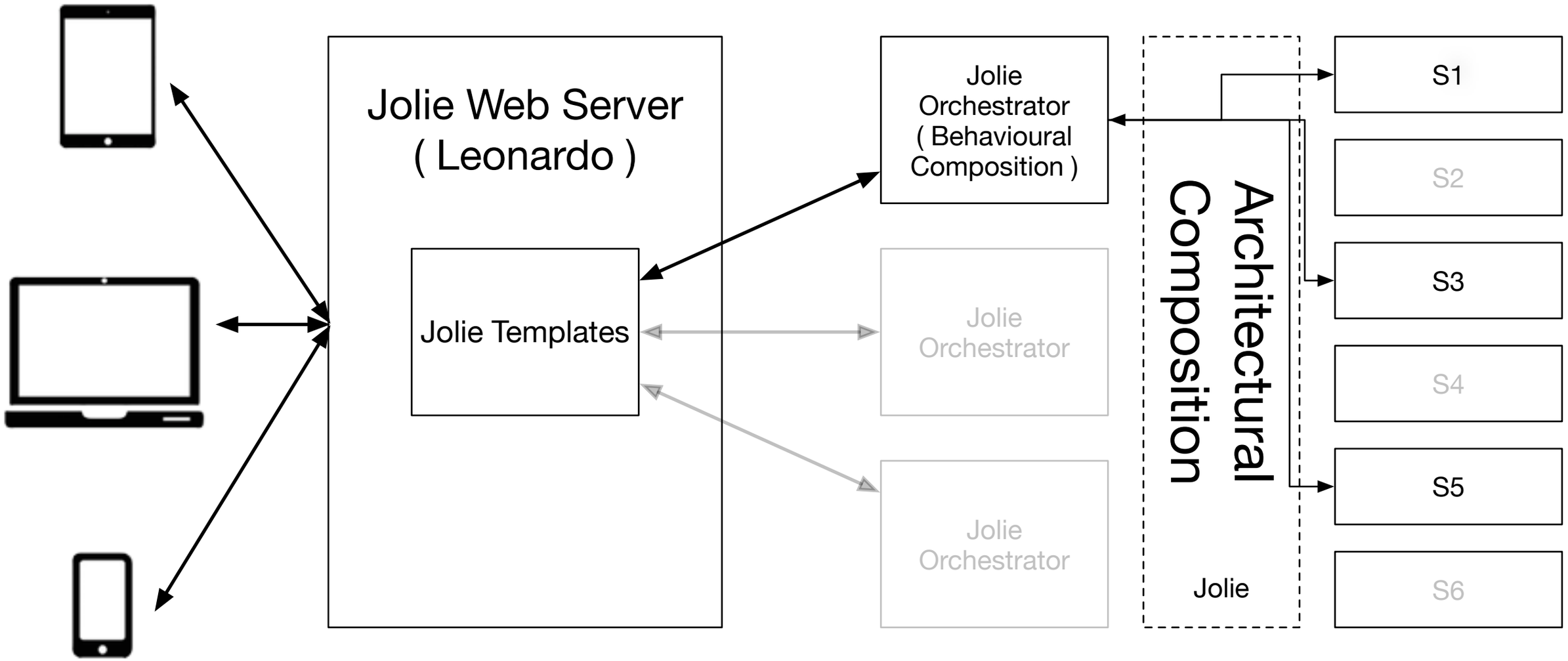
Jolie HTTP Protocol

http://localhost:8000/sum?x=2&y=3

Jolie HTTP Protocol



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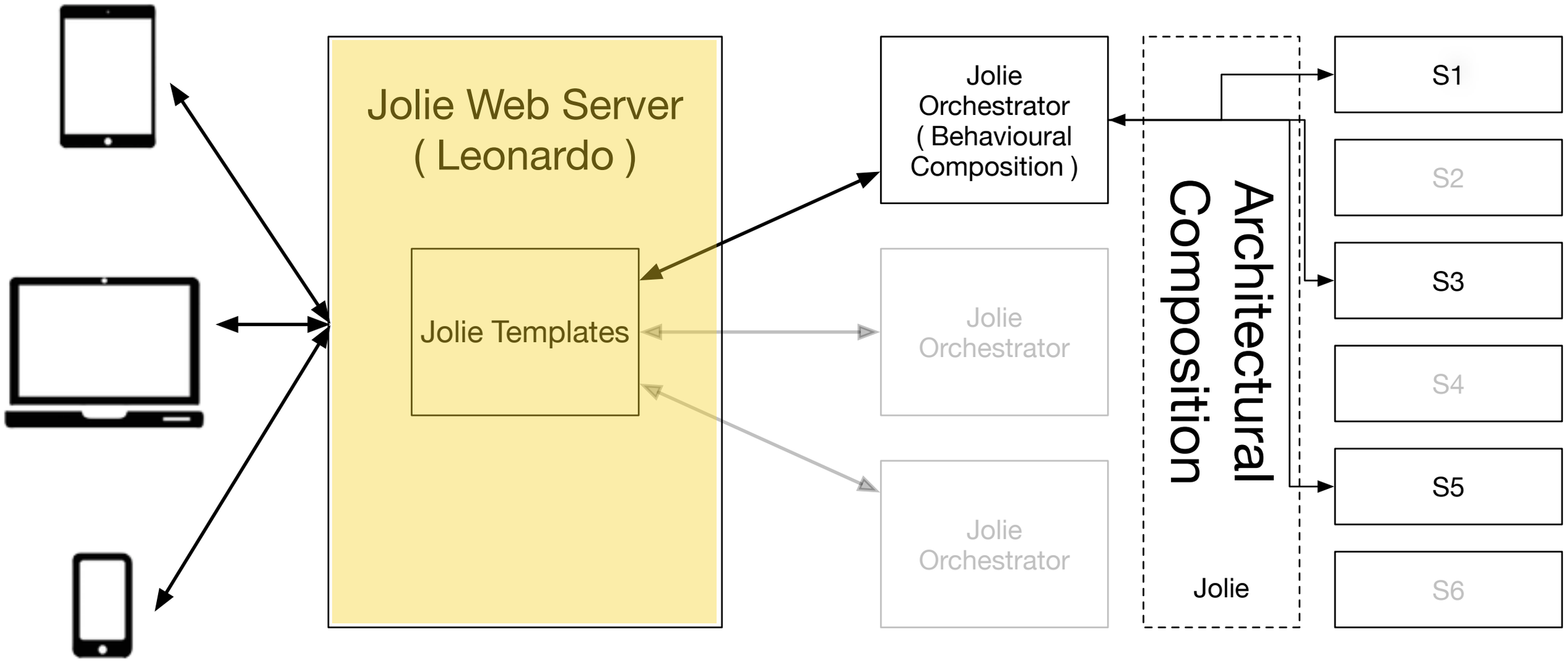


Jolie HTTP Protocol

```
type FetchBib:void { .dblpKey:string }

interface DBLPIface {
RequestResponse: fetchBib( FetchBib )( string )
}

outputPort DBLP {
Location: "socket://dblp.uni-trier.de:80/"
Protocol: http {
  .osc.fetchBib.alias = "rec/bib2/%!{dblpKey}.bib";
  .format = "html" }
Interfaces: DBLPIface
}

main
{
  r.dblpKey = args[0];
  fetchBib@DBLP( r )( bibtex );
  println@Console( bibtex )()
}
```

Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

Jolie HTTP Protocol

```
type FetchBib:void { .dblpKey:string }

interface DBLPIface {
RequestResponse: fetchBib( FetchBib )( string )
}

outputPort DBLP {
Location: "socket://dblp.uni-trier.de:80/"
Protocol: http {
  .osc.fetchBib.alias = "rec/bib2/%!{dblpKey}.bib";
  .format = "html" }
Interfaces: DBLPIface
}

main
{
  r.dblpKey = args[0];
  fetchBib@DBLP( r )( bibtex );
  println@Console( bibtex )()
}
```

Fine-grained configuration parameters

Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

Jolie HTTP Protocol

```
type FetchBib:void { .dblpKey:string }

interface DBLPIface {
RequestResponse: fetchBib( FetchBib )( string )
}

outputPort DBLP {
Location: "socket://dblp.uni-trier.de:80/"
Protocol: http {
   .osc.fetchBib.alias = "rec/bib2/%!{dblpKey}.bib";
   .format = "html" }
Interfaces: DBLPIface
}

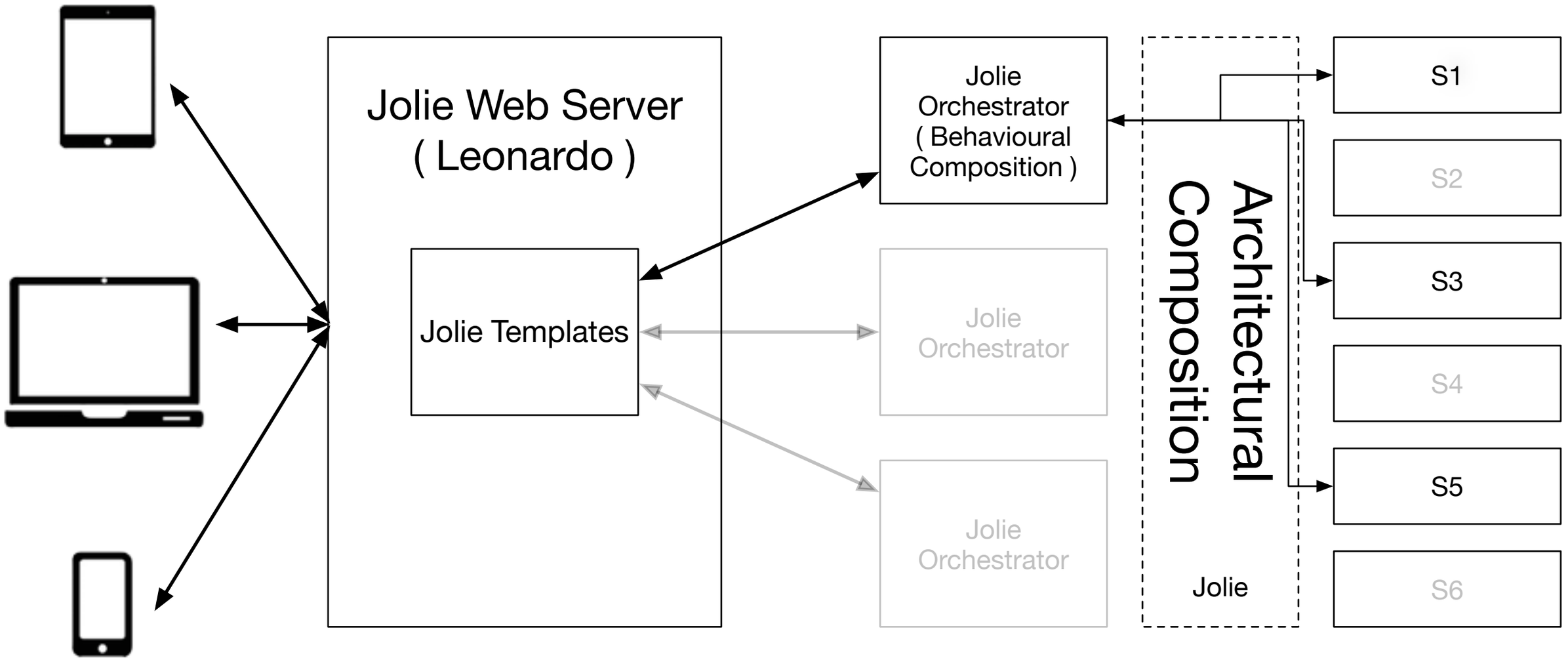
main
{
   r.dblpKey = args[0];
   fetchBib@DBLP( r )( bibtex );
   println@Console( bibtex )()
}
```

Fine-grained configuration parameters

Major Novelty:
Operation-Specific Configurations (osc) bridge the gap between RESTful and Service-Oriented Architectures

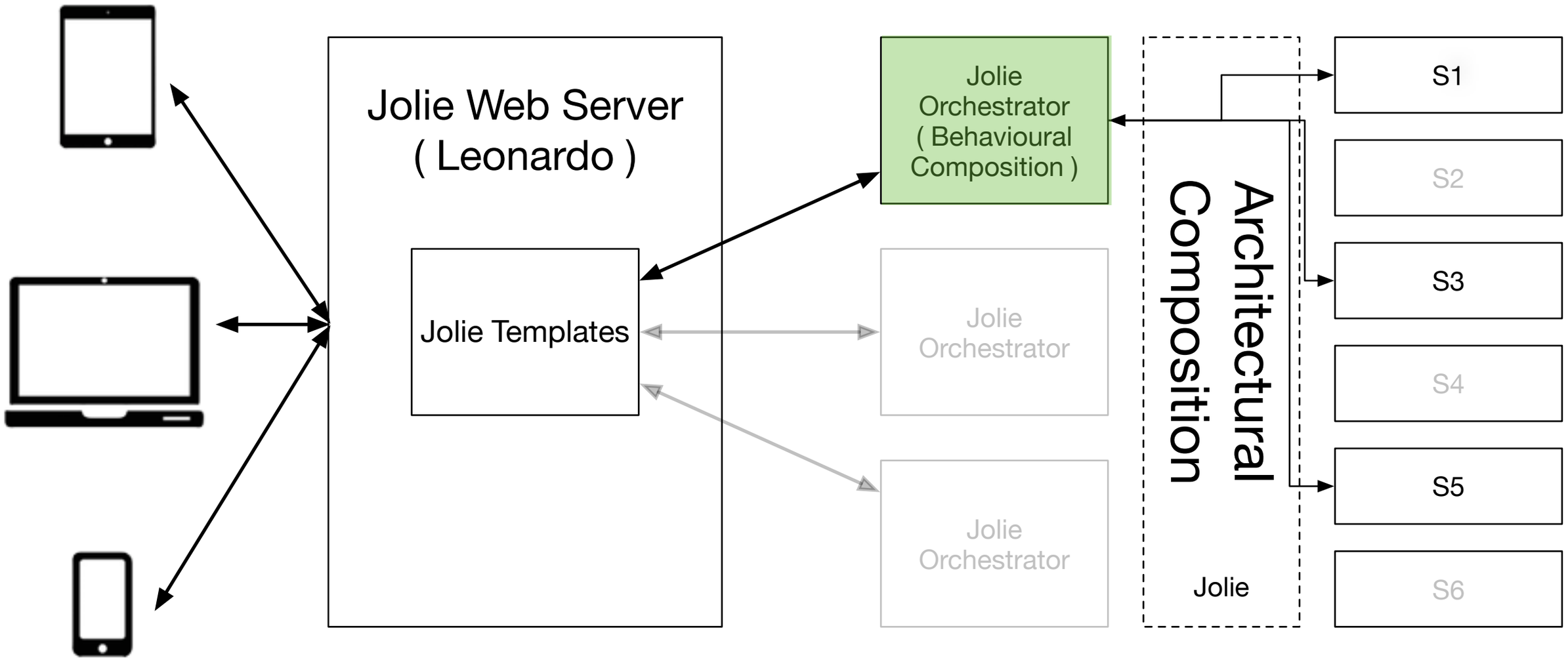
Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

Jolie HTTP Protocol



Jolie HTTP Protocol

Same instance (session) subsequent requests



Jolie HTTP Protocol

```
inputPort RISInput {
/* ... */
Protocol: http { .cookies.userKeyCookie = "userKey" }
}

outputPort Logger { /* ... */ }
outputPort Moderator { /* ... */ }

cset { userKey: addPub.userKey }
cset { modKey: approve.modKey reject.modKey }

define checkCredentials { /* ... */ }
define updateDB { /* ... */ }
```

```
main
{
  login( cred )( r ) {
    checkCredentials;
    r.userKey = csets.userKey = new
  };
  addPub( pub );
  noti.bibtex = pub.bibtex;
  noti.modKey = csets.modKey = new;
  { log@Logger( pub.bibtex )
    | notify@Moderator( noti ) };

  [ approve() ] {
    log@Logger( "Accepted " + pub.bibtex );
    updateDB
  }
  [ reject() ] {
    log@Logger( "Rejected " + pub.bibtex )
  }
}
```

Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

Jolie HTTP Protocol

```
inputPort RISInput {
/* ... */
Protocol: http { .cookies.userKeyCookie = "userKey" }
}

outputPort Logger { /* ... */ }
outputPort Moderator { /* ... */ }

cset { userKey: addPub.userKey }
cset { modKey: approve.modKey reject.modKey }

define checkCredentials { /* ... */ }
define updateDB { /* ... */ }
```

integration with cookies

```
main
{
  login( cred )( r ) {
    checkCredentials;
    r.userKey = csets.userKey = new
  };
  addPub( pub );
  noti.bibtex = pub.bibtex;
  noti.modKey = csets.modKey = new;
  { log@Logger( pub.bibtex )
    | notify@Moderator( noti ) };

  [ approve() ] {
    log@Logger( "Accepted " + pub.bibtex );
    updateDB
  }
  [ reject() ] {
    log@Logger( "Rejected " + pub.bibtex )
  }
}
```

Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

Jolie HTTP Protocol

```
inputPort RISInput {
/* ... */
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cset { userKey: addPub.userKey }
cset { modKey: approve.modKey reject.modKey }

define checkCredentials { /* ... */ }
define updateDB { /* ... */ }
```

integration with cookies

Multiparty Session

```
main
{
  login( cred )( r ) {
    checkCredentials;
    r.userKey = csets.userKey = new
  };
  addPub( pub );
  noti.bibtex = pub.bibtex;
  noti.modKey = csets.modKey = new;
  { log@Logger( pub.bibtex )
  | notify@Moderator( noti ) };

  [ approve() ] {
    log@Logger( "Accepted " + pub.bibtex );
    updateDB
  }
  [ reject() ] {
    log@Logger( "Rejected " + pub.bibtex )
  }
}
```

Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

Jolie HTTP Protocol

```
inputPort RISInput {
/*  ...  */
Protocol: http { .cookies.userKeyCookie = "userKey" }
}

outputPort Logger { /*  ...  */ }
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cset { userKey: addPub.userKey }
cset { modKey: approve.modKey reject.modKey }

define checkCredentials { /*  ...  */ }
define updateDB { /*  ...  */ }
```

integration with cookies

Multiparty Session

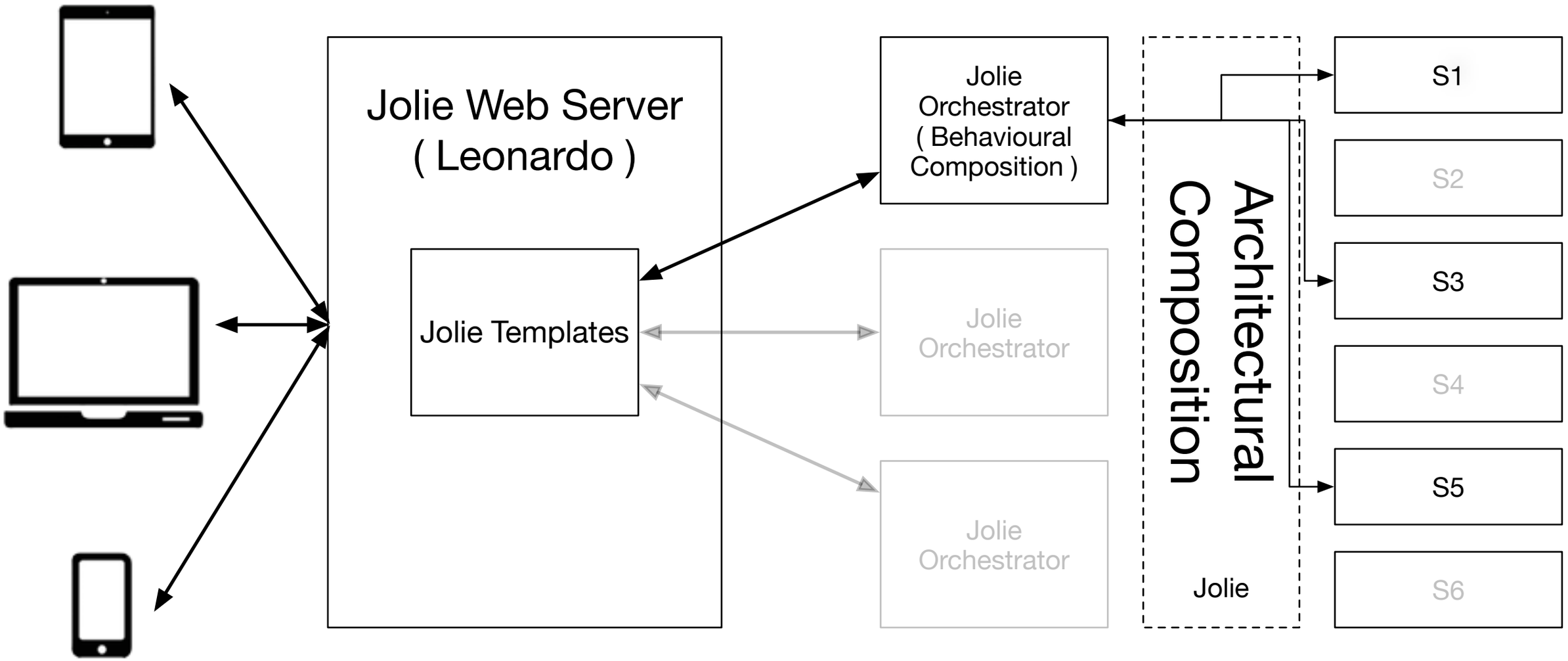
Correlation Sets defined on types (of operations).

```
main
{
  login( cred )( r ) {
    checkCredentials;
    r.userKey = csets.userKey = new
  };
  addPub( pub );
  noti.bibtex = pub.bibtex;
  noti.modKey = csets.modKey = new;
  { log@Logger( pub.bibtex )
    | notify@Moderator( noti ) };

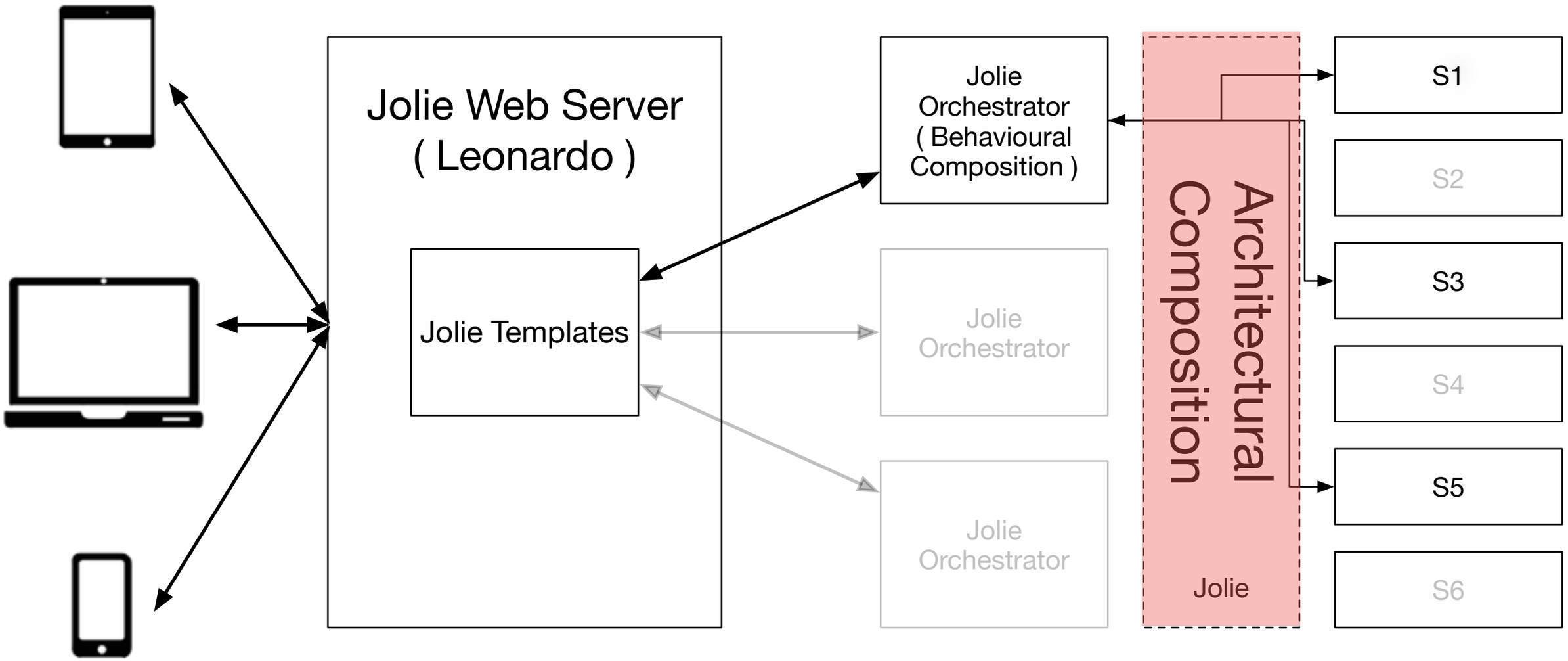
  [ approve() ] {
    log@Logger( "Accepted " + pub.bibtex );
    updateDB
  }
  [ reject() ] {
    log@Logger( "Rejected " + pub.bibtex )
  }
}
```

Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

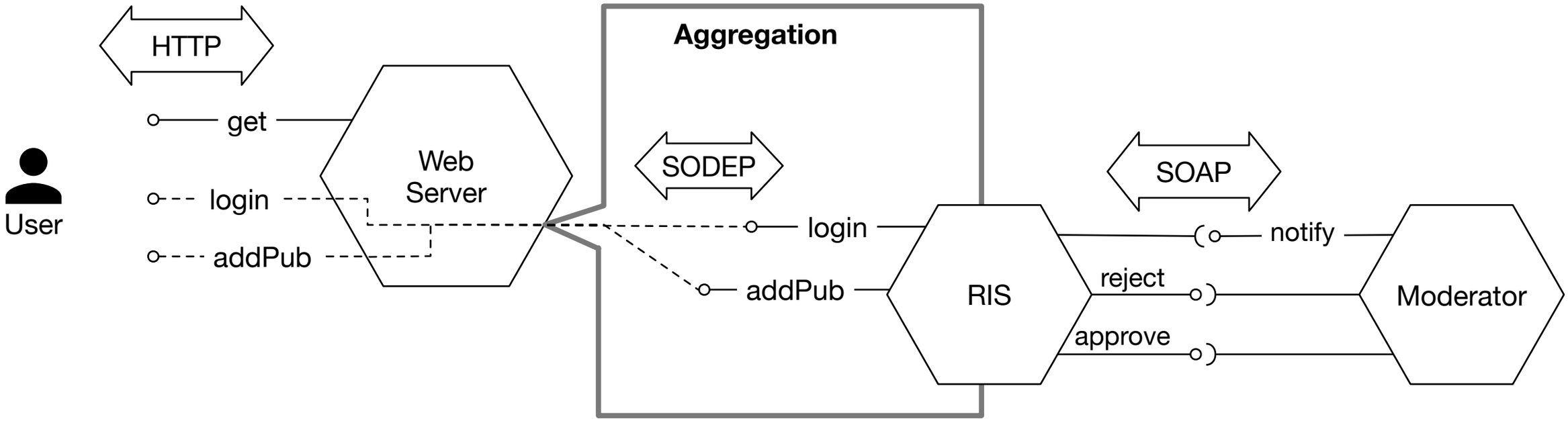
Jolie HTTP Protocol



Jolie HTTP Protocol



Jolie HTTP Protocol



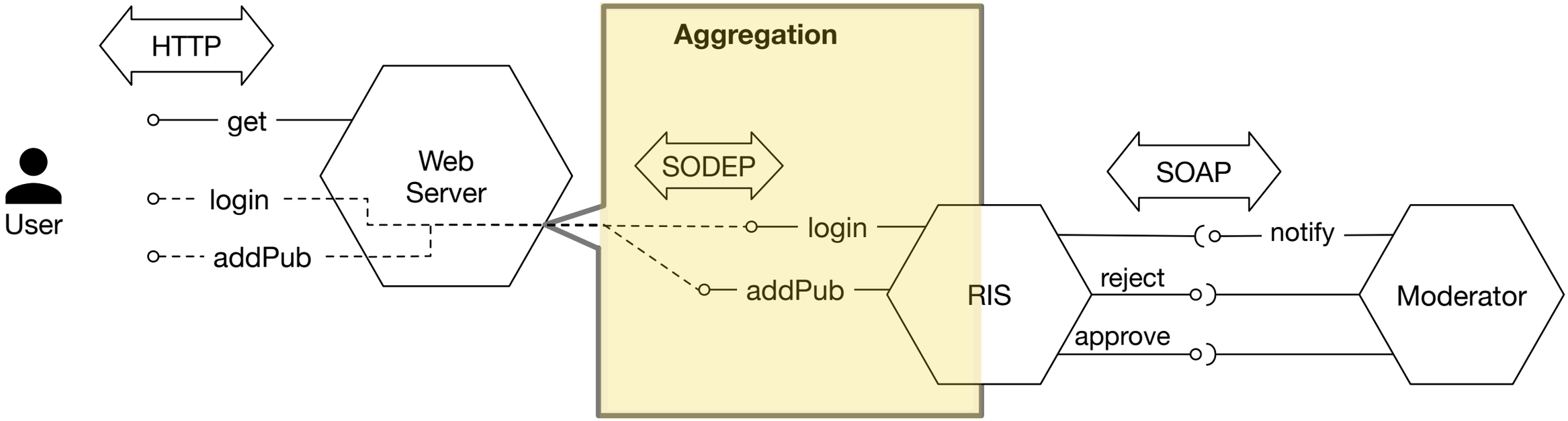

```
outputPort RIS {
Location: "socket://www.ris-example.com:8090/"
Protocol: sodep
Interfaces: RISIface
}

inputPort WebServerInput {
Location: "socket://www.webserver-example.com:80/"
Protocol: http {
  .default.get = "get";
  .cookies.userKeyCookie = "userKey"
  /* ... */
}
Interfaces: GetIface
Aggregates: RIS
}
```

```
main {
  get( req )( resp ) {
    /* ... */
    readFile@File( req.requestUri )( resp )
  }
}
```

Example taken from Fabrizio Montesi. Process-aware Web Programming with Jolie. Submitted for publication, 2015

Jolie HTTP Protocol

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Interfaces: GetIface
Aggregates: RIS
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main {
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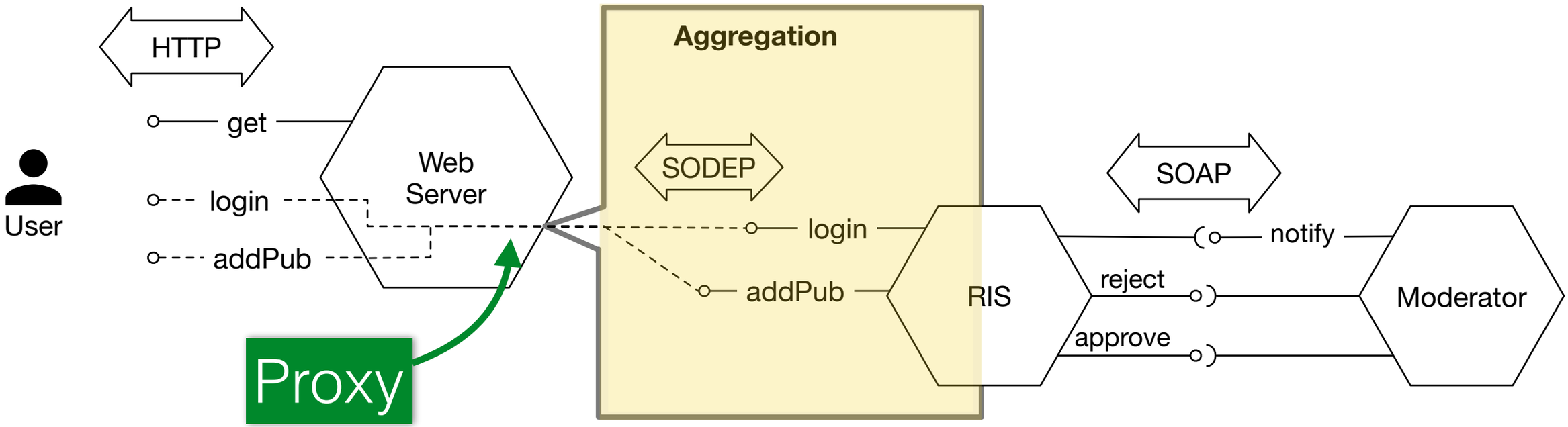
Jolie HTTP Protocol

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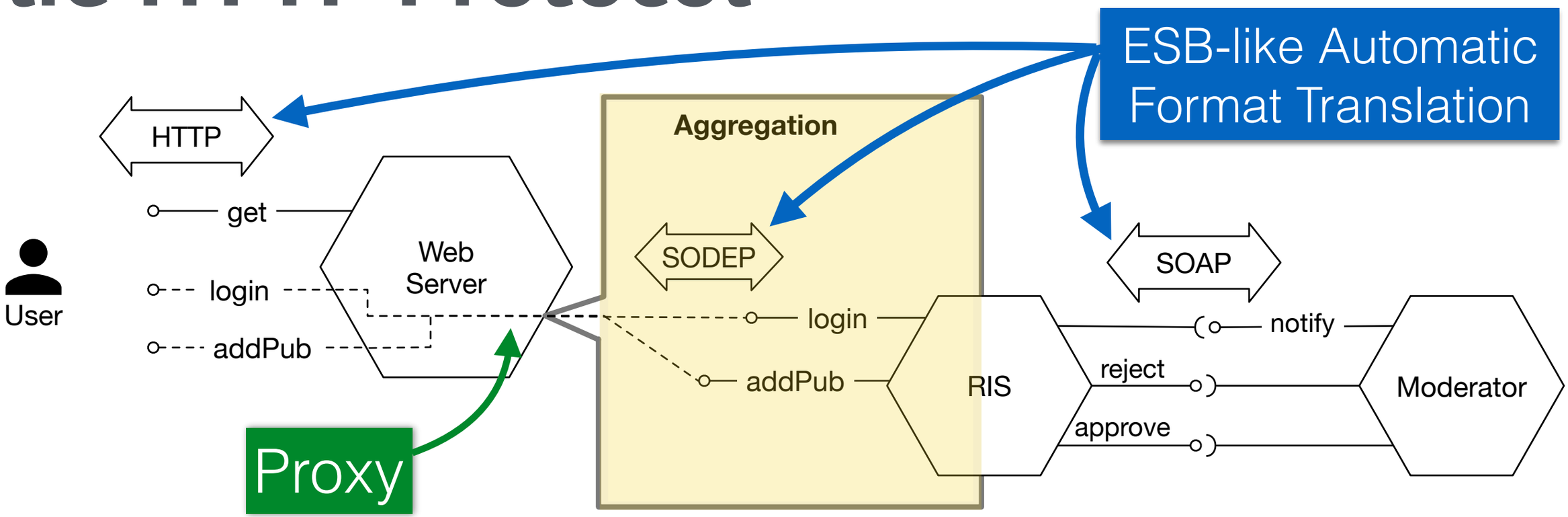


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  .default.get = "get";
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  /* ... */
}
Interfaces: GetIface
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}
```

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main {
  get( req )( resp ) {
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    readFile@File( req.requestUri )( resp )
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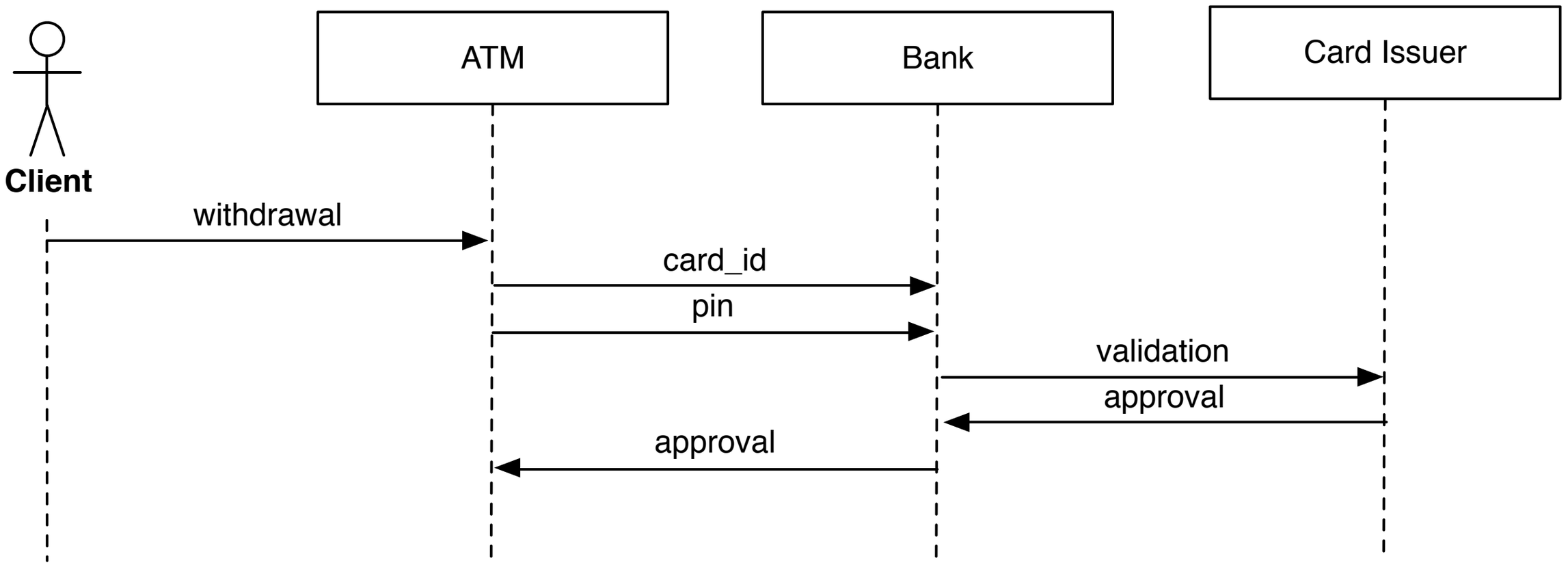
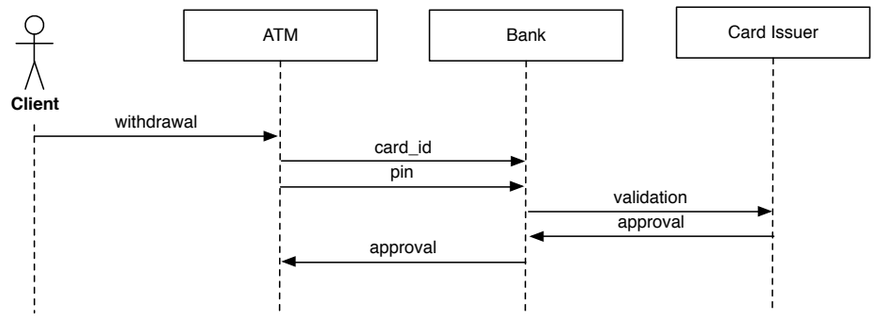
Introduction to

Choreographies

Introduction to **Choreographies**



Introduction to **Choreographies**



Introduction to **Choreographies**

$$\texttt{Client} \rightarrow \texttt{ATM}.\mathit{withdraw}(\left\{ \begin{array}{l} .\mathbf{card\_id} : \mathbf{String}, \\ .\mathbf{pin} : \mathbf{String} \end{array} \right\});$$
$$\texttt{ATM} \rightarrow \texttt{Bank}.\mathit{card\_id}(\mathbf{String});$$
$$\texttt{ATM} \rightarrow \texttt{Bank}.\mathit{pin}(\mathbf{String});$$
$$\texttt{Bank} \rightarrow \texttt{ATM}\{$$
$$\quad .\mathit{approve}(\mathbf{nil});$$
$$\quad .\mathit{reject}(\mathbf{nil});$$
$$\}$$

$$\texttt{Bank} \rightarrow \texttt{Card Issuer}.\mathit{validation}(\left\{ \begin{array}{l} .\mathbf{card} : \mathbf{String}, \\ .\mathbf{pswd} : \mathbf{String} \end{array} \right\});$$
$$\texttt{Card Issuer} \rightarrow \texttt{Bank}\{$$
$$\quad .\mathit{approve}(\mathbf{nil});$$
$$\quad .\mathit{reject}(\mathbf{nil});$$
$$\}$$

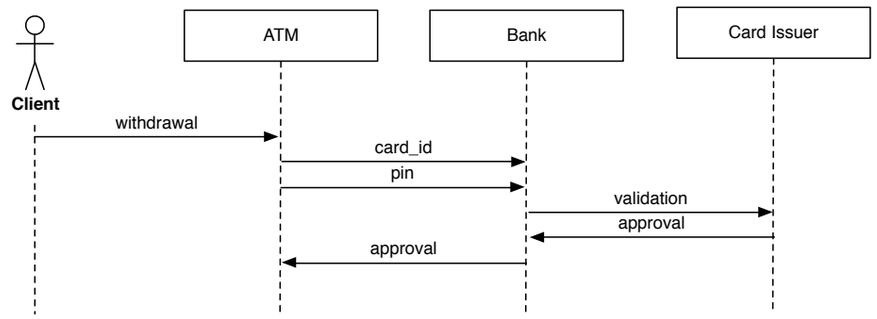
Global Types

Choreographies

$$\mathbf{req}\ k:\ \mathtt{c}[\texttt{Client}] \Leftrightarrow l_{\mathtt{A}}.\texttt{ATM}, l_{\mathtt{B}}.\texttt{Bank};$$
$$k:\ \mathtt{c}[\texttt{Client}].\underline{\mathbf{data}} \rightarrow \texttt{ATM}.\mathit{withdraw}(\underline{\mathbf{data}})$$

$$\mathbf{acc}\ k:\ l_{\mathtt{A}}.\mathtt{p}[\texttt{ATM}],\ l_{\mathtt{B}}.\mathtt{q}[\texttt{Bank}];$$
$$k:\ \texttt{Client} \rightarrow \mathtt{p}[\texttt{ATM}].\mathit{withdraw}(\underline{\mathbf{data}});$$
$$k:\ \mathtt{p}[\texttt{ATM}].\underline{\mathbf{data.card\_id}} \rightarrow \mathtt{q}[\texttt{Bank}].\mathit{card\_id}(\underline{\mathbf{validate.card}});$$
$$k:\ \mathtt{p}[\texttt{ATM}].\underline{\mathbf{data.pin}} \rightarrow \mathtt{q}[\texttt{Bank}].\mathit{pin}(\underline{\mathbf{validate.pswd}});$$
$$\mathtt{req}\ k':\mathtt{q}[\texttt{Bank}] \Leftrightarrow l_{\mathtt{C}}.\texttt{Card Issuer};$$
$$k':\ \mathtt{q}[\texttt{Bank}].\underline{\mathbf{validate}} \rightarrow \texttt{Card Issuer}.\mathit{validation};$$
$$k':\ \texttt{Card Issuer} \rightarrow \mathtt{q}[\texttt{Bank}]\{$$
$$\quad .\mathit{approve}();$$
$$\quad\quad k:\ \mathtt{q}[\texttt{Bank}] \rightarrow \mathtt{p}[\texttt{ATM}].\mathit{approve}();$$
$$\quad .\mathit{reject}();$$
$$\quad\quad k:\ \mathtt{q}[\texttt{Bank}] \rightarrow \mathtt{p}[\texttt{ATM}].\mathit{reject}();$$
$$\}$$

$$\mathbf{acc}\ k:\ l_{\mathtt{C}}.\mathtt{r}[\texttt{Card Issuer}];$$
$$k:\ \texttt{Bank} \rightarrow \texttt{Card Issuer}.\mathit{validation}(\underline{\mathbf{data}});$$
$$\mathtt{if}\ \mathtt{r}.\mathit{match}(\underline{\mathbf{data}})\{$$
$$\quad k:\ \mathtt{r}[\texttt{Card Issuer}] \rightarrow \texttt{Bank}.\mathit{approve}();$$
$$\}\ \mathtt{else}\ \{$$
$$\quad k:\ \mathtt{r}[\texttt{Card Issuer}] \rightarrow \texttt{Bank}.\mathit{reject}();$$
$$\}$$



Introduction to **Choreographies**

Main features:

- Global View;
- Modular, models asynchrony;
- Projects to correct processes;
- Deadlock- and Race-free by construction.

Choreographies for the Web?

Open for discussion!