Efficient Data Transmission Between Multimedia Web Services via Aspect-Oriented Programming

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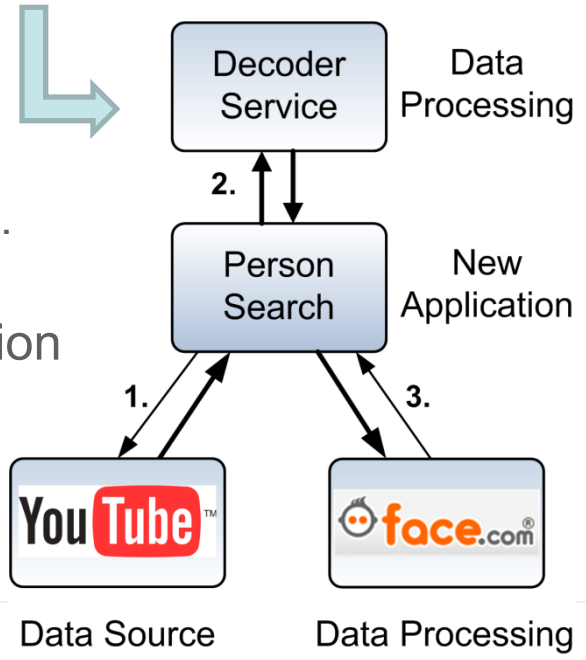
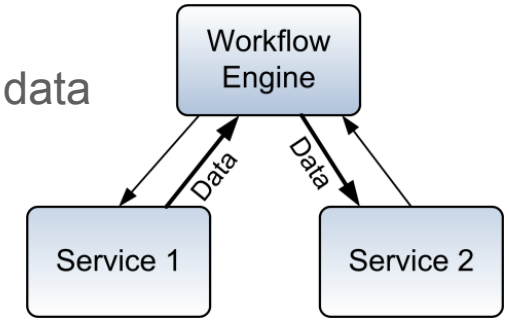
Motivation

- Plethora of multimedia web services in WWW
  - Image and video data sources
    - Flickr, YouTube etc.
  - Data processing
    - Image/video OCR, transcoding, face detection…
- Goal: Create new applications by service composition
  - Compose a value-added workflow
  - Easier development & integration



Problem Statement

- Assume you want to have a workflow of multimedia web services with
  - secure data transmission, and/or
  - reliable data transmission, and/or
  - metadata management, and/or
  - workflow modeling support (BPEL), and other features
- SOAP services offer tool support for such requirements
  - in contrast to RESTful web services
  - but multimedia web services potentially deal with large data
- **Problem**
  - **Data transmission between SOAP web services**
  - **Workflow engine can become a bottleneck**



Our Approach

- Consider data transmission as a cross-cutting concern in workflows
  - Data handling has to be addressed in many/all components
  - Address this issue by *Aspect-Oriented Programming*
- Reference technique optimizes data transmission

- **Solution**

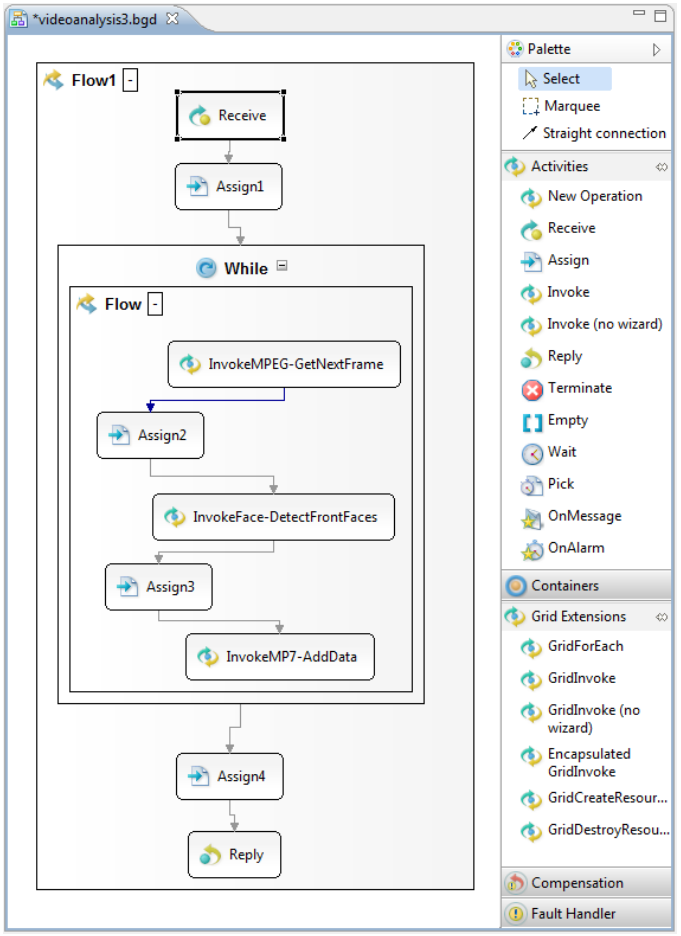
  Aspect-oriented framework for efficient data transmission

Introduction – What is *Aspect-Oriented Programming*?

- Aspect-oriented programming (AOP)
  - Aims at increasing modularity of software systems
  - Encapsulates cross-cutting concerns into advice
- Integration into existing applications via join points
- An aspect combines
  - Point cuts: description of a set of join points
  - Advice: code to be executed at specific join points

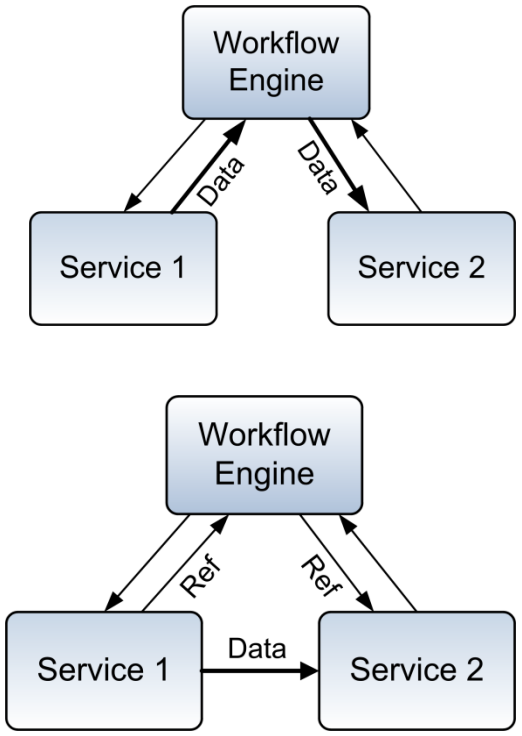
Intro – BPEL Workflows

- Business Process Execution Language (BPEL)
- Standard for service composition
- General purpose workflow language
  - Turing-complete
  - Exposed as a web service
  - Basic/structured Activities
- Explicit modeling of **control flow**
- Excellent tool support



Introduction – Flex-SwA

- Flexible handling of bulk data
  - Service-oriented environment
- Reference builder
  - Creates XML description
- Reference handling
  - Transparent for the workflow provider
- Avoid bottlenecks due to file transfers

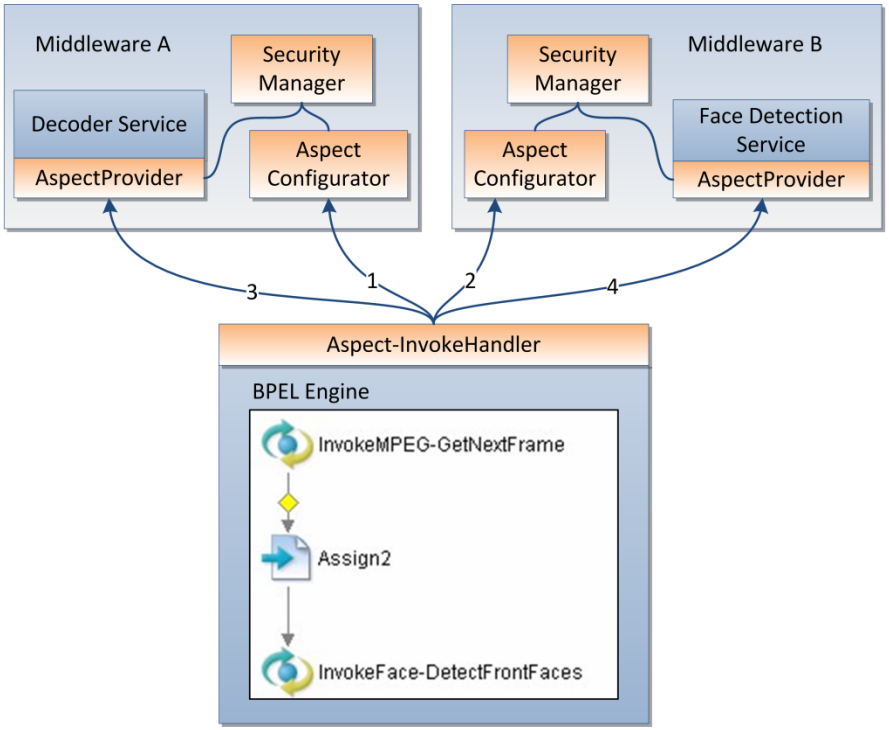


Request/Response Aspects

- Adapting data transmission requires modifications
  - On both, client and server side
  - Code must be aware of modifications
  - Adaption across different administrative domains
- Solution: Weave request/response aspects at message level
- Examples for non-functional requirements in web services
  - Data transmission
  - Security
  - Reliable messaging

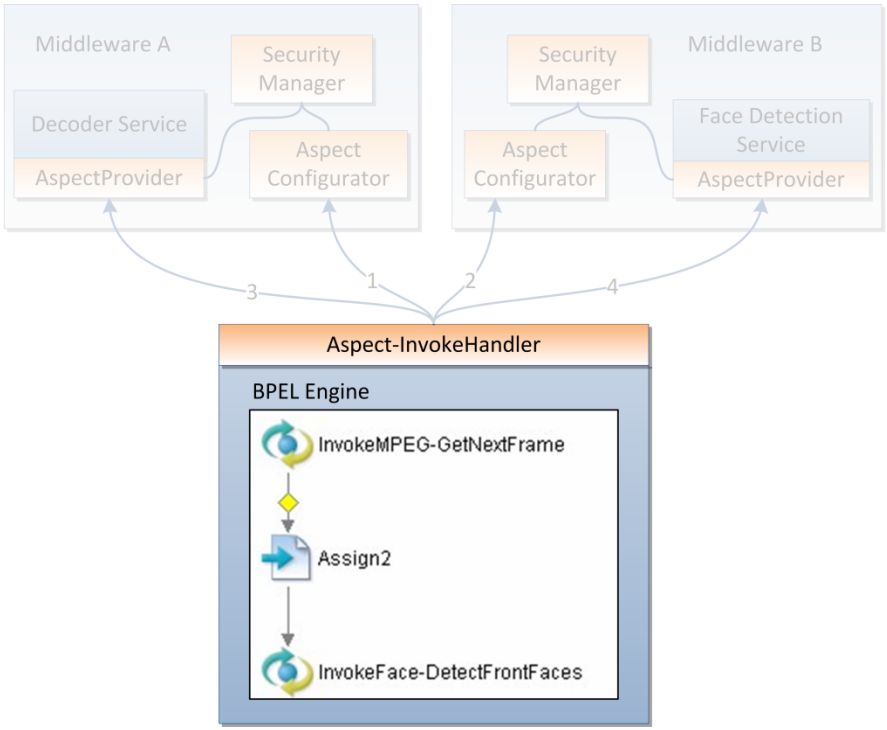
Design

- Remain independent of web service implementation
- Client-side at BPEL engine (or any other client)
- Server-side at application server (heterogeneous administration domains)



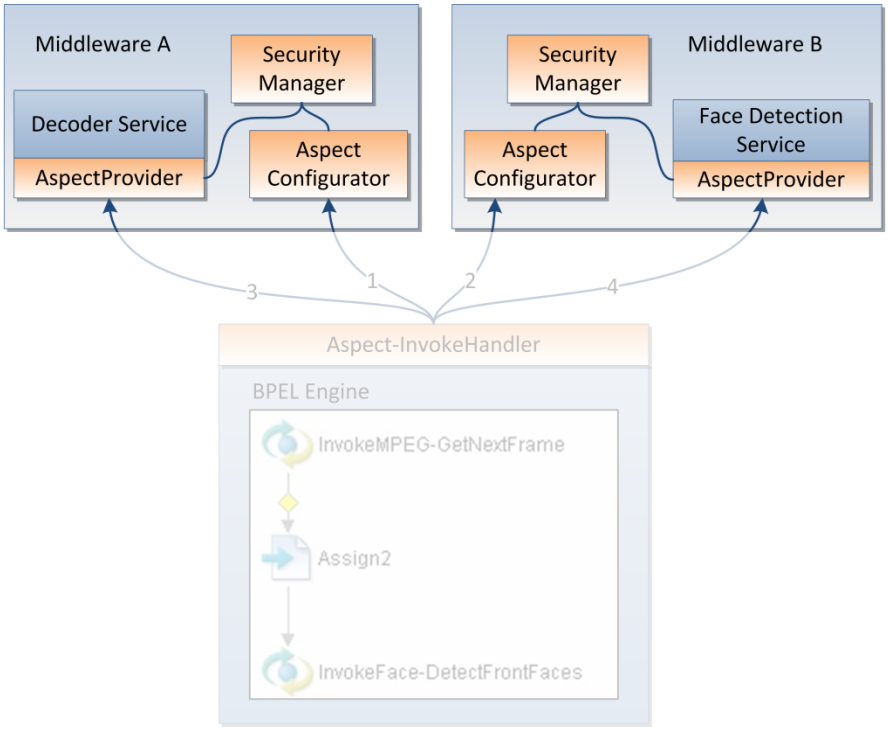
Design – Client-side

- Invoke activities are annotated to use the *Aspect-InvokeHandler* (AIH)
- AIH weaves request/response-aspects into services
  - Ensures atomic behavior
- Unchanged implementation
- Transparent for the workflow



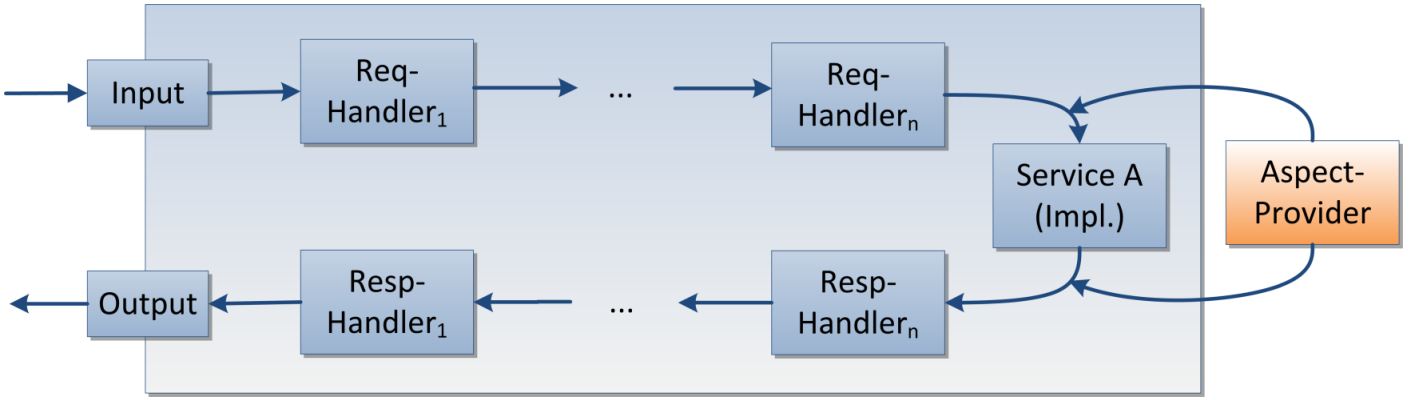
Design – Server-side

- Aspect Configurator
  - Add, remove, check
- Security Manager
  - PKI-based
- AspectProvider
  - Weaving component
  - Based on AspectJ



Implementation (server-side)

- AspectProvider
  - Woven into the Axis handler chain
  - Applies request/response on SOAP messages



Implementation (client-side)

- Schema-type of an request/response aspect

```
<complexType name="Aspect">
   <sequence>
      <element name="portType"      type="xsd:QName"    />
      <element name="operationName" type="xsd:string"   />
      <element name="field"         type="xsd:string"   />
      <element name="mode"          type="xsd:string"   />
      <element name="aspectPlugIn"  type="xsd:string"   />
      <element name="aspectData"    type="tns1:HashMap" minOccurs="0"/>
   </sequence>
</complexType>
```

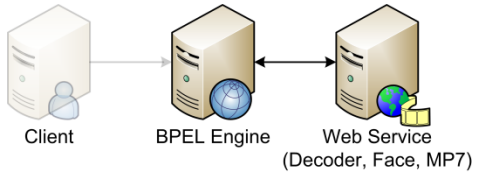
Experimental Setup – Testbed

- Web services
  - MPEG decoder, face detector, MPEG-7 converter
- Web service environment
  - Tomcat 6, Axis 1.4, ActiveBPEL
- Computational environment: Amazon EC2
  - High-CPU Medium Instances

Experimental Setup – Test Scenarios

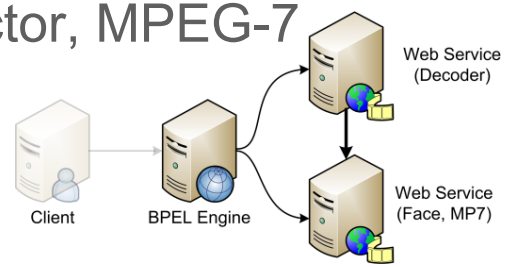
Test scenario I

- Plain SOAP
- 2 EC2 machines
  - BPEL engine
  - Service container



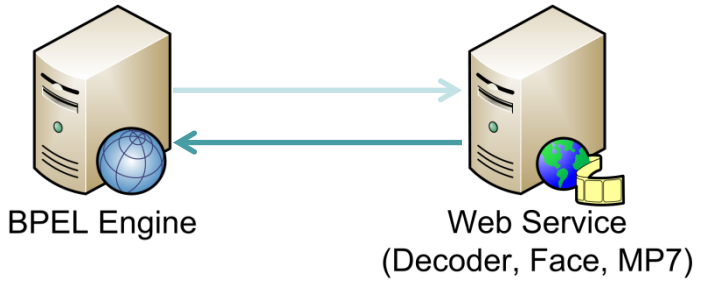
Test scenario II

- AOP / Flex-SwA-Aspect
- 3 EC2 machines
  - BPEL engine
  - MPEG decoder
  - Face detector, MPEG-7 converter



Experimental Setup – Request/Response Aspects

```
Aspect serviceAspect = new Aspect(
  new QName(
    "http://fb12.de/MpegDecoderService",
    "MpegDecoder"),
  "getNextFrame",
  "/0/imageData",
  Aspect.AOP_RESPONSE_MODE,
  "FlexSwAPlugIn")
```

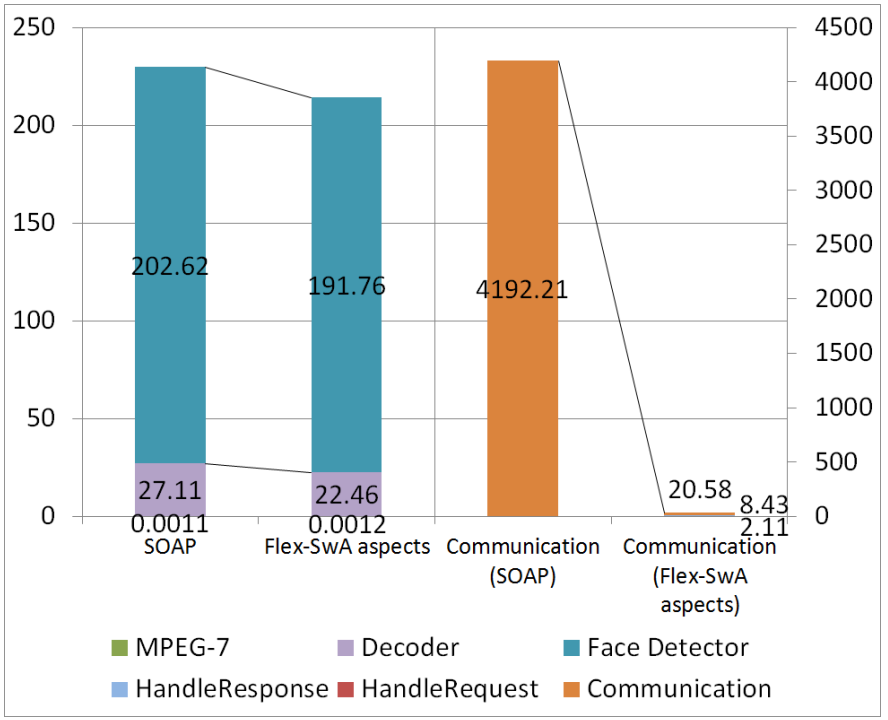


- `void setVideo()`
- `DataBean getMetaData(…)`
- **`ImageBean getNextFrame(…)`**
- `ImageBean getFrameNumber(…)`

```
ImageData
+ frameNumber
+ imageData
+ …
```

Experimental Setup – Results

- Comparison of the two test scenarios
- Impact
  - Large improvement
  - Negligible overhead



Conclusion

- Aspect-oriented framework for SOAP multimedia web services
  - Message based
  - Efficient data transmission between web services
- Reference-based multimedia data transmission
- Reduced development efforts
  - Benefit easily from rich tool support of SOAP web services
- Future work: integration of more sophisticated AOP mechanisms

Thank you for your attention!

Any questions or remarks