Providing Fault-tolerant Execution of Web-service–based Workflows within Clouds

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CloudCP 2012, Bern, April 10th 2012

From Clouds to TClouds

Cloud Computing is … “Everything as a Service” (XaaS)

- Computing power, storage, software, …

Deficiencies regarding trustworthiness

- Inhibit critical applications like financial or medical services

Motivation for TClouds

- Targets provisioning of dependable and secure cloud infrastructures
- EU-funded project comprising 14 partners

Web-Service Orchestration

Combination and coordination of Web services

- Integral part of cloud computing

We need

- Way to express (critical) workflows based on Web services
- Fault-tolerant platform to execute these workflows

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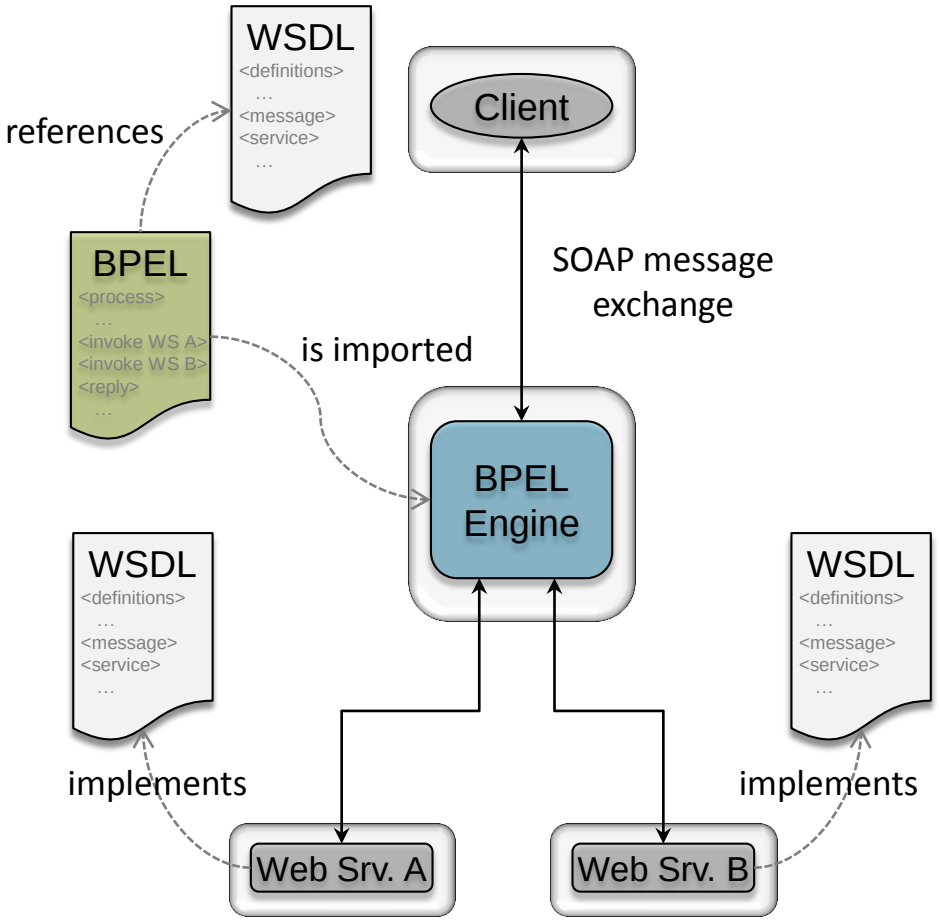
Web Service Business Process Execution Language (WS-BPEL)

- Standardized XML-based language …
- … to describe and execute Web-service–based workflows
- Tools to create, execute, and manage workflows

Standard BPEL Infrastructure



BPEL process definition

- Specifies workflow

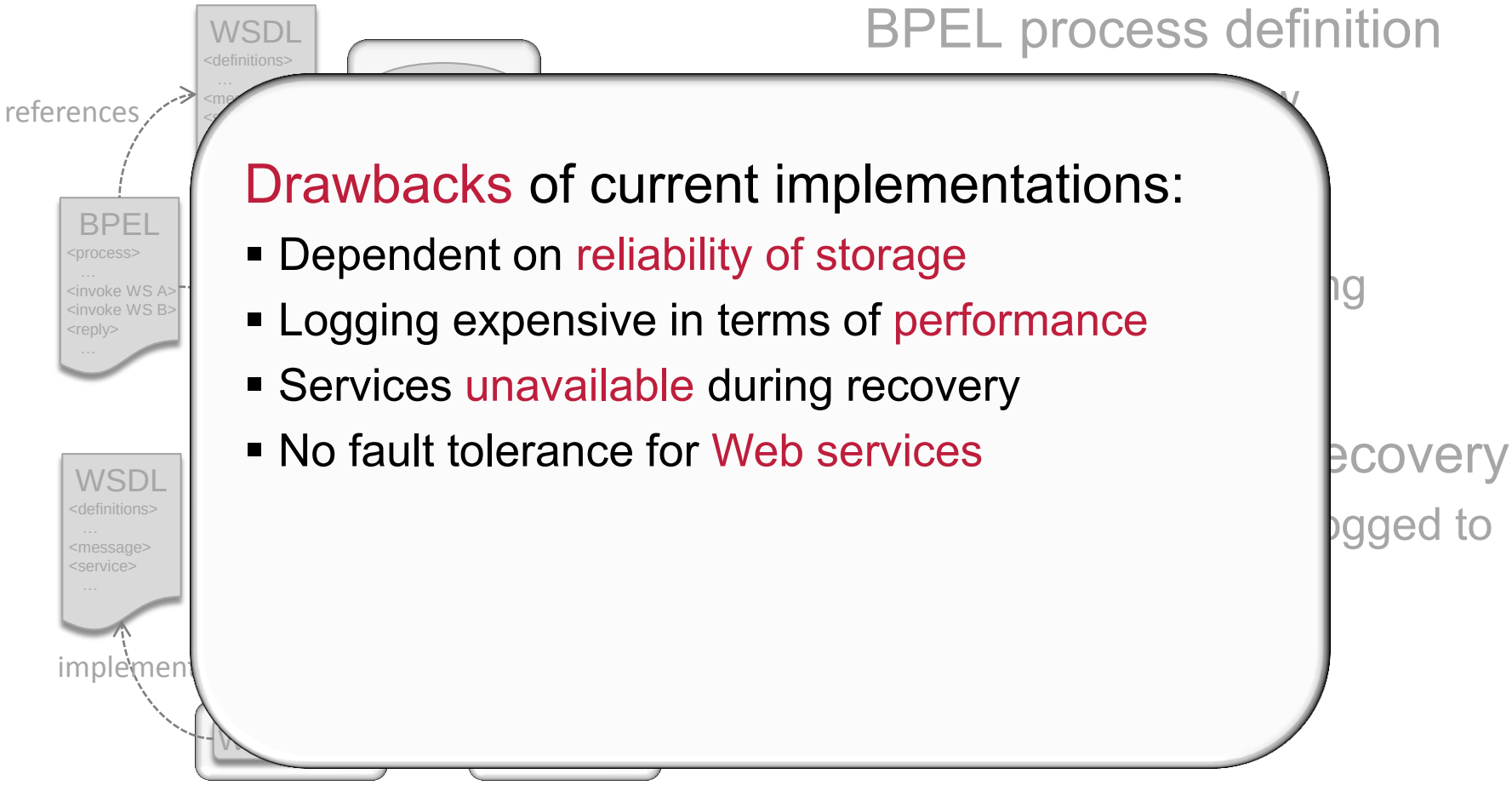
BPEL engine

- Platform for executing BPEL processes

Logging for crash recovery

- State changes are logged to stable storage

Standard BPEL Infrastructure



Drawbacks of current implementations:

- Dependent on reliability of storage
- Logging expensive in terms of performance
- Services unavailable during recovery
- No fault tolerance for Web services

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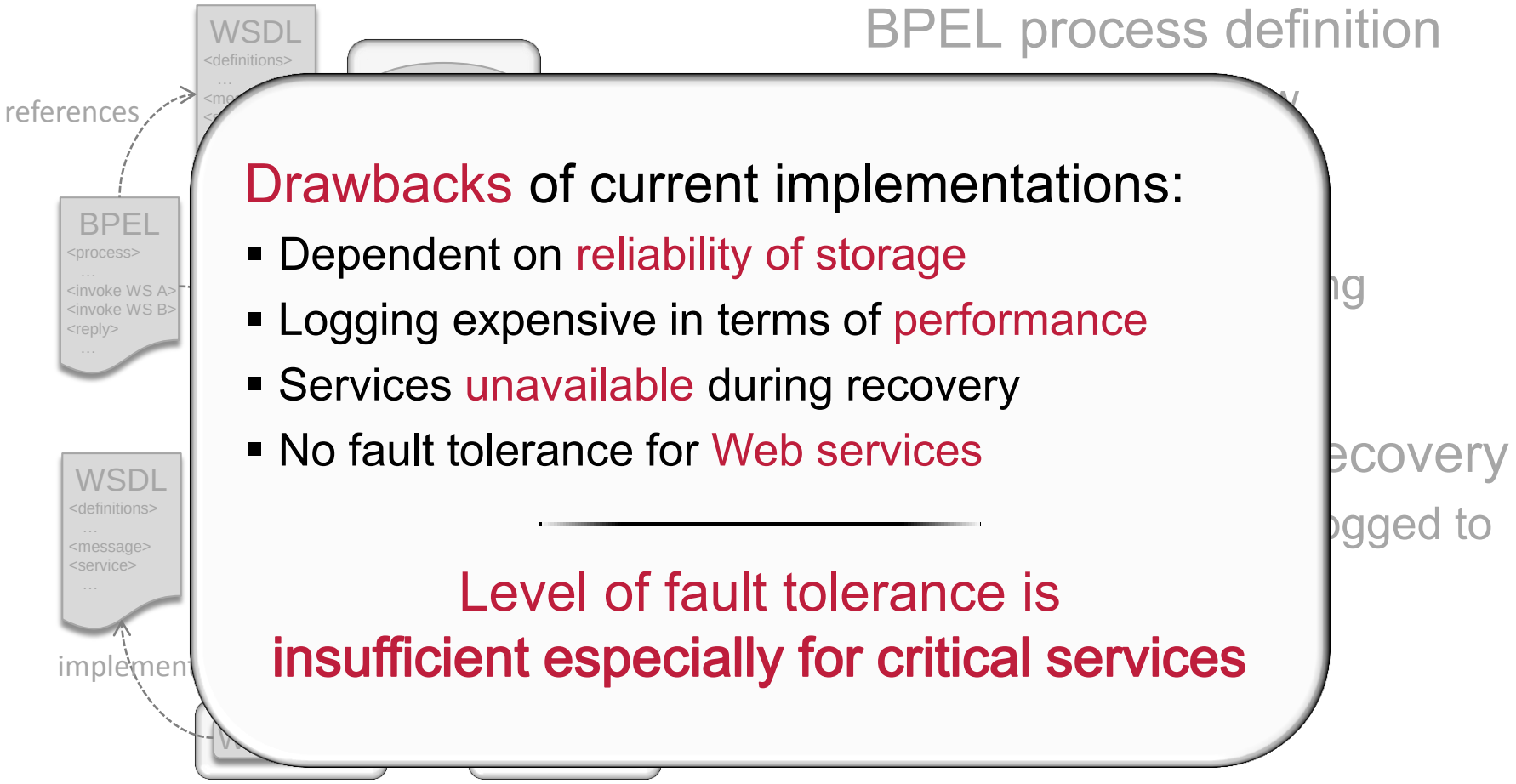


Drawbacks of current implementations:

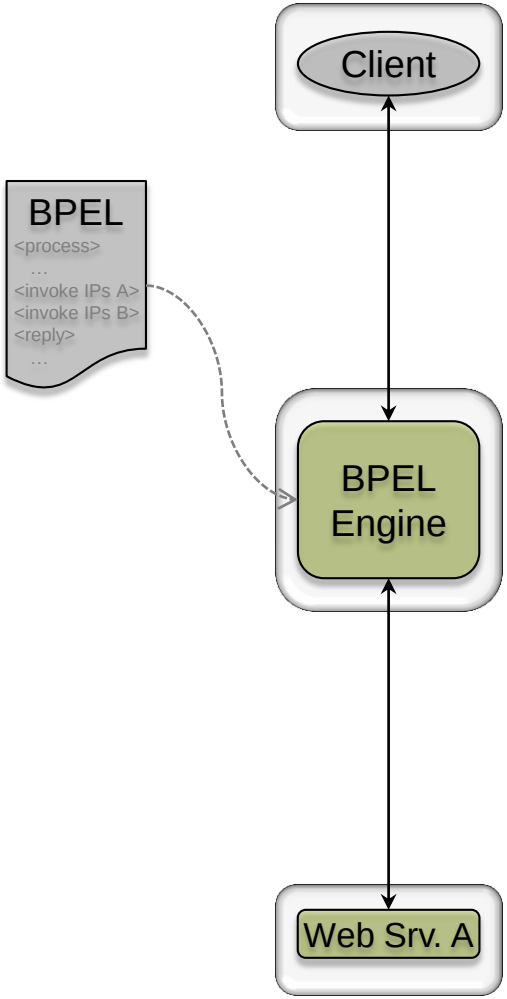
- Dependent on **reliability of storage**
- Logging expensive in terms of **performance**
- Services **unavailable** during recovery
- No fault tolerance for **Web services**

Level of fault tolerance is
insufficient especially for critical services

Reliable BPEL Infrastructure

- Motivation
- Reliable BPEL Infrastructure
- Evaluation
- Outlook and Conclusion

Reliable BPEL Infrastructure



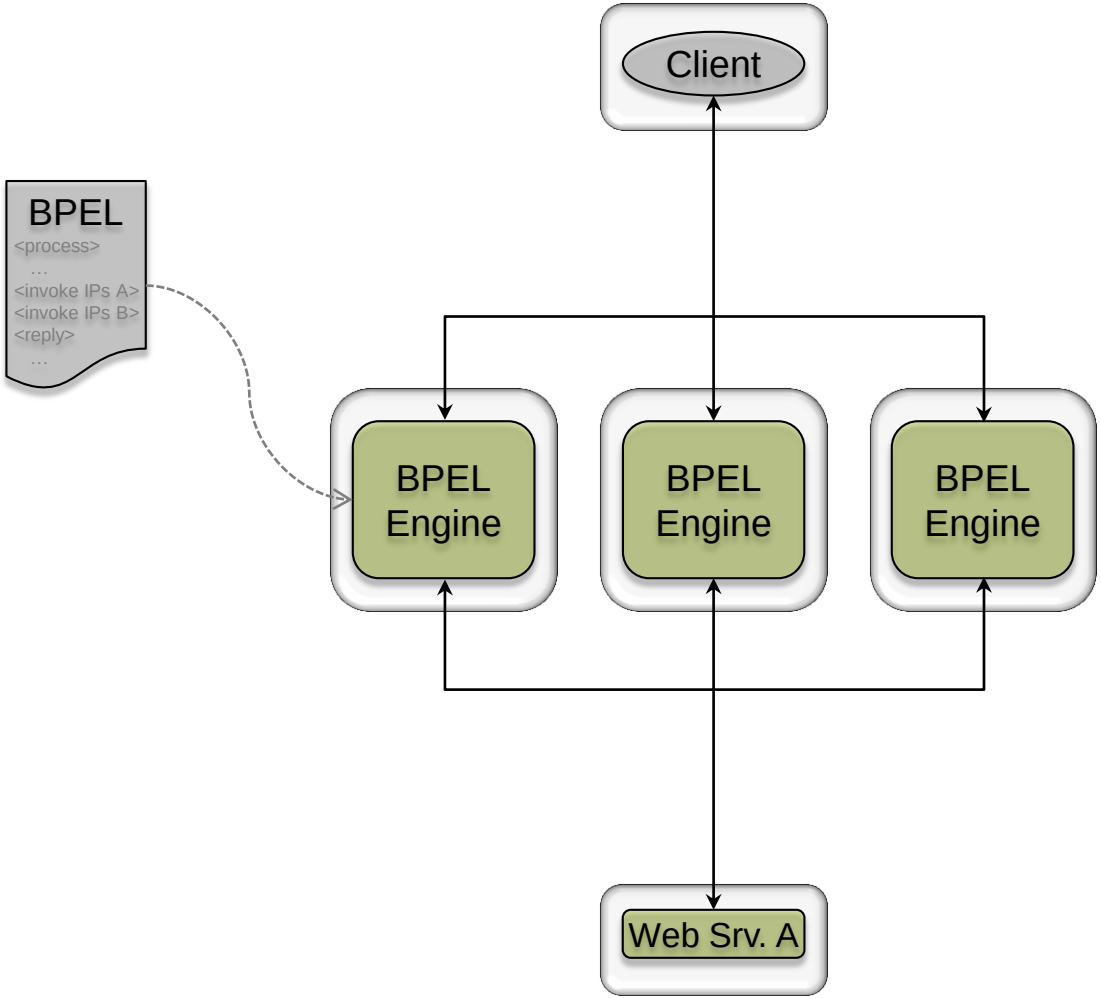
Starting Point:

Reuse current BPEL systems

- BPEL engines
- Tools

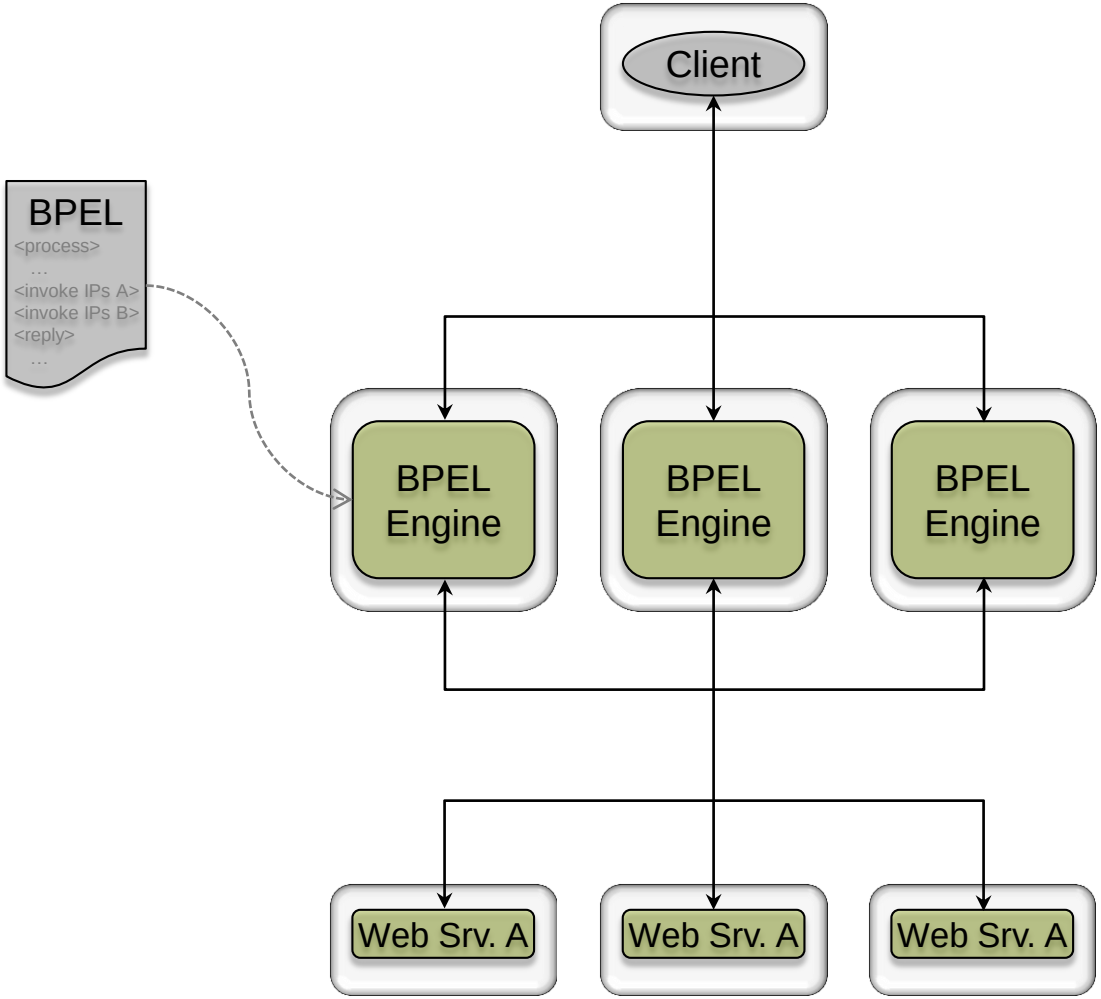
Replace standard mechanism for crash recovery

Reliable BPEL Infrastructure



Active replication for high availability

Reliable BPEL Infrastructure



Active replication for high availability

- BPEL engines
- Web services

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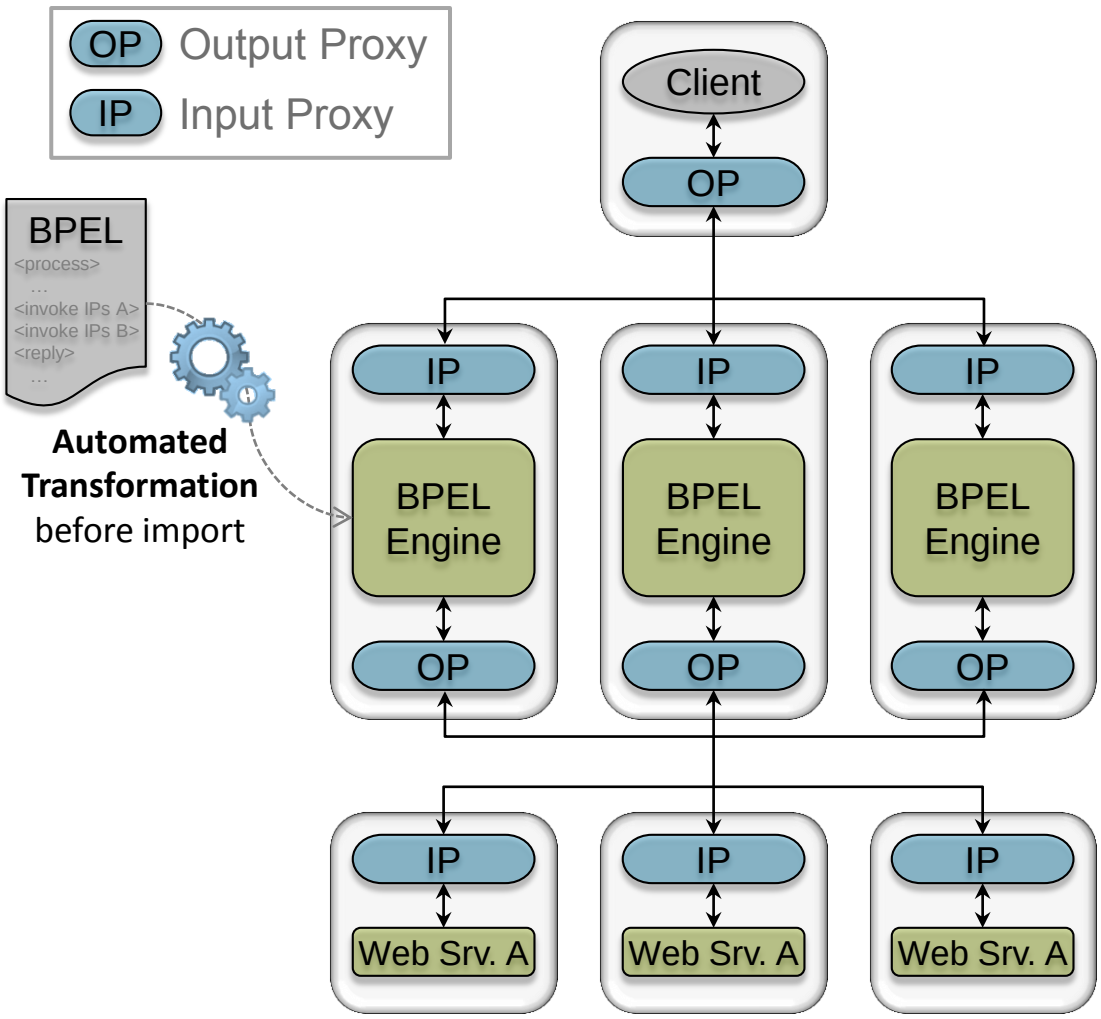

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Generic proxies and automated transformation for transparency

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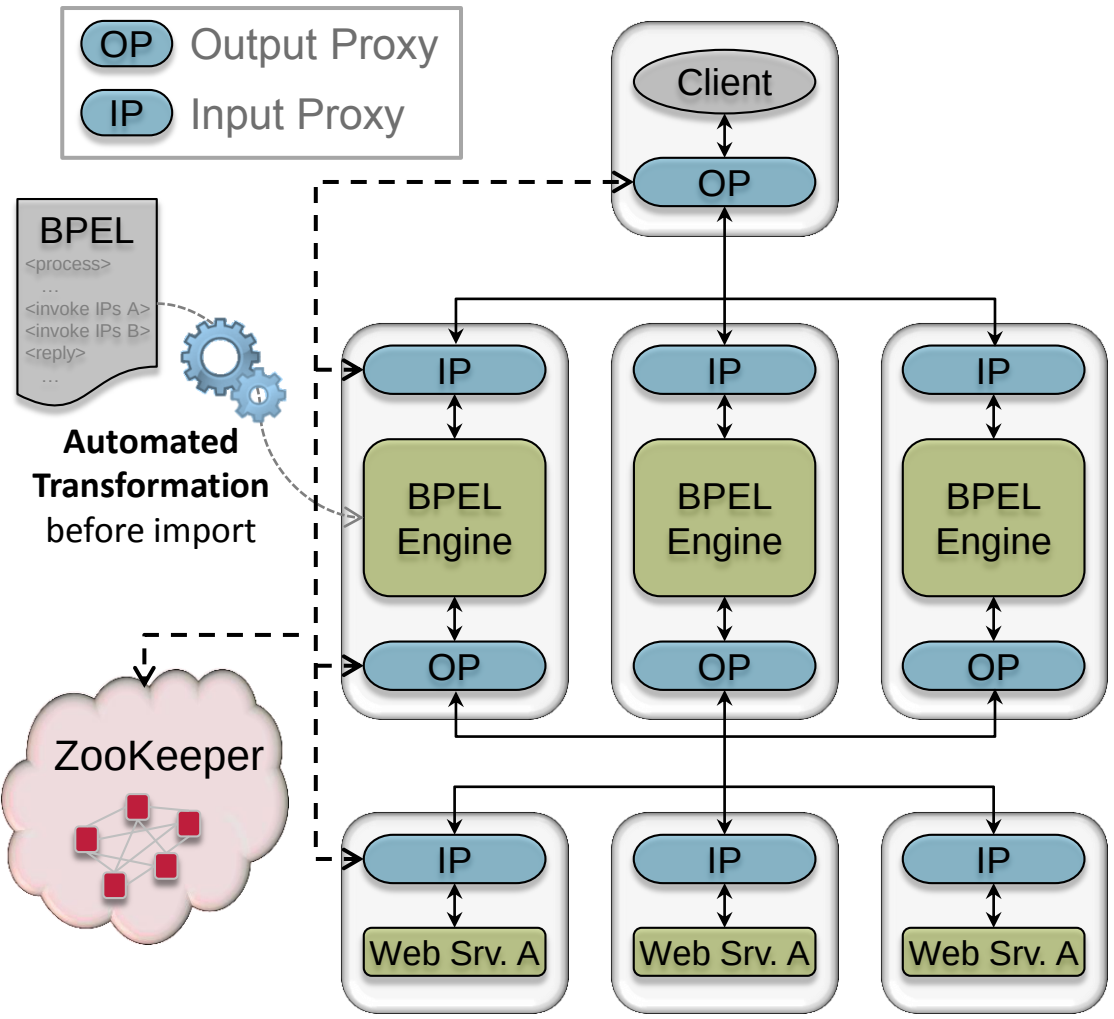

Active replication for high availability

- BPEL engines
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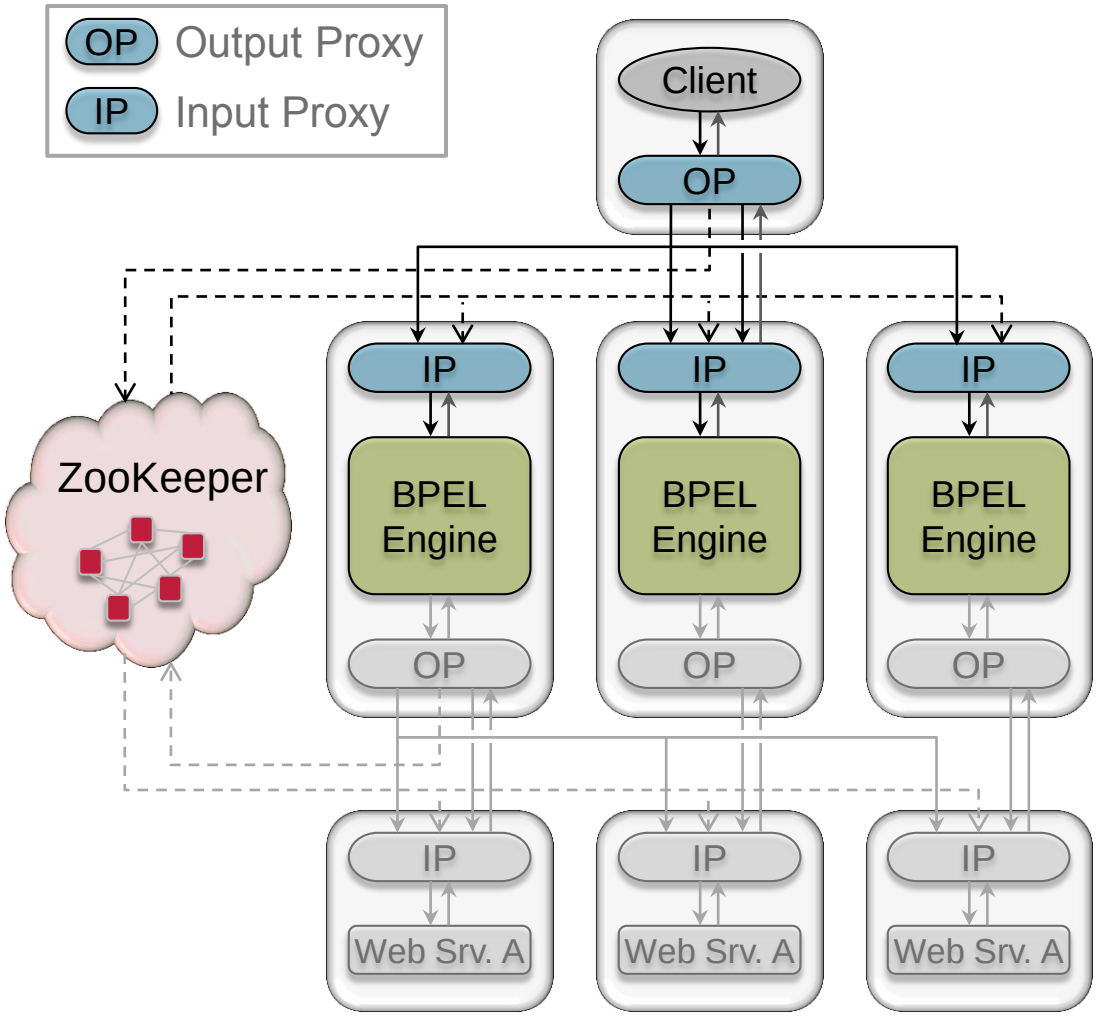
Generic proxies and automated transformation for transparency

Coordination service for simplified configuration and implementation

- Apache ZooKeeper for:
- Leader election
- Crash detection
- Dynamic configuration
- Request ordering

Details – Client / BPEL Stage



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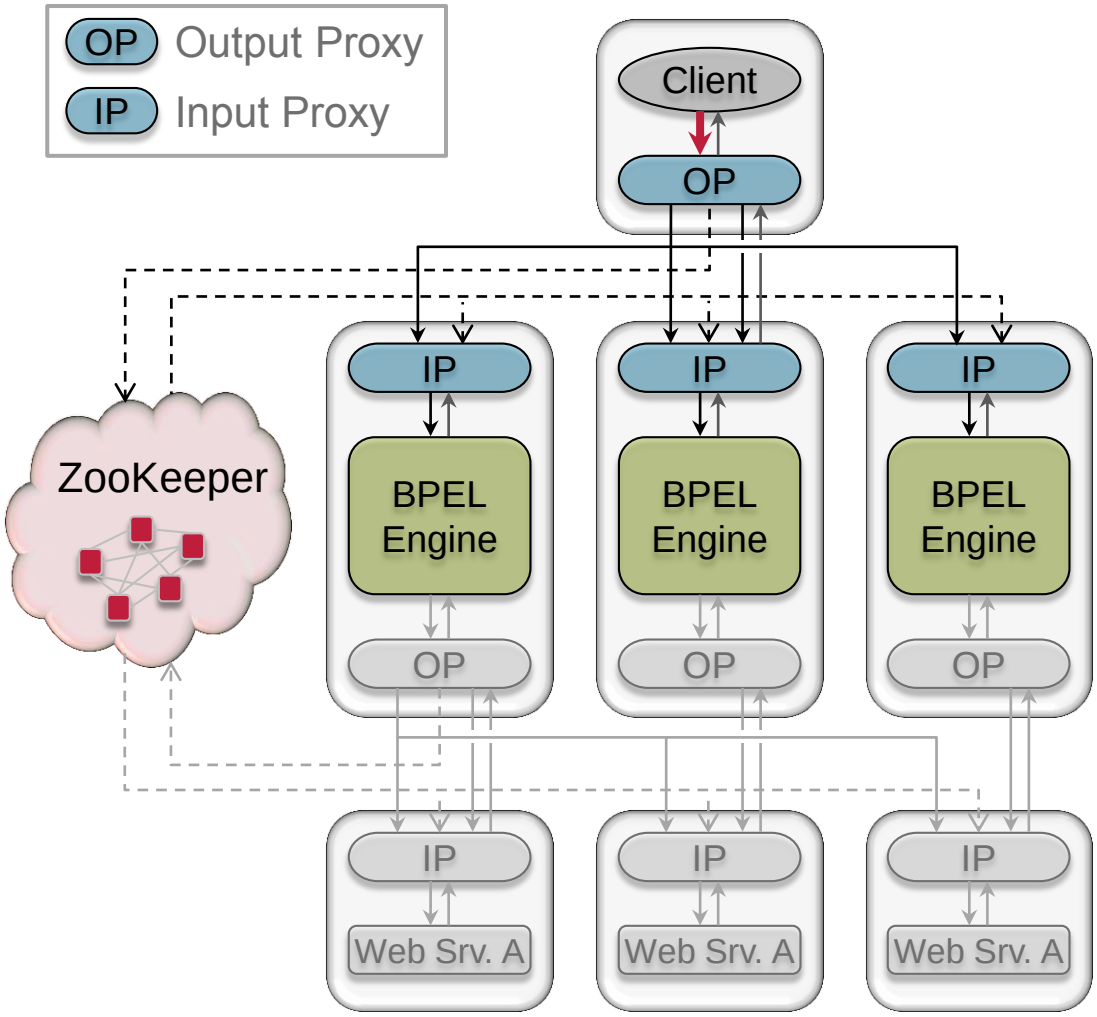

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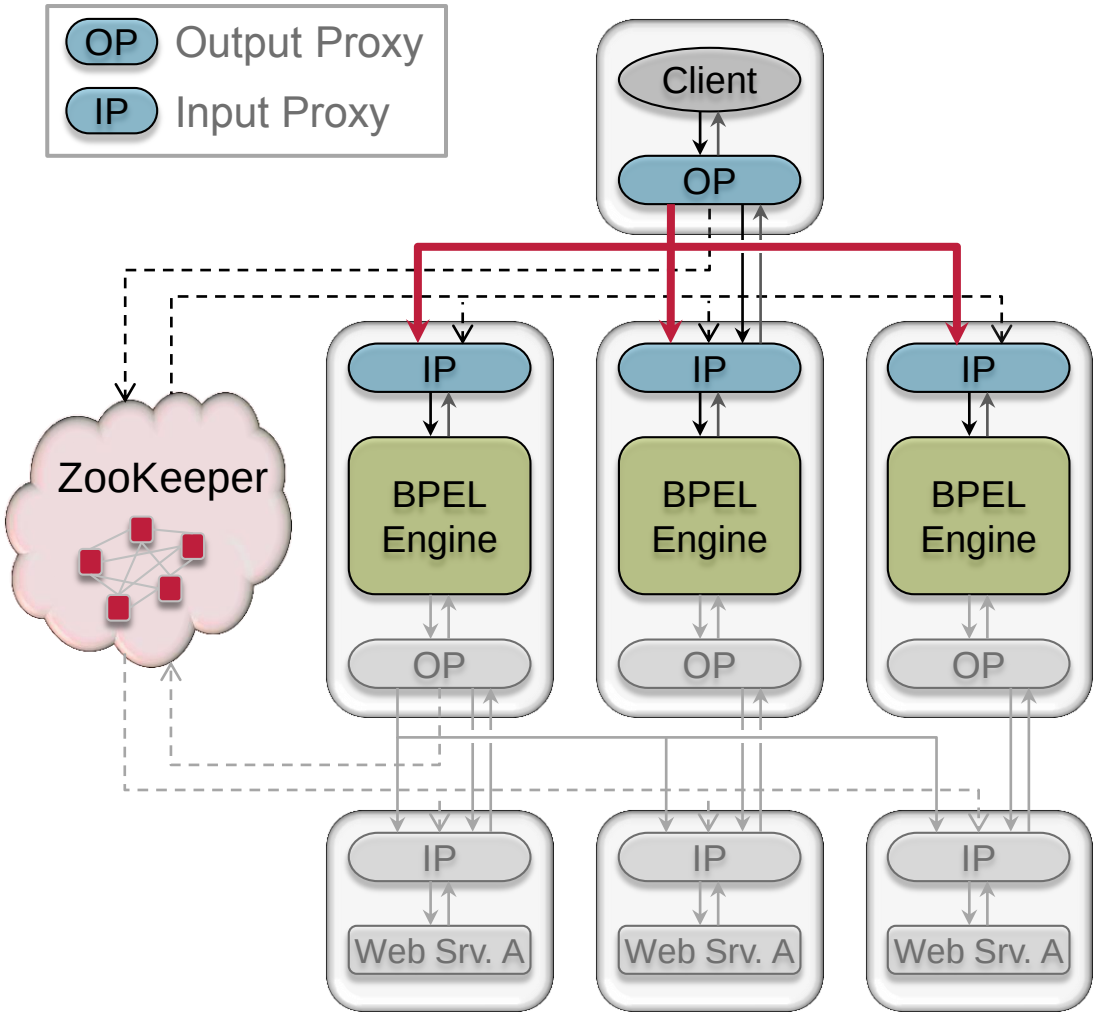

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- ZooKeeper for list of active replicas

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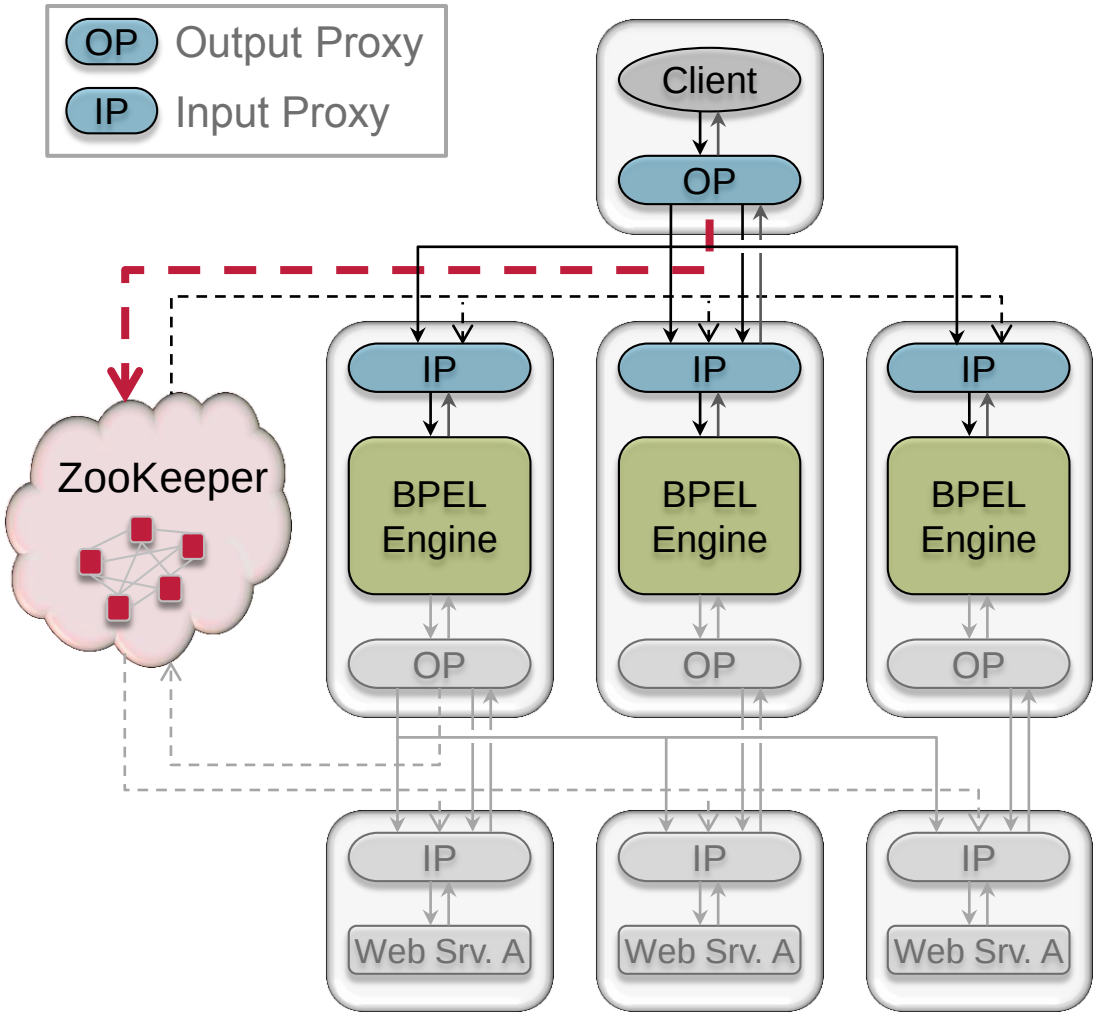

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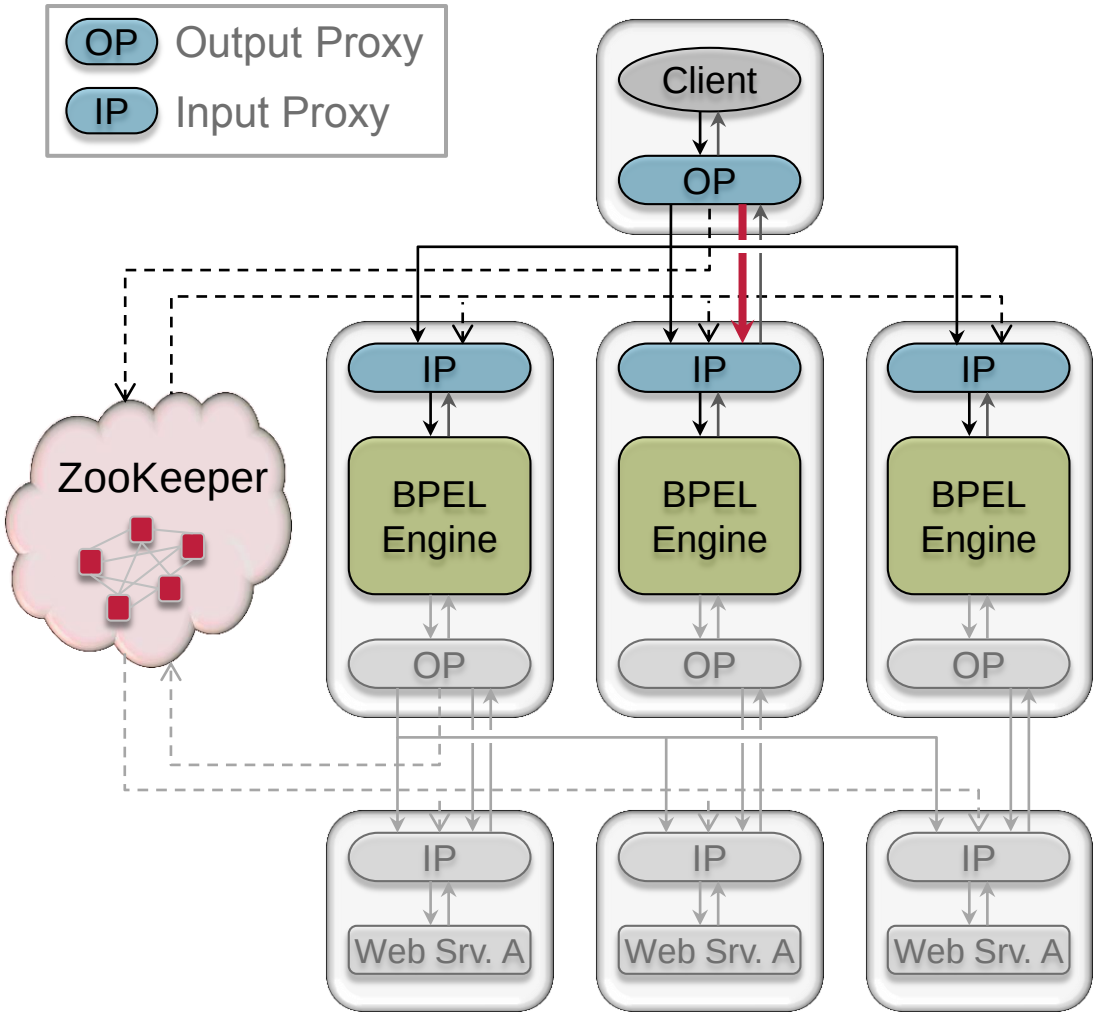

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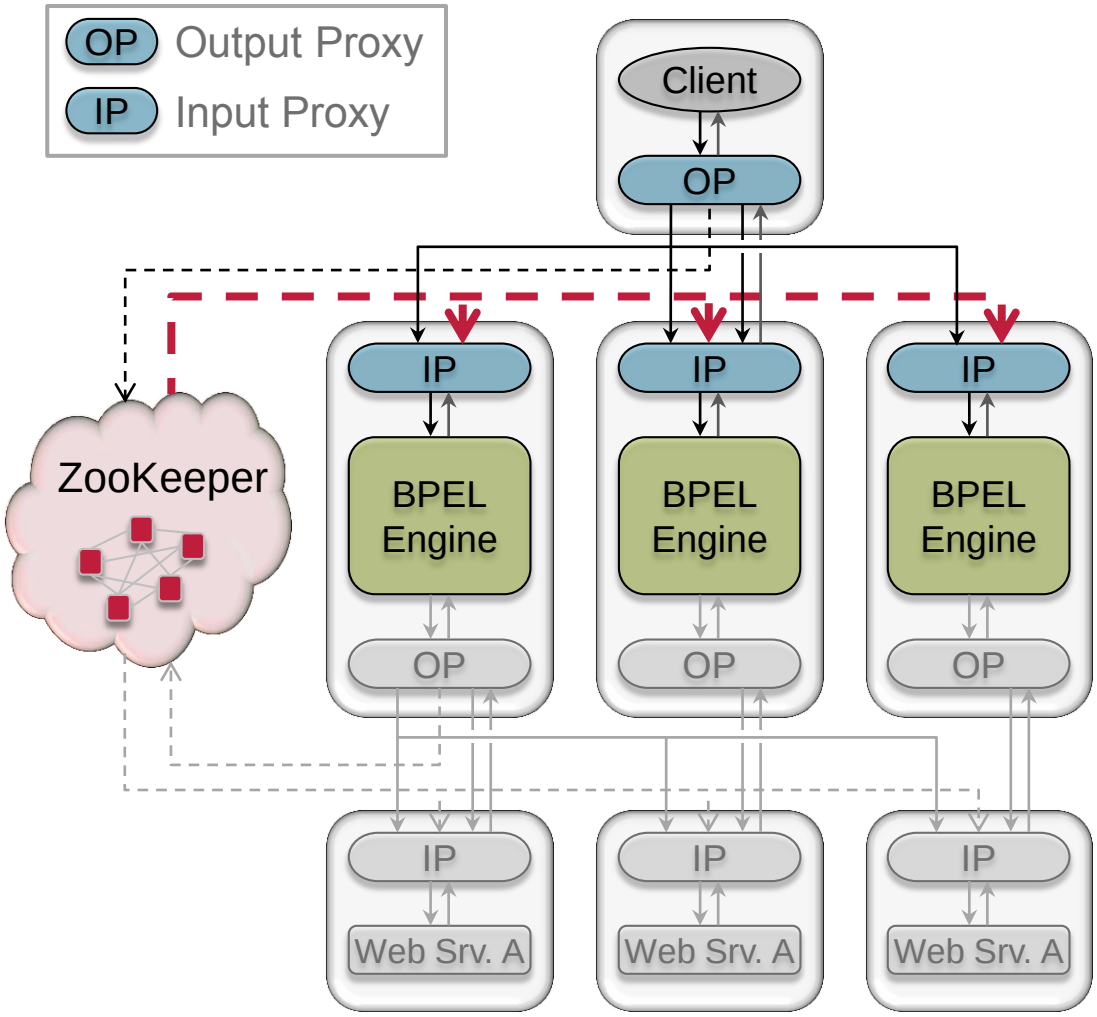

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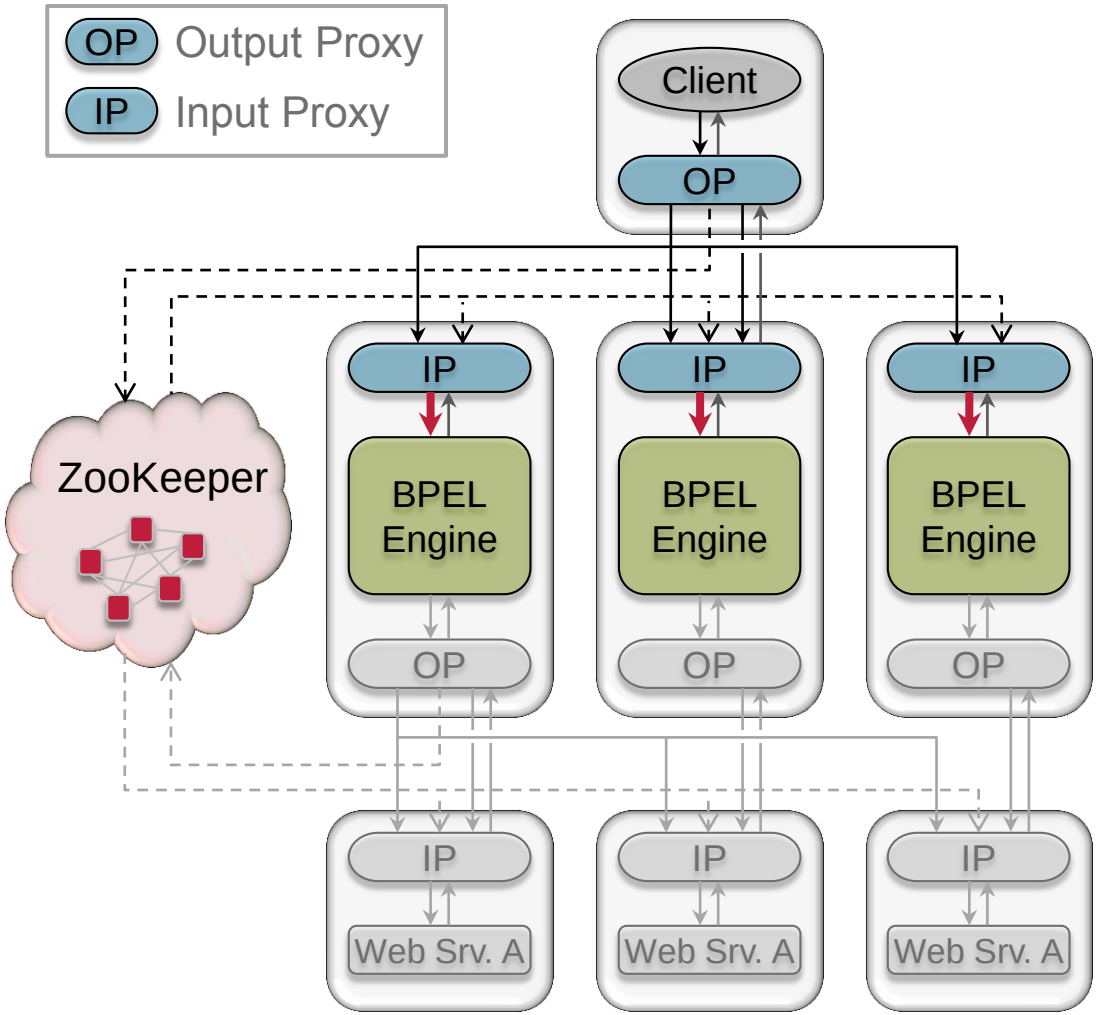

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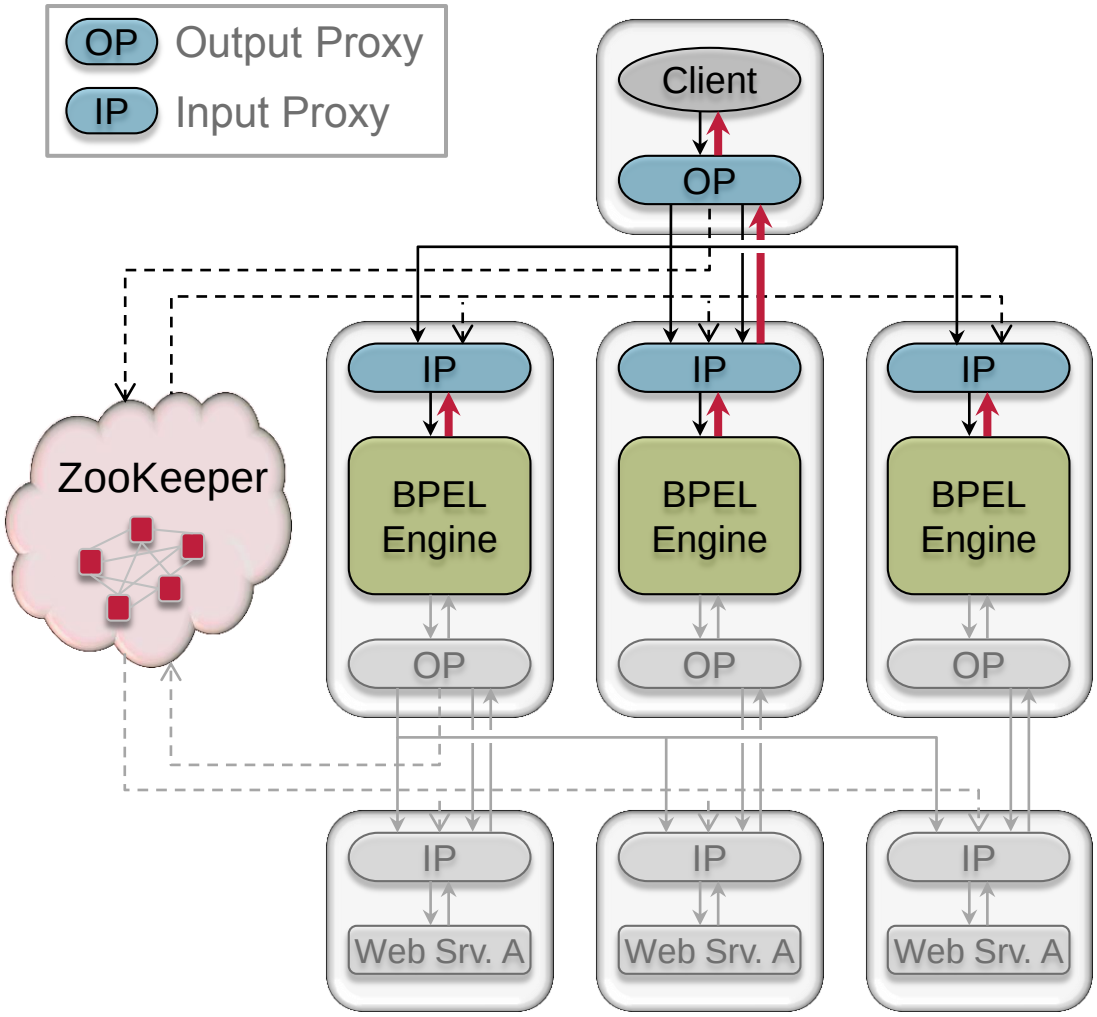

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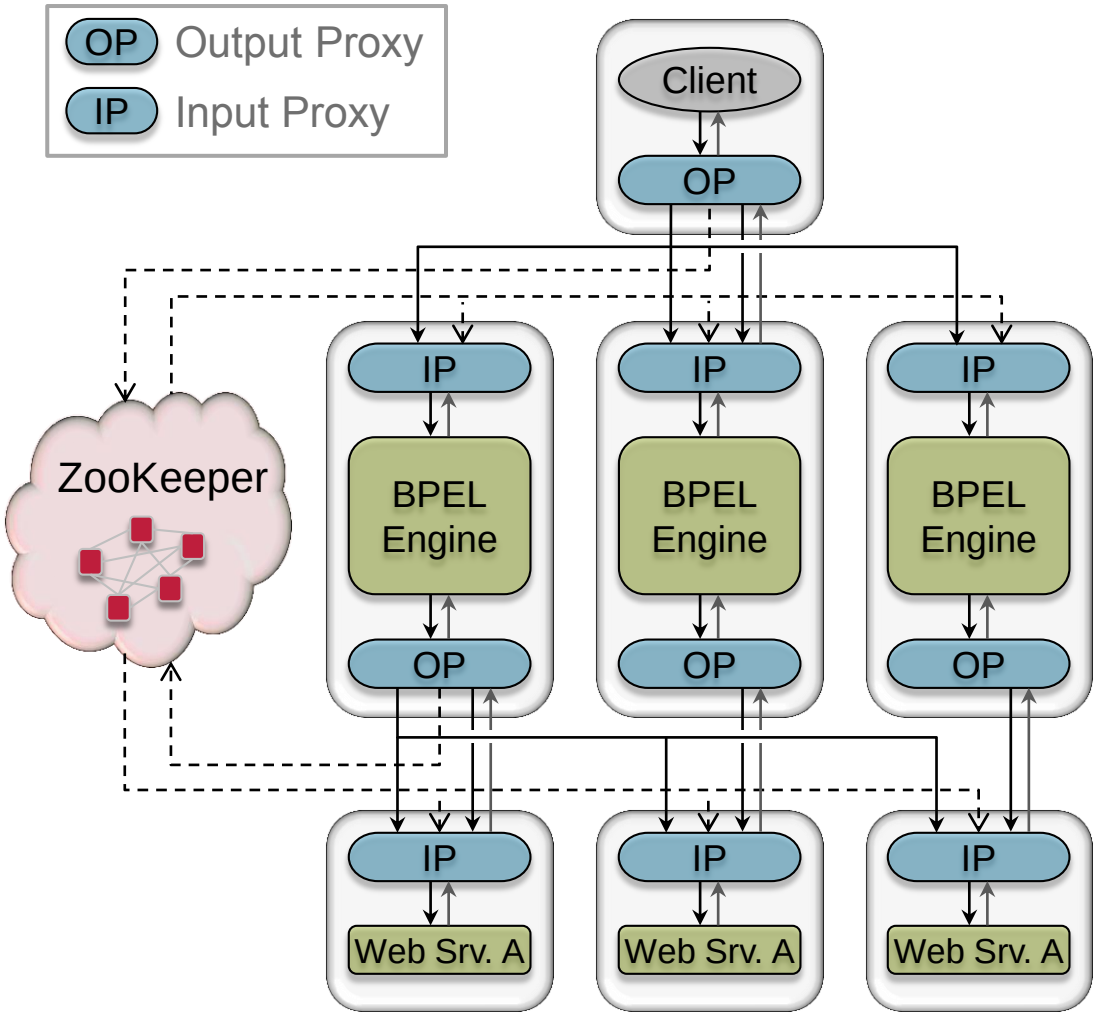

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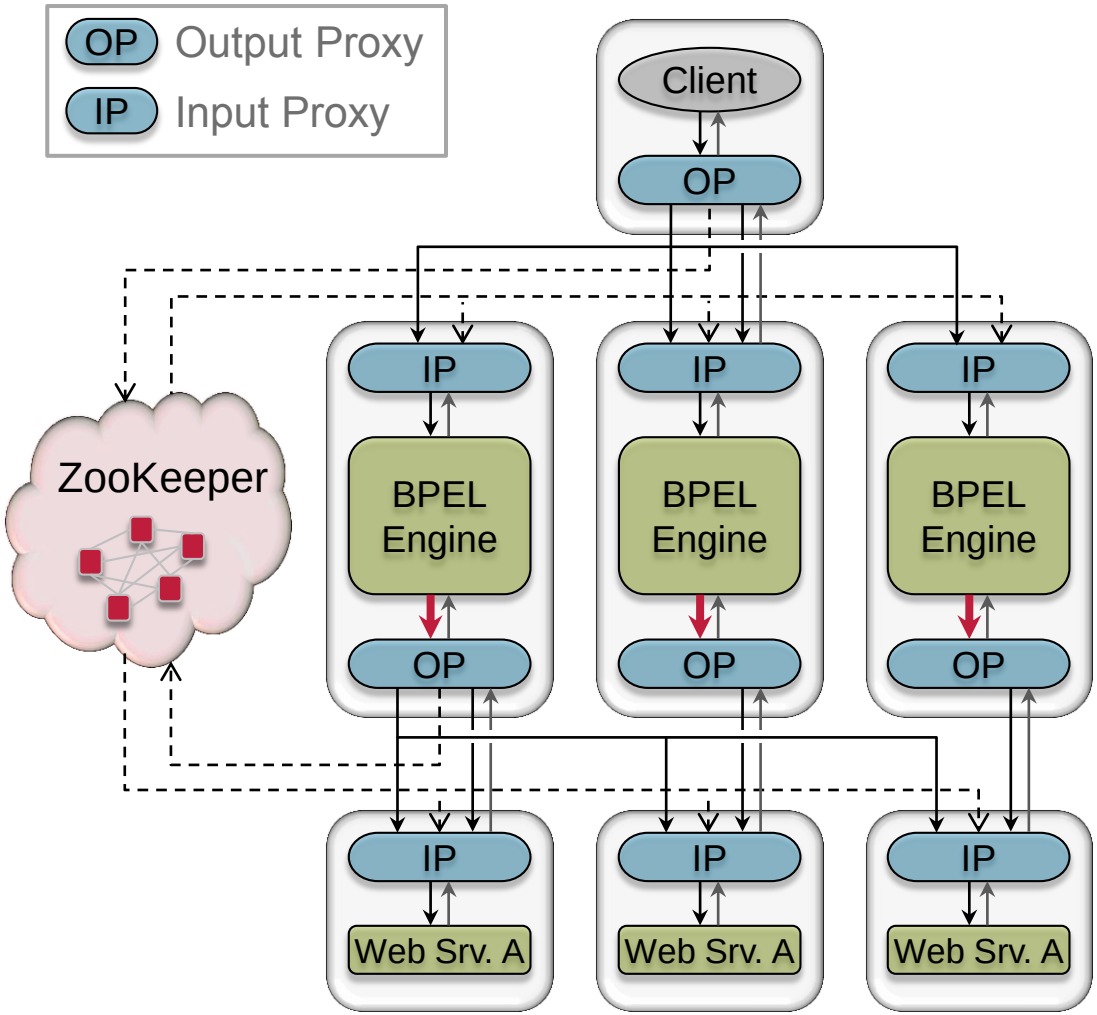

(1) Web-service calls are redirected through automated transformation

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- Call ID (request ID + counter) added

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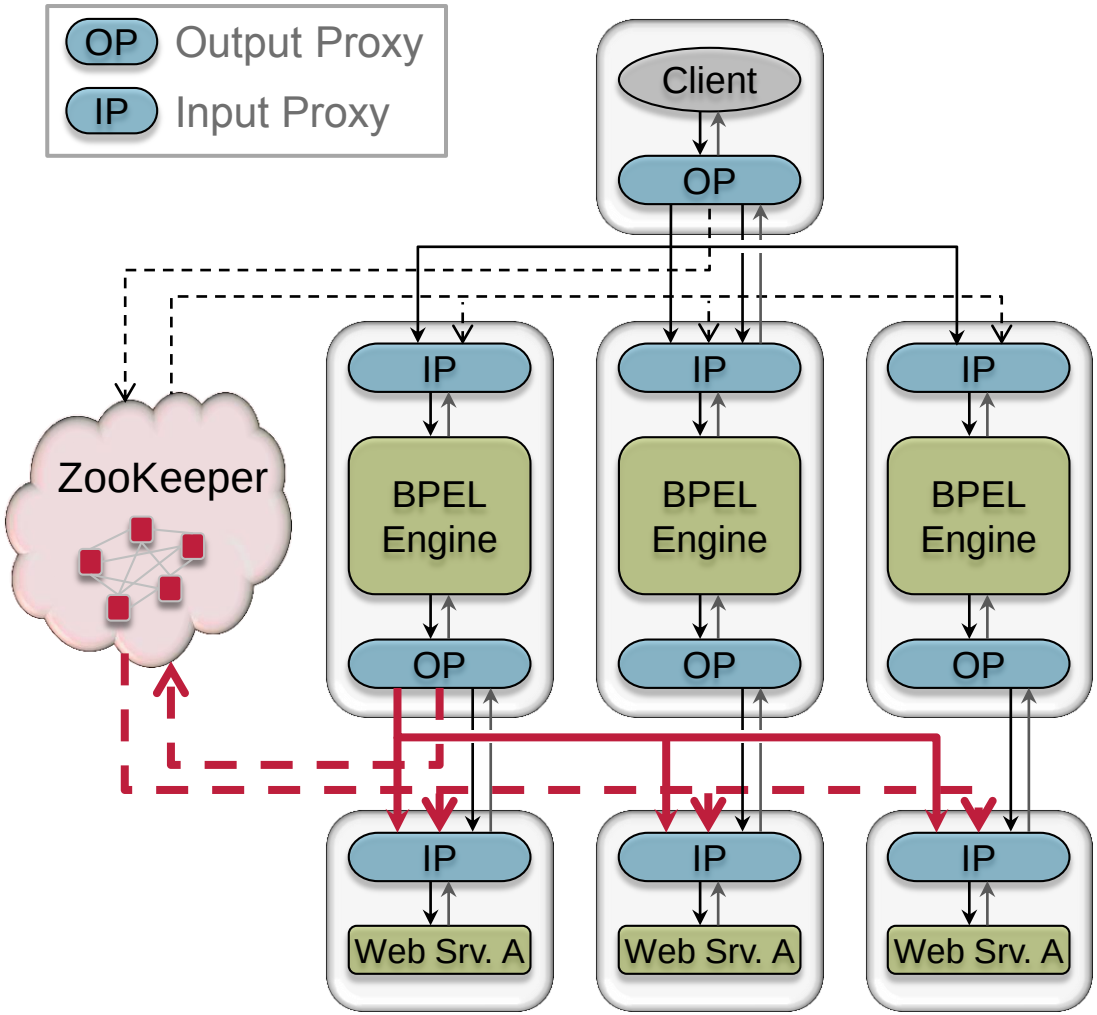

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- Delivery as in first stage

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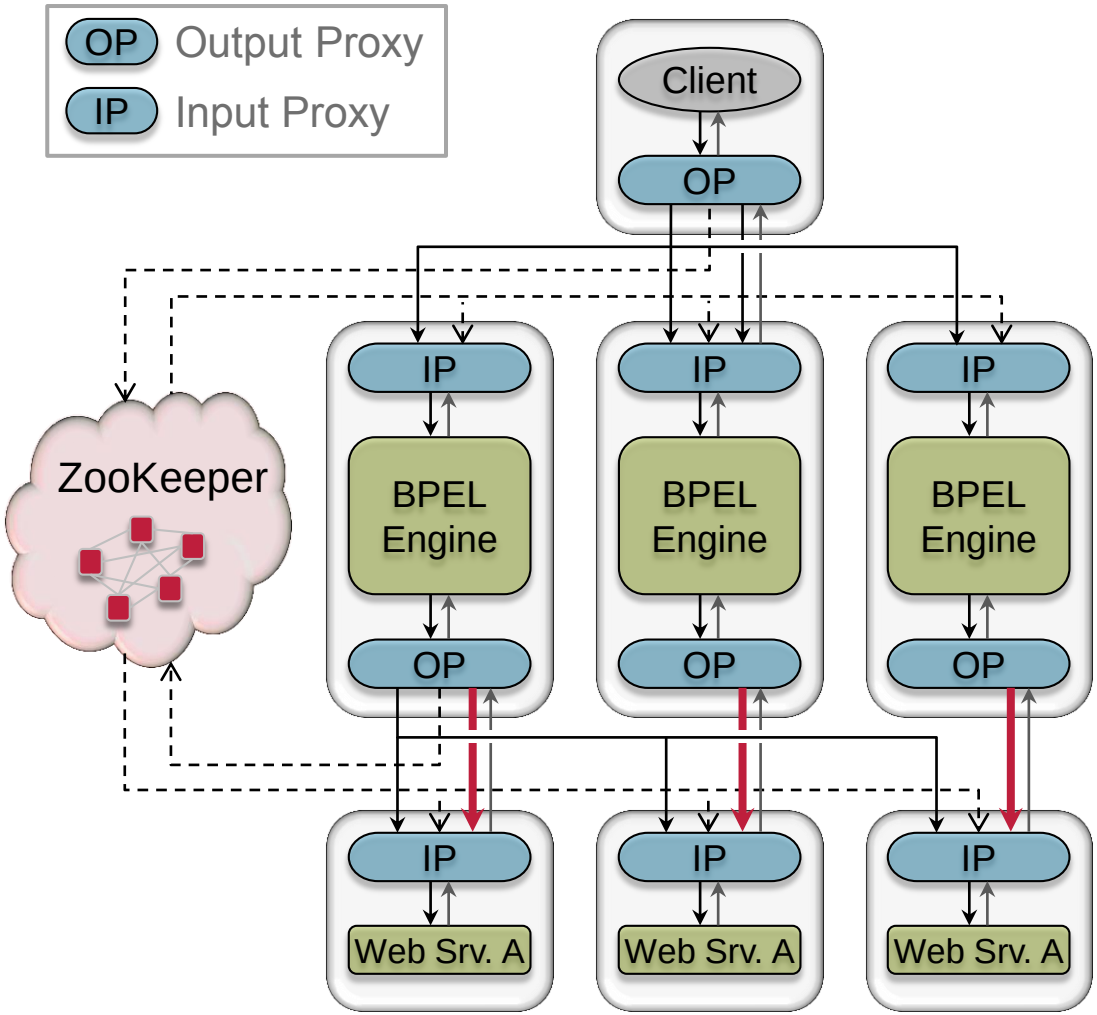

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(3) All output proxies wait for reply

- Utilizing call ID

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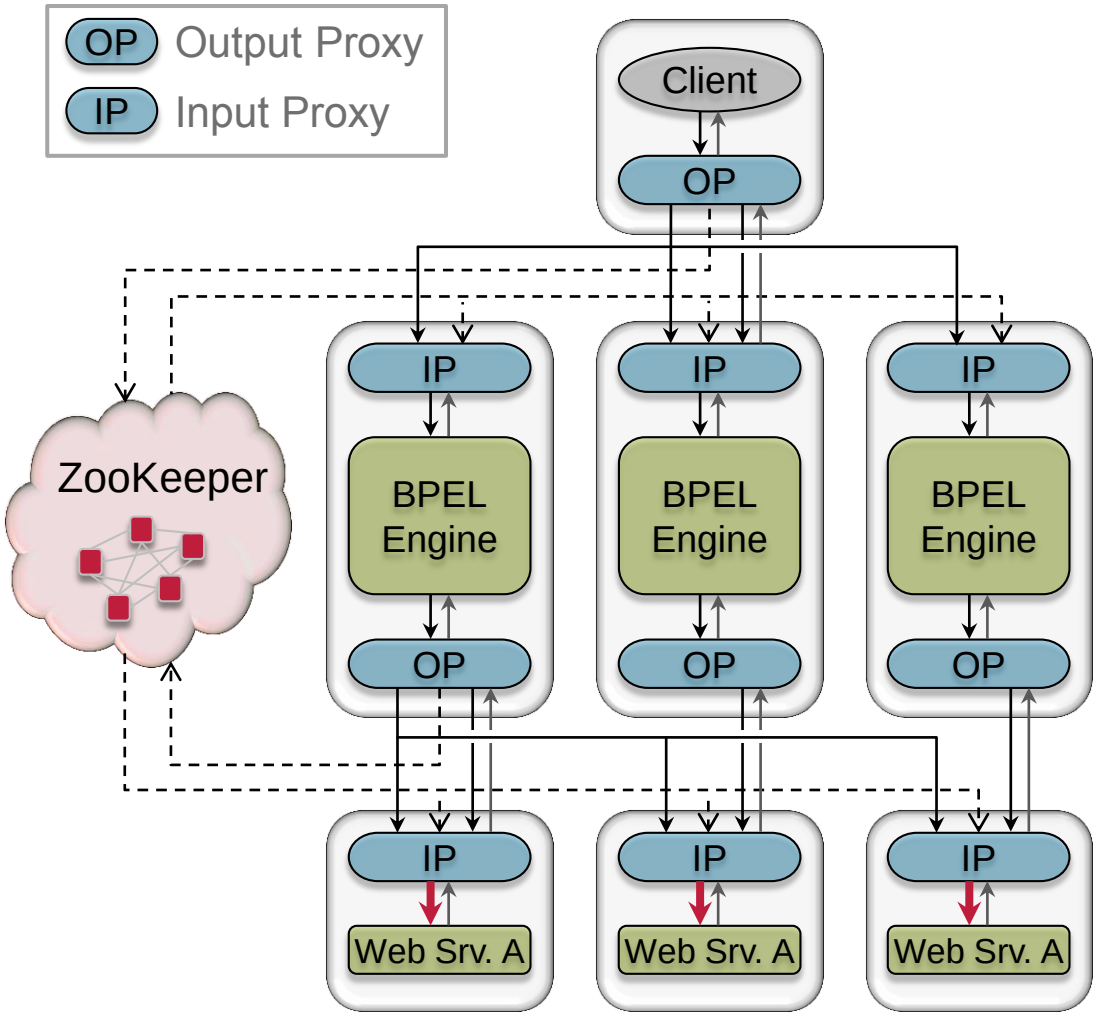

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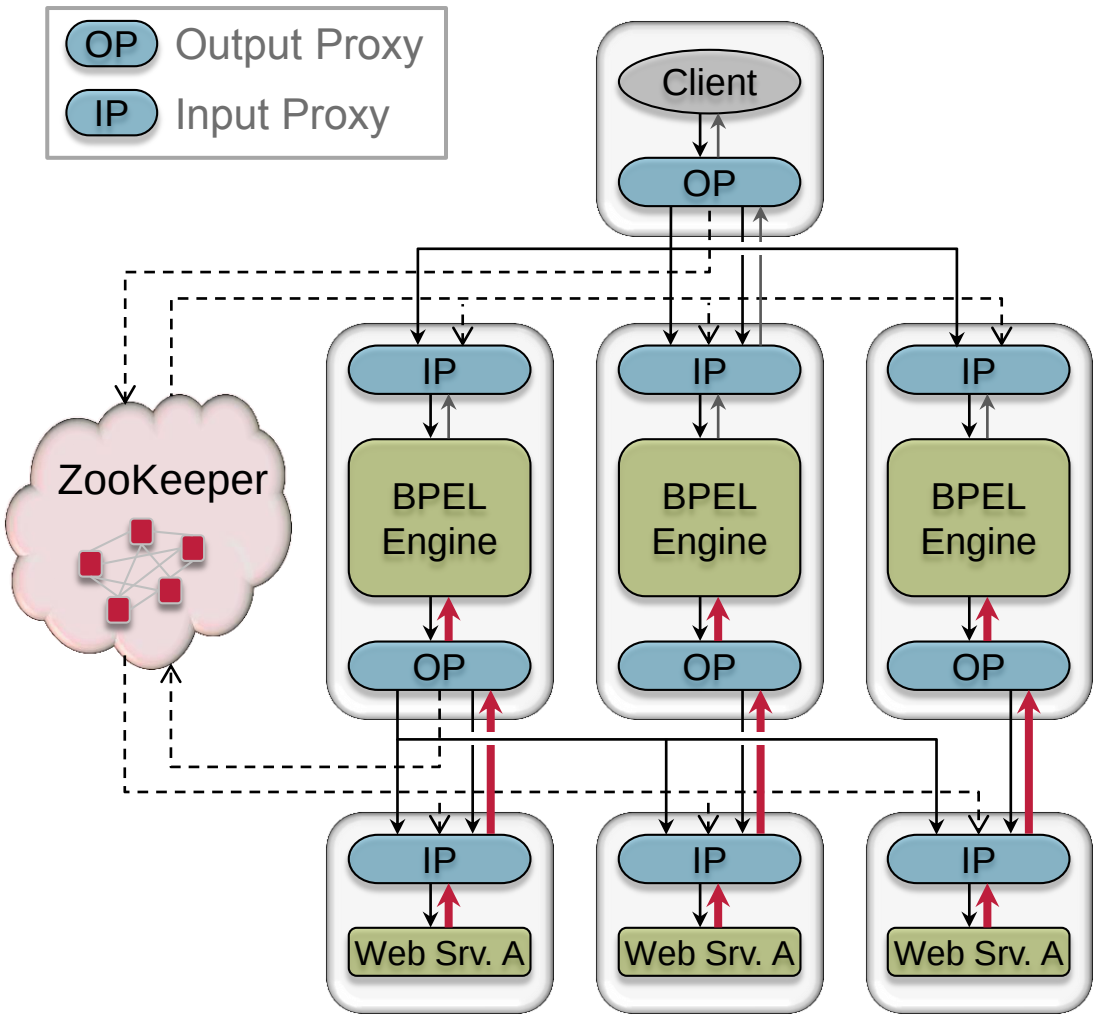

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Evaluation

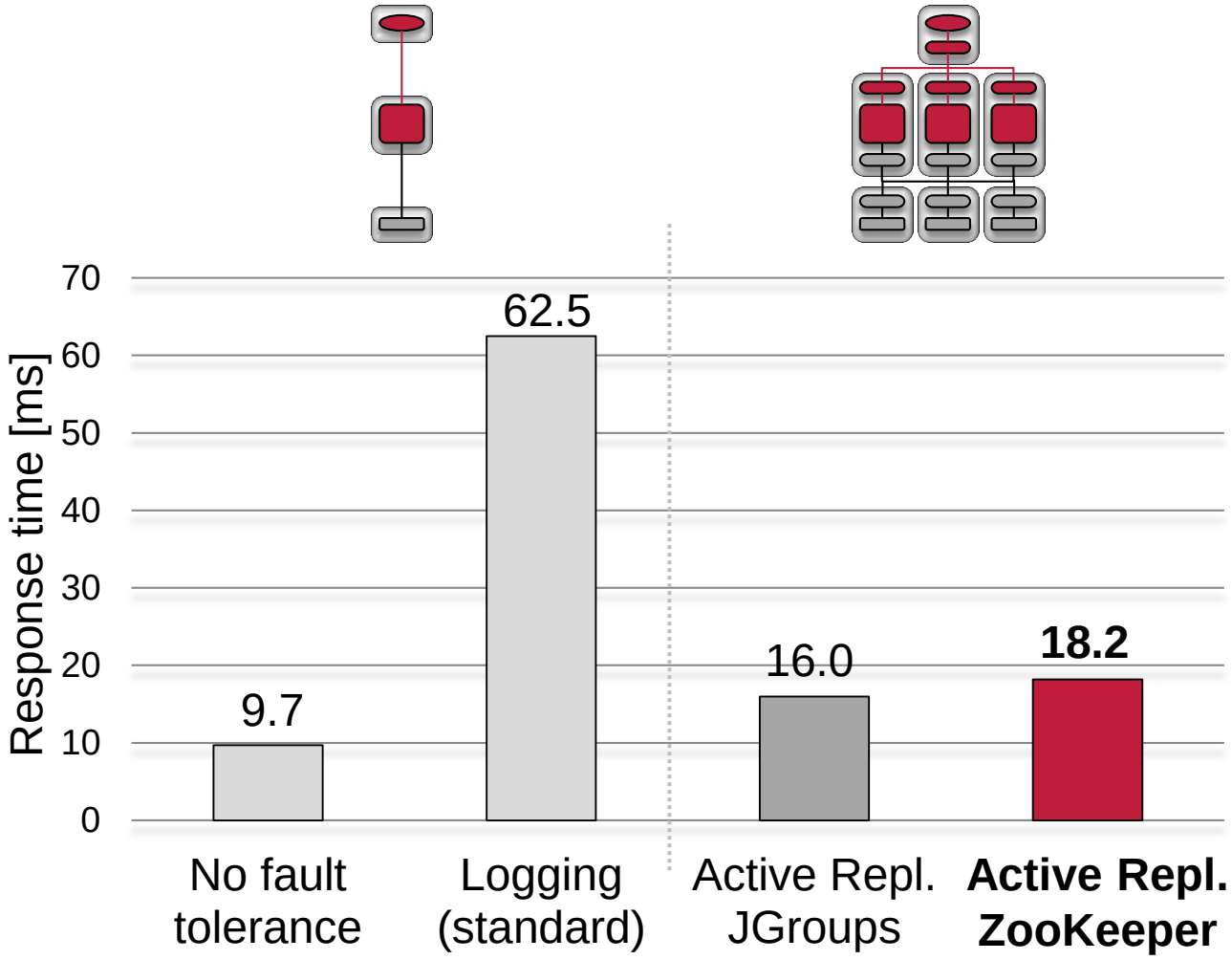
Test Setting

- Prototype implementation using Java
- 16 machines connected over switched Gigabit Ethernet
  - 1 client, 5-times replicated BPEL engine, ZooKeeper, and Web service
- Apache software stack
  - Tomcat, Axis2, ODE

Comparison of response times

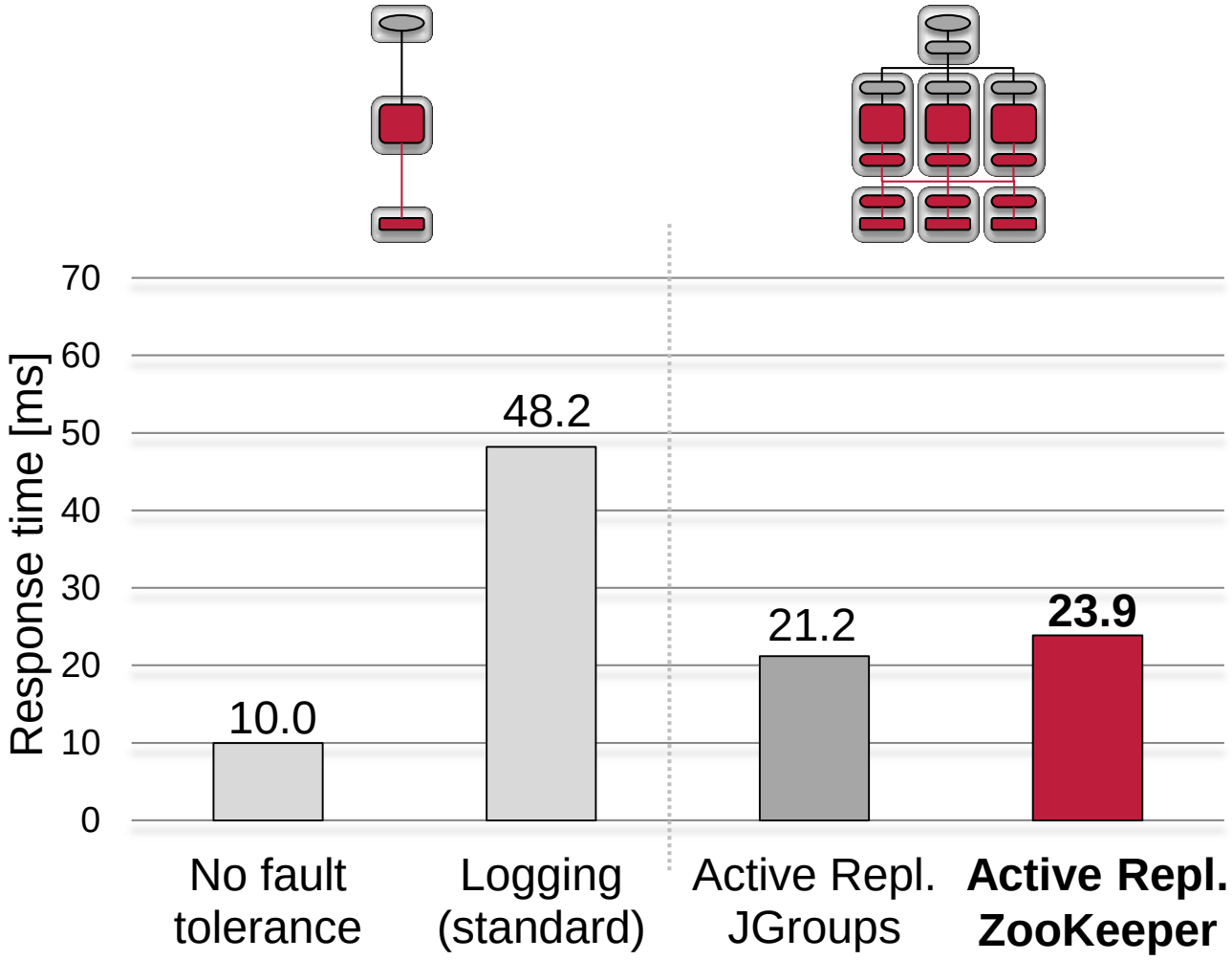
- Unreplicated
  - No crash recovery (without any fault tolerance)
  - Crash recovery enabled (standard system)
- Actively replicated
  - Integrated coordination (group communication over JGroups)
  - Externalized coordination (ZooKeeper)

Evaluation – Client / BPEL Stage



- Request from client to BPEL process without Web service invocation
- Active replication with external coordination 3.4 times faster than standard system
- Moderate overhead of 14% for externalized coordination

Evaluation – BPEL / Web-Service Stage



- Request from BPEL process to Web service
- Active replication with external coordination 2.0 times faster than standard system
- Moderate overhead of 13% for externalized coordination

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Outlook

Tolerating arbitrary faults (Byzantine faults)

- Hardware errors
- Malicious attacks

Distribute replicas over multiple clouds (cloud-of-clouds)

- Independence from a single cloud provider

Cloud infrastructure management over coordination service

- Platform and resource allocation
- Failure detection and dynamic reconfiguration
- Job control

Conclusion

Fault-tolerant execution of Web-service–based workflows in context of cloud computing is currently an open issue

BPEL would be a perfect supply for the demand…

- …but level of fault tolerance is not sufficient

Our proposed reliable BPEL infrastructure:

- Active replication of all components
- Transparency through automated transformation of workflows
- Utilizing of external coordination

Thank you for your attention!

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TClouds

http://www.tclouds-project.eu/

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement number ICT-257243.