

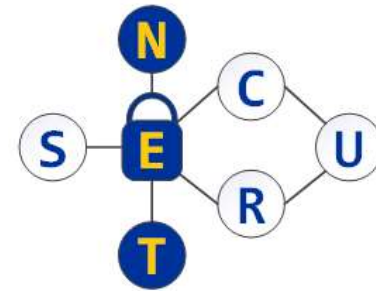
AdProv: A Method for Provenance-data Capturing, Management and Visualization of Runtime Process Adaptations

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Abstract. Provenance in scientific workflows is critical for understanding, reproducing, and auditing processes in data processing pipelines. In business processes similar recording of process executions has a crucial role in establishing process compliance and conformance, correctness of changes, and process mining. Both these research fields do not address adequately the provenance of changes in processes, a.k.a. process adaptations, especially when modifications may occur during execution. A review of the literature reveals a lack of systematic approaches and realizations for capturing provenance information about runtime process adaptations; process systems being one of the methodologies to coordinate software systems. To fill this gap, we propose a five-step method, called AdProv, to collect, store, retrieve, and visualize the provenance of process adaptations. The method also defines a data model for concepts like change events and extends the XES standard with the elements to reflect adaptation logging. Our current implementation of the method shows the feasibility of the approach and its practical applications in variety of systems and scenarios.

Keywords: Provenance of Adaptation · Business processes · Method Engineering





Provenance

"The provenance of digital objects represents their origins."

Scientific experiments are considered to be of good provenance, if they are reproducible.

For the reproducibility we are interested in the when, what, who, why and ultimately the (business) impact.

- It is a record of how digital objects/ data have changed/have been transformed,
- what operations happened on them
- at what time.
- Synonyms:
 - Traceability
 - Tracking
 - Reproducibility



State of the Art – Based on 2 SLRs

1. Workflow Provenance and Provenance of Workflow Adaptation

- Focus on both business and scientific workflows
- 1165 initial papers → 22 selected
- 5 from BPM
- 8 papers mention provenance of adaptation
- Adaptations recorded: inputs and outputs of workflows or a model version
- Not control flow adaptation

2. Adaptation Logging and Mining Workflow Logs

- Business processes focus
- 1136 initial papers → 9 selected
- 2 works mention logging process change operations for specific systems
- Typically, we discover deviations, anomalies, drifts, alignments... using process mining (change mining)
- Input – process logs
- But not the actual fact that someone made a change



Conclusions from SLRs

Provenance of **workflow adaptations** (granularity and type) not in the focus of the BPM and scientific workflow communities.

Only execution logs stored

Lack of enabling methods for developing a systems for gathering and using provenance information about runtime workflow adaptations



Methodology

Method Engineering ([11] Godkuhl, G. et al.)

A method is a guidance to problem solving or performing complex tasks

Prescriptive Nature

Steps:

State of the Art

New method description

Realisation

Evaluation



Method State of the Art: Analysis

Table 2: Method State of the Art Analysis - Summary

Method element	Status
Perspective	Only parts of what the method has to do are known
Framework	So far only some disconnected parts of the process are defined: capturing and visualization of workflow provenance in scientific workflows, logging event logs in BPM
Method components	Not explicitly and completely defined. Some components defined for scientific workflows targeting provenance of workflow execution. Some components defined for capturing adaptations in business workflows
Procedure	Partially defined procedures, not as part of a method definition (section 2)
Concepts	Some concepts defined in several scientific publications (section 2)
Notation	Some notations known and available: BPMN, XES, PROV-O. Extensions to XES for change events, data models for capturing adaptations not available yet.
Cooperation Principle	Cooperation roles partially defined in literature but not as part of any method.



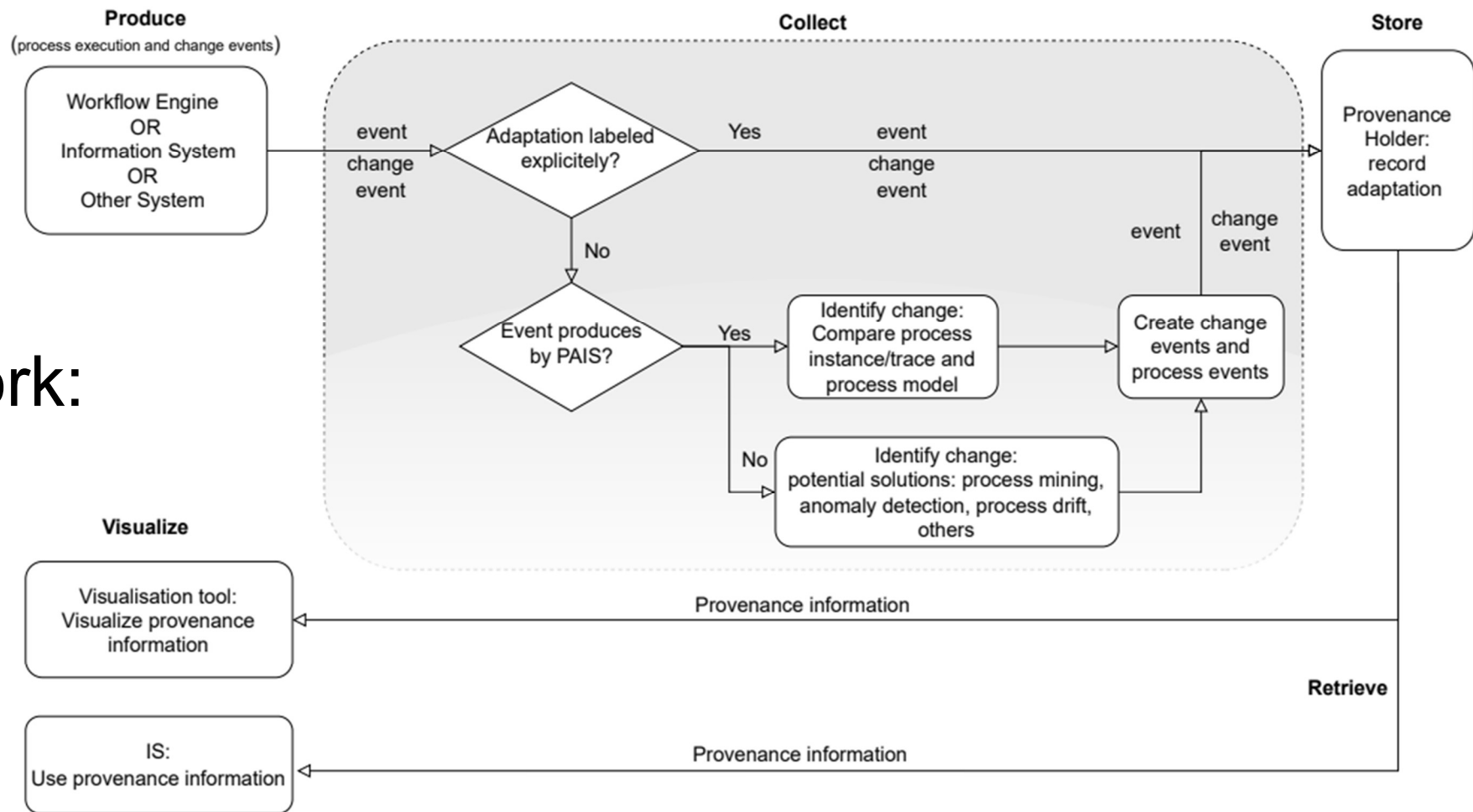
AdProv Method

Table 3: AdProv Method Components

Concept	Procedure	Notation
Process model (diagram)	Created by business analyst or scientist. Models all workflow dimensions	BPMN (or other notation)
Process (execution) events	Created by the IS carrying out the processes	Any representation used by the IS
Change events (defined here)	Created by either IS executing the processes or derived (as defined in the method)	Extended XES (or other formats)
Process logs (needed for process mining/anomaly detection etc.)	Created by the IS carrying out the processes	XES (or other formats)
Process instance state/process trace (for the comparison case)	Created by the IS carrying out the processes	XES (or other formats)
Data model for complete provenance information	Designed by Process System developers	Any notation for data modelling (UML, ER Diagrams, PROV-O, etc.)
Data model for Adaptation provenance information (defined here)	Designed by Process System developers	Any notation for data modelling (UML, ER Diagrams, PROV-O etc.)
Provenance Holder service architecture (defined in [30])	Designed by Process System developers	Any standard notation for software architecture and integration
Visualization tool and mapping model (defined here)	Designed either by Process System developers or Integrated	Existing Visualization tool for PROV-O or any other tool as desired to use by the users.

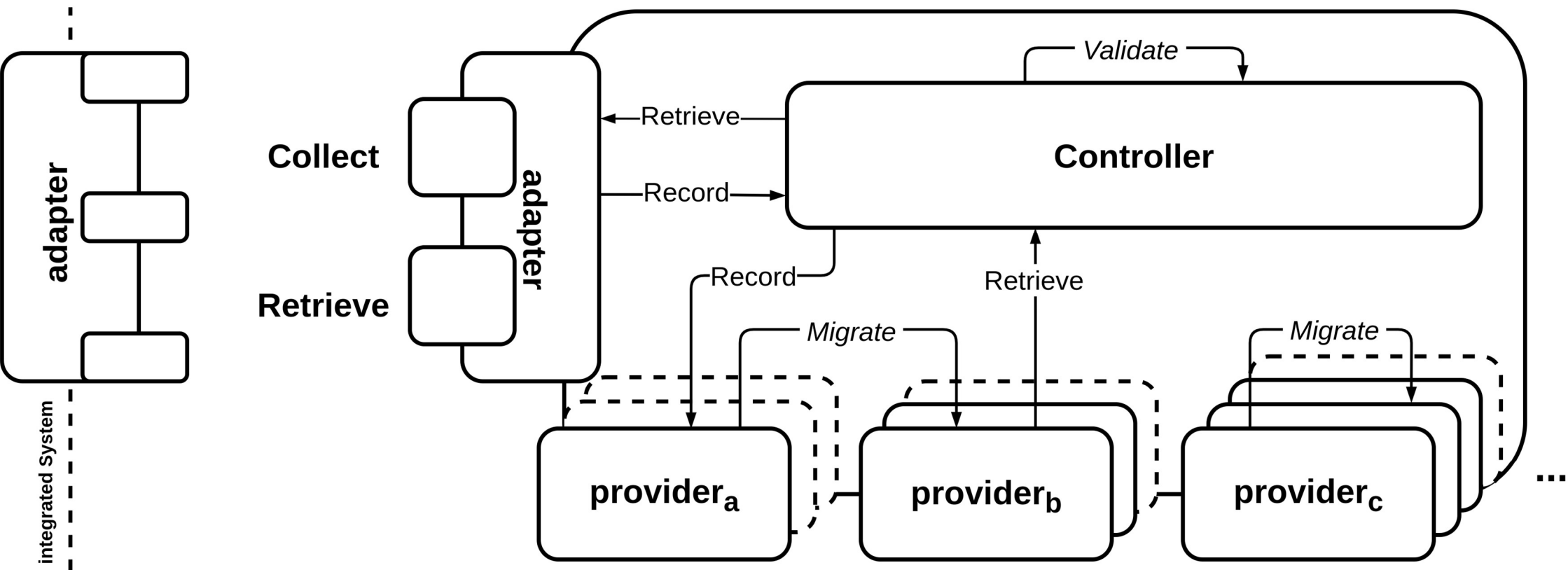


AdProv Method Framework: Steps





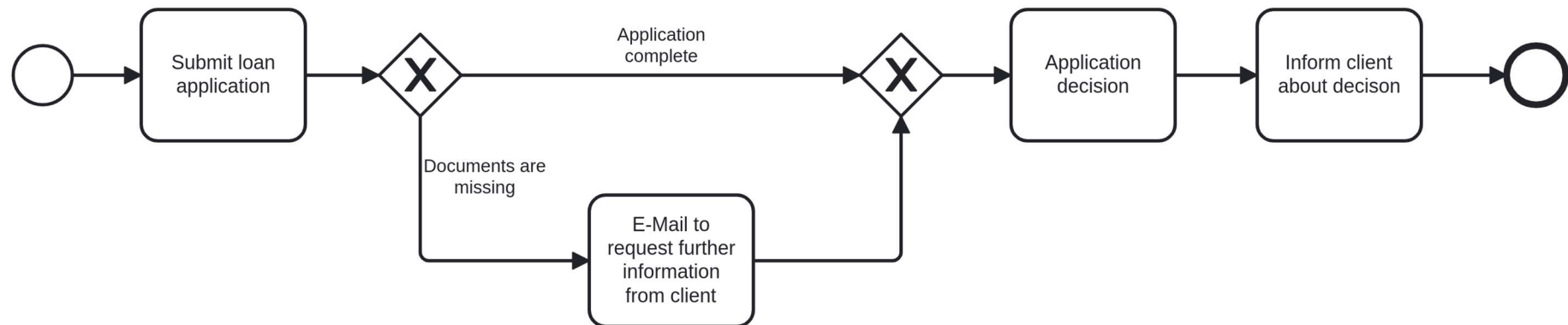
Architecture – Provenance Holder





Example

The loan origination process [7].

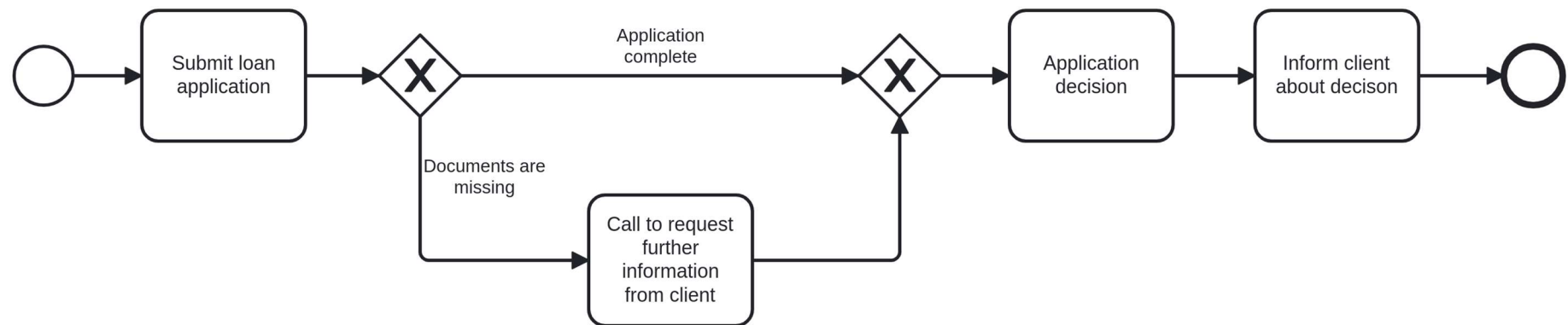


[7] Z. Dasht Bozorgi et al., "Prescriptive process monitoring based on causal effect estimation," Information Systems, vol. 116, p. 102198, 2023.



Example

Example workflow [7] with adaptation.





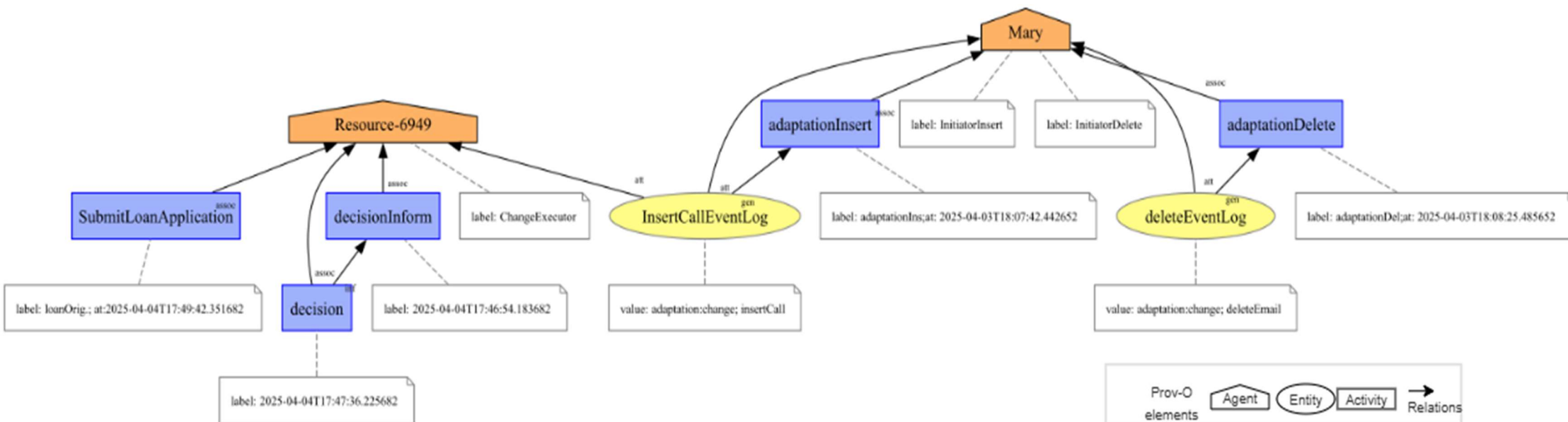
Realization – XES Extension

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<trace>
  <event>
    <string key="concept:name" value="Submit loan application" />
    <string key="processId" value="loan-origination" />
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    <string key="processId" value="loan-origination" />
    <string key="org:resource" value="Resource-6949" />
    <date key="time:timestamp" value="2025-04-04T17:48:18.267682" />
  </event>
  <event>
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  <event>
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    <string key="processId" value="loan-origination" />
    <string key="org:resource" value="Resource-6949" />
    <date key="time:timestamp" value="2025-04-04T17:46:54.183682" />
  </event>
</trace>
```

```
<trace>
  <event>
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    <string key="processId" value="loan-origination" />
    <string key="org:resource" value="Resource-6949" />
    <date key="time:timestamp" value="2025-04-04T17:49:42.351682" />
  </event>
  <event>
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    <string key="processId" value="loan-origination" />
    <string key="adaptation:type" value="delete" />
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  <event>
    <string key="concept:name" value="Call to request further information from client" />
    <string key="processId" value="loan-origination" />
    <string key="org:resource" value="Resource-6949" />
    <date key="time:timestamp" value="2025-04-04T17:48:18.267682" />
    <string key="adaptation:type" value="insert" />
    <string key="adaptation:change" value="insert Call to request further information from client" />
    <string key="adaptation:initiator" value="Mary" />
    <date key="adaptation:timestamp" value="2025-04-03T18:07:42.442652" />
  </event>
  <event>
    <string key="concept:name" value="Application decision" />
    <string key="processId" value="loan-origination" />
    <string key="org:resource" value="Resource-6949" />
    <date key="time:timestamp" value="2025-04-04T17:47:36.225682" />
  </event>
  <event>
    <string key="concept:name" value="Inform Client about decision" />
    <string key="processId" value="loan-origination" />
    <string key="org:resource" value="Resource-6949" />
    <date key="time:timestamp" value="2025-04-04T17:46:54.183682" />
  </event>
</trace>
```

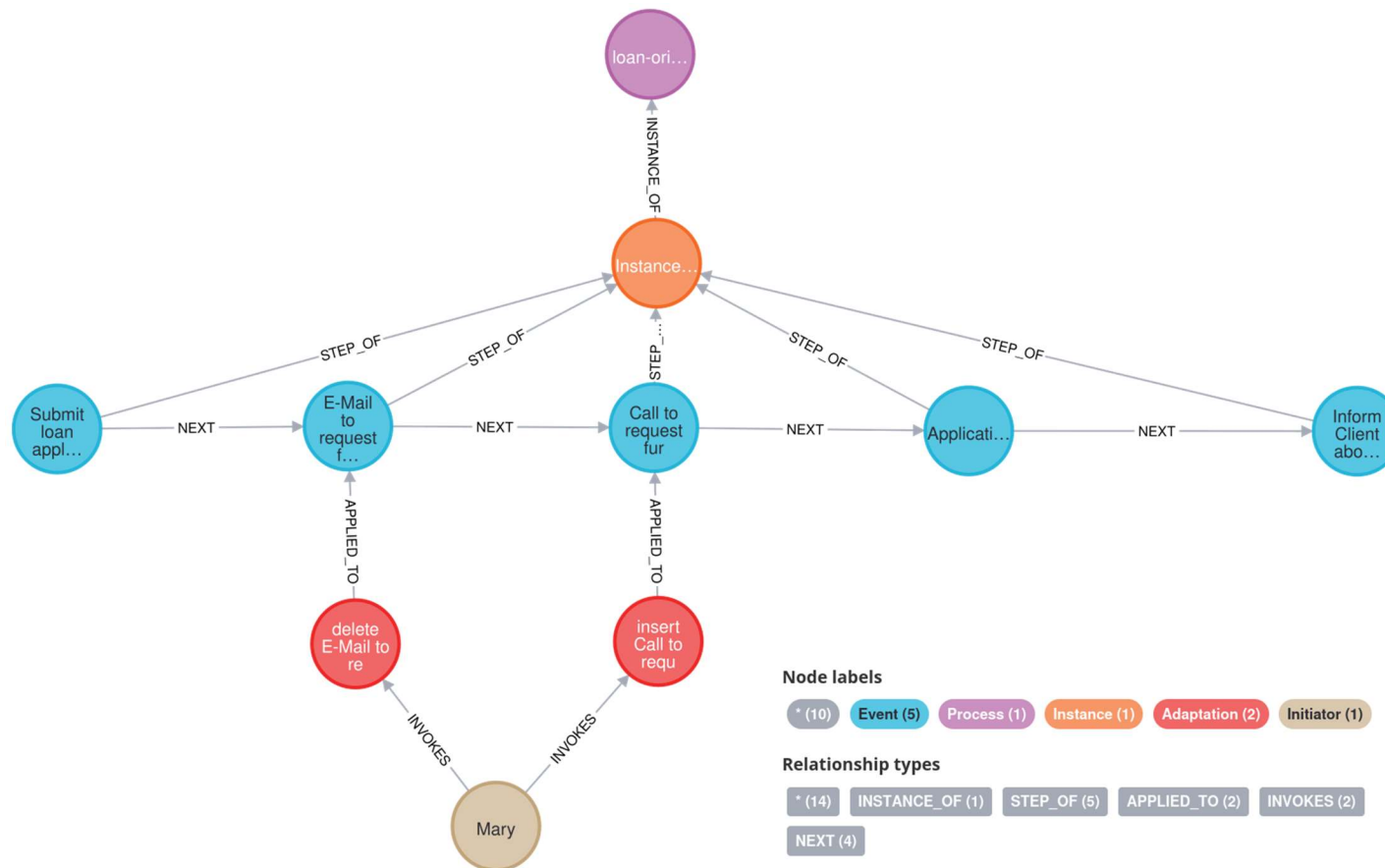


Provenance Ontology and Mapping





Visualisation of Provenance Information





Messages to Take Away

- Without data, there is not decision making (quoting Erik Proper, EDOC-CBI 2026)
- We do not store information about runtime changes
- Hence no data, and Adaptation/Changes are not first class citizen
- AdProv Method Definition
- Concept of „change events“ and the corresponding data model. XES Extension
- Implementation of method as show case of the realistic application of AdProv – i.e. technically feasible
- Provenance Holder architecture and implementation



Future Work

- Visualization: business and scientific domain
- Provenance of Collaborative Adaptations spanning several processes
- Trustworthy Collaborative Adaptations



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SYSTEMS GROUP
ENABLING FLEXIBILITY

17-09-2026 | 17

AdProv

Thank you!

