MTAT.03.231 Business Process Management

Lecture 12-13
Process Monitoring and Process Mining

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Where are we?

Process identification

Process monitoring and controlling

Process discovery

Process architecture

Conformance and performance insights

As-is process model

Process analysis

Insights on weaknesses and their impact

To-be process model

Process redesign

Process implementation

Executable process model

Process architecture
1. Introduction
2. Process Identification
3. Essential Process Modeling
4. Advanced Process Modeling
5. Process Discovery
6. Qualitative Process Analysis
7. Quantitative Process Analysis
8. Process Redesign
9. Process-Aware Information Systems
10. Process Automation
11. **Process Monitoring**
12. BPM as an Enterprise Capability
Business Process Monitoring
## Structure of a Business Process Event Log

<table>
<thead>
<tr>
<th>Case ID</th>
<th>Timestamp</th>
<th>Activity</th>
<th>Resource</th>
<th>Loan goal</th>
<th>Requested amt</th>
<th>Offered amt</th>
</tr>
</thead>
<tbody>
<tr>
<td>C001</td>
<td>18-10-2016</td>
<td>Check completeness</td>
<td>Sue</td>
<td>Mortgage</td>
<td>100 000</td>
<td>-</td>
</tr>
<tr>
<td>C001</td>
<td>19-10-2016</td>
<td>Check credit history</td>
<td>Sue</td>
<td>Mortgage</td>
<td>100 000</td>
<td>-</td>
</tr>
<tr>
<td>C001</td>
<td>19-10-2016</td>
<td>Calculate risk score</td>
<td>Bob</td>
<td>Mortgage</td>
<td>100 000</td>
<td>-</td>
</tr>
<tr>
<td>C001</td>
<td>20-10-2016</td>
<td>Make offer</td>
<td>Mike</td>
<td>Mortgage</td>
<td>100 000</td>
<td>70 000</td>
</tr>
<tr>
<td>C001</td>
<td>25-10-2016</td>
<td>Make offer</td>
<td>Mike</td>
<td>Mortgage</td>
<td>100 000</td>
<td>80 000</td>
</tr>
<tr>
<td>C002</td>
<td>20-10-2016</td>
<td>Check completeness</td>
<td>Sue</td>
<td>Car</td>
<td>15 000</td>
<td>-</td>
</tr>
<tr>
<td>C002</td>
<td>20-10-2016</td>
<td>Check credit history</td>
<td>Sue</td>
<td>Car</td>
<td>15 000</td>
<td>-</td>
</tr>
<tr>
<td>C002</td>
<td>22-10-2016</td>
<td>Calculate risk score</td>
<td>Elsa</td>
<td>Car</td>
<td>15 000</td>
<td>-</td>
</tr>
<tr>
<td>C002</td>
<td>24-10-2016</td>
<td>Reject application</td>
<td>Elsa</td>
<td>Car</td>
<td>15 000</td>
<td>-</td>
</tr>
<tr>
<td>C003</td>
<td>02-11-2016</td>
<td>Check completeness</td>
<td>Maria</td>
<td>Mortgage</td>
<td>30 000</td>
<td>-</td>
</tr>
<tr>
<td>C003</td>
<td>04-11-2016</td>
<td>Ask for additional data</td>
<td>Maria</td>
<td>Mortgage</td>
<td>30 000</td>
<td>-</td>
</tr>
<tr>
<td>C003</td>
<td>10-11-2016</td>
<td>Check credit history</td>
<td>Maria</td>
<td>Mortgage</td>
<td>30 000</td>
<td>-</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Types of process dashboards

- Operational dashboards (runtime)
- Tactical dashboards (historical)
- Strategic dashboards (historical)
Operational process dashboards

- Aimed at process workers & operational managers
- Emphasis on monitoring (detect-and-respond), e.g.:
  - Work-in-progress
  - Problematic cases – e.g. overdue/at risk
  - Resource load
Tactical performance dashboards

• Aimed at process owners / managers

• Emphasis on analysis and management
  • E.g. detecting bottlenecks

• Typical process performance indicators
  • Cycle times
  • Error rates
  • Resource utilization
Tactical Performance Dashboard @ Australian Insurer
Strategic performance dashboards

• Aimed at executives & managers
• Emphasis on linking process performance to strategic objectives
<table>
<thead>
<tr>
<th>Key Performance</th>
<th>Manage Unplanned Outages</th>
<th>Manage Emergencies &amp; Disasters</th>
<th>Manage Work Programming &amp; Resourcing</th>
<th>Manage Procurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Satisfaction</td>
<td>0.5</td>
<td>0.55</td>
<td>-</td>
<td>0.2</td>
</tr>
<tr>
<td>Customer Complaint</td>
<td>0.6</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
</tr>
<tr>
<td>Customer Feedback</td>
<td>0.4</td>
<td>-</td>
<td>-</td>
<td>0.8</td>
</tr>
<tr>
<td>Connection Less Than Agreed Time</td>
<td>0.3</td>
<td>0.6</td>
<td>0.7</td>
<td>-</td>
</tr>
</tbody>
</table>
Process: Manage Procurement

Process: Manage Emergencies & Disasters

Process: Manage Unplanned Outages

Overall Process Performance

1st Layer Key Result Area
- Financial: 0.5
- People: 0.4
- Customer Excellence: 0.65
- Operational Excellence: 0.5
- Risk Management: 0.8
- Health & Safety: 0.4

2nd Layer Key Performance
- Customer Complaint: 0.6
- Customer Satisfaction: 0.7

3rd & 4th Layer Process Performance Measures
- Customer Rating (%): 0.7
- Customer Loyalty Index: 0.6
- Average Time Spent on Plan: 0.8

- Satisfied Customer Index: 0.4
- Market Share (%): 0.8
Identify a user or users and define a clear question or set of questions that users will answer with this question.

Identify the type of dashboard elements based on the insights required to answer the question.

Identify a type of visualization (e.g. type of chart) for the element.

Determine x-axis (independent variable): longitudinal time), cross-sectional (attribute).

Determine y-axis (dependent variable): performance measure or attribute and the aggregation function.
Process performance dashboard elements

Indicator: Card displaying a process performance measure
- Example: cycle time (average, median, max, min, etc.)

Trend chart: A longitudinal performance chart that traces a performance measure over time
- Chart displaying the number of active cases (WIP) over time

Performance distribution chart: A histogram displaying the performance of the process across different components
- Histogram of total effort (total processing time) spent per resource

Cross-sectional chart: A chart that traces a performance measure across different segments (e.g. business units, countries, activity, etc.)
- Chart displaying the cycle time of the process per country

Detailed Tables
- Tables providing detailed performance statistics per case, per activity, etc.
Business Process Monitoring

Enterprise System → Event stream → Event log

Performance Dashboards

Process Mining
Process Mining

Automated Process Discovery

discovered process model

event log
Automated Process Discovery

<table>
<thead>
<tr>
<th>CID</th>
<th>Task</th>
<th>Time Stamp</th>
<th>…</th>
</tr>
</thead>
<tbody>
<tr>
<td>13219</td>
<td>Enter Loan Application</td>
<td>2007-11-09 T 11:20:10</td>
<td>-</td>
</tr>
<tr>
<td>13219</td>
<td>Retrieve Applicant Data</td>
<td>2007-11-09 T 11:22:15</td>
<td>-</td>
</tr>
<tr>
<td>13220</td>
<td>Enter Loan Application</td>
<td>2007-11-09 T 11:22:40</td>
<td>-</td>
</tr>
<tr>
<td>13219</td>
<td>Compute Installments</td>
<td>2007-11-09 T 11:22:45</td>
<td>-</td>
</tr>
<tr>
<td>13219</td>
<td>Notify Eligibility</td>
<td>2007-11-09 T 11:23:00</td>
<td>-</td>
</tr>
<tr>
<td>13219</td>
<td>Approve Simple Application</td>
<td>2007-11-09 T 11:24:30</td>
<td>-</td>
</tr>
<tr>
<td>13220</td>
<td>Compute Installments</td>
<td>2007-11-09 T 11:24:35</td>
<td>-</td>
</tr>
</tbody>
</table>

Process Map (directly follows graph)

BPMN process model
A process map of an event log is a graph where:

- Each activity is represented by one node
- An arc from activity A to activity B means that B is directly followed by A in at least one case in the log
Anatomy of a Process map

- **Initial activity** (multiple possible)
- **Directly-follows relation between two activities (and its frequency)**
- **Activity (and its frequency)**
- **Eventually-follows relation between two activities (not visualized)**
- **Activity self-loop (rework)**
- **Short loop (possible rework)**
- **Final activity (multiple possible)**
Nodes in a process map can be coloured, and arcs’ thickness can be changed, to capture:

- **Frequency**: How often a given activity or directly-follows relation occurs?
- **Duration**: processing times and cycle times for activities, waiting times for directly-follow relations
- **Other attributes**: some tools support enhancement by other attributes, e.g. cost, revenue, sales volume etc., if these data attributes are available
Example: Process Map
with frequency

Event log
5: a,b,c,g,e,h
4: a,b,c,f,g,h
3: a,b,d,g,e,h
3: a,b,d,e,g,h
Example: Process Map
with frequency

Event log
5: a,b,c,g,e,h
4: a,b,c,f,g,h
3: a,b,d,g,e,h
3: a,b,d,e,g,h
Event log
5: a,b,c,g,e,h
4: a,b,c,f,g,h
3: a,b,d,g,e,h
3: a,b,d,e,g,h

Example: Process Map with frequency
Example: Process Map
with frequency

Event log
5: a,b,c,g,e,h
4: a,b,c,f,g,h
3: a,b,d,g,e,h
3: a,b,d,e,g,h
Example: Process Map
with frequency

Event log
5: a,b,c,g,e,h
4: a,b,c,f,g,h
3: a,b,d,g,e,h
3: a,b,d,e,g,h
Process Maps

- Commercial process mining tools use process maps as the main visualization technique for event logs
- These tools also provide three types of operations:
  1. **Abstract** the process map:
  2. **Filter** the traces in the event log...
Abstraction and Filtering

• Real-life processes are really messy
  • Let's have a look at a few of them…
Examples

Patient Treatment Process @ Hospital
(Sepsis infections)

IT Incident Management @ Bank
Common process mining tools provide abstraction capabilities on top of process maps, to:

- Show only **most frequent** activities
- Show only **most frequent** arcs

Some tools offer further abstraction capabilities to:

- Show only **least frequent** activities
- Show only **least frequent** arcs
- Show only **fastest/slowest** activities
- Show only **fastest/slowest** arcs
Demo Time!
Filtering: Case filters

Case variant filter
Retain/remove cases that follow a certain sequence of activities

Case ID filter
Retain/remove cases with a specific ID

Attribute filter
Retain/remove cases that fulfil a given condition:
• Single dimension: e.g. all cases that have an event “Amend purchase order”
• Two-dimensional: e.g. all cases where activity “Amend purchase order” has been performed by Luke or Jane

Timeframe filter
Retain/remove cases that are active/contained/start or end in a given timeframe (e.g. from 1 Jan to 31 July 2019)
Filtering: Case filters

Performance filter

- Retain/remove cases whose performance measure (e.g. case duration, avg waiting time) is above or below a given value (e.g. all cases that last more than 5 days)
- Retain/remove cases where a given node or arc has a given duration range (e.g. all cases whose activity “Create invoice” taken between 10 and 20 min)

Path filter

- Retain/remove cases where there is a pair of events that fulfils a given condition (e.g. “Create invoice” directly or eventually followed by “Approve invoice”). The condition can also involve attributes and time intervals
- Retain/remove cases that start with or finish with an event that fulfils a given condition (e.g. all traces that start with “Purchase order received” and finish with “Order cancelled”)

Rework & repetition filter

- Retain/remove cases where certain activities are performed a given number of times (e.g. keep all cases where activity “Amend purchase order” is done at least twice).
Filtering: Event-level filters

Attribute filter
Retain/remove events that fulfil a given condition (e.g. all events that have a label “Amend purchase requisition” and “Amend request for quotation”)

Timeframe filter
Retain/remove events that are contained in a given timeframe (e.g. from 1 Jan to 31 July 2019)
Demo Time!
Limitations of process maps

Process maps over-generalize: some paths of a process map might actually not exist and might not make sense

- Example: Draw the process map of \([ abc, adc, afce, afec ]\) and check which cases it can recognize for which there is no support in the event log.

Process maps make it difficult to distinguish conditional branching, parallelism and loops

- See previous example… or a simpler one: \([ abcd, acbd ]\)

Solution: automated discovery of BPMN models
Discovery of BPMN models

A given configuration of node/arc sliders, and parallelism slider

Note: Apromore uses an algorithm called **Split Miner** to turn process maps into process models.
Process Mining Using BPMN

• To get an intuition of how BPMN models are discovered from an event log, let’s draw the process maps of the following logs and let’s try to imagine what is the BPMN process model corresponding to these logs:
  • [abc, abd]
  • [abcd, acbd]
  • [abcd, abcbcd]
1. [abc, abd]
2. [abcd, acbd]
3. [abcd, abcbcd]
# Automated Process Discovery: Analysis Template

<table>
<thead>
<tr>
<th>What?</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flow Analysis</strong></td>
<td>Visualize the most frequent case variant(s) using the Case inspector Use abstraction sliders to focus on the most frequent activities and dependencies. Switch to BPMN view; inspect the behavior around the gateways Check the dotted lines in the process map (arcs emanating from the start event or leading to the end event). Unexpected dotted lines indicate some cases are incomplete</td>
</tr>
<tr>
<td>1. Analyze the process structure &amp; main case variants</td>
<td></td>
</tr>
<tr>
<td>2. Identify parallelism, branching points &amp; rework loops</td>
<td></td>
</tr>
<tr>
<td>3. Analyze case entry and exit points, and check for incomplete cases</td>
<td></td>
</tr>
<tr>
<td><strong>Filtered Flow Analysis</strong></td>
<td>Use event filtering to retain/remove subsets of activities, e.g. separate automated or non-core activities, or separate activities belonging to two different systems.</td>
</tr>
<tr>
<td>Analyze different components or slices of the process separately</td>
<td></td>
</tr>
<tr>
<td><strong>Frequency analysis</strong></td>
<td>Use the Activity inspector Use the color-coding to find most frequent arcs Consider switching between frequency metrics (max, avg, ...) Use the Activities tab in performance dashboard (Apromore EE)</td>
</tr>
<tr>
<td>Analyze the most frequent activities and relations</td>
<td></td>
</tr>
<tr>
<td><strong>Handoff analysis</strong></td>
<td>Switch between perspectives Use the Resource and Other Attributes tabs in the Dashboard</td>
</tr>
<tr>
<td>Analyze handoffs between workers, teams, groups, org units</td>
<td></td>
</tr>
</tbody>
</table>
Process Mining

Automated Process Discovery

discovered process model

event log

Conformance Checking

✓/✗

process model or compliance rules
Conformance checking

Given an event log and a set of business rules or a process model, find, describe, and measure the impact of differences between the rules/model and the log.

<table>
<thead>
<tr>
<th>No. of Instances</th>
<th>Log Traces</th>
</tr>
</thead>
<tbody>
<tr>
<td>1207</td>
<td>ABDEA</td>
</tr>
<tr>
<td>145</td>
<td>ACDGHFA</td>
</tr>
<tr>
<td>56</td>
<td>ACGDHFA</td>
</tr>
<tr>
<td>23</td>
<td>ACHDFHA</td>
</tr>
<tr>
<td>28</td>
<td>ACDHFA</td>
</tr>
</tbody>
</table>

Log ≠ Rules, process model
Types of Conformance Checking

1. Rule-Based Conformance Checking
   • Checking that a process follows certain rules

2. Model-Based Conformance Checking
   • Comparing the behaviour captured in the process model against the one in the event log
Rule-Based Conformance Checking

Checking whether regulations and control measures embedded in processes are followed in practice.

Common types of compliance rules:

**Flow constraints**
- Certain activities may be mandatory e.g. a specific approval to proceed with an application.

**SLA constraints**
- Customer agreements on service quality define timeframes at the case, milestone or activity transition level.

**Resource constraints**
- Certain activities must be executed by different employees, e.g. creation and approval of an invoice.
Conformance Checking Levels

Accordingly, we can identify the following compliance checking levels:

- **Flow**: have all mandatory activities been performed? Have activities been performed in the right order and with the right frequency?
- **Temporal**: has a given timeframe between activities, process milestones or for the end-to-end process been adhered to?
- **Resource**: did everyone obey the segregation of duties?
- **Exception**: explore highly-infrequent behavior to identify possible deviations from the standard process

Procedure:
1. Define compliance rules (based on attribute-value pairs, activity orders or performance targets)
2. Apply one or more filters to keep cases that violate the rules in question
3. If needed, switch perspective to highlight non-compliance issues (e.g. show resources that violate a segregation of duties principle)
4. Assess impact on process performance
Flow Compliance Checking

Mandatory tasks: Have all mandatory tasks been completed?

To check whether all your tasks have been executed at least once, change the frequency view to “Min.” in the visualization settings of your Process Discoverer.

The numbers in your activities now indicate the minimum amount of times it has been completed in all process instances.
Prescribed time frame: Has the given time frame been adhered to?

Select the “Path” filter and define the steps that must be performed in a defined time frame. Use “Time interval” to then set your temporal figures.

Example:

Compliance rule:
Waiting time between “Inform User” and “Repair (Simple)” should not exceed 1 hours.

“Time Interval” Filter:
> 1 hour, so that only those cases are retained that do not comply with the compliance rule.
Temporal Compliance Checking

Prescribed time frame: Has the given time frame been adhered to?

Performance filter can help to check for end-to-end SLA violations.

For example, retain only those cases that get completed in at most 1 hour.
Resource Compliance Checking

1 Segregation of duties: Did everyone obey the segregation of duties?

To check whether the segregation of duties has been breached, select a “Path” filter. Now, set another filter which indicates that the same resource must have completed the tasks (e.g. creating & approving an invoice)
Resource Compliance Checking

1. Unexpected resource assignments

User the Attribute filter with two attributes (primary and secondary) to retrieve cases where a given activity was performed by a given resource (or any other combination of attributes).
## Conformance Checking: Analysis Template

<table>
<thead>
<tr>
<th>What?</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flow compliance checking</strong></td>
<td>Identify skipped activities in the process map or BPMN model</td>
</tr>
<tr>
<td>1. Check skipped mandatory activities</td>
<td>Visualize process map with the min/max frequency metrics</td>
</tr>
<tr>
<td>2. Check forbidden repetitions.</td>
<td>Visualize min/max statistics in Activity tab of the dashboard (EE)</td>
</tr>
<tr>
<td>3. Check activity exclusion or co-occurrence relations</td>
<td>Use Path filter (directly-follows or eventually-follows)</td>
</tr>
</tbody>
</table>

| **Temporal compliance checking**           | Use performance filter (to check for end-to-end SLA violations)     |
| Check temporal constraints violations      | Use Path filter (eventually-follows) with a duration constraint to identify violations of temporal constraints between two activities |

| **Resource compliance checking**           | Use Path filter (eventually-follows) and require the same Resource (or different resources) |
| Check four-eyes principle or same-case-hander principle | Use the Attribute filter and search with “Activity” as the primary attribute and “Resource” as secondary attribute to check if a resource performed an activity they were not supposed to do. |
Demo Time!
Process Mining

Automated Process Discovery

Conformance Checking

Performance Mining

event log

input process model

discovered process model

Enhanced process model
Process performance mining: Analytics & Analysis types

Extract process execution performance in an aggregate or detailed level (i.e. at the level of individual activities and directly-follows relations)

Analytics:

• Duration-enhanced process maps (activity, resource perspective…)
• Duration-enhanced BPMN models
• Process performance dashboards

Analysis types:

• Bottleneck analysis
• Workload analysis
• Rework analysis
Bottleneck analysis in the Activity perspective

Resource-capacity bottleneck (all incoming arcs are slow) [waiting bottleneck]

Slow handoff between activities (transition is slow) [waiting bottleneck]

Activity bottleneck (activity is slow)
Bottleneck analysis in the Resource perspective

- Slow handoff between specific resources [waiting bottleneck]

Diagram:
- System
- Tester4 (5 mins)
- SolverC1 (20 mins)
- Tester3 (6 mins)

Resource bottleneck
Workload analysis: overused vs underused resources

- Potentially overused resources are those with high total frequency and/or high total duration.
- Potentially underused resources are those with low total frequency and/or low total duration.
Rework analysis

Rework means repetition of activities within the same case:

- **Self loop**: an activity takes place \( n \) times in a row
- **Short loop ("ping-pong effect")**: two activities are repeated one after the other. Note: this may be confused with *parallelism*
- **Indirect repetition (loop)**: several activities are executed several times in sequence.

To analyze repetitions, one can answer the following questions:

1. What type of repetition is present?
2. How often is an activity / series of activities repeated?
3. How many cases showcase this repetition? How often does it occur?
4. Which cases are affected exactly? And how do they differ from cases where there is no repetition?
To assess the impact of rework on process performance (time and cost), we should apply filtering to isolate cases that are affected by rework.
## Performance Mining: Analysis Template

<table>
<thead>
<tr>
<th>What?</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bottleneck analysis</strong>&lt;br&gt;• Identify activity bottlenecks (high-effort activities)&lt;br&gt;• Identify waiting bottlenecks (slow handoffs and capacity bottlenecks)&lt;br&gt;• Identify resource bottlenecks</td>
<td>• In the process map, select the duration overlay (average or total duration): <strong>activity bottlenecks</strong> have long processing time; <strong>slow handoffs between activities</strong> are arcs with long waiting times; <strong>resource-capacity bottlenecks</strong> relate to activities with all/most incoming arcs with long waiting times&lt;br&gt;• Switch to the Resources perspective in the map: <strong>slow handoffs between resources</strong> are arcs with long waiting times; <strong>resource bottlenecks</strong> are resources with long avg duration (slow resources)&lt;br&gt;• Use slider with Average duration to focus on slowest or fastest nodes/arcs&lt;br&gt;• Use Activities tab in Dashboard to visualize activity processing times&lt;br&gt;• Use Animation plugin to visualize the build-up of bottlenecks.</td>
</tr>
<tr>
<td><strong>Workload analysis</strong>&lt;br&gt;• Identify overused vs underused resources/idleness waste&lt;br&gt;• Analyze resource workload</td>
<td>• In the Resources perspective: <strong>overused resources</strong> have high total frequency or high “total duration”; <strong>underused resources</strong> have low total frequency and low total duration&lt;br&gt;• Use also the Resources tab in Dashboard to visualize resource workload distribution&lt;br&gt;• Use Filtering to focus on cases where the resource(s) with the highest workload are involved.</td>
</tr>
<tr>
<td><strong>Rework analysis</strong>&lt;br&gt;Identify defects/errors and rework waste</td>
<td>• Use the Max frequency overlay in the process map to visualize the max amount of repetitions of each activity / transition&lt;br&gt;• Use the Case &gt; Rework &amp; repetition filter to retain cases with activity repetition; use the Case &gt; Path filter with eventually-follows relation between an activity and itself to isolate cases with specific loops&lt;br&gt;• Use the chart in the Activities Dashboard to visualize the distribution of max activity frequencies per case.</td>
</tr>
</tbody>
</table>
Demo Time!
Process Mining

Automated Process Discovery

Performance Mining

Conformance Checking

Variants Analysis

Enhanced process model

event log

input process model

Discrete event log

discovered process model

Difference diagnostics
Given two or more logs representing variants of the same process, find the *differences* and *root causes* for variation or deviance between the logs.

The comparison of process variants offers insights into the the “why”: Why do certain process cases differ from others?

- Why some take longer than others? (fast vs. slow cases)
- Why some end successfully, while others don’t? (positive vs. negative outcomes)
- Why is employee XY more efficient and more successful when it comes to their activities than others? (resource XY vs. remaining resources)
Variant analysis: drivers

Performance
Identify and compare variants based on performance measures and their targets (e.g. slow vs fast cases)

Logical
Identify and compare variants based on case attributes (e.g. product type, customer segment, geographic area, loan amount, claim outcome)

Temporal
Identify and compare variants based on different log timeframes (e.g. before and during COVID)
Variant analysis: approach

1. Apply the same filter one per variant, to isolate the respective sublog:
   • **Performance:** use Case > Performance filter
   • **Logical:** use Case > Attribute filter
   • **Temporal:** use Case > Timeframe filter
2. Save filtered process map and BPMN model back to the repository
3. Analyze the variants using one or more analysis techniques.
Visual comparison of process maps/BPMN models, to identify structural differences:

- Flow
- Frequency & rework
- Bottlenecks
- etc.

Consider different perspectives (Activities, Resources…)

**Variant 1:** “fast” (up to 45 min)

**Variant 2:** “slow” (more than 1.5 hrs)

[Avg duration for full log: 1.1 hrs]
Variant analysis: comparison via dashboard

Statistical comparison via dashboard charts and tables. Variants are color-coded (e.g. red for slow, green for fast cases)

Select your filtered logs and launch the Dashboard. All dashboard functionalities are also available when comparing multiple variants.
## Variant Analysis Template

<table>
<thead>
<tr>
<th>What?</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow comparison Identify notable diffs in activity flow</td>
<td>• Discover a BPMN process model from the log of each variant. Visualize them side-by-side. Look for the gateways around each task to detect for example situations where two tasks are in parallel in one variant, but sequential in the other.</td>
</tr>
</tbody>
</table>
| Frequency & rework comparison Compare activity or handoff frequency and rework | • Compare the maps of the process variants side-by-side (as above), but using the frequency overlay instead of the duration overlay. This allows us to detect the most frequent transitions between tasks. Look also for “thick” loop-backs.  
• Use a multi-low dashboard to compare frequencies of activities, resources or other attributes. |
| Bottleneck comparison Compare the location and magnitude of bottlenecks across variants | • Use filtering interface to retain all traces that fulfill the condition to belong to a variant (then repeat for the other).  
• Open the maps of the process variants side-by-side and compare the dependencies (arcs) with the highest waiting times. If the maps are too complex, use the abstraction slider with the abstraction metric “average duration” and the ordering from slow (right) to fast (left). Use the arc slider to retain the slowest dependencies.  
• Compare activity durations using side-by-side comparison of process maps or a multi-log dashboard (open the logs of 2+ variants in a single dashboard).  
• Consider comparing the two variants using the “resource” perspective to identify hand-offs between resources. |
Demo Time!

http://apromore.cs.ut.ee
Summary

Automated Process Discovery

Variants Analysis

Conformance Checking

Performance Mining

Enhanced process model

discovered process model

event log

event log'

Difference diagnostics

input process model or compliance rules

 ✓ / ✗