Executions Comparison- Latency Degradation Patterns Extraction

Fateme Faraji Daneshgar
Research Associate

Polytechnique Montréal

DORSAL Laboratory

Agenda

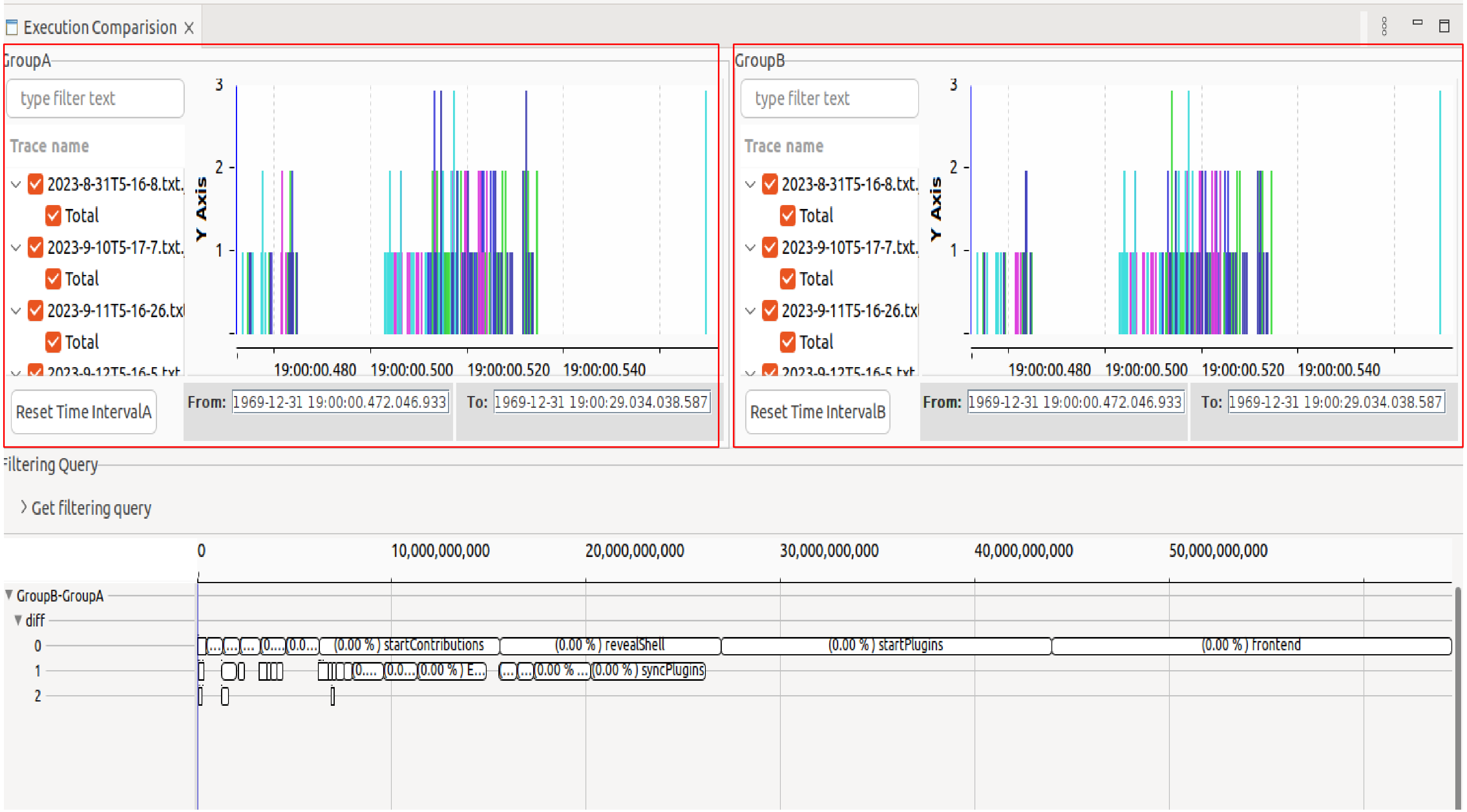
- Execution Comparison Overview
- Updates on Execution Comparison
  - Textual Specification of Desired Time Ranges
  - Resetting to Initial States
  - Experiment Reproducibility
- Extracting Latency Degradation Patterns
  - Discriminative sequential Pattern Mining

Execution Comparison Overview

- Software Performance analysis
- Latency detection
- New Software version or system updates
- Runtime discrepancies
- Pinpoint root causes

Execution Comparison Overview

- Selecting Two Groups



GroupA

☑ 2023-8-31T5-16-8.txt.
☑ Total
☑ 2023-9-10T5-17-7.txt.
☑ Total
☑ 2023-9-11T5-16-26.txt
☑ Total
☑ 2023-9-12T5-16-5.txt

From: 1969-12-31 19:00:00.472.046.933 To: 1969-12-31 19:00:29.034.038.587

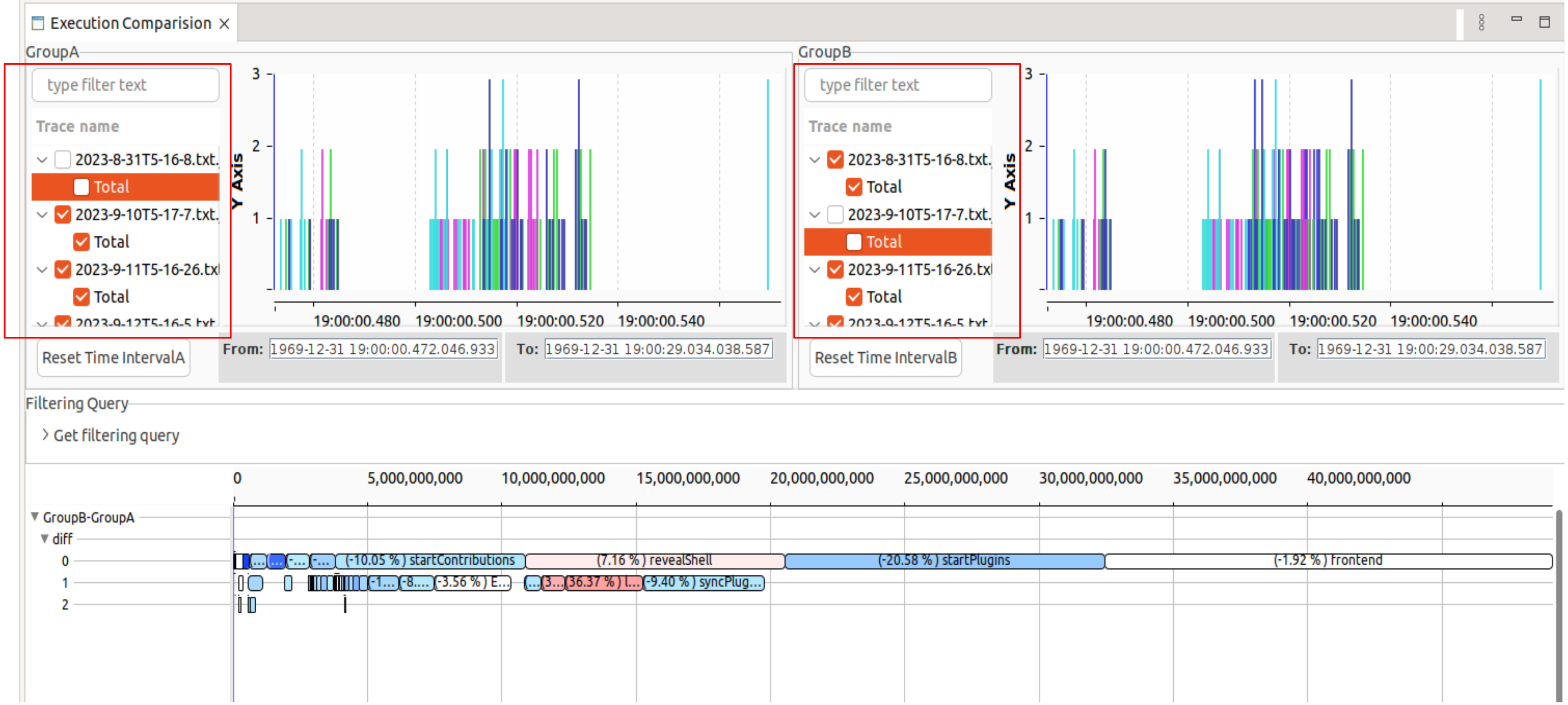
GroupB

☑ 2023-8-31T5-16-8.txt.
☑ Total
☑ 2023-9-10T5-17-7.txt.
☑ Total
☑ 2023-9-11T5-16-26.txt
☑ Total
☑ 2023-9-12T5-16-5.txt

From: 1969-12-31 19:00:00.472.046.933 To: 1969-12-31 19:00:29.034.038.587

Execution Comparison Overview

- Selecting Relevant Traces



Execution Comparision ×

GroupA

type filter text

Trace name

- ☐ 2023-8-31T5-16-8.txt.
  - ☐ Total
- ☑ 2023-9-10T5-17-7.txt.
  - ☑ Total
- ☑ 2023-9-11T5-16-26.txt
  - ☑ Total
- ☑ 2023-9-12T5-16-5.txt

Reset Time IntervalA

From: 1969-12-31 19:00:00.472.046.933

To: 1969-12-31 19:00:29.034.038.587

GroupB

type filter text

Trace name

- ☑ 2023-8-31T5-16-8.txt.
  - ☑ Total
- ☐ 2023-9-10T5-17-7.txt.
  - ☐ Total
- ☑ 2023-9-11T5-16-26.txt
  - ☑ Total
- ☑ 2023-9-12T5-16-5.txt

Reset Time IntervalB

From: 1969-12-31 19:00:00.472.046.933

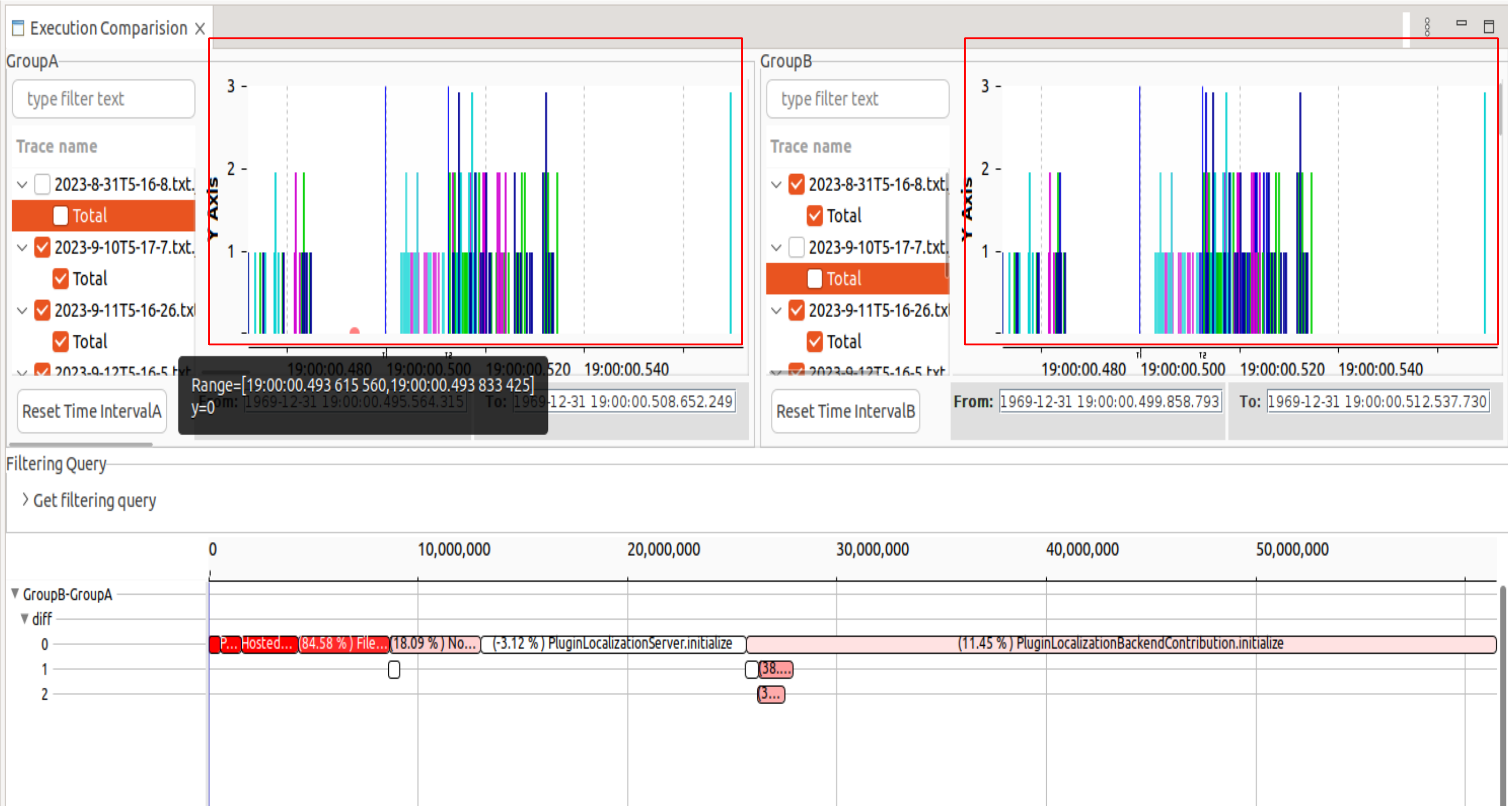
To: 1969-12-31 19:00:29.034.038.587

Filtering Query

> Get filtering query

Execution Comparison Overview

- ➢ Graphical Specification of Desired Time Ranges



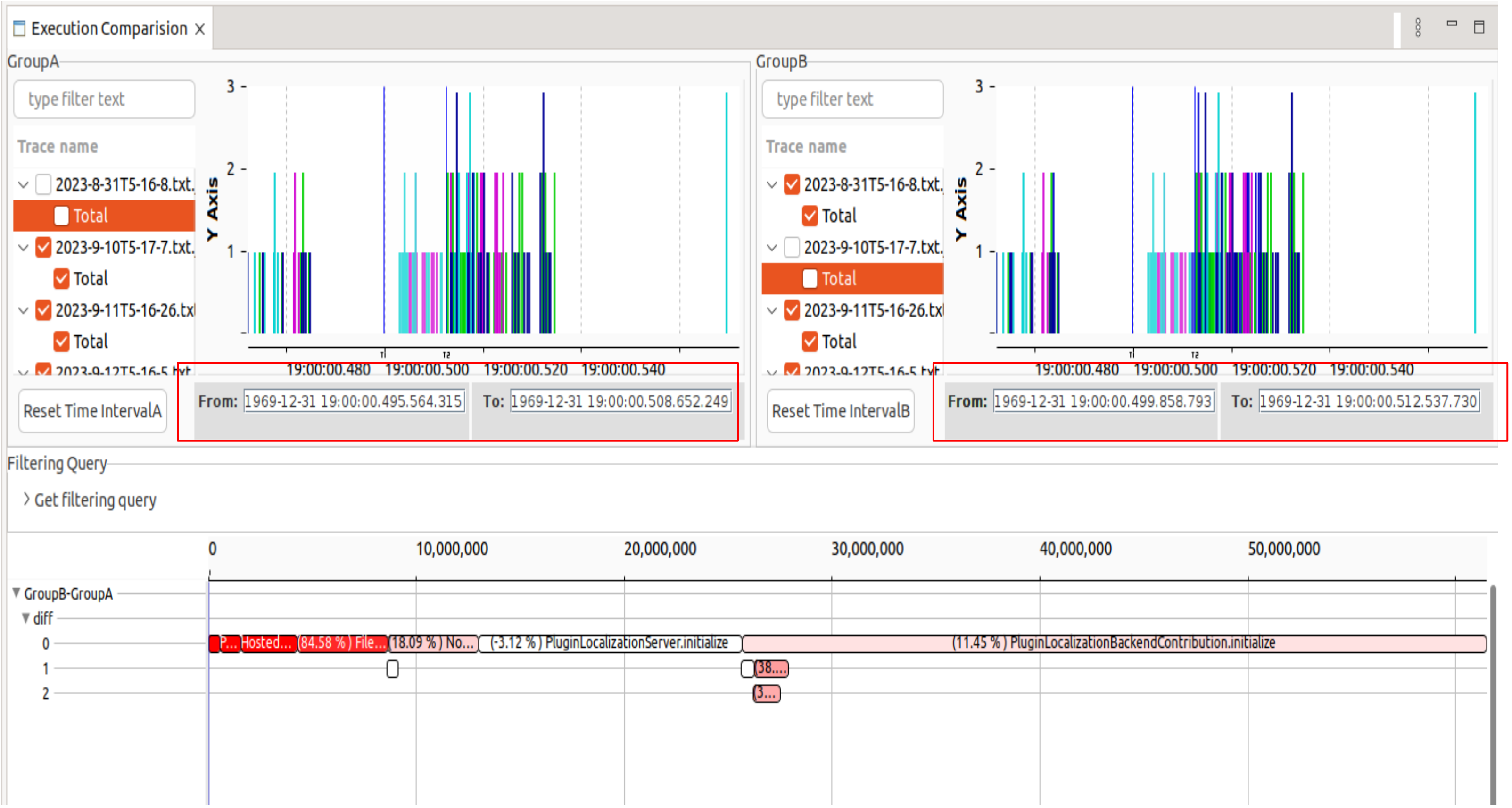
Range=[19:00:00.493 615 560,19:00:00.493 833 425]
y=0

GroupA — From: 1969-12-31 19:00:00.495.564.315 To: 1969-12-31 19:00:00.508.652.249

GroupB — From: 1969-12-31 19:00:00.499.858.793 To: 1969-12-31 19:00:00.512.537.730

Updates in Execution Comparison

- ➢ Textual Specification of Desired Time Ranges



Execution Comparision

GroupA

type filter text

Trace name

- 2023-8-31T5-16-8.txt. ☐
  - Total ☐
- 2023-9-10T5-17-7.txt. ☑
  - Total ☑
- 2023-9-11T5-16-26.txt ☑
  - Total ☑
- 2023-9-12T5-16-5.txt ☑

Reset Time IntervalA

From: 1969-12-31 19:00:00.495.564.315 To: 1969-12-31 19:00:00.508.652.249

GroupB

type filter text

Trace name

- 2023-8-31T5-16-8.txt. ☑
  - Total ☑
- 2023-9-10T5-17-7.txt. ☐
  - Total ☐
- 2023-9-11T5-16-26.txt ☑
  - Total ☑
- 2023-9-12T5-16-5.txt ☑

Reset Time IntervalB

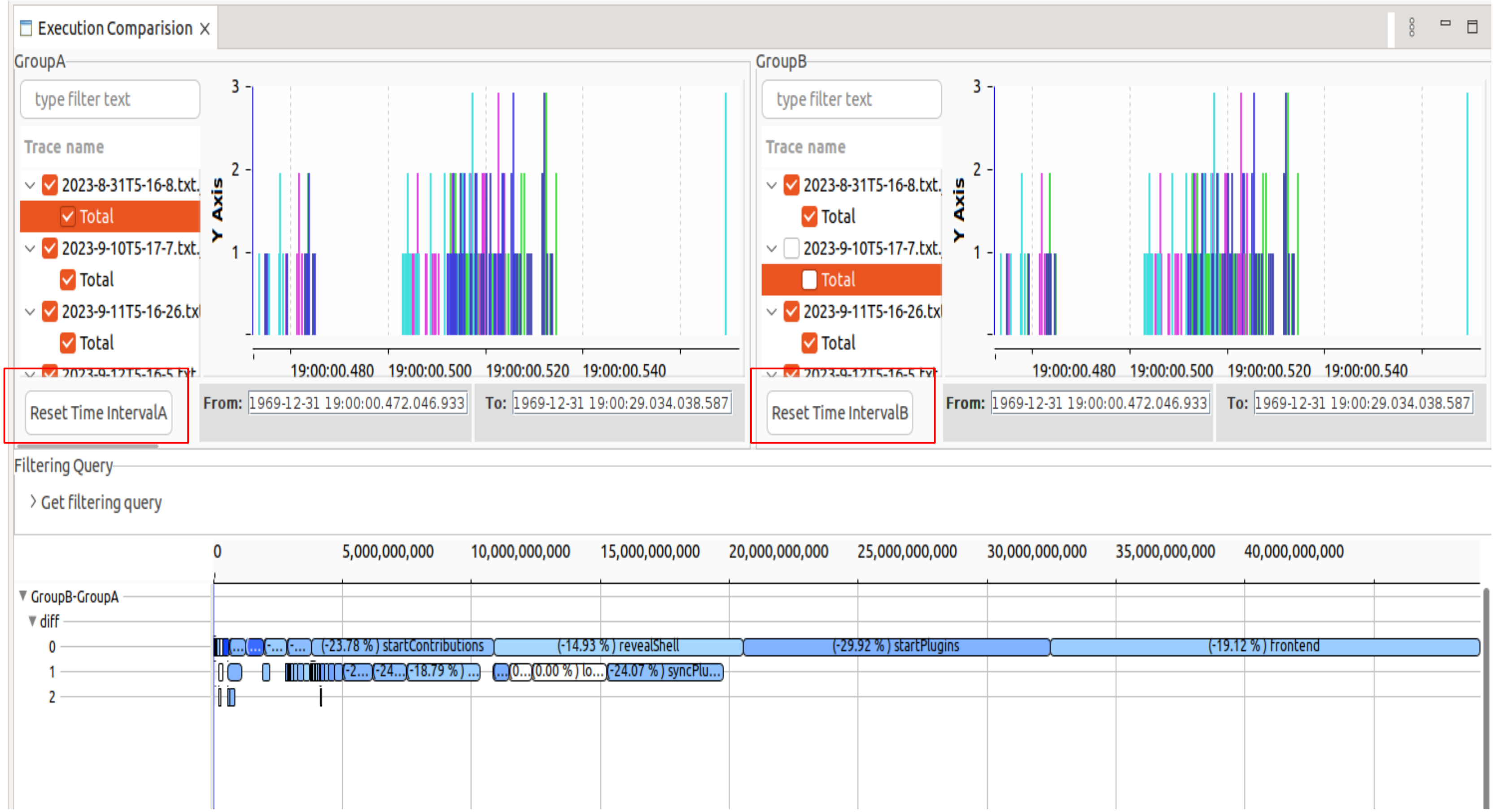
From: 1969-12-31 19:00:00.499.858.793 To: 1969-12-31 19:00:00.512.537.730

Filtering Query

› Get filtering query

Updates in Execution Comparison

- Resetting to Initial States

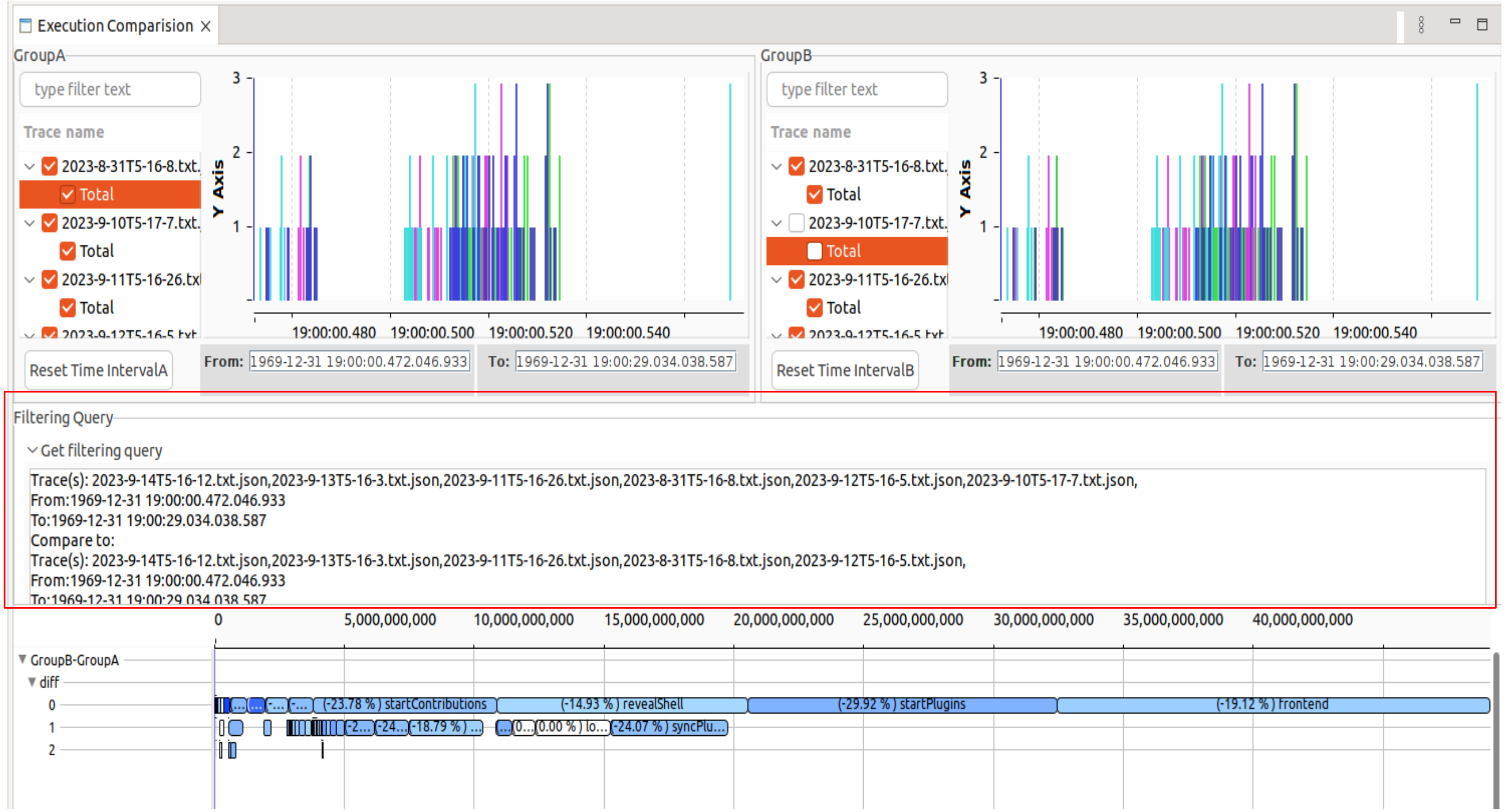


From: 1969-12-31 19:00:00.472.046.933 To: 1969-12-31 19:00:29.034.038.587

From: 1969-12-31 19:00:00.472.046.933 To: 1969-12-31 19:00:29.034.038.587

Updates in Execution Comparison

- Experiment Reproducibility



From: 1969-12-31 19:00:00.472.046.933 To: 1969-12-31 19:00:29.034.038.587

From: 1969-12-31 19:00:00.472.046.933 To: 1969-12-31 19:00:29.034.038.587

Trace(s): 2023-9-14T5-16-12.txt.json,2023-9-13T5-16-3.txt.json,2023-9-11T5-16-26.txt.json,2023-8-31T5-16-8.txt.json,2023-9-12T5-16-5.txt.json,2023-9-10T5-17-7.txt.json,
From:1969-12-31 19:00:00.472.046.933
To:1969-12-31 19:00:29.034.038.587
Compare to:
Trace(s): 2023-9-14T5-16-12.txt.json,2023-9-13T5-16-3.txt.json,2023-9-11T5-16-26.txt.json,2023-8-31T5-16-8.txt.json,2023-9-12T5-16-5.txt.json,
From:1969-12-31 19:00:00.472.046.933
To:1969-12-31 19:00:29.034.038.587

Latency Degradation Patterns

- sequence of events or conditions within a service-based system that signifies a decline in performance
- increased execution times of Remote Procedure Calls
- indicative of potential performance bottlenecks or issues that adversely affect the responsiveness and efficiency of the system

Why Latency Degradation Patterns

- Latency Degradation Patterns are critical because
  - Early Detection
  - Root Cause Analysis
  - Optimization
  - Proactive Maintenance

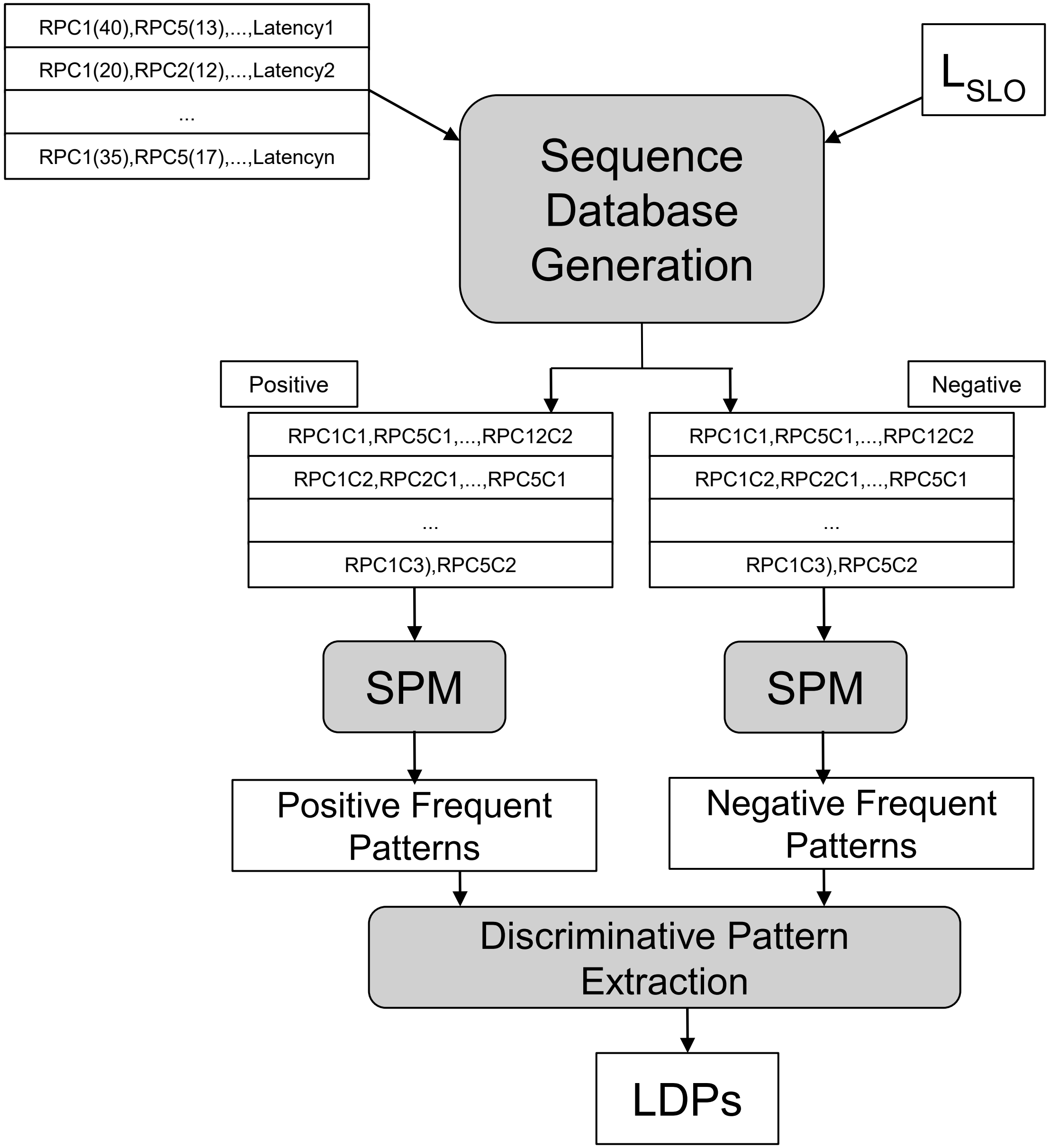
Motivation

- Existing approaches :classification/clustering and MLO
  - Transactional dataset: rows with fixed structure and size
  - Distributed service-based system traces include different sequences of RPCs even for a unique type of request
  - Sequence of RPCs

Motivation

- Example Investigation
- DeLag: Using Multi-Objective Optimization to Enhance the Detection of Latency Degradation Patterns in Service-Based Systems (IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, VOL. 49, NO. 6, JUNE 2023)
- Data Challenge Track in ICPE 2024
- Implemented by Enzo Pelous
    - Convergence Time
    - Premature Convergence
    - No Guarantee of Optimal Solution

Discriminative Sequential Pattern Mining



RPC1(40),RPC5(13),...,Latency1

RPC1(20),RPC2(12),...,Latency2

...

RPC1(35),RPC5(17),...,Latencyn

L_{SLO}

Sequence Database Generation

Positive

RPC1C1,RPC5C1,...,RPC12C2

RPC1C2,RPC2C1,...,RPC5C1

...

RPC1C3),RPC5C2

Negative

RPC1C1,RPC5C1,...,RPC12C2

RPC1C2,RPC2C1,...,RPC5C1

...

RPC1C3),RPC5C2

SPM

SPM

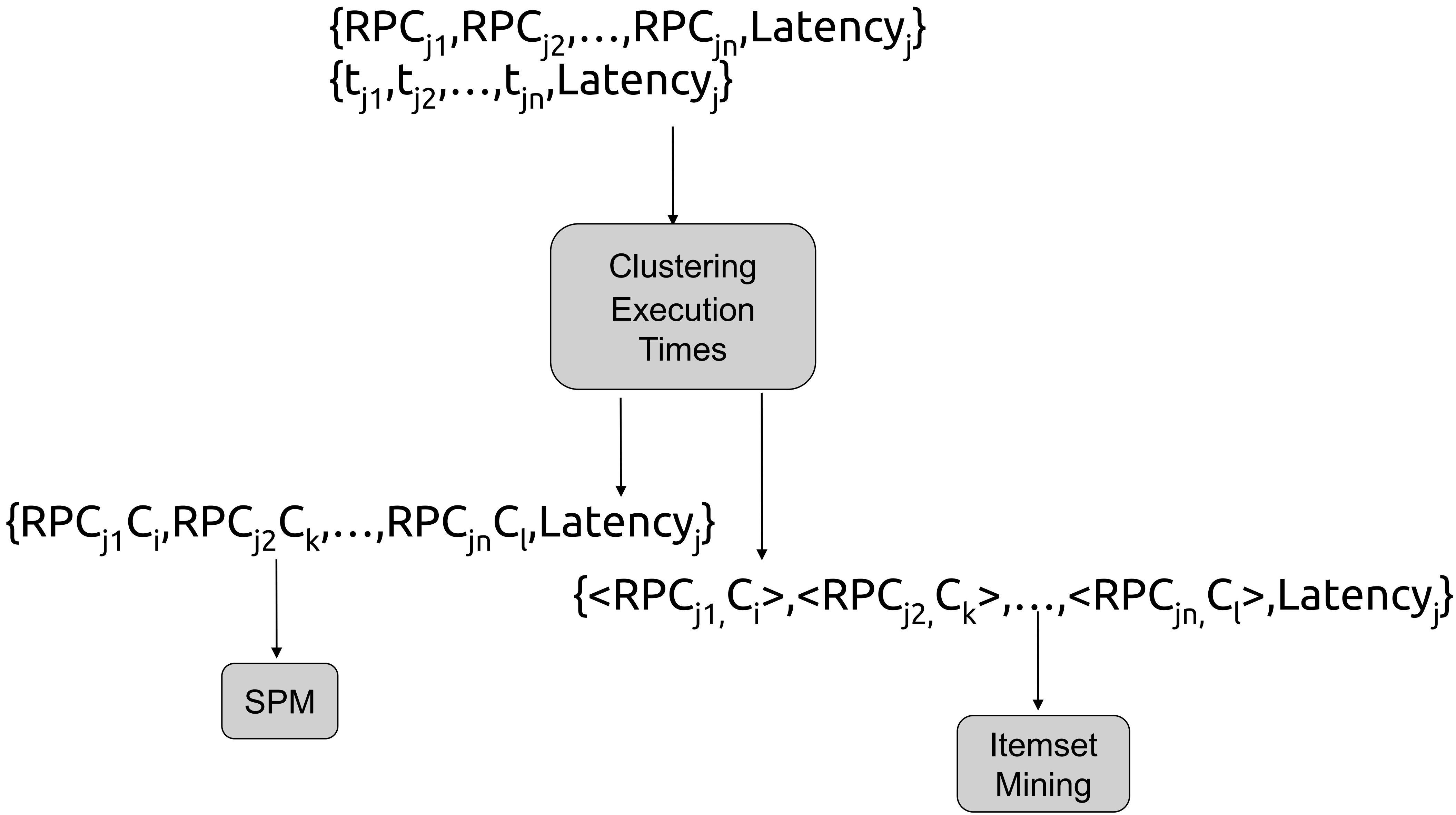
Positive Frequent Patterns

Negative Frequent Patterns

Discriminative Pattern Extraction

LDPs

Sequence Database Generation



$\{RPC_{j1},RPC_{j2},\ldots,RPC_{jn},Latency_j\}$

$\{t_{j1},t_{j2},\ldots,t_{jn},Latency_j\}$

Clustering Execution Times

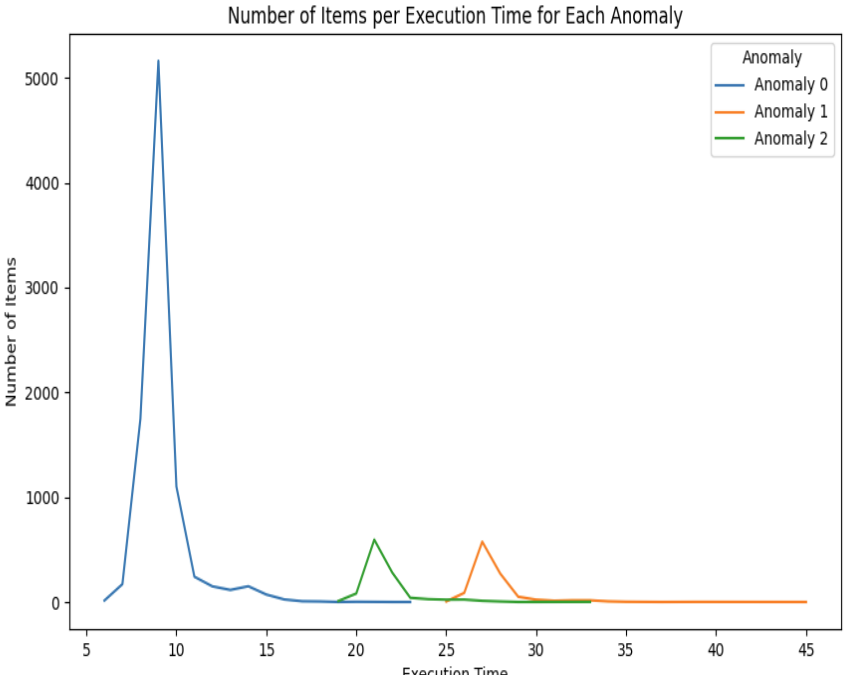
$\{RPC_{j1}C_i,RPC_{j2}C_k,\ldots,RPC_{jn}C_l,Latency_j\}$

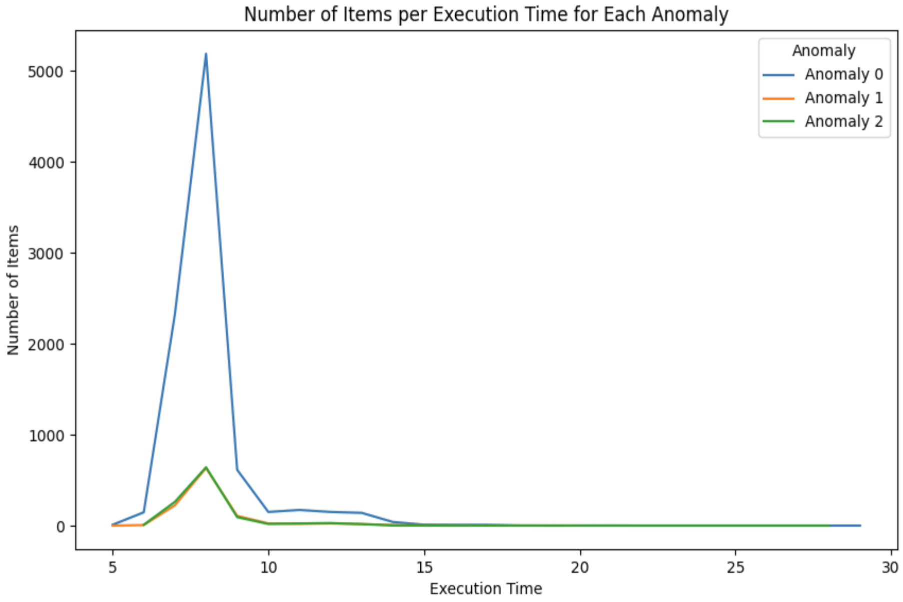
$\{<RPC_{j1,}C_i>,<RPC_{j2,}C_k>,\ldots,<RPC_{jn,}C_l>,Latency_j\}$

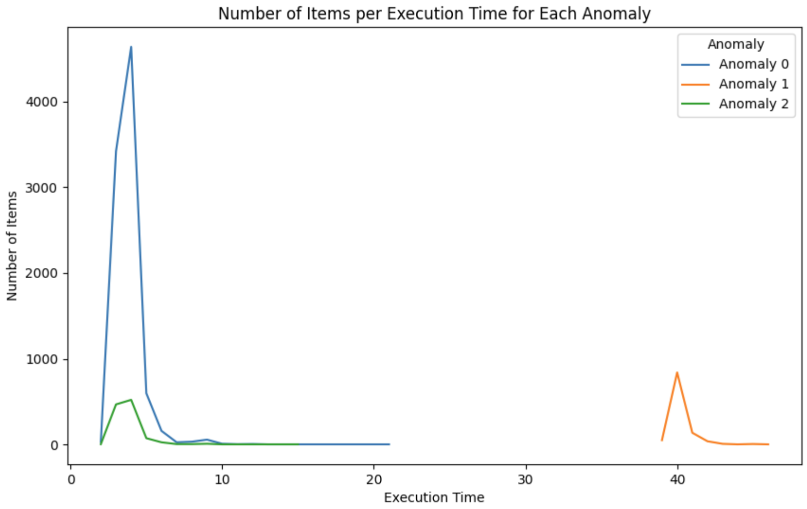
SPM

Itemset Mining

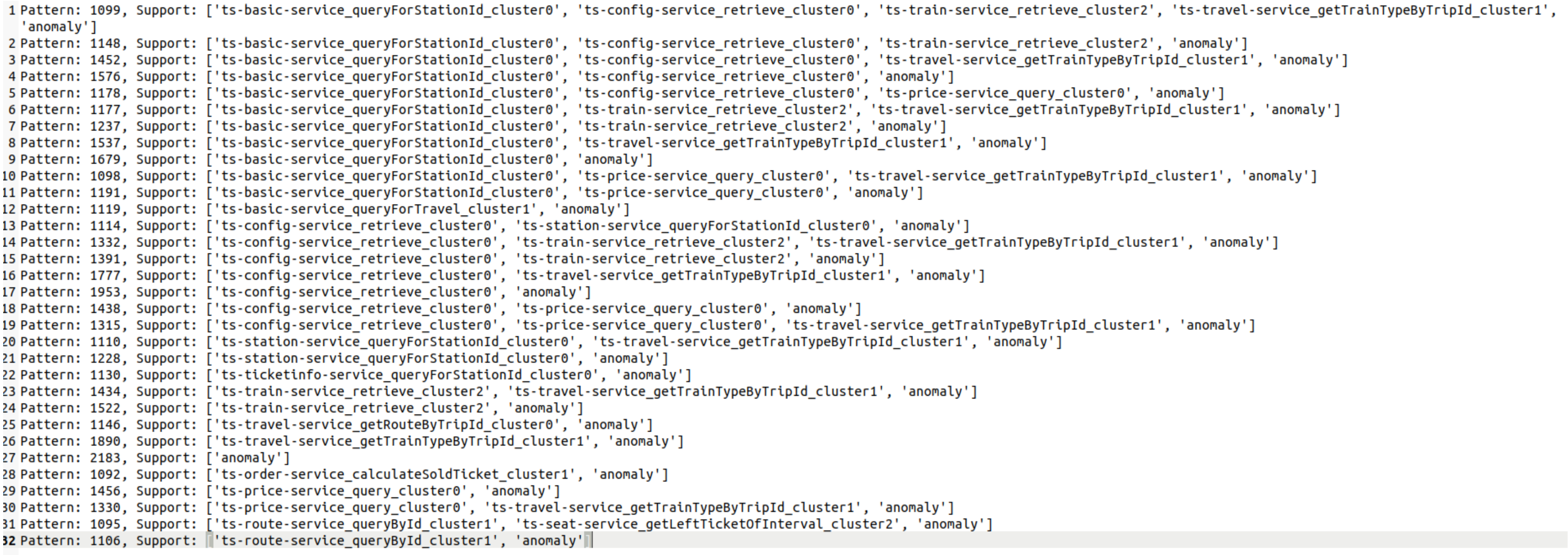
Sequence Database Generation







Results



```
Pattern: 1099, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-config-service_retrieve_cluster0', 'ts-train-service_retrieve_cluster2', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1148, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-config-service_retrieve_cluster0', 'ts-train-service_retrieve_cluster2', 'anomaly']
Pattern: 1452, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-config-service_retrieve_cluster0', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1576, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-config-service_retrieve_cluster0', 'anomaly']
Pattern: 1178, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-config-service_retrieve_cluster0', 'ts-price-service_query_cluster0', 'anomaly']
Pattern: 1177, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-train-service_retrieve_cluster2', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1237, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-train-service_retrieve_cluster2', 'anomaly']
Pattern: 1537, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1679, Support: ['ts-basic-service_queryForStationId_cluster0', 'anomaly']
Pattern: 1098, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-price-service_query_cluster0', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1191, Support: ['ts-basic-service_queryForStationId_cluster0', 'ts-price-service_query_cluster0', 'anomaly']
Pattern: 1119, Support: ['ts-basic-service_queryForTravel_cluster1', 'anomaly']
Pattern: 1114, Support: ['ts-config-service_retrieve_cluster0', 'ts-station-service_queryForStationId_cluster0', 'anomaly']
Pattern: 1332, Support: ['ts-config-service_retrieve_cluster0', 'ts-train-service_retrieve_cluster2', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1391, Support: ['ts-config-service_retrieve_cluster0', 'ts-train-service_retrieve_cluster2', 'anomaly']
Pattern: 1777, Support: ['ts-config-service_retrieve_cluster0', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1953, Support: ['ts-config-service_retrieve_cluster0', 'anomaly']
Pattern: 1438, Support: ['ts-config-service_retrieve_cluster0', 'ts-price-service_query_cluster0', 'anomaly']
Pattern: 1315, Support: ['ts-config-service_retrieve_cluster0', 'ts-price-service_query_cluster0', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1110, Support: ['ts-station-service_queryForStationId_cluster0', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1228, Support: ['ts-station-service_queryForStationId_cluster0', 'anomaly']
Pattern: 1130, Support: ['ts-ticketinfo-service_queryForStationId_cluster0', 'anomaly']
Pattern: 1434, Support: ['ts-train-service_retrieve_cluster2', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1522, Support: ['ts-train-service_retrieve_cluster2', 'anomaly']
Pattern: 1146, Support: ['ts-travel-service_getRouteByTripId_cluster0', 'anomaly']
Pattern: 1890, Support: ['ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 2183, Support: ['anomaly']
Pattern: 1092, Support: ['ts-order-service_calculateSoldTicket_cluster1', 'anomaly']
Pattern: 1456, Support: ['ts-price-service_query_cluster0', 'anomaly']
Pattern: 1330, Support: ['ts-price-service_query_cluster0', 'ts-travel-service_getTrainTypeByTripId_cluster1', 'anomaly']
Pattern: 1095, Support: ['ts-route-service_queryById_cluster1', 'ts-seat-service_getLeftTicketOfInterval_cluster2', 'anomaly']
Pattern: 1106, Support: ['ts-route-service_queryById_cluster1', 'anomaly']
```

Future Work

- Discriminative pattern mining
- Generating two sets of patterns is time consuming
- Applying two sets to generate one pattern set

Thank you for your attention