Process Mining & Predictive Monitoring

From Technology to Business Value

Marlon Dumas

Professor of Information Systems @ University of Tartu

Co-founder @ Apromore

Meet Tom

- Chief Revenue Officer @ XYZ
- Tom cares about customers, sales, revenue, efficient delivery, …
- Every week, he has different questions:
  - Why do we have so many production delays in plant X?
  - Why is the number of product returns rising?
  - What can I do to reduce delivery delays
  - Should I invest in further automation, or should in additional capacity, or in further integration between ordering system and manufacturing execution system?

Tom’s company has tons of data in their information systems!

- Request for quotes
- Orders (from receipt to fulfillment)
- Work orders (production)
- Shipments (from packaging to delivery)
- Product returns
- Customer complaints
- etc.

How to use these data?

Hire a data science consultancy

- Nice option, very useful to address specific challenges
- …but will you keep calling on them every day you need an insight?

Hire a data scientist or data science team

- Possible in larger companies, but how much time it takes them to gain your domain & business knowledge?

Set up a self-service-system that allows you to analyze the data yourself.

- Is it possible?

https://www.youtube.com/watch?v=z9b9ZeU5aac

Process Mining:
Self-Service Data-Driven Process Analysis

Step 01

Digital Footprint

Every process leaves digital footprints (transactions)

Step 02

Event Collection

Transactional data is collected from enterprise systems and other sources

Step 03

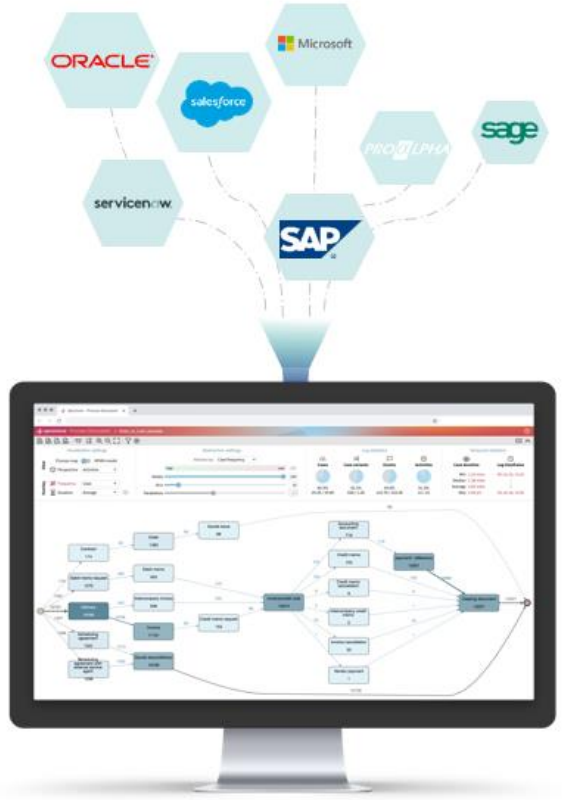
Data Preparation

Data is prepared (e.g. multiple datasets are merged)

Step 04

Process Analysis

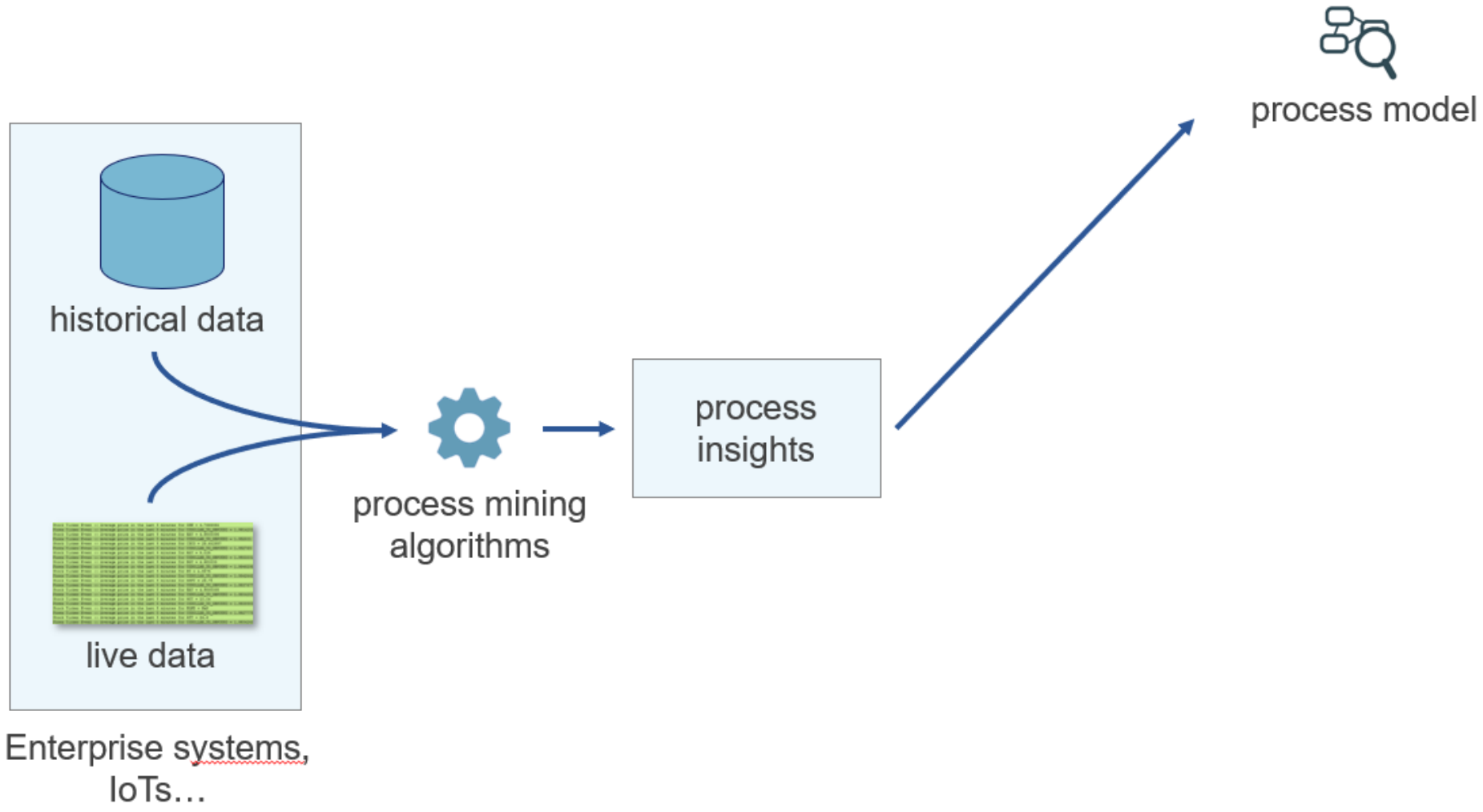
Process mining algorithms are used to extract process models and other process analytics.



Input: Business Process Event Log

Case ID	Activity	Resource	Start Timestamp	Complete Timestamp	Event Attribute
Case 1	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/01/30 05:44:00.000	2012/01/30 06:42:00.000	000:58
Case 1	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/01/30 06:59:00.000	2012/01/30 07:21:00.000	000:22
Case 1	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/01/30 07:21:00.000	2012/01/30 10:58:00.000	003:37
Case 1	Turning & Milling Q.C.	Quality Check 1	2012/01/31 13:20:00.000	2012/01/31 14:50:00.000	001:30
Case 1	Laser Marking - Machine 7	Machine 7- Laser Marking	2012/02/01 08:18:00.000	2012/02/01 08:27:00.000	000:09
Case 1	Lapping - Machine 1	Machine 1 - Lapping	2012/02/14 00:00:00.000	2012/02/14 01:15:00.000	000:00
Case 1	Lapping - Machine 1	Machine 1 - Lapping	2012/02/14 00:00:00.000	2012/02/14 01:15:00.000	000:00
Case 1	Lapping - Machine 1	Machine 1 - Lapping	2012/02/14 09:05:00.000	2012/02/14 10:20:00.000	000:00
Case 1	Lapping - Machine 1	Machine 1 - Lapping	2012/02/14 09:05:00.000	2012/02/14 09:38:00.000	000:33
Case 1	Round Grinding - Machine 3	Machine 3 - Round Grinding	2012/02/14 09:13:00.000	2012/02/14 13:37:00.000	004:24
Case 1	Round Grinding - Machine 3	Machine 3 - Round Grinding	2012/02/14 13:37:00.000	2012/02/14 15:27:00.000	001:50
Case 1	Final Inspection Q.C.	Quality Check 1	2012/02/16 06:59:00.000	2012/02/16 07:59:00.000	001:00
Case 1	Final Inspection Q.C.	Quality Check 1	2012/02/16 12:11:00.000	2012/02/16 16:12:00.000	004:01
Case 1	Final Inspection Q.C.	Quality Check 1	2012/02/16 12:43:00.000	2012/02/16 13:58:00.000	000:00
Case 1	Packing	Packing	2012/02/17 00:00:00.000	2012/02/17 01:00:00.000	000:00
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/17 07:01:00.000	2012/01/17 11:05:00.000	004:04
Case 10	Turning Q.C.	Quality Check 1	2012/01/17 11:00:00.000	2012/01/17 11:15:00.000	000:15
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/17 19:24:00.000	2012/01/17 20:01:00.000	000:37
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/17 20:01:00.000	2012/01/17 23:43:00.000	003:42
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/17 23:49:00.000	2012/01/18 06:32:00.000	006:43
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/18 06:59:00.000	2012/01/18 07:24:00.000	000:25
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/18 16:33:00.000	2012/01/18 17:55:00.000	001:22
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/18 17:57:00.000	2012/01/18 20:04:00.000	002:07
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/18 20:10:00.000	2012/01/19 06:29:00.000	010:19
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/19 16:12:00.000	2012/01/19 18:09:00.000	001:57
Case 10	Turning & Milling - Machine 9	Machine 9 - Turning & Milling	2012/01/19 18:10:00.000	2012/01/19 20:08:00.000	001:58

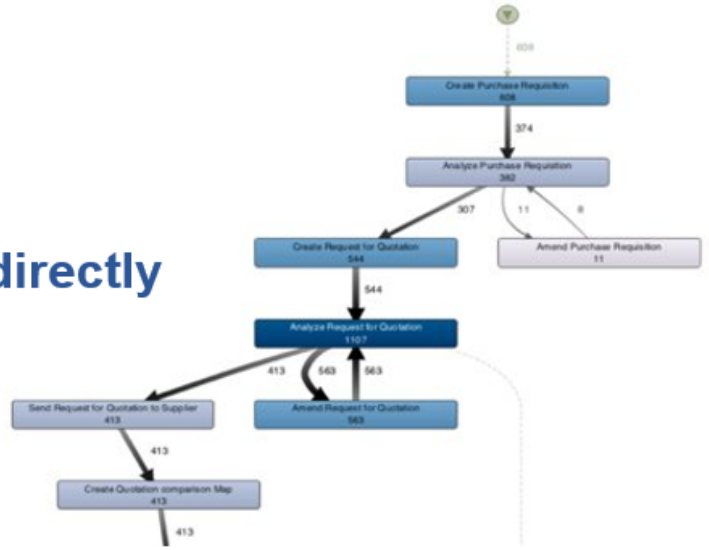
Process Mining



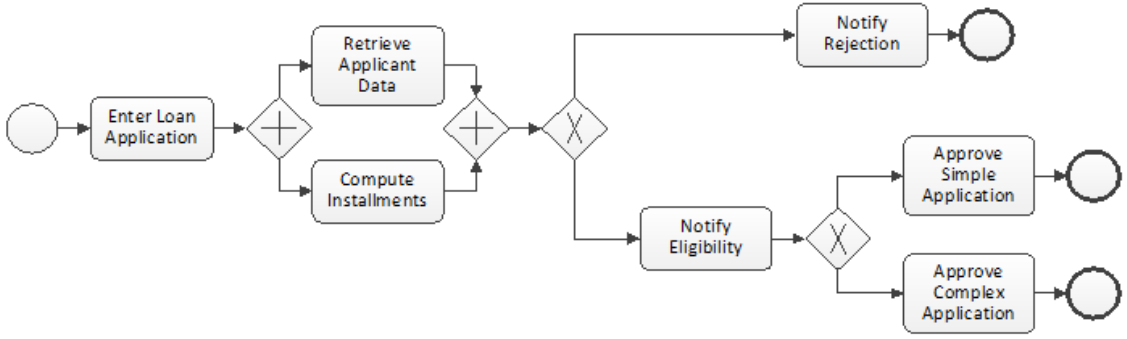
Automated Process Discovery

CID	Task	Time Stamp	...
13219	Enter Loan Application	2007-11-09 T 11:20:10	-
13219	Retrieve Applicant Data	2007-11-09 T 11:22:15	-
13220	Enter Loan Application	2007-11-09 T 11:22:40	-
13219	Compute Installments	2007-11-09 T 11:22:45	-
13219	Notify Eligibility	2007-11-09 T 11:23:00	-
13219	Approve Simple Application	2007-11-09 T 11:24:30	-
13220	Compute Installments	2007-11-09 T 11:24:35	-
...	...	...	...

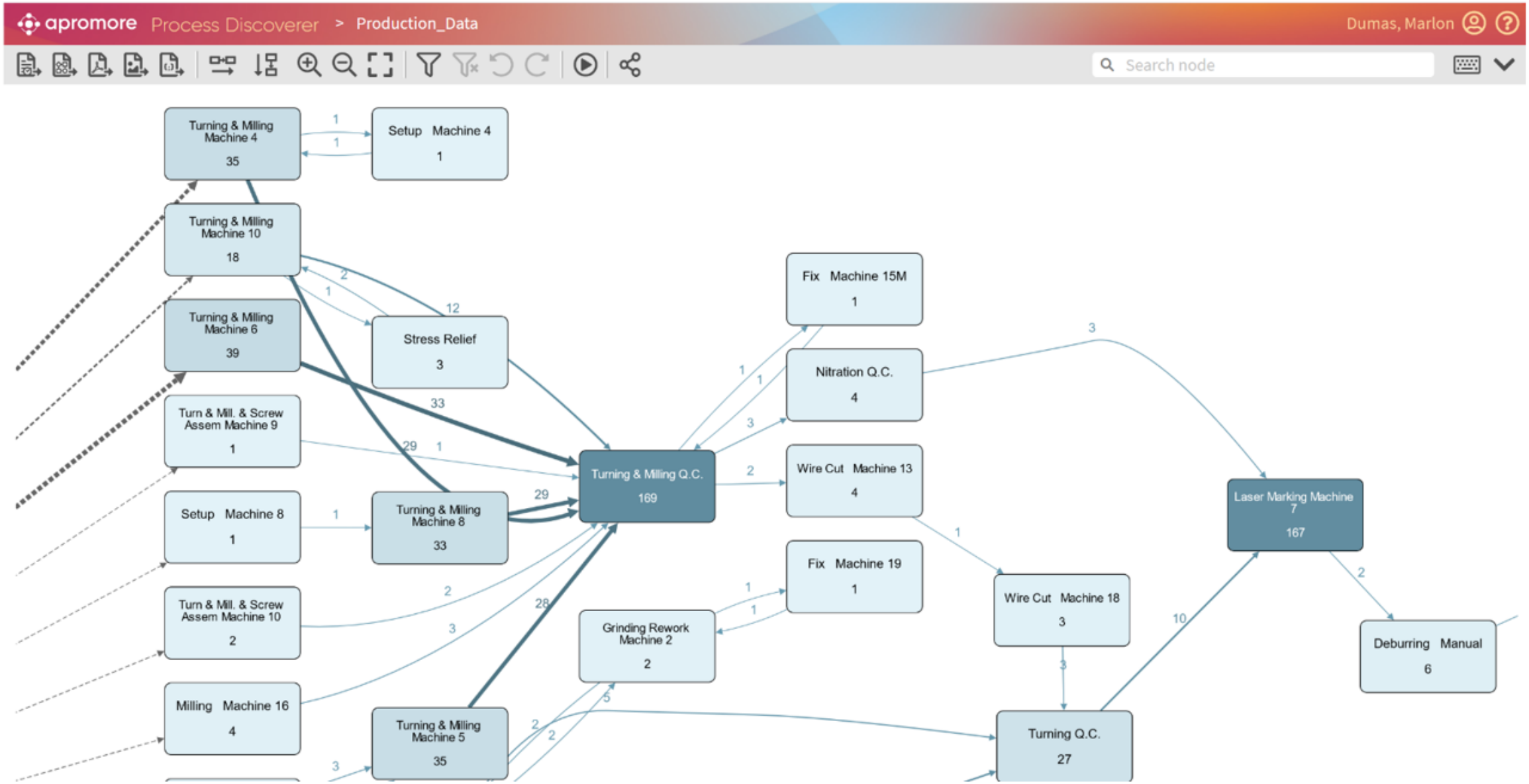
Process Map (directly follows graph)



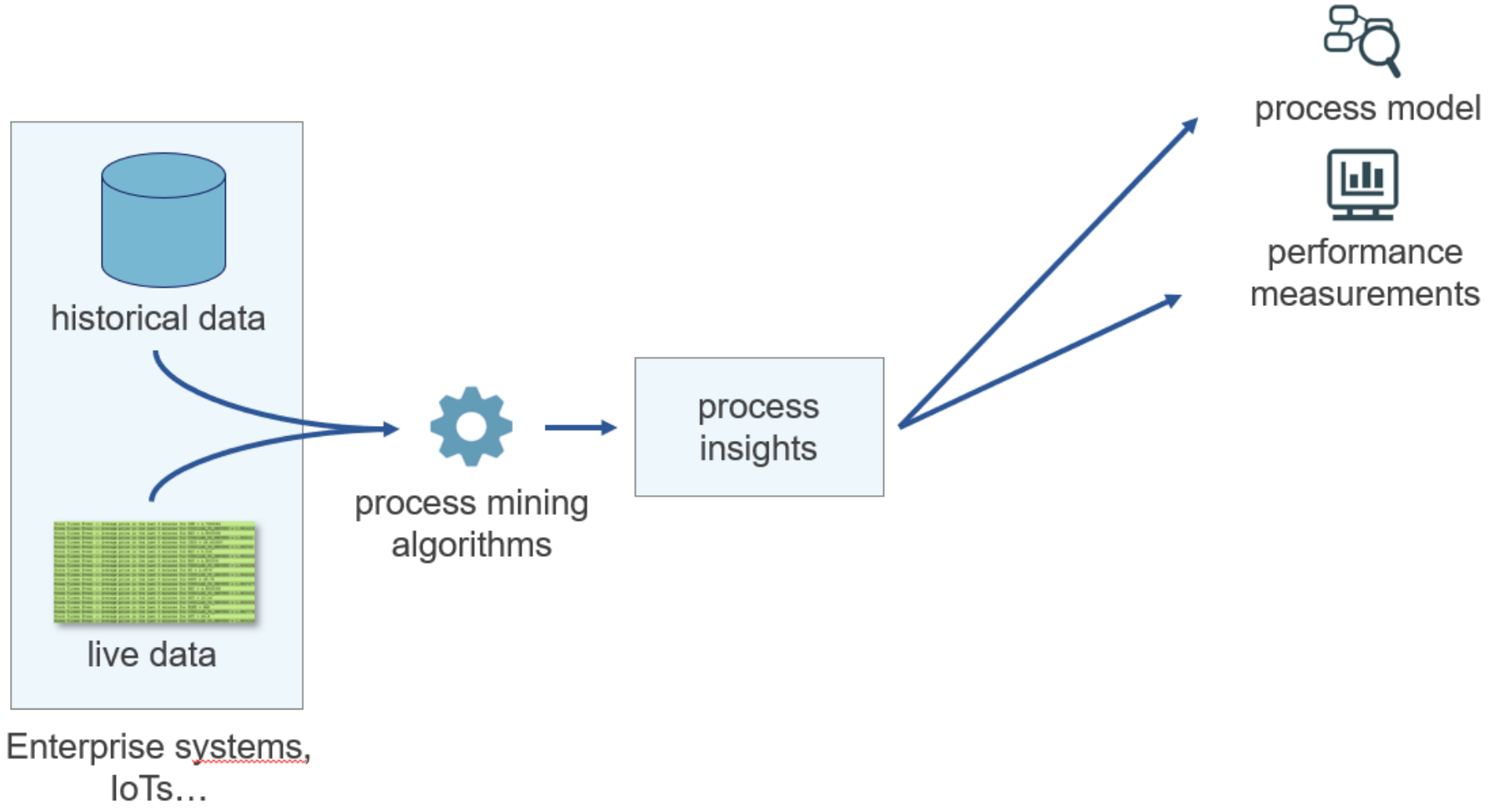
BPMN process model



Process Map of Manufacturing Process

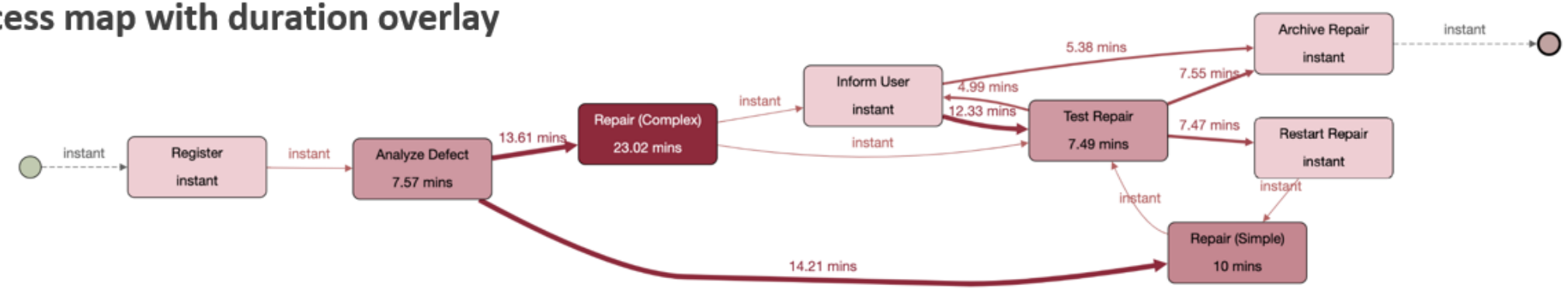


Process Mining

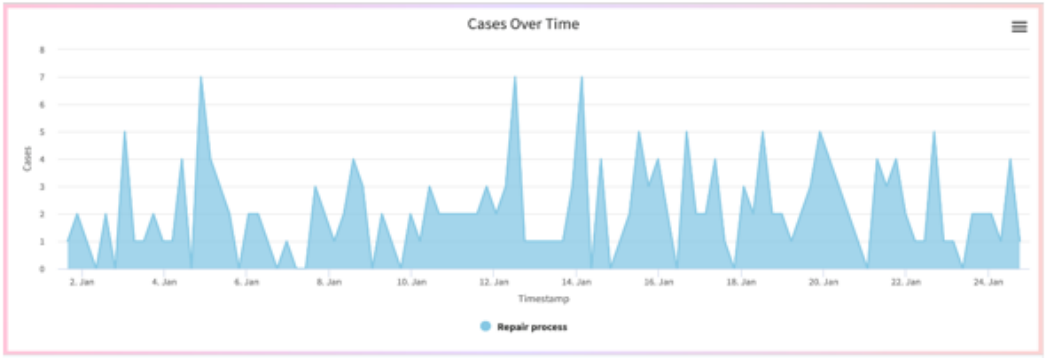


Performance Mining

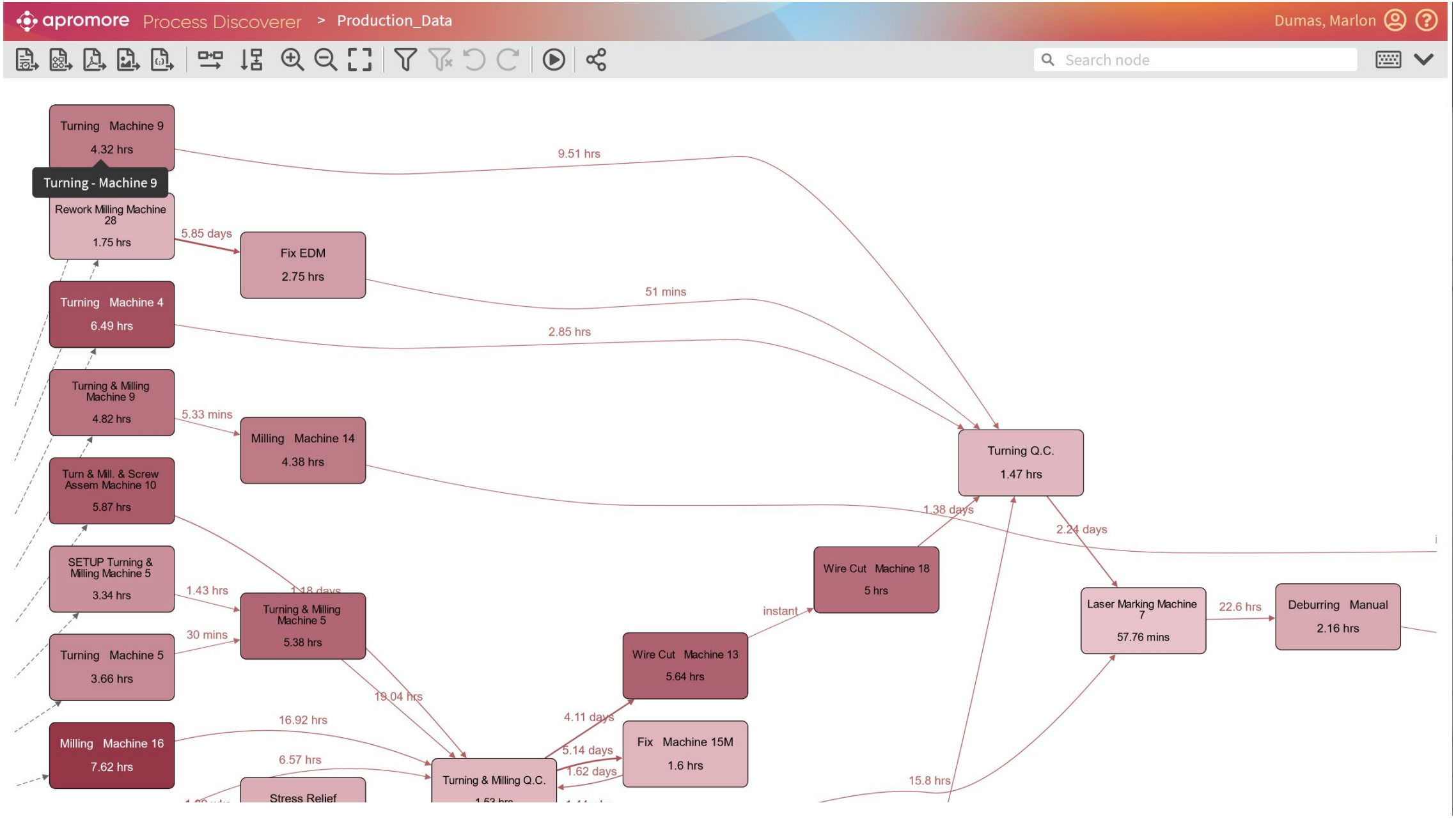
Process map with duration overlay



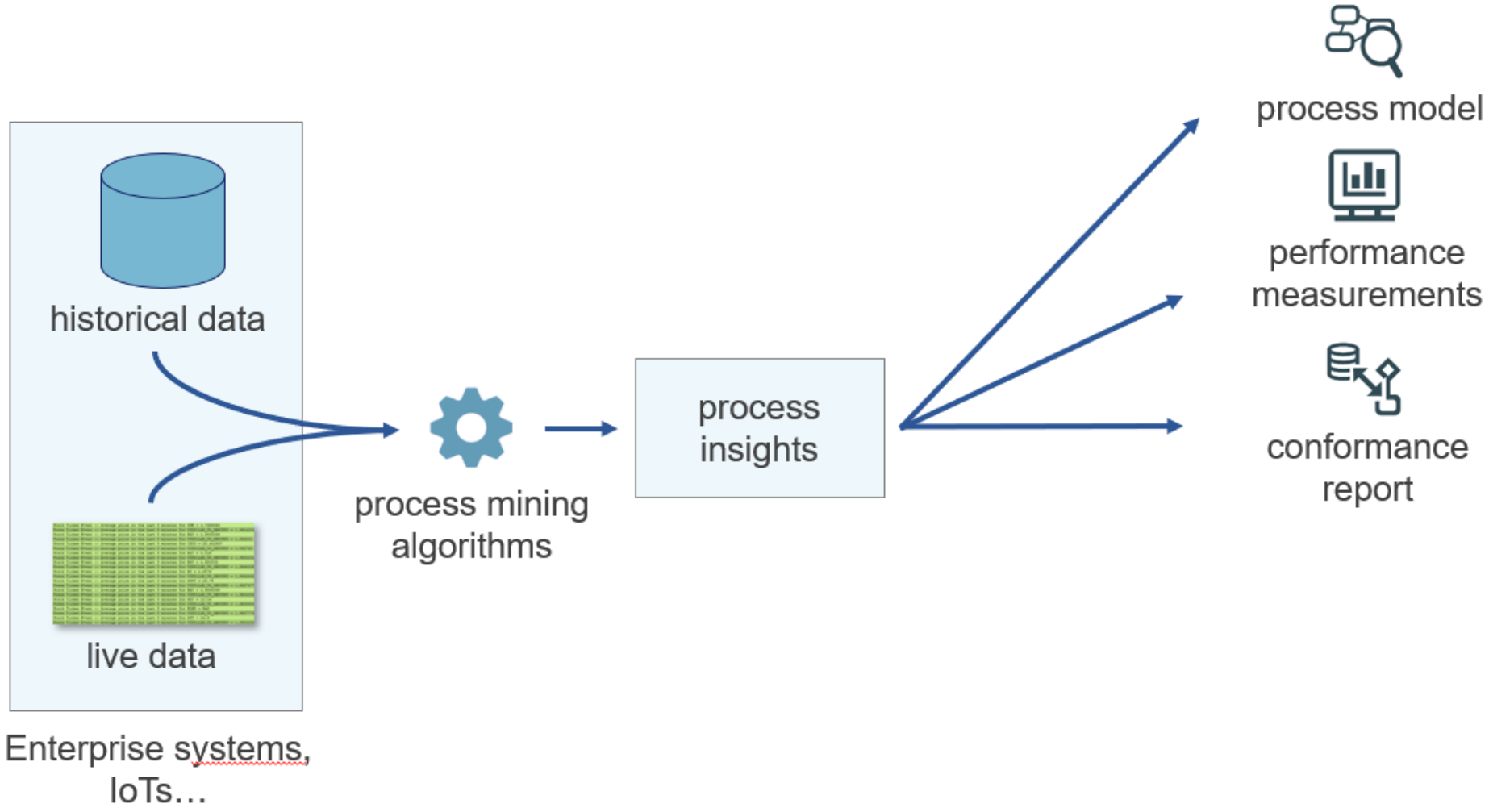
Process performance dashboards



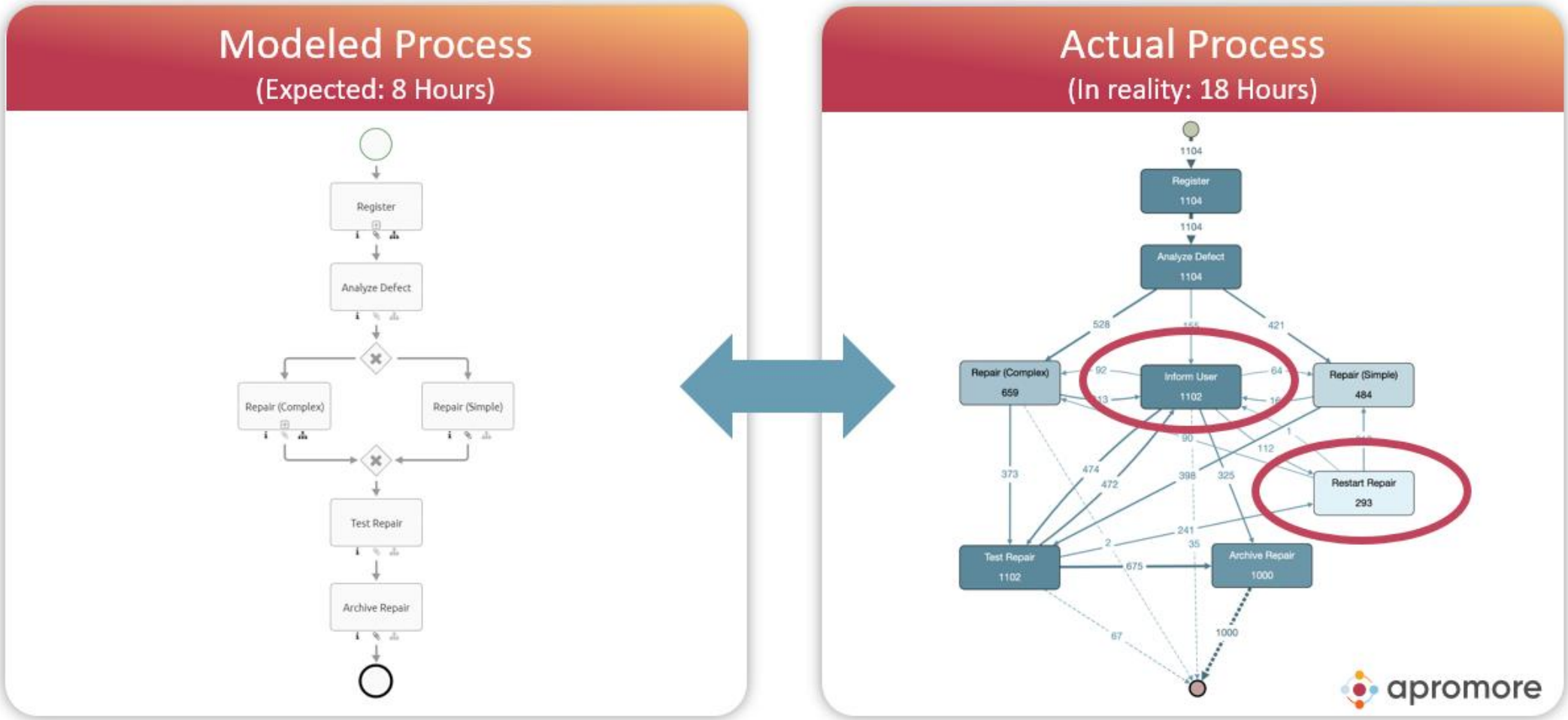
Process Map of Manufacturing Process



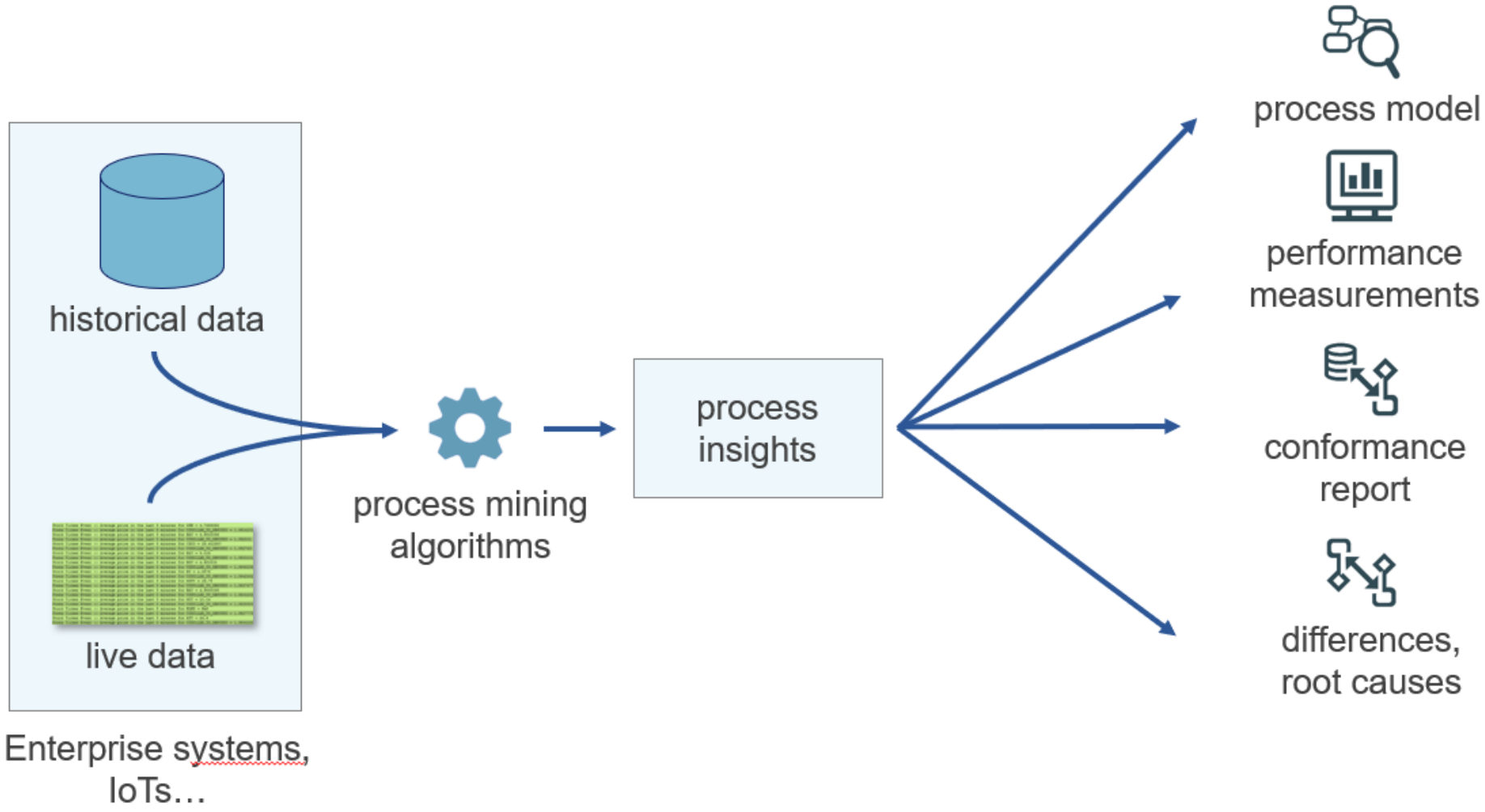
Process Mining



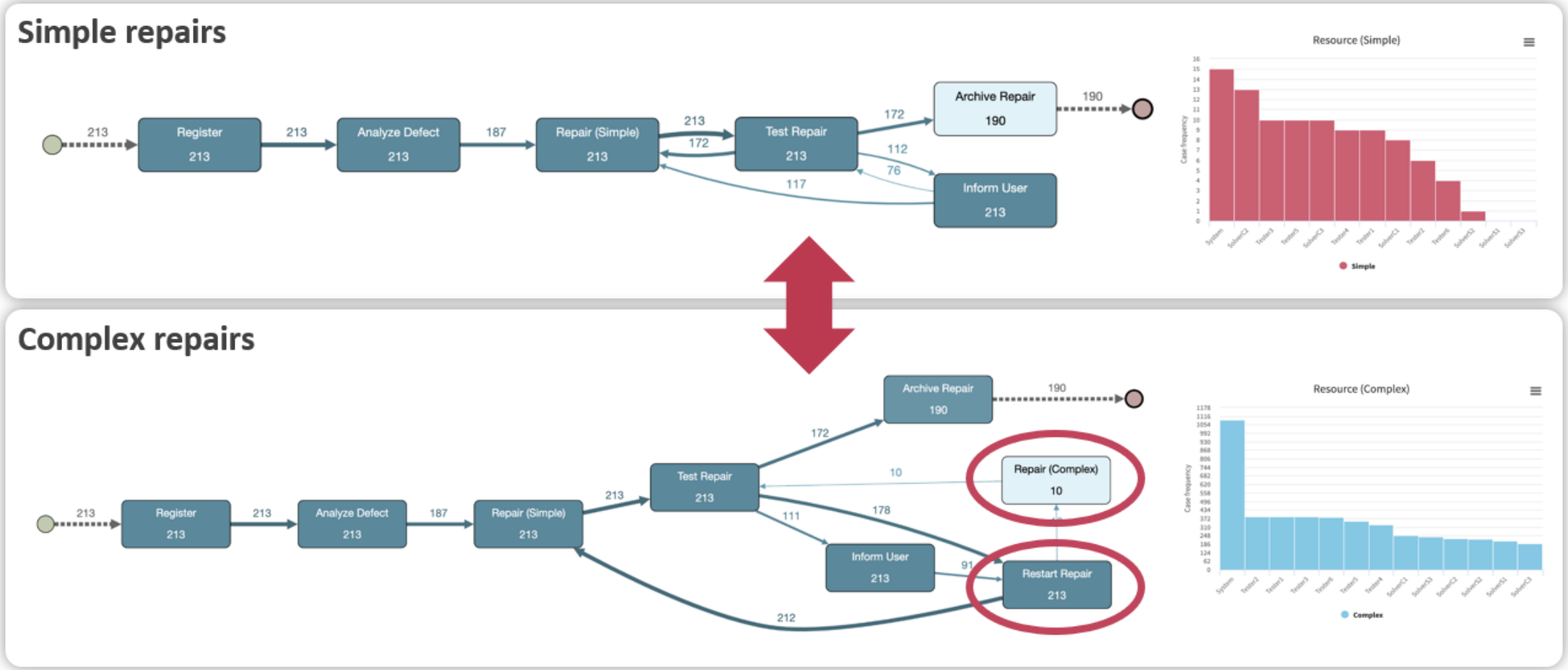
Conformance Checking



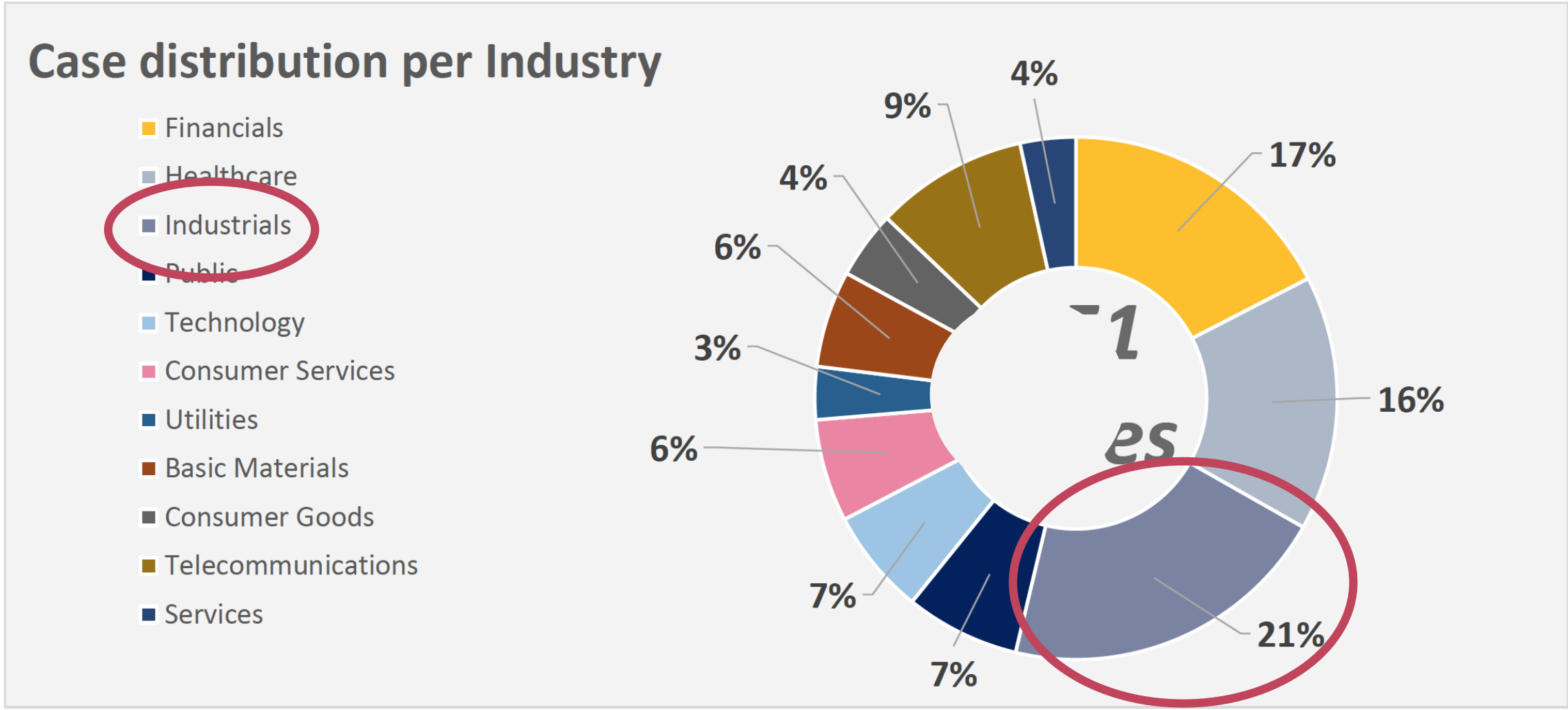
Process Mining



Variant Analysis



Where is it used?



HSPI, *Process Mining: A Database of Applications*, 2020

Uptake by organization size

MarketsandMarkets, Process Analytics Market – Global Forecast to 2023, May 2018

Case Study: Process Mining @ Meat Processor

Three feedlots → Six meat processing facilities → Distribution of products in APAC

Products

Cooked deli items, Convenience meals, Case-ready lines, and Fresh cuts

Costumers

Wholesalers, Food Services, and Retailers throughout the APAC region

Case Study: Challenges

New System

A recently deployed automated logistics solution led to significant slowdowns in end-to-end turnaround times for all the products.

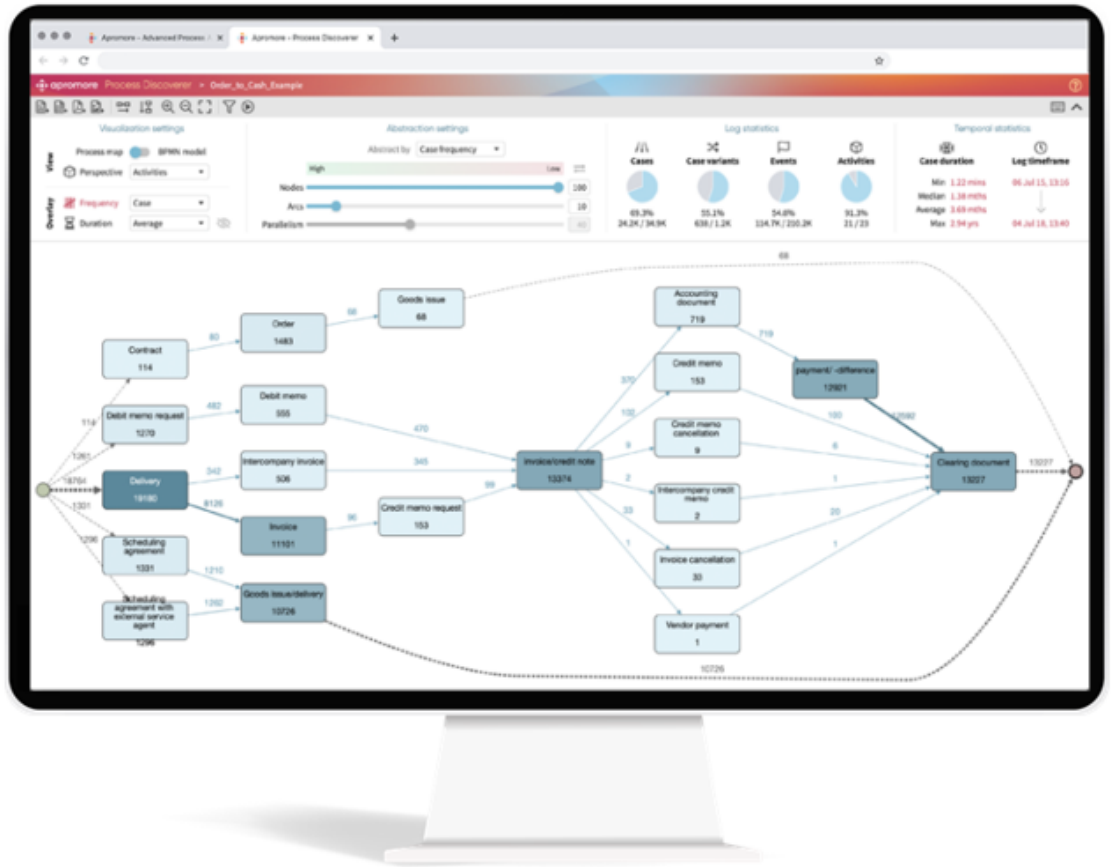
Waste

Due to the slow turnaround times, the amount of raw material and product waste increased.

Material movement

The business had low visibility of how raw material flows through the production plant.

Case Study: Analysis with Process Mining



Automated Process Discovery

Identifying the real material flows through the production plant.

Performance Mining

Understanding the process performance of all products.

Variant Analysis

Analyzing the case variants for all 20 product types.

Case Study: Results & Benefits

Improvement of turnaround times

1

- ✓ **10%** speedup on average
- ✓ Up to **30%** speedup for some products

Better decision-making foundation

2

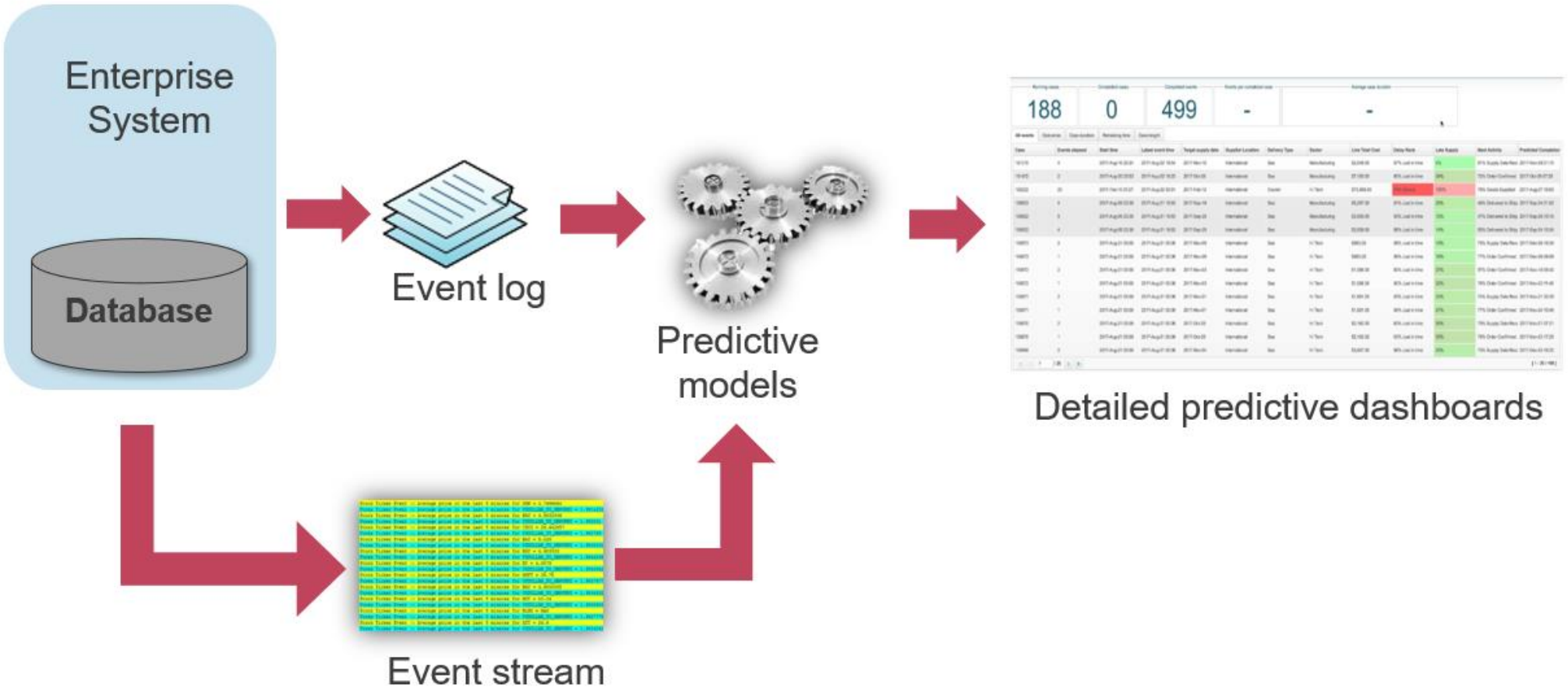
- ✓ **Clear under-standing** of all process flows

Significant reduction of waste

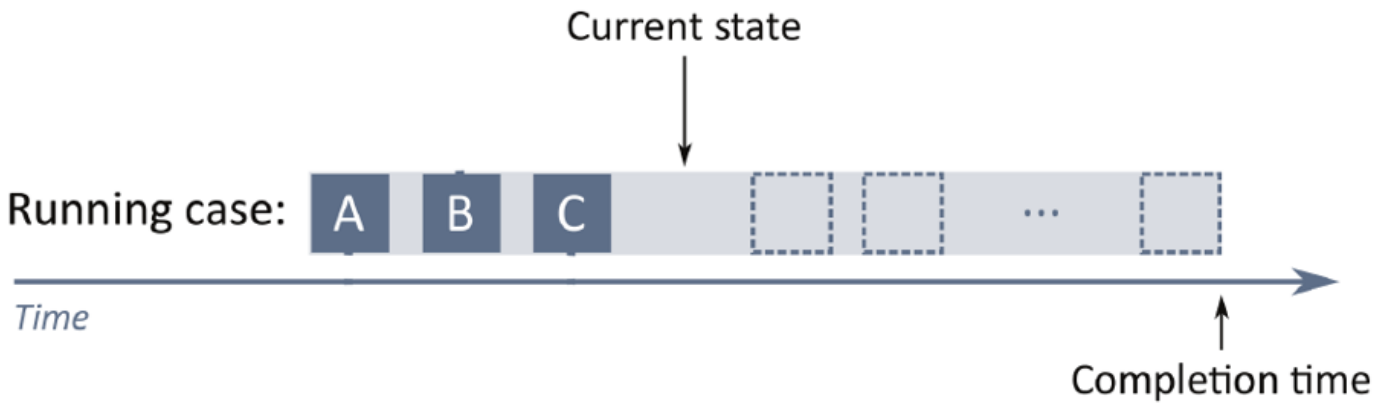
3

- ✓ Savings of more than **$800,000** every year

Predictive Process Monitoring



Predictive Process Monitoring

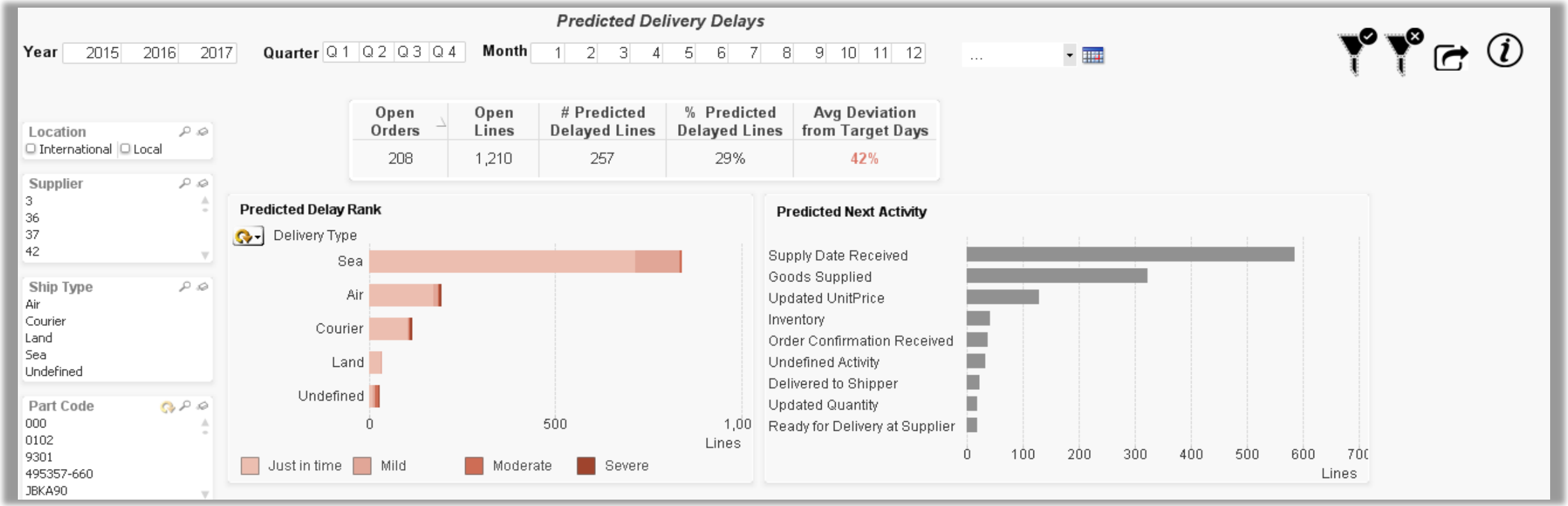


Predict **Process Outcome**	Predict **Process Performance**	Predict **Future Events**
Is this loan offer going to be rejected?	Will this claim take more than 5 days to be handled?	What activity is likely to be executed next? And after that?

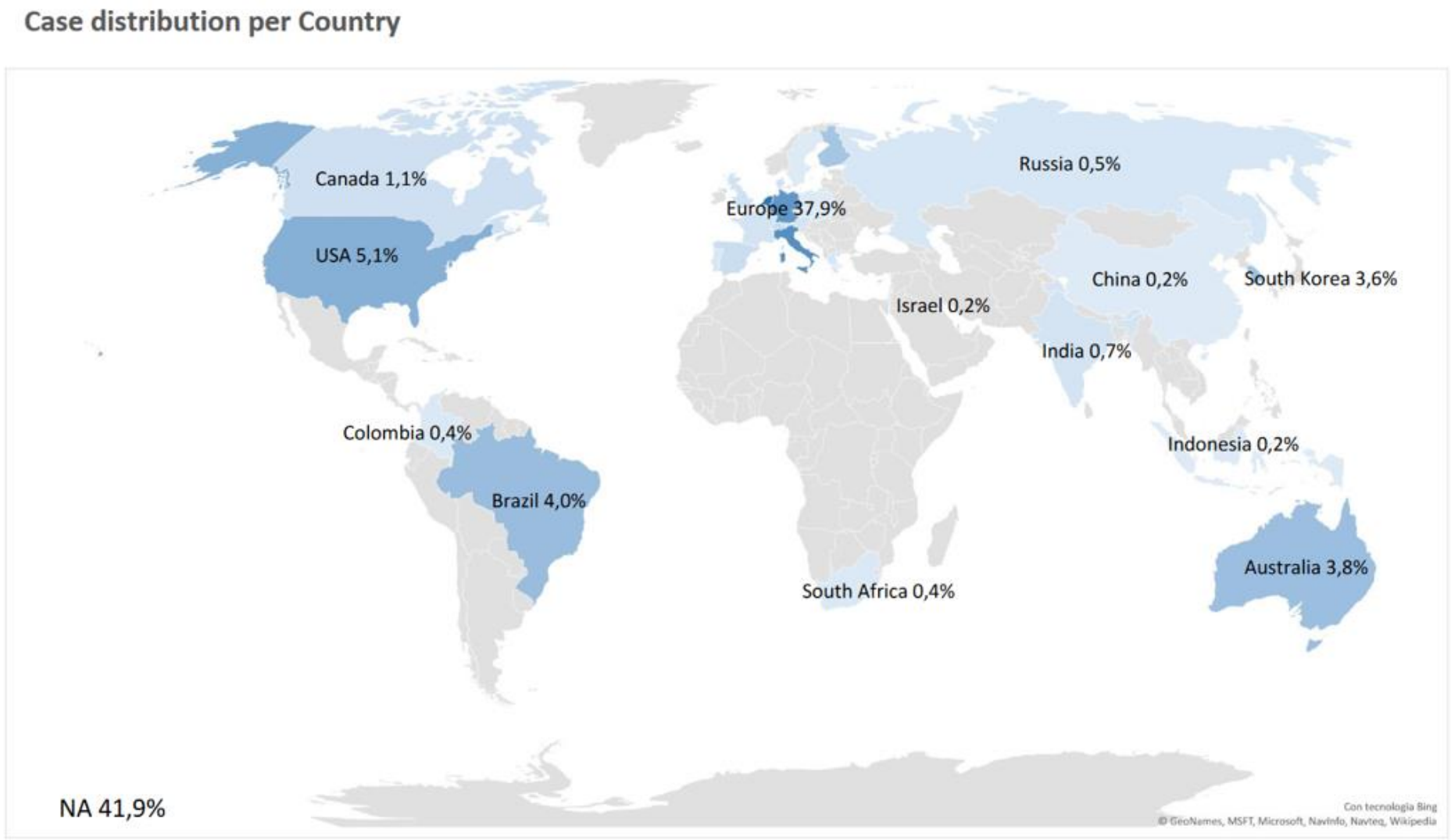
Predictive Process Monitoring: Case Study

Package delivery process @ Middle East Logistics Provider

- Developed predictive monitoring dashboard to anticipate delayed deliveries
- Combined predictions generated by process mining engine with PowerBI
- Managers immediately integrated the predictions into their daily planning and resource allocation processes → reductions in late delivery rates



Process Mining is Everywhere!



HSPI, *Process Mining: A Database of Applications*, 2020