# Stochastic-Aware Comparative Process Mining in Healthcare

## A method.

Tabib Mazhar, Asad Tariq, Sander Leemans,
Kanika Goel, Moe Wynn, Andrew Staib

QUT the university for the real world

Teaching and Research Area of Business Process Management Foundations and Engineering

RWTH AACHEN UNIVERSITY

# Comparative process mining

Compare different variants of a process…without upfront knowledge of the variants.

Event log

# Logs with trace attributes

| case ID | activity | timestamp | resource | amount | vehicleClass | … |
|---|---|---|---|---|---|---|
| 135 | create fine | 09:30 | A | $39 | A | |
| 135 | send fine | 09:39 | B | $39 | A | |
| 135 | insert notification | 09:40 | A | $39 | A | |
| 136 | create fine | 10:45 | A | $185 | C | |
| 136 | payment | 10:50 | C | $185 | C | |
| ⋮ | | | | | | |

Event log

⟨create fine, send fine, insert notification⟩ amount $39 vehicleClass A

⟨create fine, payment⟩ amount $185 vehicleClass C

…

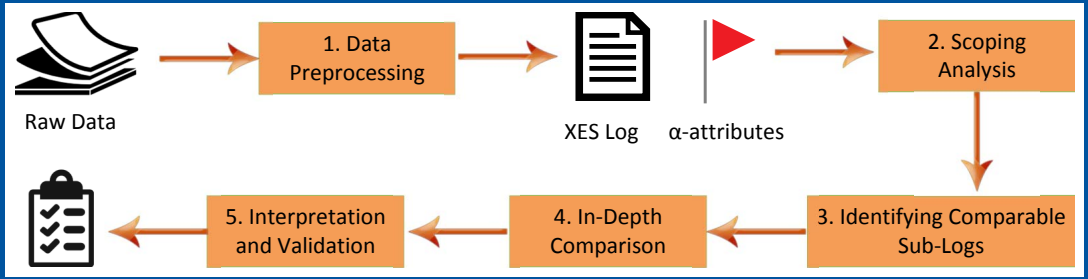
# Comparative process mining

Compare different variants of a process…without upfront knowledge of the variants.

Differences between groups of traces – by trace attributes.

Event log

# An existing method: Process Comparison Methodology




From: Syamsiyah, Alifah, et al. “Business process comparison: A methodology and case study.” Business Information Systems 2017.

# Missing: stochastic awareness

$$L_1 = [\langle \text{register}, \text{check}, \text{accept} \rangle^{10000}, \langle \text{register}, \text{check}, \text{reject} \rangle^{10000}, \langle \text{register}, \text{accept} \rangle^{1}, \langle \text{accept}, \text{register} \rangle^{1}]$$

$$L_2 = [\langle \text{register}, \text{check}, \text{accept} \rangle^{9500}, \langle \text{register}, \text{check}, \text{reject} \rangle^{9500} \langle \text{register}, \text{accept} \rangle^{1002}]$$

# About the research

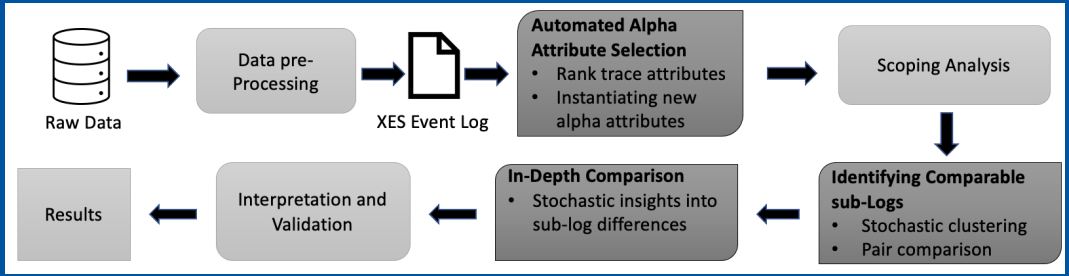
DO1 A method identifying differences between sub-logs,

DO2 that is stochastic aware, and

DO3 as automated as possible.

1. Problem identification
2. Design objectives
3. Design and development
4. Demonstration
5. Evaluation
6. Communication

# Artefact: Probabilistic Process Comparison Method




Light parts are of PCM; dark parts are new.

# P²MC: alpha attribute selection

- Remove IDs, timestamps and free-text
- Heuristic: unsupervised
  - categorise values
  - number of clusters
  - k-means clustering
  - average strength of centroid vectors
- Heuristic: supervised
  - Target: trace length
  - Random forest classifier
  - Average Gini impurity
- Ranked list of attributes

Log

# P²MC: Identifying comparable sub-logs


- Filtering
- Stochastic relations
  - pairwise EMSC
  - cluster


- Select pairs

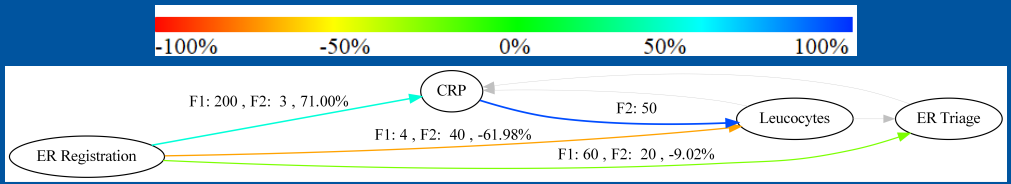
| | Log | Log | Log | Log |
|---|---|---|---|---|
| Log | 1 | 0.5 | 0.3 | 0.9 |
| Log | 0.5 | 1 | 0.5 | 0.4 |
| Log | 0.3 | 0.5 | 1 | 0.7 |
| Log | 0.9 | 0.4 | 0.7 | 1 |

# P²MC: in-depth comparison

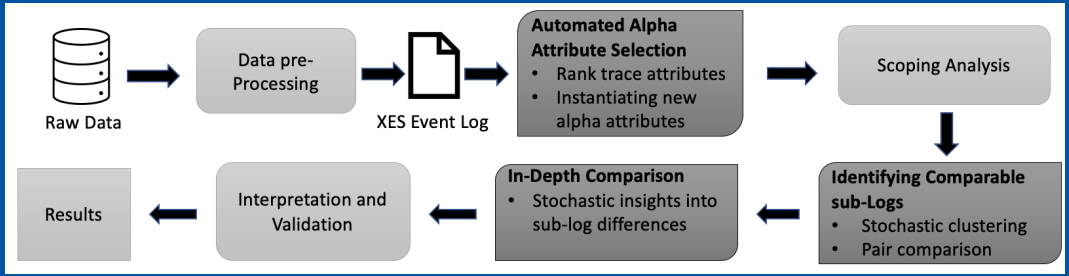
Visualise stochastic differences on common DFG

- Directly follows graph
- Filter
- Relative frequency

$$\frac{L_1(a \to b)}{\sum_{(a,c') \in DFG} L_1(a, c')} - \frac{L_2(a \to b)}{\sum_{(a,c') \in DFG} L_2(a, c')}$$



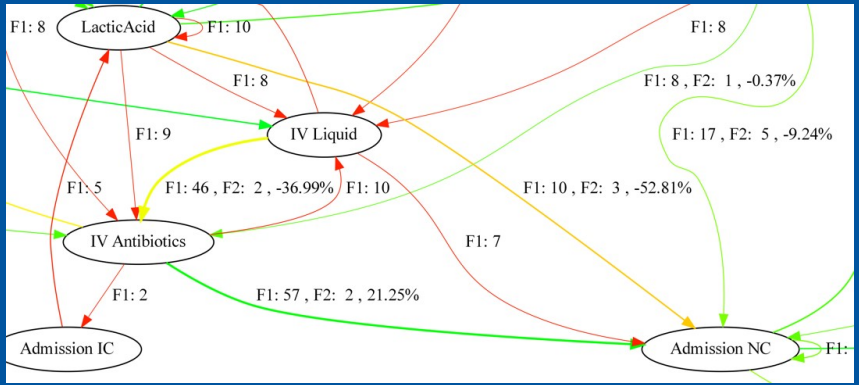
# Artefact: Probabilistic Process Comparison Method




Light parts are of PCM; dark parts are new.

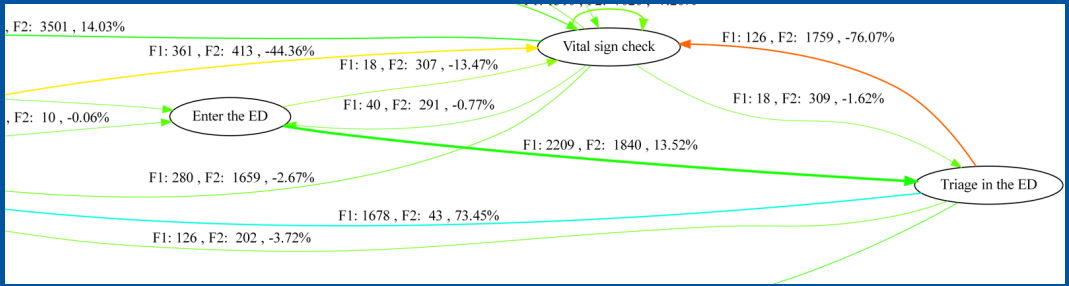
# Demonstration: Sepsis

- 777 traces
- $\alpha$ attribute: diagnose
- cluster EMSC values {C,B,E,H,D,K,R} {S} {G,Q}



# Demonstration: MIMICel

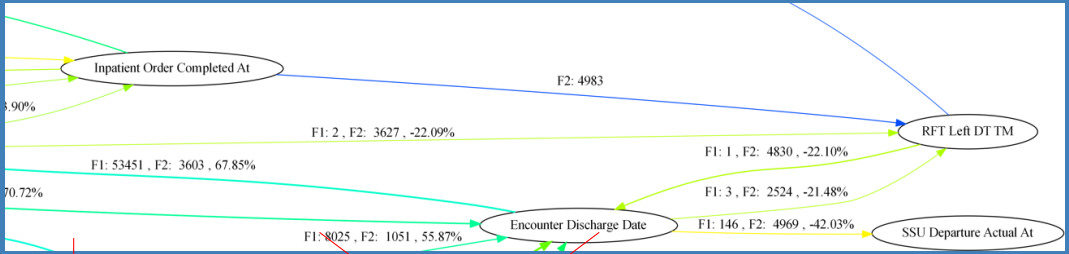
- 36 737 traces
- $\alpha$ attribute: icd_title
- cluster EMSC values
- In-depth on Headache and Altered mental status, unspecified.



# Evaluation: Princess Alexandra Hospital

2 329 846 events
134 846 traces
48 activities

ED pathways



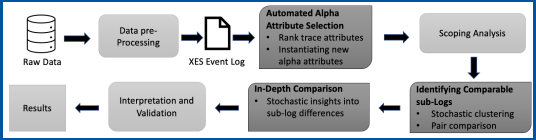

Time on ramp (0, 1.0] vs (1.0,105.0] minutes

recording issues
expected differences

3 in-depth comparisons

# You have been watching…

- P$^2$CM Probabilistic Process Comparison Method




- $\alpha$ attribute selection
- Identifying comparable sub-logs
- In-depth comparison
- Sepsis / MIMIC / PAH

Future work

- Further automate steps
- Process cubes
- Evaluate ease-of-use

Sander Leemans
s.leemans@bpm.rwth-aachen.de
http://leemans.ch

Teaching and Research Area of Business Process Management Foundations and Engineering

RWTH AACHEN UNIVERSITY

# Bold claim

Considering the stochastic perspective makes things easier


QUT
the university for the real world
B P M
Teaching and Research Area of Business Process Management Foundations and Engineering
RWTH AACHEN UNIVERSITY