SECPI: Searching for Explanations for Clustered Process Instances

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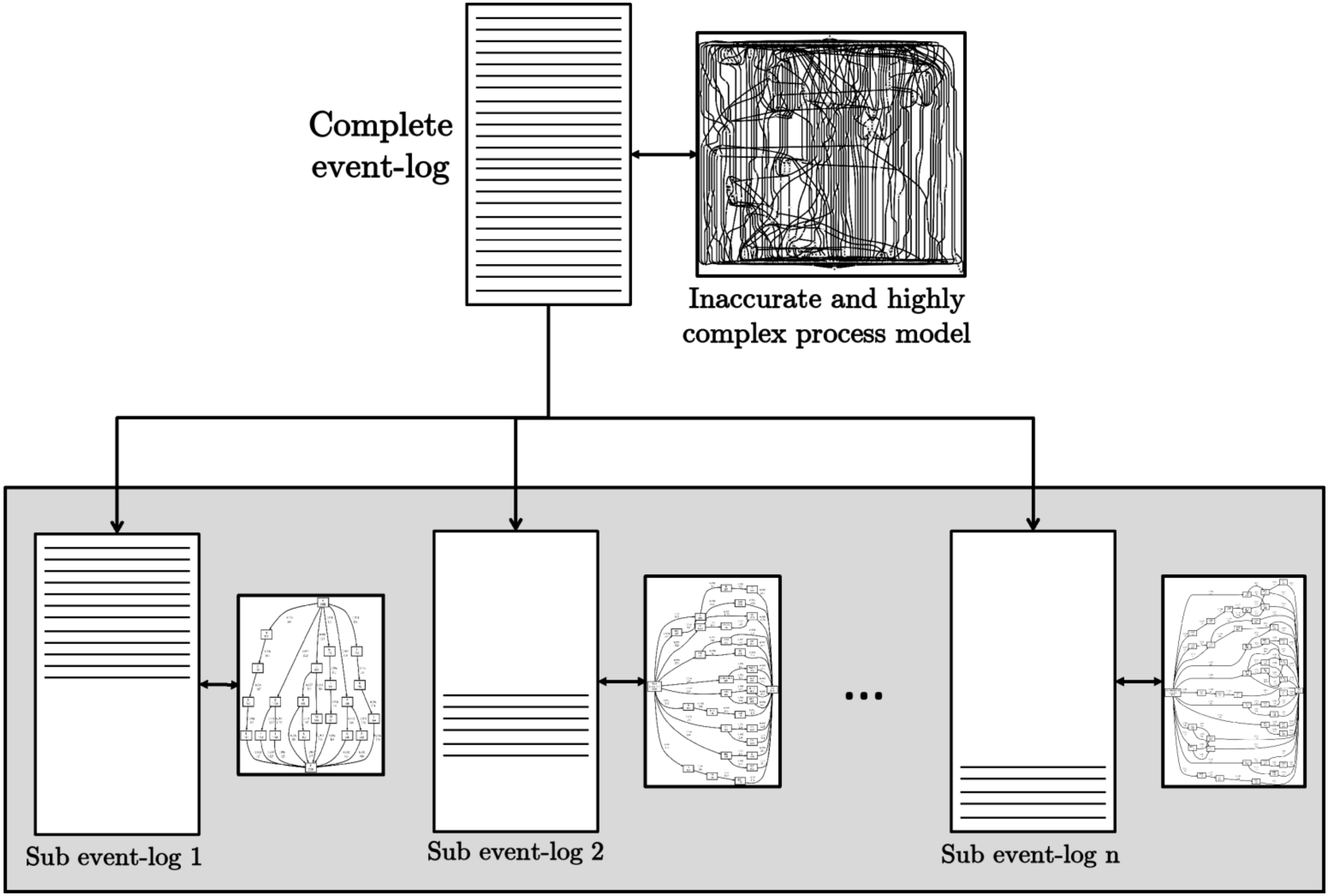
Outline

- Introduction
  - Trace clustering
  - Problem
  - Potential alternative solutions
- Our solution: SECPI
- How does it work?
- Implementation
- Evaluation
- Ideas for future work

Trace clustering



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Trace clustering algorithms

Reference	Data Representation	Clustering Bias
Greco, G., Guzzo, A., Pontieri, L., Saccà, D.: Discovering expressive process models by clustering log traces. IEEE Trans. Knowl. Data Eng. **18**(8) (2006) 1010–1027	propositional	instance similarity
Song, M., Günther, C.W., van der Aalst, W.M.P.: Trace clustering in process mining. In Ardagna et al., eds.: BPM Workshops. Vol. 17 of LNBIP, Springer (2008) 109–120	propositional	instance similarity
Ferreira, D.R., Zacarias, M., Malheiros, M., Ferreira, P.: Approaching process mining with sequence clustering: Experiments and findings. In Alonso et al. eds.: BPM. Vol. 4714 of LNCS, Springer (2007) 360–374	event log	maximum likelihood
Bose, R.P.J.C., van der Aalst, W.M.P.: Context aware trace clustering: Towards improving process mining results. In: SDM, SIAM (2009) 401–412	bag of strings	instance similarity
Bose, R.P.J.C., van der Aalst, W.M.P.: Trace clustering based on conserved patterns: Towards achieving better process models. In Rinderle-Ma, S. et al., ed.: BPM Workshops. Vol. 43 of LNBIP, Springer (2009) 170–181	propositional	instance similarity
Folino, F., Greco, G., Guzzo, A., Pontieri, L.: Mining usage scenarios in business processes: Outlier-aware discovery and run-time prediction. Data Knowl. Eng. **70**(12) (2011) 1005–1029	event log	maximum likelihood
De Weerdt, J., vanden Broucke, S.K.L.M., Vanthienen, J., Baesens, B.: Active trace clustering for improved process discovery. IEEE Trans. Knowl. Data Eng. **25**(12) (2013) 2708–2720	event log	fitness
Ekanayake, C.C., Dumas, M., García-Bañuelos, L., La Rosa, M.: Slice, mine and dice: Complexity-aware automated discovery of business process models. In Daniel et al., eds.: BPM. Vol. 8094 of LNCS, Springer (2013) 49–64	propositional	complexity

Problem

- Evaluation of trace clustering results
  - Compute intra/inter cluster similarity/dissimilarity (e.g. with a distance measure)
  - Compute fitness, precision, generalization, and simplicity of discovered process models for the clusters

- However

1) What are the driving elements that determine a clustering solution?
2) How can a clustering solution be understood by end-users, thus explained from a *domain* perspective?

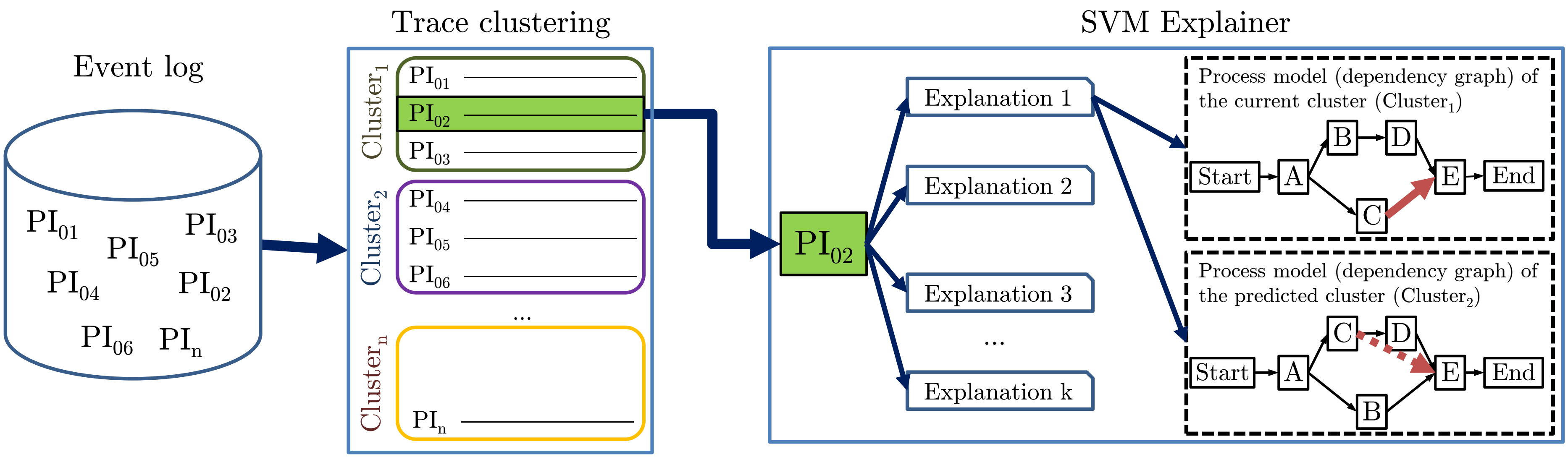
Potential alternative solutions

- Visual analysis of the underlying process models
- Process model similarity
  - Metrics (e.g. Alves de Medeiros et al., 2008; Dijkman et al., 2011)
  - Visualization (e.g. Dijkman 2007; 2008)
- Footprints and behavioural profiles
- White box classification model (e.g. decision tree)
- Cross-cluster conformance checking

➔ All these techniques are valuable, but also present disadvantages to solve the problem at hand

Our solution: SECPI

- Learn a minimal set of control-flow characteristics for each process instance individually *whose absence would prevent the process instance to be in its current cluster*
- Control-flow characteristics: SometimesDirectlyFollows(A,B)



Explanation 1 for PI_{02}: **IF** SometimesDirectlyFollows(C,E) $= 0$ **THEN** $Cluster_2$

SECPI: Steps

1. Construct the data set
   - Propositional data set consisting of SometimesDirectlyFollows(A,B)-attributes (binary variables)
   - Cluster label for each instance
2. Derive explanations from a Support Vector Machine (SVM) classifier → SECPI algorithm
   - Inspired by: Martens, D. & Provost, F. Explaining data-driven document classifications. MISQ Vol. 38, Issue 1, pp. 73-99, 2014.
   - SVM-*liblinear* because of scalability (dimensionality explosion)
   - Key modifications to Martens & Provost
     - Multi-class classification
     - Explanations are restricted to characteristics that are present in traces
     - Performance optimisations

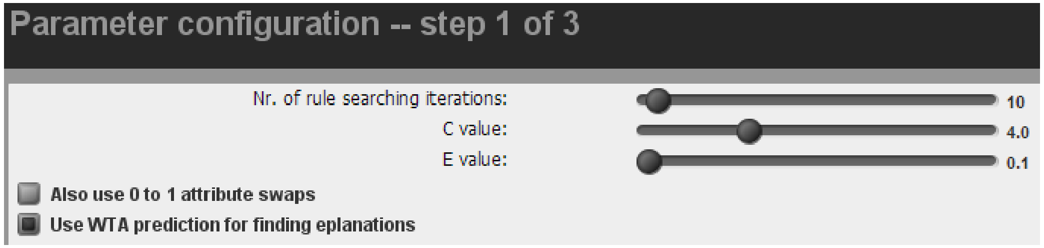
SECPI algorithm

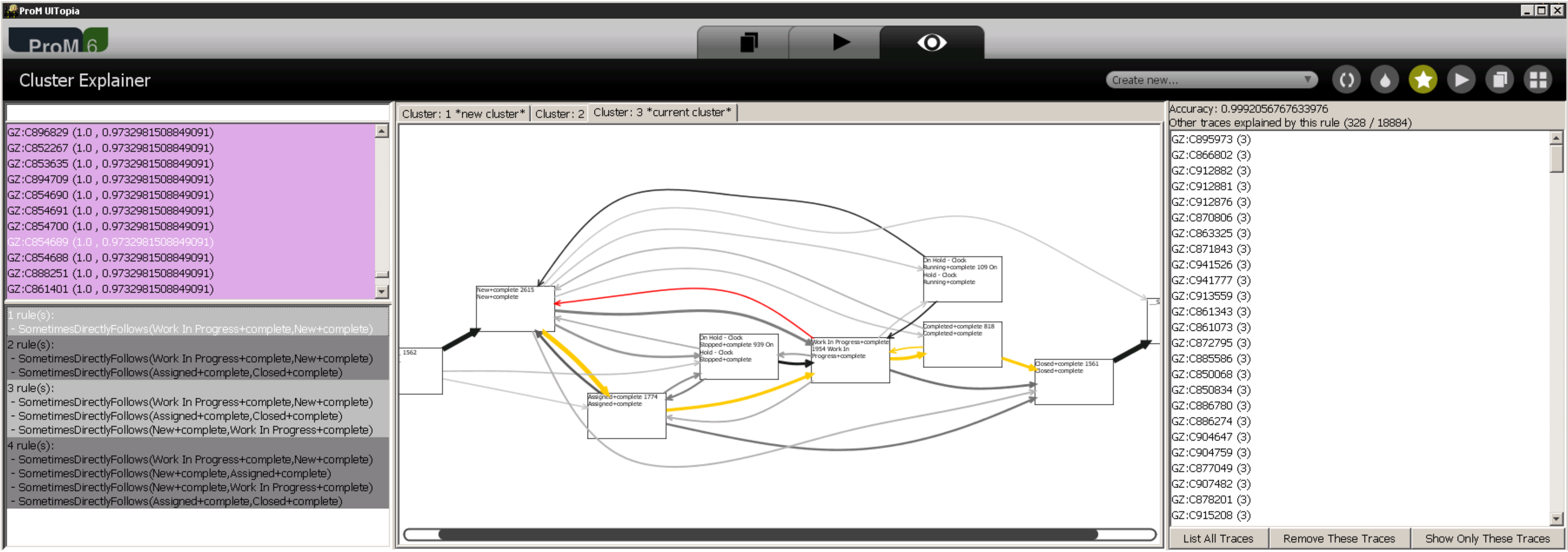
- Inputs
  - Process instance (sequence of binary attributes)
  - Classifier (SVM)
  - Three configuration parameters
    - Nr. of *iterations:* determines the length of the explanations
    - *zero_to_one*: boolean that determines whether 0-to-1 swaps are allowed
    - *require_support*: boolean that determines whether swaps of invariable attributes are allowed
- Output
  - A set of explanatory rules: set of sets of attribute indices
  - If (¬zero_to_one) → “This process instance would leave its current cluster when it would not exhibit the behaviour as represented by these attributes”

SECPI algorithm

- Step 1: Find single-attribute rules
- Step 2: Best-first search procedure with pruning
    - ○ Expand on currently available combinations
    - ○ Using the classifier’s scoring function
        - Idea: find attribute swaps that move the instance farthest away from current cluster
    - ○ Check whether any of the expanded combinations leads to a class change

ProM 6 – implementation: SVMExplainer





http://processmining.be/svmexplainer/

Evaluation

- We have compared our approach to global, white-box classification techniques
  - Decision trees: C4.5
  - Rule learner: RIPPER
- We found across 5 real-life data sets
  - Much shorter explanations
  - On par or better accuracy of the classification/explanation model

Ideas for future work

- Aggregating individual explanations into a global model
  - Finding similar explanations
  - Clustering explanations
  - Network representation
- Opportunities
  - Studying how trace clustering techniques actually work from a domain perspective
  - Other or better characteristics to be used beyond SometimesDirectlyFollows(A,B)
  - Relate exogenously defined clusters to process-specific control characteristics

thank you
danke
рахмат
謝謝
ngiyabonga
teşekkür ederim
spas
Баярлалаа
mersi
kia ora
barka
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спасибо
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blagodaram
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matondo
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köszönöm
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ευχαριστώ
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dhanyavadagalu
shukriya
mercé
мерси
kam sah hamnida
rahmat
তোমাকে ধন্যবাদ
감사합니다
xièxie
merci

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