

ALMA MATER STUDIORUM Università di Bologna

Tecniche dichiarative per il ragionamento su processi di business e loro modelli.

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Federico Chesani, Paola Mello

DISI, Dipartimento di Informatica – Scienza e Ingegneria

Outline

1. Background: the Business Process Management research field

Which research activities?

- 2. Conformance Checking and incomplete knowledge
- 3. Log generation
- 4. Process Discovery with negative information:



Business Process Management

- A 20-year-old discipline, that focus on Business Processes, and embrace all the different aspects related to
 - E.g., economics, human and resource management, process modelling, (big) data, machine learning of processes, user interaction, socio-technical systems, etc.
- It has similarities and can be applied to many different application fields
 - Industry 4.0, e-Health, Web Services, Multi Agent Systems, IoT, etc.
- In 2011 the community joined in for the definition of a Manifesto about the Process Mining, as the art of "extract knowledge from the event logs"



http://www.padsweb.rwth-aachen.de/wvdaalst/publications/p658.pdf van der Aalst, W.M.P., al.: Process mining manifesto. In: BPM 2011 International Workshops. LNBIP, vol. 99, pp. 169–194. Springer (2011)

Business Process Management – Process Mining

The starting point is the event log

- Modern ICT infrastructures provide tons of data
- Running of a business as the parallel execution of many "processes". E.g., amazon web site:
 - search of items process
 - add-to-cart&purchasing process
 - feedback&comment
- Each interaction might be related to a **process instance**, and consequently a process instance identifier
- A log is (roughly speaking) a collection of events characterized by:
 - Process instance identifier
 - Event description
 - Timestamp
 - Data fields and Actors-related fields

Instance/Cart ID	Customer ID	Completed?	When processed	When shipped	When delivered
12	12345	√	03/06/2 018	03/06/20 18	04/06/20 18
37	12345	√	03/06/2 018	04/06/20 18	
56	87654	✓	05/06/2 018		
89	87654				



Business Process Management – Process Mining

The starting point is the **event log – which reasoning tasks?**

Again, from the Manifesto:

- **Discovery:** from the log, to a (intensional) representation of the process
 - It is more than data mining: the process dimension plays a major role
 - Which language for representing a process?
- **Conformance:** given a trace, is that trace conformant w.r.t. a process model?
 - Which notion of conformance?
 - What about missing information?
- Enhancement: how to improve an existing model?

Bottom line: there are plenty of connections with Al-related approache

Business Process Management – Process Models

Logs capture a partial, incomplete, and extensional view of a process execution

How to intensionally represent a process?

- Procedural approaches: mainly focused on the control-flow aspects, usually closed
 - First proposals: variations and extensions of *Petri-Nets*. Formal semantics, lot of results available, lack of flexibility. E.g., **YAWL**
 - Current standard, **BPMN**: operational semantics only, many symbols, supports control flow, events, and role/actors
- Declarative approaches: focus on properties that each process instance should exhibit, aka constraints, usually open. E.g., Declare, based on Linear Temporal Logic





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Our research activities within the BPM research field

CLAIM:

Declarative approaches are closely related to Knowledge Representation and Reasoning. In particular, Computational Logic-based methods have several connections and provides solutions, methods and tools.

Which research directions?

- Modeling of processes: logic-based semantics for declarative process modeling languages (computational logic-based extensions for dealing with data and data-related constraints)
- Conformance Checking with complete information (Abduction, Event Calculus, with support to data)
- Conformance Checking and incomplete knowledge: given a (incomplete) trace, and a model, is the trace compliant with the model?
- Log generation: given a procedural/declarative model, can we generate examples of execution traces? Can we generate also negative examples?
- Process Discovery with negative information: given a log, can we learn declarative representations of a process? Is there any *negative* information? Can we exploit it?



Conformance Checking and incomplete knowledge



What if we observe: •(start) a b1 d (stop)

a) Can we make the hypothesis that B2 has happened, even if we did not see it?

b) ... or could it be that the model is wrong?



Conformance Checking and incomplete knowledge

Three types of incompleteness:

- 1. The log is incomplete: the trace {a, c, d} is never logged
- 2. The trace is incomplete: the logged trace {a, b1, d } is missing the activity B2
- 3. The events in the trace might be incomplete: the event a is logged, but its happening time is not known

Our approach:

- Represents the process model in terms of computational logic, and in particular through Abductive Logic Programming
- Exploits abduction to compute the set of hypotheses (abducibles) under which the trace might be deemed as conformant w.r.t. the model; deals also with constraints over data
- Exploits composability property, and through vertical and horizontal decomposition, scale up to stream of events → Map-Reduce application



Chesani, F., De Masellis, R., Francescomarino, C.D., Ghidini, C., Mello, P., Montali, M., Tessaris, S.: **Abducing workflow traces: A general framework to manage incompleteness in business processes**. In: Kaminka, G.A., Fox, M., Bouquet, P., Hu'llermeier, E., Dignum, V., Dignum, F., van Harmelen, F. (eds.) ECAI 2016 - 22nd European Conference on Artificial Intelligence, 29 August-2 September 2016

F. Chesani, P. Mello, R. De Masellis, C. Di Francescomarino, C. Ghidini, M. Montali, S. Tessaris: **Compliance in Business Processes** with Incomplete Information and Time Constraints: a General Framework based on Abductive Reasoning. Fundam. Inform.161(1-2): 75-111 (2018)

D. Loreti, F. Chesani, A. Ciampolini, P. Mello: A distributed approach to compliance monitoring of business process event streams. Future Generation Comp. Syst. 82: 104-118 (2018)



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Log Generation

- Given a procedural/declarative model, can we use it for generating compliant traces?
- Idea: sort of conformance reasoning with incomplete knowledge, BUT... here we do not know anything at all...
- What about data? Can we arbitrarily generate events with data?
- What about negative traces? Can we generate traces that violate the model?
- What does it mean "violation"? Violation of the control flow, but also violations of constraints over data...

Approach:

- Again Computational Logic, and in particular Abdcutive Logic Programming is exploited for generating trace templates
- Constraint Logic Programming is then used for grounding templates' variables

D. Loreti, F. Chesani, A. Ciampolini, P. Mello: Generating synthetic positive and negative business process traces through abduction. Knowl. Inf. Syst. 62(2): 813-839 (2020)



Process Discovery with negative information

Starting point:

- Almost the totality of process discovery techniques in BPM can be characterized as a single-class learning task...
- ... they match with the industrial perception that logs contain only "positive" information.

However:

- Logs capture only a partial view of the real world, indeed they provide information about what has been observed only
- Traces can be always partitioned into labelled groups
 - Case of two classes: usually referred as "positive" and "negative" example sets
- In real life, negative instances do happen. Sometimes, they are referred as deviant traces...



Process Discovery with negative information

Why not exploit AI techniques for binary classification tasks? Learning of a Process Model

Few observations:

- Some modelling languages are based on the notion of constraints
- Some constraints are indeed in a subsumption relation with each other

Approach: investigate ILP algorithm, and adapt it to the specific target language of Declare



Process Discovery with negative information

Ongoing research activity:

- 1. Extend the target language with support to classic normal forms (conjunctive and disjunctive normal forms)
- 2. Look for constraint-/logic-based model that allows to discriminate between examples (traces) of the two classes HOW? By adapting ILP-like algorithms
- 3. Define some semantics for "minimum" models
- 4. Look for heuristics for preferring a DNF or a CNF
- 5. Allow users to specify preferences: let's have a look to preferred extensions in computational logic...

Currently, it is the topic of a microproject within the Humane-Al-Net

F. Chesani, C. Di Francescomarino, C. Ghidini, D. Loreti, F. M. Maggi, P. Mello, M. Montali, S. Tessaris. **Process discovery on deviant traces and other stranger things**. To be submitted





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Federico Chesani, Paola Mello

DISI. Dipartimento di Informatica – Scienza e Ingegenria

federico.chesani@unibo.it

www.unibo.it