Process Querying Methods

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Editor

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Foreword

We have come a long way. Finally, thanks to the thought leadership of Artem Polyvyanyy, this book on process querying has become available. Artem describes the research area of business process querying as the study concerned with methods for automatically managing repositories of business process models [9]. Every bachelor student in computer science knows SQL, the structured query language that allows us to efficiently formulate SELECT statements for retrieving the data from a database that is currently of interest to us. So why it took so long until we had something similar available for working efficiently with business process repositories?

Let us go back to the year 2005 and let me share why I have always been excited about process querying. Business process modeling was just awfully heterogeneous at that time. The workflow patterns had just recently been published [14], which was the first step towards overcoming the Babylonian language confusion of process modeling. I saw the need for an integrated metamodel for process modeling [6], but the topic turned out to be too complicated for a PhD thesis. Several layers had to be disentangled: heterogeneous process modeling languages with heterogeneous semantics, heterogeneous process modeling tools, heterogeneous process model interchange formats, and industry was already working on what later became the BPMN standard. It was several years later that we finally saw satisfactory solutions, one in an initiative by Gero Decker, Hagen Overdick, and Mathias Weske on Oryx [2], which would later become Signavio, and another driven by Marcello La Rosa together with Hajo Reijers, Wil van der Aalst, Remco Dijkman, myself, Marlon Dumas, and Luciano García-Bañuelos [5], laying the foundations for Apromore.

But it was not only the metamodel of a language-independent process modeling repository that was missing. In 2005, we hardly understood how we could query the behavior of a process model. There had been first proposals for process query languages by Momotko and Subieta [8] as well as Klein and Bernstein [4], but the key challenge was still how to query for the behavioral semantics and not syntactic structures of a process model. Together with several colleagues, I investigated how we can calculate the behavioral similarity between two process models together with Boudewijn van Dongen, Wil van der Aalst, Remco Dijkman, Marlon Dumas, and Reina Käärik [3, 7], but we were not the only ones. My move from Brisbane,

Australia, to Berlin, Germany, in 2008 turned out to be particularly fertile. Mathias Weske's team at HPI Potsdam had several talented PhD students with whom I got to collaborate. Artem Polyvyanyy was one of them. Together with Ahmed Awad, he worked on semantic querying of BPMN process models [1]. Step by step, we developed the formal foundations based on these efforts. Behavioral abstractions such as the behavioral profiles driven by Matthias Weidlich [15] turned out to be the key mechanisms for querying—a work that Artem further extended and generated towards the 4C spectrum of fundamental behavioral relations for concurrent systems [10].

With Artem's move to join the BPM group at QUT Brisbane in 2012, and more recently the University of Melbourne, everything finally fell into its place. The research on Apromore provided the ideal testbed for experimenting and implementing process querying, first APQL [13] and more recently PQL [12]. Artem's work on a generic query architecture [11] has become the de-facto standard in this area. This book is a testament to these inspiring developments around research and practice of process querying. Already for a while, querying for process mining has become a natural extension of the original work that focused on models. Maybe, as the formal foundations have been defined, tool implementations are available, and now also a book is published, it is time to start standardizing process querying like SQL. Enjoy this book and join the efforts towards further advancing process querying!

Berlin, Germany
October 2021

Jan Mendling

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Preface

Dear Reader,
The idea of this book is due to the last decade of observations and academic discussions at scientific conferences in the areas of business process management [2, 14] and process mining [13]. These observations and discussions acknowledge the existence of a core repertoire of techniques for retrieving and manipulating process-related artifacts, for example, records of process executions, data generated by process executions, process designs, and semantic process annotations that convey domain knowledge. Such core techniques are reused in multiple contexts to support various use cases. A selection of these use cases includes process compliance, process standardization, process reuse, process redesign, process discovery and enhancement, process instance migration, and process monitoring. Moreover, the role of process querying as the mediator between the engine and the user interface in commercial process mining tools becomes increasingly important. However, process querying methods and techniques are often redefined, redeveloped, and reimplemented, with inconsistent adaptations, across scattered academic and industrial projects.

Process querying aims to identify techniques for retrieving and manipulating processes, models of processes, and related artifacts that are inherent to the various practical applications to promote centralized improvement and reuse of these techniques for the benefit of the use cases they support. It is envisaged that these core techniques will be made available for use via machine-readable instructions, called process queries, as part of domain-specific programming languages. Process model collections and process repositories, such as business process repositories, event log collections, event streams, and software code repositories, without such languages are like databases without SQL, that is, collections of tuples without effective and efficient ways to systematically derive value from them.

I became interested in the topic of process querying in 2008, shortly after starting my PhD project in Potsdam, Germany, in the group of Mathias Weske. Back then, together with Ahmed Awad and Mathias Weske, we studied ways information retrieval algorithms can improve techniques for retrieving process models [1]. However, my early interest in process querying did not go beyond a single publication.

My next acquaintance with the topic of process querying happened in 2012 when I joined the Queensland University of Technology, Brisbane, Australia, where Arthur H. M. ter Hofstede was driving research on A Process-model Query Language (APQL) [12]. While working on APQL, I got several ideas on how process querying should be done. For the next several years, I worked on formal foundations of process querying, including the work on untanglings [5, 12], behavioral profiles in general [7] and the 4C spectrum of behavioral relations in particular [3], and techniques for process model repair [8]. These works, and the ongoing thinking process that never left me, in collaboration with my colleagues, led to the definition of the problem of process querying, a concept of a process querying method, and a framework for devising such methods. Simultaneously with the above-listed activities, I was driving research on a language, called Process Query Language (PQL) [4, 6, 10, 11], for querying collections of process models based on the behaviors these models describe.

This book is intended for researchers, practitioners, lecturers, students, and tool vendors. First, all the chapters in this book are contributed by active researchers in the research disciplines of business process management, process mining, and process querying. These chapters describe state-of-the-art methods for process querying, discuss use cases of process querying, and suggest directions for future work for advancing the field. Hence, we hope the book will inspire other researchers to join the effort and develop elegant solutions to process querying problems outlined in this book. Second, by reading this book, practitioners, like business and process analysts, and data and process scientists, can broaden their repertoires of tools for analyzing large arrays of process data. Third, lecturers can use the materials from this book to present the concept of process querying and concrete methods for process querying to their students, while higher degree research students can apply process querying methods to solve engineering problems or, again, contribute to the research in process querying. Finally, several tool vendors already embed principles of process querying in their commercial tools; one of the chapters in this book comes from a vendor who develops and successfully integrates process querying ideas and methods in their toolchain. Thus, for vendors, this book depicts the existing palette of principles available in process querying to consider embedding them into their tools.

The book comprises 16 contributed chapters distributed over four parts and two auxiliary chapters. The auxiliary chapters by the editor provide an introduction to the area of process querying and give a summary of the area presented in this book as well as methods and techniques for process querying. The introductory chapter also presents a process querying framework, a system of abstract components that, when instantiated, result in a concrete process querying method. The contributed chapters present various process querying methods while also discussing how they instantiate the framework. This link to the framework makes a common theme through the book, supporting the comparison of the presented methods. The four parts of the book are due to the distinctive features of the methods they include. The first three parts are devoted to querying event logs generated by IT systems that support business processes at organizations, querying process designs captured in process models, and methods for querying both event logs and process models.

The methods in these three parts usually define a language for specifying process queries. The fourth part discusses methods that operate over inputs other than event logs and process models, for example, streams of process events, or do not develop dedicated languages for specifying queries, for example, methods for assessing process model similarity.

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PS. For further resources on process querying and the book and information about the workshop series on the topic of process querying, please refer to our Website: processquerying.com.

Melbourne, VIC, Australia Artem Polyvyanyy
October 2021

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Acronyms

The list of important acronyms used in this book is proposed below.

ABNF	Augmented Backus-Naur Form
ABox	Assertion component of a knowledge base (Assertion Box)
AML	Anti-Money Laundering
API	Application Programming Interface
BDO	Business Domain Ontology
BI	Business Intelligence
BNF	Backus Naur Form
BPAL	Business Process Abstract Language
BPD	Business Process Diagram
BPEL	Business Process Execution Language
BPKB	Business Process Knowledge Base
BPMNO	Business Process Model and Notation Ontology
BPMN	Business Process Model and Notation
BPMS	Business Process Management System
BPM	Business Process Management
BPS	Business Process Schema
BP	Business Process
BRO	Business Reference Ontology
CEP	Complex Event Processing
CF	Causal Footprints
CLI	Command-Line Interface
CMKB	Compliance Management Knowledge Base
CMM	Connected Meta Model
CQL	Continuous Query Language
CRL	Compliance Request Language
CRM	Customer Relationship Management
CRT	Current Reality Tree
CRUD	Create, Read, Update, Delete
CR	Compliance Requirement

CTE	Common Table Expressions
CTL	Computation Tree Logic
Celonis PQL	Celonis Process Query Language
DAPOQ-Lang	Data-Aware Process Oriented Query Language
DDL	Data Definition Language
DL	Description Logic
DML	Data Manipulation Language
DMN	Decision Model and Notation
DMQL	Diagramed Model Query Language
DOR	Domain Ontology Relationship
DRD	Decision Requirement Diagram
DSL	Domain Specific Language
DS	Data Storage
EBNF	Extended Backus-Naur Form
EMF	Eclipse Modeling Framework
ENVS	ENVironment Stack
EPC	Event-driven Process Chain
EPL	Esper Pattern Language
ER Diagram	Entity Relationship Diagram
ERM	Entity-Relationship Model
ERP	Enterprise Resource Planning
ETL	Extract, Transform, Load
EUM	End-User Modeler
FBSE	Feature-Based Similarity Estimation
FEEL	Friendly Enough Expression Language
FIBO	Financial Industry Business Ontology
FIRO	Financial Industry Regulatory Ontology
FTL	ForSpec Temporal Logic
GA	Guarded Automaton
GMQL	Generic Model Query Language
GPL	General Purpose Language
GUI	Graphical User Interface
HDFS	Hadoop Distributed File System
IBC	Intelligent Business Cloud
IDE	Integrated Development Environment
IPO	Input Process Output
ITSM	IT Service Management
IT	Information Technology
jBPT	Business Process Technologies for Java
JIT	Just-In-Time
KPI	Key Performance Indicator
LCA	Language Concept Appropriateness
LCST	Longest Common Subsequence of Traces
LoLA	Low Level Analyzer
LP	Logic Programming

LS3	Latent Semantic Analysis-based Similarity Search
LTL	Linear Temporal Logic
MDE	Model-Driven Engineering
MTL	Model Transformation Language or Metrical Temporal Logic
NLP	Natural Language Processing
NL	Natural Language
OLAP	Online Analytical Processing
OMG	Object Management Group
OWL	Web Ontology Language
OpenSLEX	Open SQL Log Exchange Format
PADAS	Process-Aware Data Suite
PC	Personal Computer
PIM	Platform Independent Model
PIQE	Process Instance Query Expression
PIQL	Process Instance Query Language
PNML	Petri Net Markup Language
PPI	Process Performance Indicator
PQF	Process Querying Framework
PQL	Process Query Language
PSM	Platform Specific Language
QE	Query Execution
QRES	Query Result Stack
QU	Query Understanding
QoS	Quality of Service
QuBPAL	Query Language for BPAL
RDBMS	Relational Database Management System
RDFS	RDF Schema
RDF	Resource Description Framework
REST	Representational State Transfer
SAP	Systems, Applications and Products
SBA	Stack Based Approach
SESE	Single Entry Single Exit
SLA	Service Level Agreement
SPARQL	SPARQL Protocol And RDF Query Language
SQL	Structured Query Language
SSCAN	Similarity Score based on Common Activity Names
SWRL	Semantic Web Rule Language
SoD	Segregation of Duties
TBox	Terminological component of a knowledge base (Terminological Box)
TP	True Positive
UML	Unified Modeling Language
VM*	Visual Model Manipulation Language

VQL	Visual Query Language
XES	Extensible Event Stream
XMI	XML Metadata Interchange
XSLT	Extensible Stylesheet Language Transformations