Challenges of Smart Business Process Management: An Introduction to the Special Issue

Jan Mendling^{a,*}, Bart Baesens^{b,*}, Abraham Bernstein^{c,*}, Michael Fellmann^{d,*}

^a*Wirtschaftsuniversität Wien, Welthandelsplatz 1, 1020 Vienna, Austria*

^b*KU Leuven, Leuven, Belgium*

^c*University of Zurich, Switzerland*

^d*University of Rostock, Germany*

Abstract

This paper describes the foundations of smart business process management and serves as an editorial to the corresponding special issue.

Keywords: Business Process Management, Smart Technologies

1. Introduction

Today's business world is complex and characterized by an extensive division of labor. Products and services are designed and delivered with various actors being involved within the providing organization and beyond. In order to deliver products and services in an efficient and effective manner, it is of utmost importance that the coordination between the different actors inside and outside the providing organization runs smoothly. A first step towards a smooth operation is achieving transparency of the business process that results in product and service delivery, and this transparency can be achieved by documenting the business process including the various actors involved, the activities they perform, the events and decisions that influence the progress, and the information that is produced and consumed [1, 2].

*Corresponding Author

Email addresses: `jan.mendling@wu.ac.at` (Jan Mendling), `bart.baesens@kuleuven.be` (Bart Baesens), `bernstein@ifi.uzh.ch` (Abraham Bernstein), `michael.fellmann@uni-rostock.de` (Michael Fellmann)

13 Division of labor in business processes calls for coordination support by
14 the help of information systems. The specific class of information systems
15 that explicitly support business processes is often referred to as process-aware
16 information systems [3]. Office automation systems [4, 5], workflow manage-
17 ment systems [6, 7], and recent business process management systems [1, 2]
18 all support process execution based on a specification of the process as a
19 formal business process model.

20 Business process management is concerned with all management activities
21 around business processes. In the past, activities in relation to business pro-
22 cess management have been conducted by process analysts, process managers
23 and process engineers in a labor-intense fashion with hardly any automatic
24 support except for generating the system configuration from the executable
25 process model. This has been changing in recent years. Various smart tech-
26 niques have been developed to automate or provide more intelligent support
27 for process stakeholders in various stages of business process management.
28 This special issue provides ten excellent examples of these recent develop-
29 ments towards smart business process management. This editorial presents
30 them in an overarching framework and connects them with the broader spec-
31 trum of recent contributions on smart business process management.

32 2. Business Process Management

33 In this section, we distinguish three different levels of business process
34 management. Figure 1 shows these three levels and their connections. The
35 top level is often referred to as multi process management. It is concerned
36 with the identification of the major processes of an organization and the reg-
37 ular evaluation of the priorities assigned to these processes. These activities
38 interrelate with questions of strategic management and the overall process
39 organization. The products of multi process management are often stored in
40 a central process repository. The conceptual structure of this repository is
41 also referred to as the process architecture.

42 The middle level is concerned with the management of a single process
43 and its specification as a process model. The management activities on this
44 level are often referred to as the BPM lifecycle [1]. This lifecycle is started
45 once a process is selected for redesign. First, this process is documented in
46 the discovery phase resulting in an as-is process model. Second, the process
47 is analyzed using qualitative and quantitative analysis techniques. In this
48 way, weaknesses and issues can be uncovered. Third, different directions

Figure 1: Three Levels of Business Process Management

for redesign are investigated in order to fix the issues and generally improve the performance of the process. This yields a to-be process model as a specification of how the process is meant to operate in the future. Fourth, this to-be process model is taken into implementation. The corresponding information systems are designed or reconfigured and staff is trained to work according to the new setup. Fifth, and once the process has been executed for a period of time according to the new design, process mining can be used to extract knowledge about how the process operates. Sixth, process controlling is concerned with checking to which degree performance and conformance objectives are met.

The focus of the bottom level is the management of singular process instances. Instances can be planned regarding when their activities are scheduled and which resources should be involved. With or without such a schedule, process activities are executed according to the rules defined in the process model. Process monitoring continuously checks rules such as quality-of-service assertions and trigger alerts if undesired behavior is observed. Such alerts might be the reason for adapting the course of execution for an individual process instance.

Research into process mining [8] has resulted in various automatic analysis techniques that support different activities of business process management. We refer to them as smart business process management.

3. Smart Business Process Management

The Oxford dictionary provides three connotations for smart as (i) being clean and tidy, (ii) showing quick-witted intelligence and (iii) being quick¹. All these meanings together have become a prominent attribute of information technology and analysis techniques in various application domains referred to as smart home, smart health, smart city, smart energy or smart mobility. What is in common to these smart technologies is that they integrate sensors, actuators, connectivity and analytics [9]. What they facilitate is preemptive action and coordination which is grounded in evidence, history data, state information and intelligent algorithms [10]. Since business process management is exactly concerned with coordinated action, there have been attempts to generalize the commonalities of these smart application scenarios

¹<https://en.oxforddictionaries.com/definition/smart>

in terms of their dynamic adaptation and continuous learning towards smart business process management [11, 12].

This section provides an overview of various techniques that are related to smart business process management. We also clarify how the contributions of this special issue relate to the overall spectrum of research in this area. Next, we explicate the notion of smartness in the context of information systems research. Then, we illustrate the richness of smart business process management by highlighting important contributions for each of the three levels.

3.1. Smart Multi Process Management

Prior research on smart multi process management has mainly focused on supporting repository management. This stream of research was triggered by work on similarity [13] and automatic matching techniques between business process models [14]. These provided the foundation for various automatic refactoring techniques [15] including harmonization of terminology [16], automatic service derivation [17], semantic search [18] or operations of merging business process models [19].

This special issue extends this stream of research with novel contributions on process model matching. Both *Meilicke et al* [20] and *Klinkmüller and Weber* [21] contribute to the effectiveness of automatic techniques for process model matching. The latter, *Klinkmüller and Weber*, contribute to the effectiveness of automatic techniques for process model matching. They investigate the importance of control flow information for the matching problem and combine a novel order relationship score with a bag-of-words approach in their self-configuring OPBOT matcher. The evaluation with standard datasets demonstrates the benefits of OPBOT.

Meilicke et al [20] build on the availability of various matchers from prior research. They introduce a voting technique that integrates process model constraints in a Markov Logic based optimization. Their evaluation demonstrates performance improvements over prior techniques.

This special issue introduces novel directions for smart multi process management. *Polyvyanyy et al* [22] present an overall framework for process querying. It describes generic components of a querying architecture and corresponding querying methods. Various concepts and methods are aligned with this architecture using a systematic literature review.

Kratsch et al [23] emphasize that various strategies have been proposed for prioritization of processes, but none does appropriately take dependencies

119 between them into account. Their prioritization approach takes inspiration
120 from Google’s page rank algorithm and is called D2P2. D2P2 is implemented
121 as a software prototype and evaluated using event logs data from the BPI
122 Challenge.

123 3.2. *Smart Process Model Management*

124 There is a rich repertoire of prior research on smart process model man-
125 agement. Several challenges and solutions are listed in survey articles includ-
126 ing [24, 25, 26]. Various techniques have been proposed to directly support
127 the process of process modeling during the discovery phase, [27] is a recent
128 example. Pattern recognition is used during the analysis phase to detect po-
129 tential weaknesses [28]. The redesign phase is often supported by heuristics
130 such as the ones summarized in [29]. Also recent technologies like crowd-
131 sourcing [30] bear the potential to be used here. The implementation phase
132 is classically supported by workflow management technology [6]. Recent ex-
133 tensions provide smart support for automatic service composition [31] and
134 process configuration [32]. Smart knowledge extraction from process-related
135 data is often referred to as process mining. Contributions on process mining
136 help to automatically discover models from data, check the conformance be-
137 tween model and execution, and derive information on decision probabilities
138 and execution durations [8]. Such information partially informs the control-
139 ling phase, in which the process is evaluated relative to its performance and
140 conformance objectives [33].

141 This special issue complements these diverse streams of research in the
142 following ways. *Claes et al* [34] investigate strategies that help to model
143 business processes in an efficient and effective way. Their Structured Process
144 Modeling Method (SPMM) is supported by an automated modeling strategy
145 selection and a training instrument. The benefits of the method is demon-
146 strated in a controlled experiment with 149 master students.

147 The work of *Suriadi et al* [35] focuses on resource behavior in business
148 processes. They develop a mining technique that provides insights into the
149 way how resources prioritize their work. The technique is evaluated using
150 synthetic and real-world event logs.

151 *Wynn et al* [36] address the problem of visualizing performance informa-
152 tion of business processes in an effective way. They propose a visualisation
153 framework called ProcessProler3D for supporting the comparison of process
154 performance based on event logs. Their implementation is validated in a user
155 study with industry partners.

156 *vanden Broucke and De Weerd* [37] develop a robust and flexible heuristic
157 process discovery technique called Fodina. Key features of this technique
158 are good performance in terms of process model quality and the ability to
159 mine duplicate tasks. Fodina is tested on various event logs showing good
160 performance in terms of F-measure.

161 *Martin et al* [38] are concerned with the identification of batch behaviour
162 in business processes. They introduce a batch organisation of a work identi-
163 fication algorithm called BOWI, which provides insights into batch processing
164 by the help of work metrics. The algorithm is evaluated with synthetic and
165 real-world event logs.

166 3.3. Smart Process Instance Management

167 Prior research investigates different management aspects of process in-
168 stances. The planning phase is considered in different works on schedul-
169 ing [39, 40], elasticity [41], and semantic technologies [42]. Process execu-
170 tion is typically implemented using state and transition concepts such as
171 provided by Petri nets. Recent research investigates the representation of
172 these concepts by the help of blockchain distributed ledger technologies [43].
173 Monitoring is an important concern in order to secure that performance and
174 conformance stays within expected ranges. Work on AB-BPM [44] is inspired
175 by AB-testing and combines it with process automation in a self-regulatory
176 way. Adaptation is an important mechanism for handling unforeseen situ-
177 ations. Various works describe approaches to help achieving flexibility at
178 runtime [45].

179 This special issue extends this stream of research with an approach that
180 helps to predict the behavior of a process instance, which can inform process
181 planning and execution. Evermann et al [46] define their prediction approach
182 based on neural networks. The approach is implemented and evaluated using
183 the BPI 2012 data sets. The results illustrate the impact of various types
184 of information on the prediction performance and the overall viability of the
185 approach.

186 4. Future Research on Smart Business Process Management

187 The research reported in this special issue provides a solid foundation
188 for future research into smart business process management. This research
189 will have to address challenges within the three levels of business process
190 management and across them.

191 There is potential for future research within levels. On the level of the
192 process repository, it is striking to note that research on the integration of
193 repositories with external knowledge resources has come to a pause. Around
194 the year 2000, the MIT Process Handbook [47] provided a promising starting
195 point for helping organizations to discover process innovation opportunities.
196 Mendling et al [26] describe specific challenges in this area including the
197 discovery of ontologies from repositories and the categorization of models.

198 On the level of singular models, there are various opportunities to inte-
199 grate existing analysis and redesign techniques with information generated
200 from sensory data. For instance, the potential of process innovation in the
201 retail sector based on RFID technology is highlighted in [48] as much as in
202 the logistic sector based on AIS transponder data in [49]. Social media has
203 been often discussed with a focus on product innovation, but there is also
204 the potential to more intensively leverage it for process innovation, too, e.g.
205 in the public sector [50].

206 There are also various opportunities for managing process instances in
207 a smarter way using available sensor data. Indeed, many smart initiatives
208 such as smart home, smart health, smart city, smart energy or smart mobility
209 have an inherent behavioral perspective, which has affinity with coordination
210 challenges of business process management. Clearly, smart technologies bear
211 the potential for novel ways of planning, executing, monitoring and adapting
212 process instances based on the integration of sensors, actuators, connectivity
213 and analytics.

214 Finally, there is also the potential to intensify research that spans across
215 the different levels. Most of the research across levels is currently focused
216 on (i) moving from implementation to execution and (ii) from execution to
217 mining and controlling. What is scarce is research that builds a bridge be-
218 tween the process repository and process instances. Questions in this context
219 might relate to the consistency between the multi process perspective and
220 the process instance perspective: in how far does the abstract description of
221 the process landscape align with what is actually done on the transactional
222 level? Furthermore, novel techniques that generate abstract views on an or-
223 ganization from a process perspective based on instance data could be highly
224 informative to top management, in particular if it provided performance in-
225 sights.

226 New information technology keeps on emerging and new concepts and
227 algorithms are developed to work with process-related data. These will shape
228 the way how business processes are managed in the future in a smarter way

229 as we know it today.

230 **Acknowledgements**

231 We thank the authors of the papers collected in this special issue and the
232 editor-in-chief James Marsden for comments on this editorial.

233 **References**

- 234 [1] M. Dumas, M. La Rosa, J. Mendling, H. A. Reijers, Fundamentals of
235 Business Process Management, Springer Berlin Heidelberg, Berlin, Hei-
236 delberg, 2013.
- 237 [2] M. Weske, Business Process Management, Springer, 2012.
- 238 [3] M. Dumas, W. M. P. van der Aalst, A. H. M. ter Hofstede, Process-
239 Aware Information Systems: Bridging People and Software Through
240 Process Technology, Wiley, 2005.
- 241 [4] M. D. Zisman, Office automation: Revolution or evolution? (1978).
- 242 [5] R. A. Hirschheim, Office automation: a social and organizational per-
243 spective, John Wiley & Sons, Inc., 1986.
- 244 [6] D. Georgakopoulos, M. Hornick, A. Sheth, An overview of workflow
245 management: From process modeling to workflow automation infras-
246 tructure, Distributed and parallel Databases 3 (1995) 119–153.
- 247 [7] F. Leymann, D. Roller, Production workflow - concepts and techniques,
248 Prentice Hall, 2000.
- 249 [8] W. M. P. van der Aalst, Process Mining - Data Science in Action, Second
250 Edition, Springer, 2016.
- 251 [9] L. Püschel, M. Roeglinger, H. Schlott, What’s in a smart thing? devel-
252 opment of a multi-layer taxonomy, in: P. Ågerfalk, N. Levina, S. S. Kien
253 (Eds.), Proceedings of the International Conference on Information Sys-
254 tems - Digital Innovation at the Crossroads, ICIS 2016, Dublin, Ireland,
255 December 11-14, 2016, Association for Information Systems, 2016.

- 256 [10] G. Allmendinger, R. Lombreglia, Four strategies for the age of smart
257 services, *Harvard business review* 83 (2005) 131.
- 258 [11] C. Costello, O. Molloy, Orchestrating supply chain interactions using
259 emerging process description languages and business rules, in: *Proceed-*
260 *ings of the 6th international conference on Electronic commerce*, ACM,
261 pp. 21–30.
- 262 [12] K. B. C. Saxena, Business process management in a smart business
263 network environment, in: *The Network Experience*, Springer, 2009, pp.
264 69–81.
- 265 [13] R. M. Dijkman, M. Dumas, B. F. van Dongen, R. Käärik, J. Mendling,
266 Similarity of business process models: Metrics and evaluation, *Inf. Syst.*
267 36 (2011) 498–516.
- 268 [14] M. Weidlich, R. M. Dijkman, J. Mendling, The icop framework: Identifi-
269 cation of correspondences between process models, in: B. Pernici (Ed.),
270 *Advanced Information Systems Engineering, 22nd International Confer-*
271 *ence, CAiSE 2010, Hammamet, Tunisia, June 7-9, 2010. Proceedings,*
272 *volume 6051 of Lecture Notes in Computer Science*, Springer, 2010, pp.
273 483–498.
- 274 [15] B. Weber, M. Reichert, J. Mendling, H. A. Reijers, Refactoring large
275 process model repositories, *Computers in Industry* 62 (2011) 467–486.
- 276 [16] F. Pittke, H. Leopold, J. Mendling, Automatic detection and resolution
277 of lexical ambiguity in process models, *IEEE Trans. Software Eng.* 41
278 (2015) 526–544.
- 279 [17] H. Leopold, F. Pittke, J. Mendling, Automatic service derivation from
280 business process model repositories via semantic technology, *Journal of*
281 *Systems and Software* 108 (2015) 134–147.
- 282 [18] O. Thomas, M. Fellmann, Semantic process modeling - design and im-
283 plementation of an ontology-based representation of business processes,
284 *Business & Information Systems Engineering* 1 (2009) 438–451.
- 285 [19] M. L. Rosa, M. Dumas, R. Uba, R. M. Dijkman, Business process model
286 merging: An approach to business process consolidation, *ACM Trans.*
287 *Softw. Eng. Methodol.* 22 (2013) 11:1–11:42.

- 288 [20] C. Meilicke, H. Leopold, E. Kuss, H. Stuckenschmidt, H. A. Reijers,
289 Overcoming individual process model matcher weaknesses using ensemble
290 matching, *Decision Support Systems* (2017).
- 291 [21] C. Klinkmüller, I. Weber, Analyzing control flow information to im-
292 prove the effectiveness of process model matching techniques, *Decision*
293 *Support Systems* (2017).
- 294 [22] A. Polyvyanyy, C. Ouyang, A. Barros, W. M. van der Aalst, Process
295 querying: Enabling business intelligence through query-based process
296 analytics, *Decision Support Systems* (2017).
- 297 [23] W. Kratsch, J. Manderscheid, D. Reißner, M. Röglinger, Data-driven
298 process prioritization in process networks, *Decision Support Systems*
299 (2017).
- 300 [24] M. L. Rosa, P. Wohed, J. Mendling, A. H. M. ter Hofstede, H. A. Reijers,
301 W. M. P. van der Aalst, Managing process model complexity via abstract
302 syntax modifications, *IEEE Trans. Industrial Informatics* 7 (2011) 614–
303 629.
- 304 [25] M. L. Rosa, A. H. M. ter Hofstede, P. Wohed, H. A. Reijers, J. Mendling,
305 W. M. P. van der Aalst, Managing process model complexity via con-
306 crete syntax modifications, *IEEE Trans. Industrial Informatics* 7 (2011)
307 255–265.
- 308 [26] J. Mendling, H. Leopold, F. Pittke, 25 challenges of semantic process
309 modeling, *International Journal of Information Systems and Software*
310 *Engineering for Big Companies (IJISEBC)* 1 (2015) 78–94.
- 311 [27] A. Koschmider, H. A. Reijers, Improving the process of process mod-
312 elling by the use of domain process patterns, *Enterprise IS* 9 (2015)
313 29–57.
- 314 [28] P. Bergener, P. Delfmann, B. Weiß, A. Winkelmann, Detecting potential
315 weaknesses in business processes: An exploration of semantic pattern
316 matching in process models, *Business Proc. Manag. Journal* 21 (2015)
317 25–54.

- [29] H. A. Reijers, S. L. Mansar, Best practices in business process redesign: an overview and qualitative evaluation of successful redesign heuristics, *Omega* 33 (2005) 283–306.
- [30] A. Afuah, C. L. Tucci, Crowdsourcing as a solution to distant search, *Academy of Management Review* 37 (2012) 355–375.
- [31] D. Berardi, D. Calvanese, G. De Giacomo, M. Lenzerini, M. Mecella, Automatic service composition based on behavioral descriptions, *International Journal of Cooperative Information Systems* 14 (2005) 333–376.
- [32] M. L. Rosa, M. Dumas, A. H. M. ter Hofstede, J. Mendling, Configurable multi-perspective business process models, *Inf. Syst.* 36 (2011) 313–340.
- [33] M. Zur Muehlen, Workflow-based process controlling: foundation, design, and application of workflow-driven process information systems, volume 6, Michael zur Muehlen, 2004.
- [34] J. Claes, I. Vanderfeesten, F. Gailly, P. Grefen, G. Poels, The structured process modeling method (SPMM) what is the best way for me to construct a process model?, *Decision Support Systems* (2017).
- [35] S. Suriadi, M. T. Wynn, J. Xu, W. M. van der Aalst, A. H. ter Hofstede, Discovering work prioritisation patterns from event logs, *Decision Support Systems* (2017).
- [36] M. T. Wynn, E. Poppe, J. Xu, A. H. ter Hofstede, R. Brown, A. Pini, W. M. van der Aalst, Processprofiler3d: A visualisation framework for log-based process performance comparison, *Decision Support Systems* (2017).
- [37] S. K. vanden Broucke, J. De Weerd, Fodina: a robust and flexible heuristic process discovery technique, *Decision Support Systems* (2017).
- [38] N. Martin, M. Swennen, B. Depaire, M. Jans, A. Caris, K. Vanhoof, Retrieving batch organisation of work insights from event logs, *Decision Support Systems* (2017).
- [39] R. Mans, N. C. Russell, W. M. P. van der Aalst, P. J. M. Bakker, A. J. Moleman, Simulation to analyze the impact of a schedule-aware workflow management system, *Simulation* 86 (2010) 519–541.

- [40] G. Havur, C. Cabanillas, J. Mendling, A. Polleres, Resource allocation with dependencies in business process management systems, in: M. L. Rosa, P. Loos, O. Pastor (Eds.), Business Process Management Forum - BPM Forum 2016, Rio de Janeiro, Brazil, September 18-22, 2016, Proceedings, volume 260 of *Lecture Notes in Business Information Processing*, Springer, 2016, pp. 3–19.
- [41] P. Hoenisch, D. Schuller, S. Schulte, C. Hochreiner, S. Dustdar, Optimization of complex elastic processes, *IEEE Trans. Services Computing* 9 (2016) 700–713.
- [42] M. Hepp, F. Leymann, J. Domingue, A. Wahler, D. Fensel, Semantic business process management: A vision towards using semantic web services for business process management, in: F. C. M. Lau, H. Lei, X. Meng, M. Wang (Eds.), 2005 IEEE International Conference on e-Business Engineering (ICEBE 2005), 18-21 October 2005, Beijing, China, IEEE Computer Society, 2005, pp. 535–540.
- [43] I. Weber, X. Xu, R. Riveret, G. Governatori, A. Ponomarev, J. Mendling, Untrusted business process monitoring and execution using blockchain, in: M. L. Rosa, P. Loos, O. Pastor (Eds.), Business Process Management - 14th International Conference, BPM 2016, Rio de Janeiro, Brazil, September 18-22, 2016. Proceedings, volume 9850 of *Lecture Notes in Computer Science*, Springer, 2016, pp. 329–347.
- [44] S. Satyal, I. Weber, H. young Paik, C. D. Ciccio, J. Mendling, Ab-bpm: Performance-driven instance routing for business process improvement, in: A. Kumar, G. Engels, J. Carmona (Eds.), Business Process Management - 15th International Conference, 2017. Proceedings, *Lecture Notes in Computer Science*, Springer, 2017.
- [45] M. Reichert, B. Weber, *Enabling Flexibility in Process-Aware Information Systems*, Springer-Verlag, 2012.
- [46] J. Evermann, J.-R. Rehse, P. Fettke, Predicting process behaviour using deep learning, *Decision Support Systems* (2017).
- [47] T. W. Malone, K. Crowston, J. Lee, B. Pentland, C. Dellarocas, G. Wyner, J. Quimby, C. S. Osborn, A. Bernstein, G. Herman, et al.,

- 381 Tools for inventing organizations: Toward a handbook of organizational
382 processes, *Management Science* 45 (1999) 425–443.
- 383 [48] F. Thiesse, J. Al-Kassab, E. Fleisch, Understanding the value of inte-
384 grated rfid systems: a case study from apparel retail, *European Journal*
385 *of Information Systems* 18 (2009) 592–614.
- 386 [49] C. Di Ciccio, H. van der Aa, C. Cabanillas, J. Mendling, J. Prescher,
387 Detecting flight trajectory anomalies and predicting diversions in freight
388 transportation, *Decision Support Systems* 88 (2016) 1–17.
- 389 [50] J. I. Criado, R. Sandoval-Almazan, J. R. Gil-Garcia, Government in-
390 novation through social media, *Government Information Quarterly* 30
391 (2013) 319–326.