Impact Factor: 5.731

IJETIR

ISSN (Online) 2583-0554

International Journal of Emerging Technologies and Innovative Research (IJETIR)

Volume 4, Issue 10, October 2024

The Evolution of Business Processes: Addressing Paradoxes in an Era of Digital Transformation

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Abstract*: BPM combines operational expertise and technology to develop and manage business processes. Human actors, information systems, and smart commodities interact via digital channels throughout the digital transition. This interconnected world creates economic opportunities but also complication. BPM may improve business process identification, analysis, design, implementation, execution, and monitoring. To encourage transformational thinking and additional study, this research note addresses a few significant transformative themes and their implications for BPM ideas and IT artifacts.*

Keywords: Hyper-connectivity, Business Process Management (BPM),Paradoxes, Digital Transformation, Integration Challenges, Agility vs

I. INTRODUCTION

Current study examines "[...] how to best manage the (re-)design of individual business processes and how to develop a foundational BPM capability in organizations catering for a variety of purposes and contexts" .

Organizations' capacity to manage managerial and operational business processes depends on business process management. Business process management (BPM) connects all organizational functional areas to clients, other firms, suppliers, and customers. The socio-technical nature of organizations leads BPM to consider business processes as IT-enabled organizational structures. Rosemann and de Bruin (2005) list six BPM capabilities. Governance, Strategy, Methods, Technology, People, and Culture. BPM is essential to everyday operations and economic success for all businesses (Mullich 2011). As Giddens 1984; Beverungen 2014 highlights, business processes define an organization as a socio-technical structure, making them part of its DNA.

BPM scholars have produced ideas and IT artifacts that manage business processes outside traditional engineering, management, and IT traditions of work simplification/quality control, firm performance, and digitalization since the 1990s. International conferences like AIS 2017; BPM Community 2019; Institute of Innovative Process Management e.V. 2017; journals like Emerald Group Publishing Limited 2017; and books like Dumas et al. 2018; vom Brocke and Mendling 2018; vom For almost 30 years, Brocke and Rosemann 2014 have shown the field's expanding relevance, variety, and maturity.

Technology-driven economic and social change, "digital transformation," affects organizations. A global workforce that can develop new business models from these new opportunities, widespread internet access of a wide range of physical devices, huge amounts of data that can be replicated and shared for almost no cost, real-time big data processing algorithms, and more are IT trends (Brynjolfsson and McAffee 2014). Brynjolfsson and McAffee (2014) argue the Digital Transformation might upend civilization like 19th-century industrialization in Europe.

Further analysis shows that our society's Digital Transformation has produced a Hyper-Connected World (World Economic Forum 2016) where artificial and human actors engage via many channels. Hyper-connectedness makes new business operations possible, but it makes controlling them difficult to achieve societal or corporate goals. This trend is becoming so strong and disruptive that it may transform the tools and resources enterprises need.

In particular, firms must rethink the norms to obtain the resources and essential competencies needed to flourish in their markets. We monitor this trend and investigate how new technologies change BPM in society.Since their relationship to BPM is least understood, this research note focuses on four technical enablers: IoT and Cyber-Physical Systems link processes as artificial agents. Big Data Analytics automatically analyzes massive volumes of business data. Finally, Real-Time Computing allows organizations analyze data in real time to adjust operations. Digital relationships are created via social computing.

Since Blockchain, Internet of Things, Semantic Technologies, Artificial Intelligence, and Cognitive Computing (Roeglinger et al. 2018) may benefit BPM, they are not examined further. The chosen technologies challenge BPM stakeholders' key roles, such as strategy for process owners, modeling and analysis for process analysts, and implementation for system developers (Fig. 1). In addition

Fig. 1 BPM framework structuring this research note

Show how these subjects support or contradict one other to reveal our discipline's contradictions. We used Dumas et al. (2018)'s BPM Life-Cycle Model to define these tasks. This model emphasizes business process managers' vital duties but does not describe a process execution phase or how and why process participants perform business processes in their jobs.

This study report has two goals. We begin with BPM and digital transformation research and practice updates. We recommend extra study in our second section to understand BPM in a connected world. We anticipate these changes to drastically alter BPM theories and IT artifacts, necessitating theory testing and artifact redesign and evaluation. Beyond that, we expect new issues that need new IT artifacts and theories that were impossible without today's technology. We concentrate on operational processes, one of the three key areas influenced by the Digital Transformation (Westerman et al. 2011), even if we don't cover all BPM aspects.

The paper format is:

1.The four IT enablers are detailed in Sect.

2. In Section

3, the enablers' effects on BPM are discussed. Section

4 suggests BPM research directions, while Section

5 finishes with a call to action.

FOUR INFORMATION TECHNOLOGY ENABLERS

We investigated four information technology enablers—social computing, smart devices, big data analytics, and real-time computing—in our collaborative research project RISE_BPM. We next provide a quick overview of each enabler and some of its implications for the subject of BPM.

SOCIAL COMPUTING

White-collar professionals may network with clients and develop social media communities that promote cooperation, communication, and teamwork.

People share information, stories, views, and experiences on social media. They link clients with perhaps untapped product and business audiences. These exchanges show that Social Media provides unfiltered information that spans organizations, clubs, groups, and corporations. Online forums, blogs, consumer-to-consumer email, product or service

ratings websites and forums, Internet discussion boards, corporate-sponsored chat rooms, and social networking websites are social media.
User-Generated Content (UGC) strongly affects business-client communication,Mangold and Faulds (2009) discovered. Author names and publishing times appear on social media. Publishing in plain English makes publications semi-structured. Emoticons, colloquialisms, and abbreviations impede automatic interpretation of UGC. To increase communication semantics, machine-driven information linking needs tags and links.
Organizations may benefit from obtaining and evaluating UGC as a source of information. These sources may include Instagram posts about faulty items, email service provider product user forums with enhancement suggestions, and tweets on the creator's next patent, publication, or product release. DELL used social media post analysis to find over 550 unique product ideas from its online community Idea Storm (Gardner 2014). Data mining on consumer data has improved customer relationship management due to user-generated content analysis (Ngai et al. 2009).
White-collar workers collaborate and exchange information using Groupware and Corporate Social Media in many firms. Included are email, instant chat, and ad hoc process management (Geyer et al., 2006). When integrated, social media platforms allow workers to exchange information and manage their daily tasks while connecting customers, stakeholders, and process players publicly. These technologies are used for informal, non-routine business processes that don't work well with top-down mass transaction process designs in BPM Systems.
Social media may be utilized for office work follow-up and communication. Skype accounts let workers rapidly request support throughout a procedure. The efficacy and management value of a business application are lowered when so much vital activity goes beyond its knowledge. Thus, organizations increasingly provide workers specialized social media tools to share process knowledge (Bernstein, 2000). Knowledge-intensive and creative processes significantly depend on white-collar professionals undertaking linked knowledge-intensive decision-making activities, making "soft knowledge" vital (Di Ciccio et al., 2015; Di Ciccio and Mecella, 2013; Hill et al., 2006). On social media, writers want to share current, relevant content with friends, acquaintances, and coworkers. Process integration into contextual data may enhance, explain, or unify BPMS or intra-organizational IT system events. They may clarify concepts since they are frequently expressed by relevant parties.

SMART DEVICES

Global corporate architecture and information processing will change with smart device usage. Gartner Inc. (2017a) predicts 20.4 billion connected devices by 2020, up from 8.4 billion in 2017. IoT endpoints and services will cost over $2 trillion in 2017. The Gartner HypeCycle anticipates IoT peaking or disillusioning (Gartner Inc. 2017b).
Smart device sensors can track surrounding digital and physical events and the device's condition. They reason, store, and analyze data independently using built-in hardware. They can transmit and receive digital data from WfMS and Enterprise Systems and have actuators to do physical actions within and around a device (Beverungen et al. 2019).
Atzori et al. (2010) expect smart gadgets will change industry, healthcare, transportation, logistics, and personal and social life. Artificial agents like smart meters, cars, machines, phones, and others will start, operate, influence, and finish commercial processes. A business process engine cannot control their inherent properties. Control moving from build-time to run-time prevents top-down process engineering and decentralizes corporate operations.
Digital faults can be corrected, but physical deeds cannot. Smart devices can disclose business operations. Unsafe corporate operations employing physical Smart Devices must be avoided.
Machine tools, a mechanized sector, were among the first to use Smart Devices. Integrating the "world outside" into a machine's data processing appears reasonable, and current and future applications (Atzori et al. 2010; Perera et al. 2010) concentrate on field event detection and business operations integration. Oracle displays how smart equipment uses its own and surrounding data to identify concerns and notify other systems (Acharya 2015). Information systems monitor events and execute commercial tasks like equipment upkeep.
Hamburg Port Authority installed 300 roadside sensors to regulate traffic (Ferretti and Schiavone 2016, p. 278). Moveable bridges may redirect port road traffic as ships arrive. Ferretti and Schiavone (2016), p. 279, say the system weights cars to compute rail and truck traffic on 140 port bridges. Information helps establish, maintain, and reorganize

these infrastructures, improving the port's "integration with customers, reduce direct contacts and formal information exchanges, and made easier and shorter."

BIG DATA ANALYTICS

Over decades, social computing and smart devices have generated more data (Hilbert and Lopez 2011). Big data generally has all four "V's"—volume, velocity (data expand fast), variety (data are heterogeneous), and veracity (data quality fluctuates). Smaller but more complicated databases may be called "big data".

Data are being gathered for non-research uses. Understanding data using data and analytic tools is the toughest issue. Data mining, machine learning, process mining, stochastics, databases, algorithms, large-scale distributed computing, visualization and visual analytics, behavioral and social sciences, industrial engineering, privacy and security, and ethics are recent data science subfields. Process mining integrates BPM, data science, and big data.

Process mining answers key BPM questions using event log data. Van der Aalst and Damiani (2015) define an event log as a collection of events that are associated with a case or process instance (e.g., order number), an activity (e.g., evaluate request), a timestamp indicating the activity's execution time, and optional attributes like the resource executing the event or the type of event.

Process mining utilizes event log data to locate a process model (such as the BPMN model or Petri net), validate that event data fits a specified (or found) process model, and develop a process model by projecting temporal information to measure business process performance.

Event log mining contextualizes business process data with other process events in Big Data analysis. Social media and smart devices may add, enhance, or contradict BPMSs. Data quality and granularity (e.g., continuous process IDs) are needed to analyze event log data.

This study explored the causal relationship between process instance and activity contextual information and process performance across time. Rework may influence case length and quality, therefore the resource handling a process step may matter. Resources' timings may affect how long individuals wait for their jobs. Process duration may change.

Assessing patient treatment methods using health care event data. According to a Dutch hospital research, health-care event data may answer questions like "what is the most common treatment process," "among which persons are hand-delivers performed in an organization," and "how efficient are hospital processes." Despite professional recommendations and standards, patient peculiarities, disease combinations, and staff heterogeneity preclude organized illness care. Event data may rethink and enhance corporate processes.

REAL-TIME COMPUTING

Due to dispersion, recent data processing developments enable real-time processing of massive data volumes. Companies may use this information to quickly modify strategy and operations to meet emerging business demands. Real-time does not imply vehicle safety systems with tight deadlines and catastrophic timing errors (Stankovic 1988). Real-time computing means near-real-time. This strategy decreases event processing delays so users always get the newest information.

Four technologies have shaped business real-time computing. Complex event processing (CEP) filters, composes, collects, and detects social media postings and consumer orders (Cugola and Margara 2012). In-memory analytics examines RAM data instead of HDD. Corporate users may experiment with consumer data in real time and make quick choices thanks to performance improvements (Acker et al. 2011). Apache Spark Streaming parallelizes high-volume, high-velocity data streams for real-time big data stream analytics. Zaharia et al. (2013). Finally, data stream mining mines fast, continuous data. This includes methods that capture data streams' dynamic nature and generate suitable approximation mining results to handle their high data rate (Maimon and Rokach 2005).

Real-Time Computing lets BPM use intelligence and make evidence-based choices rapidly. This allows real-time process execution and OLTP/OLAP integration. In a digital and globalized environment, organizations must adapt quickly while making data-driven choices that are done, influenced, and halted outside of traditional BPMSs.

Real-time computing aids BPM in several ways. Real-time business activity monitoring may aid decision-making by speeding up reactions to various scenarios. An airline that utilizes real-time data to manage seat availability for its 2000 daily flights to accommodate as many people as possible, or a movie streaming service that instantaneously records client segment preferences so its content staff can push the most popular films. Fraud and non-compliance detection are further benefits of real-time computing. Big data stream analytics detects credit card theft on payment systems (Li 2017).

IMPLICATIONS FOR BPM

The authors described the four typical BPM stages (Fig. 1) and four enablers in a workshop and follow-up talks. Three to four academics discussed how a technical enabler affects BPM during the workshop. Each researcher in this session has considerable BPM project and writing expertise. Total 60 BPM-related effects were found. The whole 16-person research team presented, debated, and aggregated findings. The 23 consolidated concepts identified 11 problems. Our diverse BPM ideas led us to choose a consensus-oriented interpretivist research method, even if some researchers' comments were subjective. This epistemic theory of truth for conceptual modeling research is well-established (Becker and Niehaves 2007). We list these difficulties in our four primary categories.

STRATEGY

The addition of IT enablers accelerates process lifecycles and necessitates a deeper integration of the four phases of our system. Business analytics is another. Social media and smart device integration may start business operations. Visit Schloss Dagstuhl and look at http://www.dagstuhl.de/17364.

Procedures may have an impact on management and governance in the real world.

Challenge 1 Adapting business process management to rapid technology advancements is organizations' largest strategic issue. Companies should shorten and modify process lifecycles more often. Using process data to model, implement, and analyze a process' lifecycle may help. This strategy proposes BPM-AB-Testing integration (Satyal et al. 2019). The third wave of BPM (Smith and Fingar 2003) may move management focus from revolutionary re-engineering to incremental, on-the-fly business process adjustments. If business process IT architecture is basically unchanged. BPM teams will be interdisciplinary, not process analysts, owners, designers, and participants. Like applications management, (Biz)De-vOps builds software development, operator, and user teams (Bass et al. 2015).

Challenge 2 Hyperconnected consumers and businesses adopt omni-channel interactions (Verhoef et al. 2015). Social computing has prompted firms to adapt their communication strategies to better engage with customers (Tiago and Ver´ssimo 2014). Omni-channel strategies let organizations employ additional technology (Mangold and Faulds 2009). Process mining and other data science methods must combine data from various systems to find process IDs due to fragmentation. Social media's openness allows users to network with strangers. Social media allows consumer networks to do business, yet the conversation is public. Even with stakeholders involved in design, modeling, implementation, execution, and process improvement, social media makes business process management harder (Erol et al. 2010).

Challenge 3 Due to smart devices, business processes may have physical and digital effects. Corporate activities may move cars and bridges. If business activities are limited to BPMSs, Process Engines, and Enterprise Systems, database rollbacks or other digital actions may fix instance issues. If smart devices physically disrupt corporate operations, remedial actions may be difficult. According to Meloni et al. (2017), modern business processes may become safety-critical, demanding greater process quality and dependability than BPM IT systems can supply. Probabilistic Big Data Analytics methods forecast unobserved data inaccurately, which contradicts process designers' actions (Ghahramani 2015). Probabilistic data science may be confined to digital business processes or those with adequate data to train the model. If unchecked, this digital process barrier would prevent process managers and participants from using data science to smart device behavior processes.

Challenge 4 Smart Devices as autonomous players increase business process complexity and unpredictability as a central business process engine no longer makes choices. Chatbots may soon communicate explicitly with BPMSs (Mendling et al. 2018a). Thus, several software platforms and smart devices will store data from a single corporate procedure. Dispersed process data and distributed process control will complicate and burden business process participants. Process managers demand faster and more efficient methods to re-integrate data on a business process before analyzing process data.

MODELING

Process modeling has to include more modeling components in today's hyperconnected environment, and conceptual models need to be more tightly coupled with field data and operational procedures.

Challenge 5 Business process modeling languages must allow new structures to include new information and consequences for the four IT enablers. Process modeling languages must be abstract enough to accommodate top-down business process improvement and bottom-up event log and sensor (re-)organization. A comprehensive approach would enable stakeholders to debate a process from several perspectives and utilize process models to negotiate abstraction layers. For real-time process execution, future modeling languages must incorporate activities/control flows with analytics/decision making. According to Dos Santos Franc´a et al. (2015), modeling human agents' beliefs, intents, wants, sentiments, choices, cooperation, and contingency events might help explain the unpredictability of knowledge-intensive systems from a human Finally, process modeling languages cannot handle social computing or smart devices that may function as sensors or actuators.

Challenge 6 Process data and workflow models should be connected with process models. Effective process model development reduces costs and speeds launch. Process models may combine field data with operational processes to speed up a process's life-cycle. Build on best-practice data from process handbooks, reference model collections, or process participants to expedite modeling (Mendling et al. 2017b). Friedrich et al. (2011) suggest using automated text analysis to find reference processes in unstructured texts. Process mining uncovers business process variations and workarounds (Alter 2014). Complex modeling languages integrate process modeling options with runtime decisions utilizing process data and other sources.

IMPLEMENTATION

The introduction of Social Computing and Smart Devices emphasizes, from the standpoint of process engines, the need of implementing processes across dispersed systems, which may include different information systems and physical objects. Workflows must also be more swiftly integrated into software systems and organizations, adhere to conceptual models, and be grounded in empirical data and data analytic skills to enable real-time control flow management.

Challenge 7 It will be difficult to simplify all the new features (La Rosa et al. 2011). Many issues enhance process complexity. Process information systems must incorporate business-impacting data, devices, and social media. This uses near-real-time data to evaluate process activities and provide process participants evidence-based control flow ideas.

Challenge 8 To represent the scattered socio-technical environment, business procedures must be established and implemented across applications, Smart Devices, and social networks. Smart devices use sensor data autonomously, limiting process engine business process control. Due to this lack of control, new methods are required to manage and guide scattered process instances to meet requirements. More (and more diverse) process participants and organizations impede business process adoption. Businesses assess and update business process redesign methods (Kettinger et al. 1997) and best practices (Mansar and Reijers 2005) due to rising complexity. According to Alter (2014), process participants often deviate from corporate processes. Dispersed participants, information systems, and gadgets may experience workarounds and unpredictability (Wolf and Beverungen 2019). Thus, hyper-connected corporate processes will be more volatile, unpredictable, and difficult to govern.

Analysis

Process analysis requires event logs and many other data points from information systems, people, and Smart Devices. Based on this data, analytics may have a bigger influence on processes in the future, but we must overcome the challenges of making these data useable, including data quality, privacy, security, and ethical data science.

Challenge 9 Correct and straightforward data analysis and interpretation are the key analytical challenges. Predictive analytics is being studied but not yet used (Teinemaa et al. 2019). Due to the volume of data accessible for study, the discipline struggles to transform data analysis into strategic process enhancements that close a process's life-cycle. Beyond a 'single focus' approach, analysis methodologies should automatically add domain knowledge to help analysts comprehend findings in context (de Me-deiros et al. 2007). More efficient or easier display of the data is required to make the analysis output accessible to specialist consultants and process participants.

Challenge 10 Social media and smart devices provide data that must be examined to contextualize corporate processes. Analyzing all activities and resources might disclose an organization's state. The data used for business process analysis is often unstructured and not meant for it, thus it must be processed. NLP is needed to categorize and analyse human-written information outside of automatic IT systems (Leopold et al. 2014). Analytical approaches must additionally enrich, integrate, and filter data from organized, semi-structured, and unstructured sources (Di Ciccio and Mecella, 2013). We need new methods to manage process participants' views, goals, and intentions, machine states, physical activities, and noisy unstructured data, which demands additional data preparation before relevant analysis. Knowledge-intensive processes are largely dependent on business process actors (Di Ciccio et al. 2015).

Challenge 11 Like data science, business process analysis must be fair, accurate, discreet, and transparent (van der Aalst et al. 2017). Increasing process data volume and reach, including Social Media and Smart Devices, makes those concepts increasingly significant. Understanding human process participants' thoughts, goals, and intentions creates ethical concerns concerning data misinterpretation, particularly if they are shared. Data scientists must be ethical while analyzing process participants' performance and personal data. Process mining for social network identification (van der Aalst et al. 2005) must be ethically created and used (Fahrenkrog-Petersen 2019).

II. DISCUSSION

The difficulties in the preceding section seem valid, however closer study revealed that some conflict. We summarized the difficulties into seven paradoxes the BPM discipline must overcome to create new IT goods and concepts. The paradoxes underscore the need for coordinated study cycles on these components' dialectics.

Paradox 1: Due to Social Computing and Smart Devices, business process strategies, models, implementations, and analyses become more complicated, and process life cycles accelerate and demand tighter integration. We need new technology and organizational approaches to fulfill these competing goals. Changing process management and participant roles might be crucial.

Paradox 2: To handle more process information, modeling languages must use more modeling constructs, increasing process model complexity. Still, conceptual models must be developed more cheaply and effectively. We must build modeling languages that meet both goals by lowering complexity and directing modelers through the design process efficiently. The models must also be actionable artifacts that smoothly integrate process ideation, execution, and data analysis.

Paradox 3: Data analysis and process execution must coordinate to allow process participants to make real-time choices. Process execution environments and data are distributed across businesses, information systems, and Smart Devices, resulting in noisy, incomplete, or contradictory data. These limitations need significant data preparation that hinders real-time decision making. Process managers must select which process performance dimensions to focus and how much data preparation is necessary and justifiable from a business standpoint.

Paradox 4: Process optimization requires near-real-time analysis of big data. Many data analysis techniques employed for this purpose are probabilistic, therefore their suggestions are not necessarily data-driven. In a Smart Device-filled environment, processes may have safety-critical physical manifestations that clash with (possibly erroneous) probabilistic algorithms. Reconcile both factors to allow process participants to adjust commercial operations while meeting safety criteria.

Paradox 5: Complex IT artifacts for BPM are harder to develop and execute, using more resources. People and Smart Devices may take independent activities, making central business process engine steering obsolete. Therefore, we must clearly determine when it will pay off to apply the resources required to establish standardized procedures and when they will have a deliberately inadequate definition, understanding that people and artificial actors may change processes as needed.

Paradox 6: Companies must standardize most business operations to take advantage of economies of scale and save expenses. Smart Devices' autonomy will make things adapt to their usage and context, resulting in customized products. Individualizing goods leads to personalized service methods, which opposes standardization attempts. Thus, companies must manage certain process sections for efficiency and others for commercial value. BPM must establish theories and artifacts that enable managers to balance these objectives by using higher-level abstractions.

Paradox 7: Complex BPM IT objects need data-driven field evidence to evaluate. Since process performances and data may vary, the same process may develop differently in each circumstance. This reliance on field evidence hinders design science research's ability to generate theories for design and action (Gregor and Jones 2007) that apply beyond specific settings (Gregor and Hevner 2013), making projects harder to organize and record.

III. CONCLUSION

This research note studied how hyper-connected society information technology enablers affect business process design, modeling, execution, and analysis. These events might derail BPM principles and IT systems. Our issues show that BPM is becoming more sophisticated and needs to be utilized more often. These competing trends were operationalized with seven paradoxes to drive future business process research and provide next approaches.

Connecting process owners, analysts, and system developers' design and process participants' execution was difficult and contradictory. Future BPM research must show how role shifting and recombining may help manage quicker and more complex processes. Organizational routines theory (Pentland and Feldman 2008) may help improve IT artifacts and organizational structure and investigate business process conflict.

Researchers should advance BPM in this new era. This study should follow these guidelines to create a consistent BPM body of knowledge without local optima.

Finally, our study showed the possibility of inter-disciplinary and international research that reconciles business and technological viewpoints on business processes. BPM transcends borders, thus we urge other researchers to do so. Acknowledgements DEAL open-access financing. This study was funded by the EU's Horizon 2020 initiative under Marie Skłodowska-Curie Grant agreement no. 645751.

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