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Jan Mendling
WU Vienna, jan.mendling@wu.ac.at

Gero Decker
Signavio

Richard Hull
IBM Research

Hajo A. Reijers
Vrije Universiteit Amsterdam

Ingo Weber
Data61, CSIRO

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How do Machine Learning, Robotic Process Automation, and Blockchains Affect the Human Factor in Business Process Management?

Jan Mendling
Wirtschaftsuniversität Wien, Vienna
Austria
jan.mendling@wu.ac.at

Gero Decker
Signavio
Germany

Richard Hull
IBM Research
USA

Hajo A. Reijers
Vrije Universiteit Amsterdam
The Netherlands

Ingo Weber
Data61, CSIRO
Australia

Abstract:

This paper summarizes a panel discussion at the 15th International Conference on Business Process Management. The panel discussed to what extent the emergence of recent technologies including machine learning, robotic process automation, and blockchain will reduce the human factor in business process management. The panel discussion took place on 14 September, 2017, at the Universitat Politècnica de Catalunya in Barcelona, Spain. Jan Mendling served as a chair; Gero Decker, Richard Hull, Hajo Reijers, and Ingo Weber participated as panelists. The discussions emphasized the impact of emerging technologies at the task level and the coordination level. The major challenges that the panel identified relate to employment, technology acceptance, ethics, customer experience, job design, social integration, and regulation.

Keywords: Business Process Management, Process Automation, Artificial Intelligence, Machine Learning, Robotic Process Automation, Blockchain.

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1 Introduction

The business process management (BPM) discipline investigates methods and techniques to organize business processes in an efficient and effective manner (Dumas, La Rosa, Mendling, & Reijers, 2013). A key idea of BPM involves improving business processes by redesigning information systems to best support the people who are working in the process. Indeed, many early office automation systems (Hirschheim, 1985), workflow systems (van der Aalst & van Hee, 2004), and various more recent process-aware information systems (Dumas, van der Aalst, & ter Hofstede, 2005)—which researchers often subsume under the term BPM systems (dumas et al., 2013)—all focus on this idea. Such systems hold and provide information to workers, schedule and coordinate specific pieces of work, and support decisions on how to best proceed.

Recent advancements in the area of artificial intelligence, machine learning, cryptography, and distributed systems have provided the foundations for new technologies, including robotic process automation (Aguirre & Rodriguez, 2017), chatbots (Shawar & Atwell, 2007), self-driving cars (Daily, Medasani, Behringer, & Trivedi, 2017), smart objects (Beverungen, Müller, Matzner, Mendling, & vom Brocke, 2017), blockchains (Nakamoto, 2008), and the Internet of things (Atzori, Iera, Morabito, 2010). Several recent papers discuss the implications of the emergence of these technologies for BPM (e.g., Beverungen et al., 2017; Mendling et al., 2017; Oberländer, Röglinger, Rosemann, & Kees, 2017). These technologies will likely affect how organizations design and execute business processes in the future. However, it is not clear in which specific way they will change BPM.

This paper summarizes the research background and the major arguments of a panel discussion at the 15th International Conference on Business Process Management. The panel discussed to what extent the emergence of recent technologies including machine learning, robotic process automation, and blockchain will reduce the human factor in business process management. As Shazia Sadiq highlighted, these technologies have a broad potential to affect BPM; however, it is not clear whether this impact will yield a peaceful decentralization (Star Trek scenario) or of darkness and extinction (Terminator scenario). Thus, this paper also contributes to our understanding of what impact these emerging technologies will have on the way processes are designed.

The paper proceeds as follows. In Section 2, we overview BPM and summarize research that discusses the impact of technology on business processes. In Section 3, we sketch some of the emerging technologies and investigate their impact at the task level and the coordination level of business processes. In Section 4, we discuss challenges and opportunities for research. We provide an edited transcript of the panel discussed in Appendix A.

2 Business Process Management and Technological Impact

In this section, we overview BPM with the BPM lifecycle's assistance. New technologies allow one to design processes in novel ways. With reference to the redesign phase of this lifecycle, we discuss how technology affects the way how one can improve processes.

2.1 BPM Lifecycle

The BPM lifecycle model describes how the different management activities associated with BPM relate to one another. At the single process level, the lifecycle has five different phases: process discovery, process analysis, process redesign, process implementation, and process monitoring (see Figure 1) (Dumas et al., 2013). At its heart, the model illustrates how one can organize a BPM project or a BPM initiative such that it arrives at an improved process.

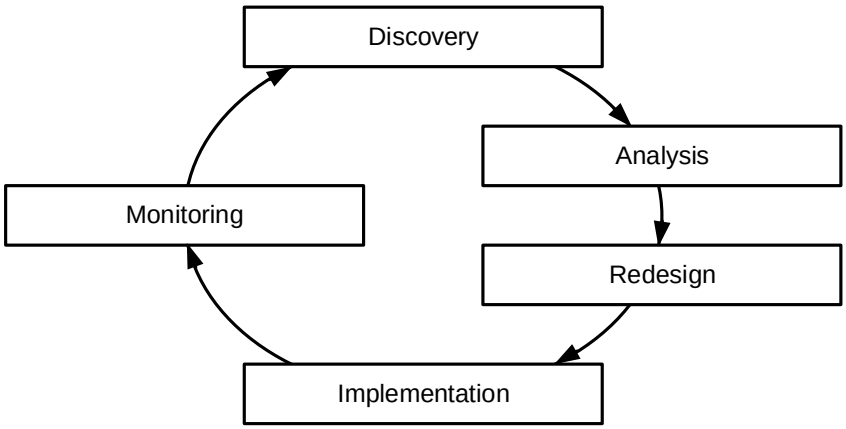

Figure 1. BPM Lifecycle

The BPM lifecycle starts with the process discovery phase. It focuses on one specific process. This phase focuses on producing detailed descriptions of a business process as it currently exists (i.e., the "so-called" or "as-is" process model). During process analysis, one applies analytical tools and techniques in order to determine a business process's current weaknesses. Process redesign addresses the most important weaknesses and yields a reworked design of the process (i.e., a "to-be" process model). One subsequently uses this model as the basis for process implementation. Process implementation refers to the various steps to put the to-be process into operation, such as implementing information systems and measures to facilitate organizational change. In the process-monitoring phase after one has implemented the redesigned process, one continuously collects and analyzes execution data for their compliance with performance and conformance objectives. Failing to meet objectives or changes of the goals and the business environment can trigger new iterations of the BPM lifecycle.

Subjecting a business process to the management activities of the BPM lifecycle can lead to improvements at the task and coordination levels. An organization achieves improvements at the task level when it improves the duration, the costs, the quality, or the flexibility of a singular task. An organization achieves improvements at the coordination level when the overall organization of handoffs between the tasks leads to faster processing, lower costs, better quality, or more flexibility. Some indications suggest that striving for improvements at the coordination level might have a relatively stronger impact on process performance than improving singular tasks. Blackburn (1992) investigated the flow-time efficiency of business processes in various industries and found that the cycle time of most business processes contains more than 95 percent of waiting time. At least for speeding up a business process, this finding means that reducing the waiting time between the tasks (coordination level) is more likely to improve flow-time efficiency than reducing the processing time of individual tasks (task level). One needs to keep this finding in mind when we discuss the impact of specific technologies on a business process: the technology might have a dominant impact at the task or the coordination level.

2.2 Technological Impact on Business Processes

New technologies affect how organizations execute and coordinate tasks in a process. Thus, one can see a new technology's impact most visibly in the redesign phase of the BPM lifecycle and, in particular, in specific redesign heuristics. Reijers and Mansar (2005) present an extensive list of such heuristics. Many of these heuristics explicitly refer to information technology as a means to achieve process improvements. For instance, the task automation heuristic suggests that one should take an existing task and subject it to automation. This heuristic relates to the task level. This heuristic ideally produces a faster, cheaper, and more accurate execution of the task. The interfacing heuristic represents another example. It incorporates the idea that organizations can use standardized interfaces to integrate their operations with partners' and customers' information systems in order to make processes faster and more reliable. This heuristic impacts the coordination level more strongly than the task level. These heuristics describe two examples of information technology that affect business processes.

The 1990s saw a strong wave of business process reengineering (Hammer & Champy 1993) together with major investments in information technology newly introduced to the market back then. At the same time, researchers, including Brynjolfsson (1993), observed a productivity paradox of information

technology. Apparently, investments in information technology did not always lead to productivity gains. Some of the works that have tried to resolve this paradox demonstrate that productivity gains from information technology investments require organizations to change their business processes in order to reap the potential benefits (Mukhopadhyay, Rajiv, & Srinivasan, 1997; Grover, Teng, Segars, & Fiedler 1998). From the perspective of new technology, Mooney, Gurbaxani, and Kraemer (1996) distinguish automational effects, informational effects, and transformational effects. Automational effects emerge when an organization uses a new technology to automate tasks that it previously did manually or with partial system support. Informational effects materialize from better tracking, monitoring, and analytical insights. Transformational effects relate to the changes in the mechanisms of coordination, which include disintermediation, outsourcing, or offshoring.

3 Emerging Technologies

In this section, we focus on three specific technologies that might affect business processes' potential to automate tasks and facilitate new ways of coordination: machine learning, robotic process automation, and blockchains. We briefly sketch their central characteristics and point to more detailed references.

3.1 Machine Learning

Machine learning is a branch of the artificial intelligence research area. One prominent category of machine-learning applications is classification (Bishop, 2006). One can find classification tasks in various domains that require expert judgment, such as in healthcare (e.g., determining if someone has a tumor), law (e.g., determining whether to sentence someone for a crime), or construction (e.g., determining whether a certain construction would be stable). With the availability of big data in certain application domains, the potential of applying machine learning for classification has also increased. For instance, Sim (2016) emphasizes the importance of technologies such as IBM Watson for various diagnostic tasks in a medical context. One also needs big data to *train* machine-learning techniques such that they can provide accurate classification results. In this way, machine learning has the potential to partially automate a broader spectrum of tasks that experts have conducted in the past. It might also help to coordinate different tasks in a business process. In the context of BPM, these observations raise the questions for which specific application scenarios machine learning can be effectively devised and which type of training data is required to make it useful in a practical setting.

3.2 Robotic Process Automation

Robotic process automation (RPA) is an industrial response to the huge amount of manual work that individuals perform on a daily, weekly, or monthly basis to support a broad array of high-volume business processing (Aguirre & Rodriguez, 2017, Lacity & Willcocks, 2016). RPA is mostly associated with the task level. The application areas include finance and accounting, IT infrastructure maintenance, and front-office processing. The so-called robots are software programs that interact with systems such as enterprise resource planning and customer relationship management systems. The robots can gather data from systems and update them by imitating manual screen-based manipulations. From a business perspective, RPA solutions are appealing because they automate repetitive tasks while being minimally invasive into the overall processing that they support. An increasing number of organizations have begun to adopt RPA solutions recently; however, this growth might diminish in the future when the next generation of enterprise resource planning systems and IT infrastructure directly incorporates services for accessing data and making updates. RPA raises interesting academic research questions such as how to design and program robots and to integrate them with BPM systems, how to leverage RPA as a vehicle to support AI-enhanced processes, and how to use artificial intelligence techniques to program RPA solutions based on goals.

3.3 Blockchain

Blockchain, the technology underlying crypto-currencies such as Bitcoin, is a distributed ledger technology that enables organizations to engage in transactions without the need for a commonly trusted authority. It is a promising technology at the coordination level and a potential infrastructure for facilitating inter-organizational business processes. Its key strength is that it supports transactions between parties that do not trust each other over a computer network in which trust emerges from a combination of peer-to-peer technologies, consensus making, cryptography, and market mechanisms. Smart contracts are user-definable programs that the network of computer nodes in a blockchain executes. With the addition of

these smart contracts, one can design the control logic between transactions in order to meet a diverse set of use cases that span the financial industry, logistics and supply chains, healthcare, sharing economy, and many more. Proposals from the BPM research community include using smart contracts to express processes, particularly inter-organizational ones, in an imperative form such as BPMN (Weber et al., 2016), in an artifact-centric form (Hull et al., 2016), or in a rule form (Mery & Selman, 2017). In this way, large parts of the business logic of inter-organizational business processes can be compiled from process models into smart contracts to ensure that the joint process is correctly executed. Executing inter-organizational business processes using smart contracts on a blockchain can remove several barriers (Weber et al., 2016, Mendling et al., 2018). First, the blockchain can serve as an immutable public ledger, so that participants can review a trustworthy history of messages. Second, smart contracts can offer independent process monitoring from a global viewpoint. Third, encryption can ensure that data relevant for making decisions is visible while the remaining data is only visible to the process participants that require it. Blockchain technology raises interesting research questions such as how to devise novel execution and monitoring systems for inter-organizational business processes, how to define appropriate mechanisms for process evolution and adaptation, and how to identify patterns of redesigning processes using blockchain technology.

4 Impact of Emerging Technologies on Business Process Management

In this section, we discuss the impact of the various emerging technologies on BPM. We first discuss the impact at the task level and then at the coordination level.

4.1 Impact at the Task Level

To determine the impact of the various technologies, we follow Autor (2015) and distinguish three different types of tasks:

1. Routine tasks are explicit and codifiable. They include the calculations involved in bookkeeping; the retrieving, sorting, and storing of structured information in association with clerical work; and the precise execution of *repetitive* physical operations in a stable environment.
2. Abstract tasks require problem-solving capabilities, intuition, creativity, and persuasion. Tasks of this kind are typically associated with professional, technical, and managerial occupations. They require employees with a high degree of education and analytical capabilities. They emphasize inductive reasoning, communication, and professional expertise in *open and underspecified* contexts.
3. Manual tasks require situational adaptability, visual and language skills, and personal interactions. Manual tasks typically characterize food preparation and service jobs, cleaning and janitorial work, grounds cleaning and maintenance, health assistance, and jobs in security and protection services.

Emerging technologies will likely strongly impact routine tasks since they often provide the potential to benefit from what Mooney et al. (1996) call automational effects. As such, these technologies could displace workers in these routine tasks because they follow precise, well-understood procedures that can be either codified or mimicked. Machine learning and RPA will likely contribute to this trend. The panel discussion highlighted data entry and data validation as examples of routine tasks increasingly replaced by automatic solutions that companies such as Parlamind provide. As a consequence, we might observe a substantial decline in employment in clerical and administrative support.

Emerging technologies could also have a strong impact on abstract tasks. For these tasks, we might see informational effects. The panel discussion emphasized that systems already yield much better results for tasks such as diagnosing skin cancer. A serious challenge for these tasks involves the trust in the correctness and accuracy of the solutions. The panel described one example: the process of assessing whether to grant an asylum application or not. German authorities trialed a prototype system that could have sped up the application processing drastically; however, the country did not end up using it because decision makers lacked trust in its accuracy.

Emerging technologies can also have a transformational effect on manual tasks. Applications related to the Internet of things, Industry 4.0, and the industrial Internet contribute to these developments. For example, in a classical picking process in a warehouse, workers pick the products from their respective

positions. Companies such as Amazon have introduced picking robots that connect to the order information systems. In this way, the company has transformed the picking process from manual work to work that machines perform.

One generally finds jobs intensive in either abstract or manual tasks at opposite ends of the occupational skill spectrum: professional, managerial, and technical jobs are on the one end and service and laborer jobs on the other. The computerization of routine tasks likely leads to the simultaneous growth of high-education, high-wage jobs at one end and low-education, low-wage jobs at the other end. Both developments will take place at the expense of middle-wage, middle-education jobs—a phenomenon that Goos and Manning (2003) call "job polarization". Various economic studies at different levels of abstraction have also confirmed this phenomenon (Frey & Osbourne, 2017). However, the panel emphasized that jobs with routine tasks will continue to exist because the emerging technologies still have too many limitations. Currently, they are not profitable for tasks not highly standardized.

4.2 Impact at the Coordination Level and Work Organization

While emerging technologies may have a substantial impact on separate tasks, one needs to remember that any job involves more than one task. Many middle-wage, middle-education jobs include routine tasks but not exclusively so. The automation of routine tasks generally *enhance* the more complex tasks that such jobs comprise and that automation cannot replace (Autor, 2015). One can see as much in particular at a *level* where one needs to *coordinate* the tasks of many parties. Most business processes draw from a variety of inputs: labor, capital, intellect, creativity, technical skills, intuition, rules, and so on. Typically, each of these inputs plays an essential role. Thus, improving one task does not make another superfluous. In other words, productivity improvements in one set of tasks will likely increase the economic value of the remaining tasks either in a single job or a process as a whole.

One can find an iconic representation of this idea in the O-ring production function that Kremer (1993) has studied. In the O-ring model, failure of any one step in the production chain leads the entire production process to fail. Conversely, improvements in the reliability of any given link increase the value of improvements in all of the others. Intuitively, if n − 1 links in the chain are reasonably likely to fail, the fact that link n is somewhat unreliable has little consequence. If the other n − 1 links are made reliable, then the value of making link n more reliable rises as well. Analogously, when automation or computerization makes some steps in a work process more reliable, cheaper, or faster, the value of the remaining human links in the production chain also increases. Benefits in this dimension might result from easier coordination of inter-organizational business processes using blockchains. The panel discussed the case of AgriDigital that achieves such improvements in the agricultural sector.

Kremer (1993) discusses the application of the O-ring model for the case of automatic teller machines (ATMs). ATMs appeared in the 1970s and their number in the U.S. economy quadrupled from approximately 100,000 to 400,000 between 1995 and 2010. One might expect that such machines would have wiped out the job of bank tellers in that period. Yet, U.S. bank teller employment actually rose, albeit modestly, from 500,000 to approximately 550,000 over the 30-year period from 1980 to 2010 (although, given the growth in the labor force in this time interval, these numbers do imply that bank tellers declined as a share of overall U.S. employment). Bessen (2015) explains this somewhat paradoxical development in observing that two forces worked in opposite directions. First, by reducing the cost of operating a bank branch, ATMs indirectly increased the demand for tellers: the number of tellers per branch fell by more than a third between 1988 and 2004, but the number of urban bank branches rose by more than 40 percent. Second, as the routine cash-handling tasks of bank tellers receded, information technology also enabled a broader range of bank personnel to become involved in customer service. Increasingly, banks recognized the value of tellers supported by information technology as salespersons who forge relationships with customers and introduce them to additional bank services such as credit cards, loans, and investment products.

5 Impact beyond Singular Business Processes

Clearly, the emerging technologies we mention in this paper impact more than singular processes. The panel discussed the things they might impact and the challenges that this impact might bring for society. We summarize this discussion in seven points.

1. **Employment**: the panelists expect that a good share of today's job profiles will change or disappear in the next decade. Frey and Osbourne's (2017) model, for instance, sees a high

probability of computerization for jobs such as dishwashers, court clerks, and telemarketers, which could imply that people have to become more flexible and change jobs more often than in the past. At least a share of the workforce will find having to become more flexible challenging. However, it does not mean that our society will run out of work. The past two centuries of automation and technological progress have not made human labor obsolete. The employment-to-population ratio rose during the 20th century, and, although the unemployment rate fluctuates cyclically, we have not seen any apparent long-run increase in unemployment according to Autor (2015). Two effects compete here: technology's destructive effect of labor substitution and a capitalization effect of rising employment in sectors that achieve productivity gains (Frey & Osbourne, 2017). It is difficult to foresee how these effects will balance out.

2. **Technology acceptance**: the panelists observed that the emerging technologies mentioned often have low acceptance. As for why, one reason may concern the level of perceived behavioral control (Venkatesh, Morris, Davis, & Davis, 2003). Indeed, technologies such as machine learning, RPA, and blockchain are complex and difficult to understand, which might explain low perceived behavioral control. Paradoxically, trust in human experts is high even though they often do not agree or come to consistent diagnoses (Schön 1983). In particular, solutions based on artificial intelligence need techniques that explain automatic decisions. Otherwise, people and decision makers may not adopt fast enough even though the technology has high factual accuracy.
3. **Ethics**: new technologies have effects that can be judged as good and bad from an ethical perspective. On the downside, artificial intelligence-based solutions might simply adopt the biases and prejudices that the training data includes. Such biases are concerns of ethical standards in systems engineering (Spiekermann, 2015). On the bright side, technologies have the potential to speed up processes that people find stressful due to their long duration. The panel featured the example of a partially automated asylum application-handling process. Beyond that, technology has also the potential to make business processes fairer and less susceptible to corruption.
4. **Customer experience**: the panelists observed that organizations often use emerging technologies mentioned to improve customer experience. New process designs increasingly use insights from design thinking (Norman, 2013). Technologies such as chatbots offer scalable solutions for customer communication and interaction, which were formerly too expensive with human workers. However, in this context, one faces challenges in balancing automatic interaction and human interaction. Customers might or might not realize that chatbots serve them. In case they realize, one needs to question how they will act and perceive the interaction.
5. **Job design**: one can make similar observations about the design of the workplace and the support of office workers. Research has established that job design has an impact not only on performance but also on creativity and employee wellbeing (Oldham & Fried 2016). Using emerging technologies can contribute to building an attractive workplace. In specific scenarios, such technologies might also have the potential to protect workers from risks (e.g., sending a remotely navigated drone instead of humans to a contaminated area). An important question concerns how one can best integrate automated tasks and human work.
6. **Social integration**: the panelists observed that novel information technologies have the potential to make people happier and more satisfied with their life. For instance, Ibarra et al. (2016) describe how tools can help older people to make online contributions. The panel also mentioned the case of elderly people using online tools to make appointments for knitting together and the case of education management systems adapting to the pace of the learner. On the downside, various actors have increasingly begun to use social media to manipulate elections and to disintegrate society. Currently, we have no clear account on the balance of benefits and drawbacks of these technologies from a social perspective.
7. **Regulation**: the panel highlighted that regulations are often discussed as a means to handle the impact of emerging technologies such as blockchains and cryptocurrencies. Blind (2016) highlights that regulations have an ambivalent impact: empirical evidence shows the dampening effect of compliance cost and stimulating effects of regulatory incentives. The panelists mentioned the healthcare sector as an example where regulations hinder the adoption of new technologies. On the other hand, anecdotal evidence suggests that entrepreneurs in the blockchain space value regulatory clarity because it gives them certainty

regarding the legality and taxation of their ventures. In many cases, national legislators and regulators and supranational organizations have or will become active in setting the rules regulating the usage of specific new technologies.

All these seven aspects require the research efforts of interdisciplinary teams. Insights from computer science, psychology, business administration, economics, engineering, political sciences, law, and other studies have to be integrated to investigate them in an adequate way. Also, curricula will have to evolve beyond the narrow boundaries of specialized fields in order to develop a broader perspective on these developments. Business processes will continue to be relevant research subjects in understanding the impact of new information technology on the profitability of existing business models and the emergence of new ones. We call for the BPM research community to reach out to these neighboring disciplines to study the impact of emerging technologies such as RPA and blockchains and directions for further improving them.

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Appendix A: Transcript of the Panel Discussion

Occasion of the panel

15th International Conference on Business Process Management

Time and location of the panel

Thursday 14th September 2017, 10:40h - 12:10h

Auditori, Vertex, Universitat Politècnica de Catalunya, Barcelona, Spain

Video documentation

Part 1: https://www.youtube.com/watch?v=6kpJDWE3sxc

Part 2: https://www.youtube.com/watch?v=p2z1uRKGdoo

Part 3: https://www.youtube.com/watch?v=EYB2ZHg7Ygo

Panelists

Jan Mendling (Chair)

Ingo Weber, Data61, CSIRO, Australia

Gero Decker, Signavio, Germany

Hajo Reijers, Vrije Universiteit Amsterdam, NL

Richard Hull, IBM, USA

Jan: I am very happy to welcome you here in the audience. We are heading into a panel discussion. There are some exciting developments technology-wise that make us talk today about the human factor in BPM and how far emerging technologies are challenging this human factor in BPM.

I am very happy that we have four experts here as panelists and I want to briefly introduce you to these people. Next to myself, there is Hajo Reijers. He received a PhD degree from Eindhoven University of Technology and is now a full professor at the Vrije Universiteit Amsterdam. Welcome Hajo. Next to Hajo, we have Gero Decker. He received a PhD degree from HPI in Potsdam, took his work into practice and founded Signavio with others. Very happy to have you here Gero. Next to Gero, we have Ingo Weber. He received a PhD degree from Karlsruhe and after working with SAP, he moved over to Australia to join the University of New South Wales and then Data61, CSIRO, which some of you might know by its old name NICTA. And we have Rick Hull with us. He received a PhD from University of California in Berkeley. He was a professor at the University of Southern California for about a decade, and then switched to industry, first at Bell Labs, and now with IBM Research.

Let me set the scene of what we are going to talk about. One thing that is important when we talk about processes is that processes are inherently complicated matters, because there is division of labor in bigger organizations. That means much of the work that needs to be done is split up in smaller pieces: there are different persons, different parties and different companies involved with separate tasks, and we need to coordinate them in order to integrate the fragmented results of these pieces of work. And many of the developments that we see recently have an impact, either on the way how certain tasks are performed in an enterprise setting or on the way how these tasks are coordinated. To mention just two examples, there are technologies that build on artificial intelligence and machine learning, robotic process automation is one of the terms in this context. All these refer to training techniques associated with tasks that can be automated, such that humans are potentially replaced with IT based robots to do their work. On the other hand, there are developments in terms of coordination – blockchain is one of the technologies that facilitates coordination between different parties, and this also raises the question, if we will have infrastructures like blockchain to take care of coordination.

One of the questions that is raised in this context is how does that generally impact work, on a smaller process level but also on a greater scale. How does this affect society? And one of the challenging question is: do we run out of work?

I want to briefly read out a small piece that I just recently found, and found quite interesting to reflect upon, and I quote verbatim. It is a piece from the American documentation institute and they write the following:

> *There is a sizeable fraction of the workers which is unable to adapt to a new or different industry. Recognition that this type of unemployment (personnel who cannot adapt) is a chronic effect of scientific and technical advance, not of population growth, may lead not merely to retraining programs in rapidly evolving fields, but a new attitude toward education*. (Heilprin, 1964)

This sounds nice when you think of ourselves as being those in research and teaching promoting education. One of the interesting things is that this quote is from the mid-1960s, so it is not very recent. I would like to invite the panelists to make their entry statements, such as they can share with you their general observations around these different topics and then I would invite you to bring in your comments, ideas and questions such that we can discuss this topic in a broader audience.

So Hajo, do we run out of work?

Hajo Reijers: Well, it wouldn't be so bad from some perspectives, but I understand that your question is of course a question that is on the minds of many people, economists and other people. I think there is also a genuine fear about the effects that automation has on the work that people do and indeed there have been incredible changes over the recent past.

My position, however, is that fear for running out of jobs is heavily exaggerated and I think one of the key elements to understand how this impact works is, that there should be a distinction actually between jobs that people do and the tasks that these jobs are composed of. Any job is composed of multiple tasks and what we see over the past decades is actually that automation, all kinds of algorithmic approaches - what they do is that they target one particular type of task, which is often part of the jobs that people have. These task are what you can refer to as routine tasks or to tasks, for which there is a certain procedure behind it, there is a sort of repetition, sort of a structure that can be unveiled, can be discovered and that can be translated into an algorithmic approach. These tasks clearly can be aimed at, can be targeted with automatic approaches. By the way these kind of routine tasks are not always the cheapest tasks in the jobs that people do. There may be other things manually that require manual skills, but these routine tasks are at an enormous rate being automated in all kinds of areas. And if it economically pays off this will continue. Now what I find interesting is that when you look in different areas in different studies and when you look at the automation effects of the routine component in something that is bigger, it is not so much that the overall system or the overall process is being reduced with specific parts of it. More than that, the overall value of the system or the job that this task is part of is actually enhanced. So let me give you an example here. I read an interesting study about the use of the introduction and the use of ATMs in the United States. ATMs were introduced in the 1970s. In a study that looked at the replacement effect of ATMs on tellers - people who would be working at banks and would actually hand over money to people who visited these banks, you could clearly see that this element of the job of these tellers, the human tellers, was replaced and was automated with these ATMs. These ATMs, the use, the introduction and the presence of these systems in the 1990s approximately quadrupled. But what happened is that these people who previously did this part, handing over money to clients, that this kind of job did not diminish, it actually increased over in the same time period. And there were two factors behind it. One of them was that because the overall job became more economical to hand over work in an automated way. There were also opportunities for banks to open more branches; so there was an actually need for more personnel, and also personnel who were previously working as tellers. But more importantly, these tellers had other tasks that they would do. They, the human tellers, would explain to clients what the other Bank products were, for example. They would introduce their clients to these bank products and would also do, I would say, minor sales elements. And these parts of their job were actually enhanced through the automation of the more routine part of their work. So instead of a decline, you would see an increase, though it was a small increase, and to be honest the number of tellers as part of the labor population has decreased over time but in absolute numbers this went up.

And this is actually a part of a sort of a wider phenomenon, which is sometimes referred to as the O-ring theory. If you have any type of system that is composed of different parts and the overall system would stop working when one of these parts fails, by improving one part that actually the value of the overall

system enhances and doesn't diminish. And you can see this also in business processes where, if you enhance a certain task in a process, the overall process becomes more valuable and it becomes also more important that the other tasks in this business process are executed well or with a high quality. So, having said all this, this explains my statement that it's not so much that jobs will go away. Jobs will be affected, heavily affected by automation and keep being affected, especially jobs which of course contain to a large extent routine tasks will be heavily affected, but I think the fear that these jobs will completely disappear, those fears are exaggerated.

Jan Mendling: Thank you very much Hajo. So, we are talking about these repetitive tasks. They seem to be the key to understand what is going to happen with these new technologies. I want to hand over to Gero, because he is not only the co-founder of Signavio, he has also expertise from being involved with a company that is called Parlamind. And there are some scenarios more concretely visible that illustrate what we have talked about. So Gero, maybe you can share some of your experiences in this context.

Gero Decker: Sure. I'm an engineer by heart, so I love technology and I love experimenting what's possible and push the boundaries**.** You know overall I'm excited about all of the things that are available now and how it could affect things. But on the other hand, I am an entrepreneur. Having brought things to market and having to convince people that they actually have to pay money for using that type of stuff, gives you a reality check of what's actually needed and what is viable in the marketplace. So talking about AI in particular, conceptually, theoretically it can do so many things and it is an exciting thought exercise. It helps you build self-optimizing, self-learning machines that can do all kinds of things that humans did before. The question is when you want to bring that to market and make that work – what are the economics behind that and when does it actually work and when doesn't it work. Parlamind is an interesting example. It's a company that I've invested in very, very early, and what they do is, they automate customer service request emails or customer service requests. They specialize on e-commerce only at the moment. So you order something at Amazon; or you order something at Zalando. You have questions like "where is my package, next Monday is the birthday of my girlfriend, I am waiting desperately, what can I do to speed this up", or "I ordered the wrong thing, I want to cancel it, or the thing that arrived is the wrong thing, I want to exchange it, how does it work?" This use case is interesting because it seems to be very repeatable, a very replicable scenario so that it is very easy to build an AI, a self-optimizing machine, that respond to these kinds of requests. Because it's one domain, you have a high volume of requests that you can learn from and it's actually something that is replicable over the companies, so it is not specific to one company but it is replicable to let's say, ten thousands of online shops out there. And with that type of scenario you can build a machine that understands the sentiment of the email. So, for example, this person is angry or this person is happy, or there is some urgency in there, or here it's about conciliating someone. For example, "next Monday is the birthday – I understand that it is super important to you. We will make sure we do everything to make your girlfriend happy." And this will be a robot saying that. I is not a human but a robot saying that. And saying, well we can offer you, 10 Euro more for overnight shipping, to make that work and the likelihood we have seen in the past is that, in the area that you work in – that you should be fine. In other areas, however, I have seen a lot of attempts of applying AI and it has been super complicated and super hard, and did not return the investment that you have to make. Why? Because it is super specific to the particular use case, the training data that you need is specific to one company or to one's special task at hand, and you simply don't get economies of scale to make that work at a reasonable price. To give you one example: a friend of mine has a company that specializes in dynamic pricing. This is what amazon introduced, every person at every moment in time gets a personalized price, and you optimize on certain criteria like for example getting rid of your stock until a certain date and reaching the maximum price until then. And what they found was that AI technology and machine learning technology works great, if you have more than a billion in revenue with your company. If you have less than a billion in revenue for your retailer, the machine learning is simply not powerful enough, and it's much smarter to have people sitting there, building all kinds of rules and decision models for pricing and campaigns and tailoring the price to the specific person, because you simply don't reach the scale for machine learning technology to be economically viable. Long story short, great technology – but I think we are still early in the game to find out where is the viability of those things and where can we make it work, not only conceptually or theoretically, but also economically to return the investment that you want to have in business. If that investment is not returned, people will still do things for a long time to come.

Jan Mendling: Thank you very much Gero. I want to turn to Rick with this observation you made that many things are much more complicated. Data is versatile, and Rick has strong expertise in data management, which he accumulated over several decades. Rick, I would like to ask you to comment on

how the scene has changed in terms of how we work with data in order to make all these scenarios work in the last couple of years. How do you look at that?

Richard Hull: Thank you. I want to mention three areas where data is really central to how the BPM world is changing, both because of AI and because of Blockchain. And the first thing I want to hit on, and it's kind of related to what we were just listening to is, namely, data entry. So much of business process comes down to getting data into the system, maybe at the beginning to launch a process or maybe in the middle because more data is needed. And it's really kind of a curse of our existence I would say – and I think it's going to be a curse of our existence for quite a while. Just one example in a back office processing for human resources for hiring, terminating, promotions turns out that about 60% of the labor today is focused on data validations. Data comes in and if it's wrong, it has to be fixed – that can be a major pain. Now, how is AI helping in that? It's through the conversational front ends, as an alternative to forcing people to work with one kind of menu based situations or putting in through forms that are handwritten. Conversational front ends, that are given to us by natural language understanding, natural language generation and kind of machine learning to figure out how conversations should be going, allow the data entry to be more natural, more intuitive, easier, and faster to go in. But at the same time as just mentioned, the target for those conversational front ends is still a very, can be a heterogeneous environment. Now, even though the conversational front end is kind of simplifying, not only do I want to put data in, but I want to make sure that it's consistent with the other data, that may be in my environment. That can be a challenge because that data may be spread across multiple silos. So, there is still this challenge of data integration.

This brings us to the second thing I want to get at, which is blockchain. What's interesting is that in this room, of course, everybody's heard of blockchain, but probably half of you have kind of been reading up on blockchain and understand where it's going. I think for others that I have talked to it is still kind of an unknown, you are thinking, "oh yes, maybe I should start looking at it". The thing about blockchain is it does represent a disruptive moment for business process or at least for some large portion of business processes. This is because blockchain enables seamless data sharing between multiple organizations that are trying to do business processes. To have a single shared repository of data, a single ledger, if you will. And it's got the encryption and consensus and this and that, so that even though it's a single shared repository, people are able to trust that the different organizations are able to trust it and it has privacy guarantees built in. For example, maybe I am working with Ingo on something, but then Hajo won't be able to see it, if I don't want him to see it. So, it provides this basis because of the underlying technology, it provides a new way of enabling a shared repository. So this new approach is very different than today's approach to having multiple companies work together where each company has its own silo of information. This totally streamlines or gets rid of the friction of data inconsistencies in many ways. Instead of having my copy of data and Ingo's copy of data, we have one copy of the data. And as the data goes in, we can be checking whether it's consistent with other data that's already in there. Now, what are the implications of this shared repository? First off, it is going to change the way a lot of business processes deal with crossing silos within an organization or crossing boundaries between companies. That friction is going away, it is going to lead to the development of shared data models so the companies have to get together about, what's the data schema of what they are representing. So suddenly, there's economic motivation for industries to arrive at as standardized data models. In essence this is going to bring back the whole attempt of the Semantic Web community. Right? The Semantic Web Community was truly hoping that we would come up with standardized ontologies for healthcare, for logistics, for finance and accounting, for HR and etc. Because of blockchain people will want to start sharing information against a common data model and so these common data models will arise.

Now moving to the third thing that I want to mention. Even though blockchain right now is focused on going between organizations, the same principles will start to pervade within organizations so that if you have different silos within an organization even those will start saying "oh I want the benefits of a shared data model, oh I can use blockchain as that basis for the shared data model." As the data becomes more uniform and standardized, this actually will be an enabler for a shift in business process management from a process centric or a data centric perspective towards a goal centric perspective. This will be an opportunity for people instead of saying: "oh I need to put this data in and I want this task to happen etc." They will be able to say: "this is my goal and the goal can be expressed in the vocabulary of the shared data model." And so now this will enable the emergence of applying AI planning technologies against processes as we know it.

So, just to summarize, I am trying to get at three mechanisms where blockchain and AI are going to be transforming how we do business processes. It will create a lot of employment for us, the research community, because there's a lot of details to be worked out. And as Hajo was saying, it will be transitioning the kinds of jobs that people do, but it will be allowing more people to think about kind of goals and the business values and the objectives that they are trying to reach. Thank you!

Jan Mendling: Thank you very much. You mentioned blockchain and I am looking at Ingo now because he is kind of the mastermind behind the blockchain activities in CSIRO. Ingo, you guys in Australia are working on various scenarios and, as Rick said, the concept is quite abstract for many people. Maybe you can illustrate some of the applications that you have been working on and your perceptions of what this technology is going to bring.

Ingo Weber: Thank you Jan. Maybe that was a little bit too much honor. So, I want to do exactly that but before I do, I just want to briefly take a step back and look at the premise of the question for the panel which is: will machines eat the human factor in BPM? Now there are two premises in there, one is that basically all human touch is good and, two, that people will mind if their tasks are automated. And as Hajo was referring to these routine tasks, I think there are a lot of tasks that some of us have to do, where we wouldn't really mind those tasks being automated and that will lead to this transformation. Also in terms of all human touch is good – in these routine tasks, quite often we find ourselves in a situation where the best performance a human can achieve is not stuffing up. And so it is not necessarily a bad thing if this work is transformed. Also of course the ethics of humans making decisions or the way they perform tasks are not always perfect. You have things like corruption or bias. I think of things like corruption that we can probably reduce by automating tasks. For example if we take customs processes in developing countries that in some countries there is a lot of corruption, you have to bribe the right people to get your goods through customs on time. Reducing that is probably a pretty good thing, at least for the general society, probably not so much for the customs official. But when it comes to the ethics, we also have to consider the ethics of the AI, because if you have a bias in the data from which you learn, you can learn to make unethical decisions and can automate them such that they always be made in this unethical way. A different question also is from this broader perspective is if people lose their jobs, then we have to also reconsider that wealth distribution and purpose in life to a large degree for many people are associated with work. And that I think is a challenge to society as a whole, which we probably won't be solving in the BPM community or on this panel today.

But now coming back to your actual questions or blockchain opportunities and scenarios. Blockchain, I think, has two primary features that are great in this regard: one is that they enable inter-organizational processes, collaborative processes in a different way, they enable potentially more complex supply chains for one example. They might make it easier for Fijian producers to export their goods to Australia, which can be very positive. Topics like these we are working on. There is a startup company in Australia, AgriDigital, with whom we interact quite a bit, and they want to reduce the cash flow issues in grain supply chains for Australian farmers, which is a very important topic for these farmers. In Australia the suicide rate among farmers is about twice as high as for the average population, and to some degree this is attributed to cash flow problems, with the farmers not knowing how they are supposed to pay the salaries and for the goods in the next month and by using blockchain to make this process smoother and make the payments faster, that can be fantastic. I think back office automation can happen also to some degrees in the banking sector with settlements potentially happening much quicker and needing less human routine operations to be performed. The other thing that you can also get out of blockchain is that you have reliable data, data that's more reliable than previously. There is a start up from some friends of mine in Sydney, who want to bring supply-chain financing and invoice financing to a broader share of the market. Invoice financing, meaning that you can take an invoice, go to the bank and get a loan against this invoice or sell the invoice to somebody. And for a lot of small companies this is currently not possible because the volume of the invoice is not big enough and the checks that are needed by people are too costly for the banks to be interested in doing that. So, I think when we talk about automation in this sense we also have to realize that, yes some tasks that are currently performed by people may be automated away, but also, potentially, we can create new business models and processes which increase the overall market dramatically and there are many opportunities in that regard.

Jan Mendling: Thank you very much. I would like to open up the discussion for the broader audience and I invite you to comment and challenge the different observations that our colleagues shared here.

Gregor Engels: Thank you. I have to say I work in two very huge projects. One is on work 4.0[1] asking what the impact of digital transformation on the employees is. What I have learned there is that we as computer scientists are not able to speak about the human factor, so we need people from other disciplines. In this project, there are ten professors and only two computer scientists, all the others are from psychology, sociology, from economics, from law and so on. And I think we need this discussion, this opening of our community to these areas. This morning, we saw in the talk[2] by Alan this pyramid of values. We are very good in this functional values, but in all upper layers we have no idea how to realize systems, so that people become happy, satisfied and so on. So, what I would like to ask you, why do you think that you are qualified to speak about human factors, you are computer scientists, maybe business informatics people. You have no idea about humans.

Gero Decker: How we are qualified to sit here? Because we got invited. So, we didn't self-select ourselves. Maybe I can speak to that a little bit. We at Signavio deal with a lot of companies out there applying process management. What is interesting to me is, we always look at what are people trying to achieve, what are the goals, what are their challenges. Five – ten years ago a lot of people were focusing exclusively on the lower part of the pyramid – how can I save cost? How can I streamline things? How can I make things faster? So, a lot about operational efficiency and making operations run smoother for the company. What we have seen as a trend in the last two, three, four years is that a lot more companies are using process management now. What we have seen is actually the upper right corner of Miguel's chart of digital transformation,[3] or both upper parts, so for customer experience and for employee experience, which is very interesting. We have a lot of customers who optimize processes with the main goal of building in a more attractive workplace, because it is so competitive to find people that they have to make sure that the environment that people work in is attractive, is appealing, that it brings out the best of the people. So, this is interesting. I haven't seen this particular piece and research how to increase employee happiness through designing process in one way or the other. But it's happening out there in practice. Customer experience – I have seen a couple of things here at the conference as well on how do you actually get back to the roots of process management, if we remember where process comes from: it basically puts the customer at the center and tries to work in a way that you achieve the customer's goals or fulfil his need. That seemed to have gotten lost a little bit in the last 10, 15, 20 years, and the focus was a lot more on the internal things happening within one company. But in the latest survey that we did with our customers, actually 35 percent of all initiatives are mostly driven by customer experience and improving that. I'll give you an example: imagine you are a car insurance company. What are your interaction points with a customer today? You have exactly one interaction point with a customer every year and that is when you send the invoice and tell them they just renewed their contract. Right? So, these nice letters are the only touch point that you have with your customer. But what you actually want to provide as an experience is that you want to be there for your customer every day when they enter their car. You want to make sure that they understand that when they enter the car and they touch the steering wheel, that you are the safety net for them. Right? Whatever happens to you on this particular day, I am there with you, I am working with you to keep you mobile, to keep you safe, to lead your life in a way that you want to lead it. This has a heavy impact on how you design your product, your service and this has a huge impact on processes and the things that you have to do to deliver on that customer experience. So, I see good signs in there, walking up the pyramid and in practice I see a lot of optimization towards those things already.

Richard Hull: Let me add to that. I think you are right as computer scientists we're probably not so qualified, but there's some good news in some industrial settings and it started with Apple Computer and their approach to designing products. Apple pioneered a new way of thinking about making products, putting the user first, the consumer in their case. And so there has evolved a method that we call design thinking. And now at least at IBM, when we endeavor to create a transformation or some technology for a client, one of the first things we are doing is a so called "design thinking workshop". This is a systematic method of steps that we go through, starting with who are the stakeholders, who are going to be using whatever this technology is. And we think in terms that there might be multiple stakeholders and for each one systematically: what are they trying to do? What are they thinking? What are their pain points and what are the feeling? So, there's a strong discipline now of thinking in terms of the user as the starting

[1] See http://www.bmas.de/SharedDocs/Downloads/EN/PDF-Publikationen/a883-white-paper.pdf?__blob=publicationFile&v=3
[2] Alan W. Brown: A Leaders Guide to Understanding New Business Models in the Digital Economy. Slides and video recording of the keynote are available at https://bpm2017.cs.upc.edu/keynotes/keynote-brown-2/
[3] Miguel Valdés: Intelligent continuous improvement, when BPM meets AI. Slides and video recording of the keynote are available at https://bpm2017.cs.upc.edu/keynotes/keynote-valdes-2/

point before getting down to what are the kinds of solutions we're going to provide and then finally underneath that, what are the kinds pf processes that we will be setting up to support those solutions.

Person 1 in the audience: I think that what is happening when you get more computational power, is that you start to do more unnecessary things. It was the case before when you tried to break the Enigma: People calculates by hand and then suddenly you have a massive computer and you said: oh this computer will solve every calculus that is needed of mankind. And with more and more, we have more graphics, and now we have AI. So, what I actually want to say is that we're starting to do the unnecessary things, which will become more necessary, because of the experience. So, I totally agree with what you say. You start to do more things and you have more possibilities, so that is what will happen. And also maybe you can start to have new revenue streams from that.

Person 2 in the audience: Thank you very much for the questions before and your comment on the inter-disciplinary nature of how BPM has to collaborate with our disciplines, because I see a lot in the industries right now that BPM alone is not really surviving. We have to join with some other disciplines so that we could give the business value. Because right now the companies are facing not only how to improve the processes; but also how to find good people, how to really find a good profile, a fitting profile for the qualifications, that they are looking for. And that is coming to my first question about the vision within academia: how would you like to shape all the syllabus that you are producing right now to fit to the industry needs, because frankly I have to speak, we are working on digital transformations, and we hardly find people who can really do things. Most of the things people work, being specialist on some issues, but for some certain point of view in a company and doing digital transformation, you need good affinities on the technical side, you need an understanding of the organizational structures and people, and you need also to understand processes. And not every studying program provides this all, and you have to be a good project manager. So, the requirements of the industry is higher than before and they expect also that once that the students are getting out of the university, they have to work and they have to function. So that is my first question: How the academia has visions to change or to adjust the syllabus or to fit into the industry needs.

My second question is about the human factor in the BPM. I don't think it is just only the questions of how much automation and how much digitalization that we would need. Sometimes we are driven by some factors, especially the demographical structures change. I went to Japan last year and I visited a hotel, there is not a single person when I go to the receptions, there are robots. I got all my processes done via my mobile phone and because Japan is one of the greatest country that has an eldering or aging society and they don't have much workforce to really respond to the needs of the communities. That is one of the issues that probably we have to see how the technology could help and to what extent the technology could really deliver. What do you think in your opinion, up to what certain level of service delivery that could be really positive for the society? And to what extent of these kind of technologies, we are going to not be working anymore, if we see the issues from the theme "I, Robot" [movie from 2004], for example.

Hajo Reijers: So let me indeed try to pick up on the role of the universities may have, I think on the one hand we must be modest. I've been working in industry, I've been in touch with industry over the past 20 years, I always get request, why don't you train people more to do this because we need this more and we need that more. And I think what universities can accomplish in an educational program of students is in the sense modest. You cannot prepare people for all the challenges which are multifaceted as you are pointing out, a good project manager, somebody who knows from a technical perspective what's going on, the human side to it. You cannot address all these elements, but I do think that there is a fundamental change that needs to be made and I think you can also observe this in different settings where for example in educational programs, that I am aware of which were traditionally much more focused on a particular type of technology, in even the state-of-the-art of that technology, that there is a shift towards helping students assess the impact of these technologies, for example, in business process settings, where the technology itself is of course important and is current, but where there's a complete understanding that once the students will graduate that there will be new technologies. So, for example, in the curriculum that I am aware of in Amsterdam, courses relate to digital innovation where students take a particular technology and look at existing processes or existing business models to think through, how these things could be affected by incorporating new types of technologies. And of course the students have to understand that technology, but it's not so much the education on that technology, which is the essence of that part. And I myself am in favor of having people think, train them to rethink existing structures or existing processes with knowledge, profound knowledge, of new technologies. And I think that this is something that is very helpful to prepare them for, I would say, a situation where we are fully

aware that the technology and streams of new technologies will be evolving all the time. So, if you have this mindset that you are trained in changing existing structures, because new things happen, I think that is a very important strength for our future students.

Ingo Weber: I first would like to also address the first of the two questions. So if we want to *really* solve problems, quite often we have to work in an interdisciplinary way. I probably don't need people from other sciences to help me write a BPM paper. But if we want to, for example, apply blockchain in the food provenance sector, that is different. Wil [van der Aalst] raised a point I think two days ago: how do you know that the data that's on the blockchain, that is being fed into the blockchain, is actually correct. If you look at food provenance, let me give you an example: a box of prime beef from Queensland in Northern Australia makes its way to China, and somewhere along the way the prime beef in the box is being sold separately and replaced, and so it "multiplies". There was another example of a vitamin company, who produces I think one million bottles per year globally, and in China three million bottles of their products are being sold every year. So, with these issues, food provenance, medicine, etc. you have to understand that the product is genuine. And so, the data that is being fed into a blockchain solution has to be trustworthy as well. To come back to the beef example: we at CSIRO, we have different divisions across different sciences and sectors, so for example we have an agricultural business unit and they are looking at things like analyzing the beef and being able to tell from which pasture it came, on which piece of land the cow lived and fed. And if we combine that with blockchain, then of course we can get a very valuable solution in total. But I agree [with Gregor], we by ourselves might not be able to solve the real problems for the customer, so for the industry.

As for the second question about ethics: what I was referring to when I started talking about it, I think there was this example of one company from the Silicon Valley adding facial recognition software to one of their photo products, so it could recognize faces. And it turns out they trained this product only with the pictures from their employees, which were primarily Caucasian and Asian. And that led to a case, where the picture of somebody with an African background was then matched to a monkey. When we look at things like machine learning, we have to consider these issues that we don't have these kinds of racial biases in the training data and in the algorithms that we produce.

Claudio Di Ciccio: I like the title [of the panel] a lot, and AI, machine learning, blockchain, I see them as technologies. So the aim for which they are used might vary. I was thinking in certain cases, we like when computer-aided systems can prove to be more effective and more efficient, because they allow us to reduce the efforts and ultimately time, so we save costs, make more money, etc. But how about instead having another viewpoint, which is not necessarily using these technologies to make things faster, more efficient, quicker, whatever, but just to try to reduce the human risk. Like for instance, I remember during the Fukushima disaster, we sent human beings to check the situation, this is high risk. Maybe in that case the automation of this activity—I know I'm dreaming—would have been much more effective. So, instead of thinking about these techniques as eating the human factor, we can use these techniques to protect the human. [This is] question number one. The second question is more regarding the self-adaptation of humans. There are certain jobs that for sure are going to decrease in appeal and eventually disappear. But this requires people that were working in that area to re-adapt to do something different. However, we all here are into computer science or related fields, and we are quite used to change the topics of our research continuously, but some of us and our friends and relatives are not used to it. They can do one thing very well and then –this is like business process reengineering tasks–it could be hard to really re-adapt again. What I had in mind is that looking far ahead, couldn't it rather be the risk that having these technologies we can even increase the gap between who can actually have this at hand and who cannot. Because who cannot and does not adapt is left behind. And isn't this risky, in this case, for the human factor? Not directly, but rather for the evolution and self-evolution. Like big fish eats small fish.

Gero Decker: So let me address the saving humans question. I fully agree. Everything you said is totally correct. The one constraint is, what is actually accepted by people and where do they have reservation of applying that technology. I give you two examples that we were involved in and where we simply couldn't get through, although to us it was all obvious that technology would have been the better solution. One is recommendations for medical treatments. It is proven that if you take the knowledge that is out there and you derive certain rules from it, you let the machine learn certain things, then machines in many cases make better decisions than the doctors at hand. Yet doctors don't accept that and they refuse that type of technology. So, adoption is, at least in the cases we have been involved in, very minimal, because just of the reservations of the different people involved and having fear of letting go of certain things. Another example in Germany, a while ago we had a huge wave of immigrants, refugees coming to the country.

And all of the asylum applications where you basically decide whether to let that person in to grant asylum or to reject them was completely overwhelming the authorities. More than a million people came, and the agencies and the processes were designed to handle 50,000 cases a year. So, we brought in decision management technology and all of the good stuff that you can do with technology, and we said: look we can go from nine months cycle time of this process and we can nail it down to two or three days. From days of time spent on each case we can reduce that to one or two hours. And we can make better decisions with the technology and we can show that as a proof of concept that the technology actually delivers faster and better results, unbiased, much better than the people involved. And they would have been able to minimize the backlog like immediately and solve a huge problem for those people not knowing what their future is, whether they can stay or not and so on and so on.

But in this example, many people involved simply said they don't trust the machines. Let's rather hire 7,000 additional people to do the job. Did they find 7,000 people? Of course not. Did the backlogs go away? Not at all. Is it still a problem? Yes, just reservation and people not wanting to adopt technology. So, I think this is the biggest barrier. Maybe I am too optimistic of what technology can do and maybe I only see the good parts of it, but I think the bigger question or the bigger problem we have right now is that people don't adopt it fast enough.

Richard Hull: I just want to respond to your second question which was the adaptation of the workforce towards new kinds of jobs, and I want to make an argument for optimism. I think that there's a new research area that AI people could be looking at and it would be to combine two existing capabilities into a third new partial solution to the problem of retraining the workforce. The one capability is this notion of the AI-driven interaction with humans. We see chatbots and we see other kinds of conversational interfaces, we see virtual reality systems. Imagine if those things were aimed towards helping workers get into a new kind of work. So, here I have got a worker, he is doing one thing, now he is put into a new kind of position. Can we be coaching him, almost as if you had a human coaching him in the background, but now it's more an AI-driven system, so we can do it at scale. The second kind of technology that may be applicable here is this so-called education management systems and the idea of personalized education pathways. So we're starting to see this kind of technology of a digitized style of education, where for each student it takes into account what are their interests, what are their skills, what do they already know, what are their learning styles. It is an AI driven approach to cater to each individual in the best way. So, maybe in a few years we can take these two things, AI-enabled interfaces and personalized education pathways train workers in a much more efficient way.

Shazia Sadiq: I have a comment just for fun. So there's two futures sometimes, particularly around AI. There is the terminator future human of annihilation and then there is the Star Trek future of human empowerment. We as a community push the boundaries of human knowledge. Mathias [Weske in his keynote[4]] very nicely explained it in a sense that puts us in a position of responsibility to be careful with the narrative that we use in terms of technological advancement. So, will machines eat the human factor, why didn't we say machines amplify the human factor. So, I'd like to get your positions on it and it would be nice if you disagree, just for fun.

Hajo Reijers: First of all, I almost never dared to disagree with you Shazia. So, it's quite a challenge. So, if I understand you correctly, you'd like me to disagree with you turning this perspective, right? You'd like me to support the Terminator, the terminator future. I simply don't believe in that it is true, but I agree with you that framing and the way we talk about technology says a lot about, also may instill fear in people and how we talk about this. In the discussion that we just had, how easily we of course talk about technology and use of it as Rick did, which is a fantastic technology: AI, to train people for example, attain new jobs. The pure mentioning of AI, I would say for many people is already something which it instills fear, which is alien to elderly people, who already have a problem with working with their smartphone. How are you going to convince them that if they would use an AI training system to get on the path again? That's going to be a huge challenge. So, as in many things the way we position it, the way we discussed and talked about these things has an impact of course on how people will perceive this and how successful it may be. Even if we are on the path, if we all aim towards this, I would say more this Star Trek scenario. That's the best I can do.

Ingo Weber: So, this was exactly what I was getting at, when I said I want to look at the premise of the question, in my opening statement. To take a different stand, I am almost 100% convinced that there will

[4] Mathias Weske: BPM: Reflections on a Broad Discipline. Slides and video recording of the keynote are available at https://bpm2017.cs.upc.edu/keynotes/keynote-weske-2/.

be a percentage of people who won't be able to cope. They will be left behind. And that is what I meant with challenges for society at large in terms of wealth distribution and in terms of finding purpose in life. If you work, if you derive purpose from your work and of course you get a salary, that is individually of course a challenge if you don't have that anymore. But also for the state it is a challenge, because if some people don't receive a salary, then how do we raise taxes? Can we tax the work of robots or the robotic process automation? Probably not. So, I think there are many challenges and if you want to be pessimistic, then there is ample opportunity to follow the Terminator scenario.

Gero Decker: Let me jump in on that. The question is, what the scope of what you are looking at is. If you look at the world overall I believe in the Star Trek vision and technology amplifying what we do but that's often not the scope or horizon that people look at. So, for example, another scope for people, the more relevant scope might be, what happens to one particular company. And there is simply no way around getting the truth and what's necessarily going to happen, that there are organizations and certain industry verticals that are going through massive transformation. Where in five years from now, you will only see a fourth of the people working there. And there is no hiding from that. And people try to fight an argumentation: yeah, but we create all the jobs in other parts of the organization. No! 80% of the workforce will be gone in five years. That's the truth, because technology does the job better, more efficiently, with higher quality than what the people are doing today. And that is of course a difficult discussion with people. And people reject that thought, but these are then the kinds of people who perceive things as the Terminator scenario. So, then the question is how do you make it work for everybody? Because, if you compare the world now versus the world 50 years ago where people could stay with one company for the whole life, this is simply not the case anymore. And you need to educate people about that and show them the opportunities outside of the scope that they are currently in. But to those people technology feels like terminator.

Richard Hull: I'll try to be short but I couldn't resist the opportunity to be controversial. I think there are two forces driving how AI is going to get used. The one force is economic, corporations, business. What makes businesses run more profitably and so how are they going to want to use AI. That is one side. The other side is going to be basically the public. Public opinion – how academics are talking, how government is talking, etc. And that's going to have two different impacts. One is for the workers – businesses generally want their workers to be productive, so they will be paying attention that AI is used in ways that help those workers be more productive and they will also be making the human factor easier for those workers, enabling those workers. Now what about AI in terms of society at large. And this gets to all these ethical questions and my feeling is that corporations generally are not so worried about the impacts of AI at large, they are not so worried about, say, the influencers that AI driven recommendation engines or AI driven information sources, kind of lead to and etc. I think this is where there is the fear of kind of a Terminator future, but where the force of public opinion and governments and academic institutions will have to play an important account or balance.

Hajo Reijers: Short, two nice news articles, I read recently: one feeds the terminator scenario the other feeds the Star Trek scenario. The terminator scenario is that in 2020 it is expected that in Germany one out of five of the elderly people above 55, will live in poverty. That's in 2020 and its one of the richest countries of the world, which is showing that people cannot keep up. That is the Terminator perspective. Let's say the Star Trek part is about a new initiative that I read about, it brings together people of 80 years and older, who like to knit. And what they do is that they bring these people together which is fantastic for them to sit to be together and all be knitting and selling this stuff against design prices all over the world, because they are genuine granny wool shawls and what have you, and these people love it. There is almost no production cost and all the money they earn is fed back to these people, which is a fantastic initiative.

Jianwen Su: So I found these questions not interesting, because the interesting question is how machines will eat the human factor and this is a very broad question and there's a legal aspect for sure, there's a political aspect, there's a cultural aspect and now let me ignore all of these and come back to the technical questions. Actually, I want to come to the earlier question about adoption. Rather than complaining about politicians not adopting, let's put ourselves in their shoes and see what's going on out there. A month ago I sat in a room with hospital administrator on one side, researchers on the other side. The researchers were presenting fantastic results about thyroid cancer diagnostics, very nice results. But the hospital administrators did not have time to actually comprehend this, because they have to make real decisions to actually replace that particular procedure in the actual medical diagnostic process, and this is a big effort to do. Also, a few months ago, I read about Stanford Hospital, they have discovered a very

effective procedure to detect skin cancers. And they actually got 21 licensed practitioners, the doctors, in the same place and given them same pictures asked them to detect skin cancers and that is compared with the human, I mean the machine and the result is comparable. So now in Stanford's case, because in the [United] States, I know that they had to go through FDA approval and FDA had go through, it's a long process. Now I am thinking in these cases the hospital treating in Shanghai or FDA approval panel and what evidence can we presented to show them that this is really good. So now I want to get to the technical side of this, how can we assess the quality of these machines work in replacing humans work? So, do we need another profession, called maybe "machine humans certifier and software tester" to do this. Now getting more detail or closer to this community. I'm inviting the entire panel to speculate what are the technical questions, research questions that we can help to address this equality issue.

Hajo Reijers: So, I'm not sure if I can answer that overall question, but I know a little bit about the state of the art in skin cancer diagnosis. We are working together in the Netherlands with surgeons in this area and as you are saying, there's a huge increase in the accuracy of automated techniques to diagnose skin cancer indications. There have been all kinds of tests on these accuracy in labs and the results are stunning. The question is of course how and I think that is the way you position the question, how we can assess whether the use of these technologies will actually be effective. So what is happening now, what I'm involved in with a group of skin cancer surgeons in the Netherlands and a health insurance company, is that we are actually going to do a double process, so it's a methodological approach, that in one area in Eindhoven, where there is a group of family doctors, who are very open to innovation, that we are going to do both paths. So, it is incredibly expensive but we are going to follow the patients through the automated diagnosis, and the same patients going through the traditional process to determine the differences between, if there are any differences in their diagnosis and also the follow-up steps that are being suggested here. So, this is a really a methodological approach, it's not a technological solution but simply testing in real life, outside of the lab, whether and how these things can be applied. So, in a sense it's perhaps not the cancer, that you are looking for from a technological perspective but I think there's a lot of methodological side to it.

Ingo Weber: So for the blockchain side, this is something that we actually addressed in our report published in June, which was commissioned by the Australian Treasury Department.[5] One of the things that we said is: the legislator has to define what the rules are. Like, how can a company provide evidence that this is sufficient for the legislation. If you look at the Australian legal system, a blockchain transaction doesn't have any legal standing as yet, but an email, which is way easier to fake, has the same legal power as a letter with a handwritten signature.

And so the legislators, yes, they need to progress on that. I think yes, I agree with your statement, we basically need a profession of people who work for certification authorities who understand the machine learning and blockchain technologies etc. well enough to be able to make assessments.

Gero Decker: Maybe just the entrepreneur's perspective on that topic. My observation is bringing products to market in the medical space is incredibly hard due to all the regulation, clinical trials that they might have to go through and so on and so on. That's why my observation is that there is a lot less innovation happening, because there's a lot less incentive for people to do so. There's a lot less money around it seems, getting investment for these types of things is incredibly hard. I don't know if the system, like in terms of certification is too strict, I am not an expert for that, but my observation is just that, we don't see the advances we could see due to the nature of that and the smartest people staying out of that area.

Richard Hull: So very interesting question, how people trust a machine learning algorithm or an AI output more generally. I think there's going to be an evolution. Part of it is there's a lot of trust for human experts today, even though human experts will often disagree with each other. There's not a uniformity of opinion, when you get a bunch of human experts together. Take this panel as an example. I think part of helping people have more trust in machine learning answers will be making it more clear that human answers are not necessarily uniformly consistent. So, there's kind of a consciousness-raising that will go on.

I think often when people are doing medical procedures, they do try to get a second opinion. That's an illustration of people already saying: "oh, I know that humans don't have the absolute truth." At the same time I think there's going to be increasing trust in machine learning and AI, as it pervades our culture more and more as it improves. So as automated conversation systems get better, people will start to say: "oh, I

[5] http://www.data61.csiro.au/en/Our-Work/Safety-and-security/Secure-Systems-and-Platforms/Blockchain

see the computer is getting smarter" – this is the Star Trek version of the computer. And also I think as we see that in the physical world like the self-driving cars, which so far have a very low accident rate.

I see an evolution. The final point I'd make is this emphasis now in explanation of AI results. I know DARPA has put a big emphasis on that. I also start to see it around in the research community, so that putting the more human face onto something that was just a black box. This will be another contributor in the positive direction.

Jan Mendling: So we had various very interesting perspectives. I would now like to invite the panelists to maybe think for a second what could be one takeaway that you want to share with the audience in terms of what we have to do as the BPM community about this; and maybe I take the first turn. What I observe is that, at stages, we have been talking about the perspective of design. And design is something that is not only just technical, but it has a very strong connection with various organizational and psychological questions. In that regard, I'm very happy that we have a BPM management track in the future that helps us to reach out to other communities and bring in these perspectives. What does work in terms of processes, in terms of what do people accept, what do people adopt? I think this is important to reflect, not only what can be done, but also what really works. We as a community should address these questions. Maybe Hajo you want to start: What are your conclusions from these discussions.

Hajo Reijers: So, my conclusion follows up on the first question we got from Gregor. I see the future is bright if experts work together. I believe in, if we have been talking about a topic which of course has IT very central in it, I think computer scientists play a very important role in thinking through what these things will happen but they should work with other experts and I think that is something that the BPM community is especially good at. I think this is also something that Mathias told in his keynote that we always had this broader perspective that we welcome the expertise from other areas to look at the things we are studying. I also know from the people I work with, for example Barbara Weber likes to work with psychologists to address all kinds of interesting issues. So, my takeaway is experts should work together and we as BPM discipline are very well positioned to do so.

Gero Decker: I mean technology is exciting and but to me AI, machine learning, blockchain, they are all just part of a toolbox that you should keep in the back of your minds, don't get distracted too much by that. I think the big leverage of BPM is actually the human factor, so that's why I am super excited about this Track 3 to increase the importance of the people side of things and the management side of things in BPM. And to me, being a practitioner out there, this seems to be the biggest barrier to adopting all of the great things that we invent here. It's not so much that we tweak the algorithm from here to there but the bigger challenge is that people out there have to really make it work in the organizations. And I think the BPM community could help a lot more. People won't go away anytime soon, let's focus on them.

Ingo Weber: Probably allow me to challenge us as a community. Lately, whenever somebody in Australia talks about innovation and process in the same sentence, in excess of 90% percent of the cases they refer to robotic process automation. And I have not seen any papers, any works on this side in this year's conference. So, I think this is a bit of a black spot that we should invest in. When it comes to blockchain, of course, there are so many research opportunities, new business models that can be enabled by them. And I am very excited to be a part of that journey.

Richard Hull: Similar to Hajo, I want to come back to Gregor's first question, which was what can academia be doing to help train the workforce for the future. And I am reminded of something that IBM was pushing three or four years ago, maybe not as successfully as they wanted, but it was so-called Services Science and they said, that we need to think about employees of the future as having a fairly broad knowledge of different aspects of how companies run from maybe economics and management to different engineering disciplines and financial considerations and sales considerations. So kind of a broad knowledge and then also a specific area of depth. So maybe it would be depth in business process management, maybe data management, maybe economic factors, maybe finance factors.

I think that in universities, they do attempt to give that kind of shape. Somebody has a major, maybe it is computer science, but they are required to take a few courses outside their discipline. What's happened, though, is that the schools of engineering, the breadth is limited, and it's often things to do with science, with math, and other kind of technical considerations. Then the schools of Arts and Sciences, the humanities side, they have a notion of breadth and that breadth is history and sociology and languages. I think what could be advantageous is that if engineering schools would rethink what constitutes an appropriate breadth factor for their graduates. They could bring in ethical issues, they could bring in

design factor, they could bring in psychology and human factors along with concentrations in technical areas

Jan Mendling: Thank you very much, and with this, I want to conclude. Please reach out to your colleagues at your universities and to your practitioner partners who can bring in new and complementary perspectives into these discussions. It will be great to see some of these points being raised and analyzed in next year's BPM papers. Thank you very much for being here.

About the Authors

Jan Mendling is a Full Professor with the Institute for Information Business at Wirtschaftsuniversität Wien, Austria. His research interests include business process management and information systems. He has published more than 300 research papers and articles, among others in the *Journal of the Association of Information Systems*, *ACM Transactions on Software Engineering and Methodology*, *IEEE Transaction on Software Engineering*, *Information Systems*, *European Journal of Information Systems*, and *Decision Support Systems*. He is a board member of the Austrian Society for Process Management, one of the founders of the Berliner BPM-Offensive, and member of the IEEE Task Force on Process Mining. He is a co-author of the textbooks *Fundamentals of Business Process Management* and *Wirtschaftsinformatik*.

Gero Decker is co-founder and CEO of Signavio, a Business Process Management software company headquartered in Berlin, Germany. He was named "Innovator of the Year" by MIT Technology Review and received numerous awards for Signavio as one of the fastest-growing companies in Europe. Prior to Signavio, Gero has worked for SAP and McKinsey. He holds a PhD in Business Process Management from Hasso-Plattner-Institute and is a co-author of "The Process".

Richard Hull is a Senior Research Scientist at the IBM T.J. Watson Research Laboratory in Yorktown Heights. He received his Ph.D. in Mathematics from the University of California, Berkeley, in 1979 and served as a professor of Computer Science at the University of Southern California for more than a decade. He then spent over a decade at Bell Labs (first as part of Lucent Technologies, and then Alcatel-Lucent). While there his research impacted two products and he became a Bell Labs Fellow and an ACM Fellow. He joined IBM Research in 2008, working initially on data-centric business process and Business Artifacts; these became foundational elements of the IBM Case Manager product and the OMG Case Management Modeling and Notation (CMMN) standard. His current work is focused on infusing AI into BPM and applications of Blockchain. Dr. Hull is co-author of the book "Foundations of Databases" (1996), holds 12 US patents, and has published over 150 articles in refereed journals and conferences.

Hajo A. Reijers is a Full Professor of Business Informatics at the Vrije Universiteit Amsterdam, the Netherlands. He also holds a position as part-time, full professor at Eindhoven University of Technology. Previously, he worked as a management consultant in the BPM field for Deloitte Consulting and led an R&D team within Lexmark. On his topics of interest, such as process innovation and conceptual modeling, he published over 200 scientific articles, chapters in books, and professional viewpoints. He is one of the founders of the Business Process Management Forum, a Dutch platform for the exchange of knowledge between industry and academia.

Ingo Weber is a Principal Research Scientist & Team Leader of the Architecture & Analytics Platforms (AAP) team at Data61, CSIRO in Sydney. In addition, he is a Conjoint Associate Professor at the University of New South Wales (UNSW) and an Adjunct Associate Professor at Swinburne University. He has published over 80 refereed papers and two books. Prior to Data61, CSIRO, Ingo worked for UNSW in Sydney, Australia, and at SAP Research in Germany. While at SAP, he completed his PhD with the University of Karlsruhe (TH). He also holds an MSc from the University of Massachusetts, Amherst, USA.