August-Wilhelm Scheer

Enterprise 4.0 –

From disruptive business model to the automation of business processes

Volume

2

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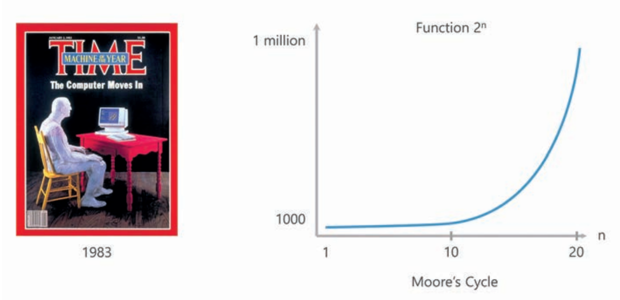

Figure 1.01: Time Magazine 1983 and Moore's Cycles

In 1983, the PC was distinguished by TIME Magazine as "Machine of the Year" (see Fig. 1.01), even though usually only important people are mentioned. Already at this time, the magazine wanted to highlight the great importance of the computer. Since then, around 20 Moore's cycles on the development of information technology are behind us, after each of which performance doubles. Performance has therefore increased by a factor of millions. Now quantity is changing into quality; possibilities to develop new products and processes are arising which were unthinkable just a few years ago. Catchphrases like "Industry 4.0" or "Software is eating the world" (Andreessen, 2011) are proof of the high expectations of researchers and practical experts in the power of digitization for change. Many changes in the private sector are already apparent through social media and the Internet.

This work will deal with digital changes by companies. In Part 1, drivers of success for the development of digital business models will first be analyzed and demonstrated using numerous examples. Subsequently, new business models will be developed as holistic industry concepts for consulting companies, industrial companies and universities. In this way, service, industrial and public organizations and a wide range of disruptive opportunities for change will be dealt with. They show the profound influence on structures and should inspire the reader to develop concepts for his own company.

Part 2 will deal with implementation concepts for the design and management of digital companies. This concerns above all the automation of business processes, because these form the core of digital business models.

In the foreground is the examination and assessment of the organizational effects of digitization, so that technical aspects should only be dealt with only as far as is necessary for their understanding.

The illustrations used throughout the book are available online as PDF at www.aws-institut.de/enterprise4-0.

Part 1: Development of digital business models

A. Drivers of success of digital business models

Roughly speaking, a business model is the way a company earns its money. This includes, for instance, a revenue model that describes who pays the revenues for a product or a service. This question, which at first appears simple, is already more complicated in the digital world. For example, the users of social media services receive the services of the provider virtually for free, because the provider earns revenues through income from advertising. Here the rules are being bent and this makes the issue of revenues more complicated than it seems at first glance. Another aspect of a business model is the description of the resources required. This includes information about important partners. A differentiated description of additional components can be found in Osterwalder & Pigneur, 2011. There, a total of 9 building blocks for a business model will be mentioned, to which a brief commentary with reference to digitization will be added here:

(1) Customer segments

It is a fundamental questions in digitization whether the company wants to serve the B2B, B2C or B2B2C market. At the same time, there is a strong trend towards supporting the end customer.

(2) Value proposition

In digital business models, business is directed more towards customer needs through outside-in thinking as against inside-out thinking.

(3) Distribution channels

With digitization, there is the demand for omni-channel approaches, in which all channels such as stationary distribution, telephone, computer, Internet, call center and mobile connections are integrated.

(4) Customer relations

These are becoming more intense in the digital world through the use of social media.

(5) Sources of income

These concern the complex revenue models of platform companies already addressed.

(6) Key resources

In the case of exponentially growing companies, these are kept as low as possible. In particular, no time- and capital-intensive material resources in the form of factories or buildings need to be built or a large employee base established.

(7) Key activities

These describe the most important activities of the business model and therefore also define the need for resources. In the case of digital business, this should be as low as possible.

(8) Key partnerships

In the digital world, this means to outsource many activities in order to accelerate growth.

(9) Cost structure

By replacing material with information, digitization tends to lead to lower costs than in the analogue world. This is an important competitive advantage.

The approach of Osterwalder and Pigneur is tried and tested in practice and provides some good insights. The elements of the approach will therefore be addressed frequently below. However, in the foreground we find the effects of digitization on the elements of business models, which are described as the drivers of success of digital business models. These enable new business models.

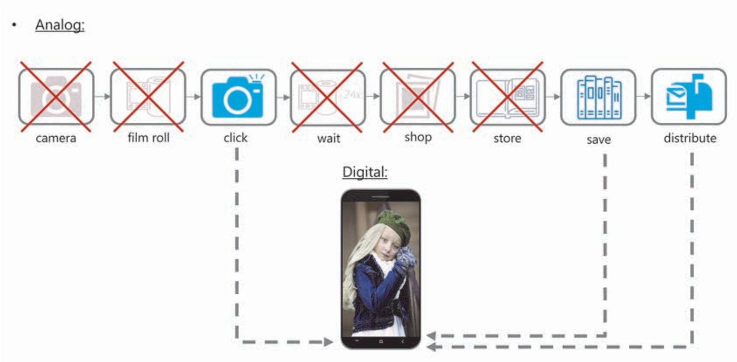

Figure 1.A.01: Disruptive Innovation: Photography-process

The development of disruptive business models is typical of digitization. A disruptive business model describes where a given product or a given service is totally redefined by digitization, existing providers lose their economic and technical competences and new providers appear which oust the previously successful companies. In Fig.1.A.01, this can be seen using the example of the process of photography. In the analog world, one previously needed a camera and some film. One could then photograph a subject, but would have to wait so long until the complete film was used before developing them. These would then have to be taken to a photography shop to be developed, incurring waiting times. After receiving the prints, these would be stuck in an album. If additional prints were required - to send to friends, for instance - these had to be produced again at a photography shop and sent by mail.

Figure 1.A.02: Disruptive Innovations/Innovator's Dilemma

This entire process no longer exists today. With a smartphone, photography is just one of many functions. It is almost always available and images can be viewed immediately, stored, and then sent all over the world at the push of a button. This disruptive innovation has led to far-reaching changes in the market (see figure 1.A.02). The global company Kodak, with tens of thousands of employees, had to file for bankruptcy in 2012. The online company Instagram, for editing and sharing digital photos and videos, on the other hand, was at the same time sold to Facebook for about one billion US dollars. Fewer than 20 employees operate the online service. A particularly bitter point is that Kodak held the patents for digital photography, but was unable to successfully exploit these.

It therefore applies for all the drivers of digitization dealt with in the following that existing companies must carefully examine their business model as to whether and in what form they can include the effects of digitization in their model and how they can prevent internal resistance.

At the same time, the founders of companies can start in green pastures, constantly develop new business models from the combination of success drivers of digitization and take on existing companies.

I. Opportunities for start-ups

This leads to the first driver of new business models: that existing companies have difficulty fundamentally changing their business models and therefore start-up companies offer the opportunity to change the market disruptively and aggressively. One reason for this is the well-known phenomenon of the "Innovator's Dilemma" (Christensen, 1997). It describes that existing, successful companies protect their existing competencies for too long. Human factors also play a role here. Managers who were previously successful in their environment and with their skills can only be moved with difficulty to pass on their position to new, younger employees with other skills.

Fig.1.A.02 shows examples of disruptive digital innovations and business models. The online company Airbnb, which does not have its own room capacities, but merely connects (private) providers of accommodation options with those looking for accommodation, already has a market capitalization on the same scale as well-known international hotel groups.

In the time in which the company Amazon rose from a company in a garage to a global enterprise, the traditional German company Quelle had to file for bankruptcy. Both had mail order as their business model - Quelle more on the basis of a paper catalog, while Amazon already captured the digital world.

A revolution is also coming in the automotive industry. Besides the digitization of infotainment applications, the electric drive is also a challenge. Both developments support each other and show that digitization can also be combined with other technologies. 3D printing is another example of this.

Existing successful companies are therefore well advised not to rely on their past successes, but rather to attentively and self-critically observe the phenomenon of the innovator's dilemma.

In the first wave of digitization, such sectors which create “information-like” products or services (e.g. media companies) were changed, but sectors which create material products will also be changed in the next innovative thrusts, whether their products are enriched by digital services, replaced by digital services or changed with new technical procedures supported by IT (3D printing, electromobility).

The drivers of digitization highlighted in the following are personalization, self-control, the increasing occurrence of products with low marginal costs, smart services, community effects, lean organization with exponential company growth, artificial intelligence (AI), infrastructures and new forms of enterprise which are described as platform enterprises, and which edge themselves as agents between customers and suppliers.

The large number of drivers of success and their diversity show the revolutionary force of digitization (Brynjolfsson & McAfee, 2014) Thanks to different structures and weighing of drivers, a multitude of new products and processes is arising in all sectors. In doing so, the connection between product and process is very close and in many cases, in particular for services, is identical. This work therefore focuses primarily on the development of digital processes.

II. Personalization/Individualization

Who would have thought that people want to order their muesli individually mixed over the Internet. The online company mymuesli.com has however done precisely this rather successfully. The possibility to orientate marketing, products and services to the individual wishes, needs or abilities of the customers seems unlimited (see Fig. 1.A.03). In this way, messages can be configured to personal interests by, for instance, sending sports news immediately, while cultural or political events are offered rather low down in order of priority. Digital learning offers (e-learning) can be configured to learning speed and the special interests and abilities of the learner in terms of content and relating to different learning resources such as texts, videos or educational games. However, material products can be individualized even more so. Contrary to Henry Ford's motto in the 1930s that “A customer can have a car painted any color, so long as it's black”), the automotive industry has since expanded its offer to an almost incalculable number of variations of colors and feature requests.

This trend of personalization is expanded by digitization. For example, furniture can be designed by the customer online by individually designing cupboards or shelves by width, height or shape, as indicated in Fig. 1.A.03 by the company Okinlab in Saarbrücken. Using a simple CAD system, the end customer designs the individual product, the geometry of which is then implemented in corresponding NC programs and then produced by carpenters with NC-controlled machines. Running shoes or ski boots are also a well-known example of individual products. In a sports shop, the customer can have their feet scanned, and then production is based exactly on his individual dimensions. The Internet provides the rapid transmission of data and supports logistics.

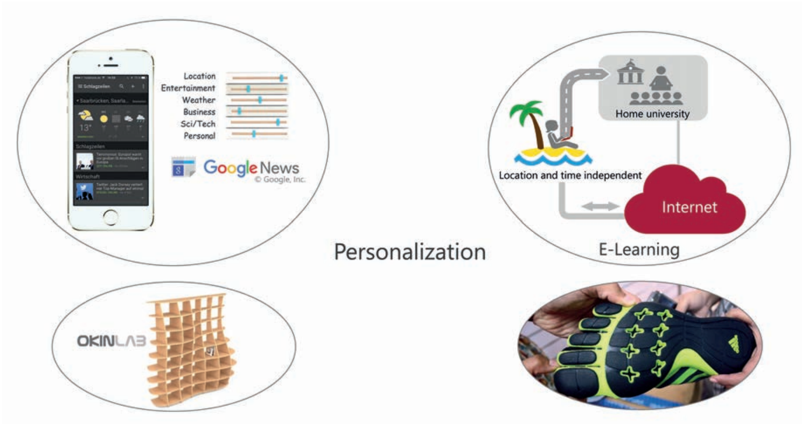

Figure 1.A.03: Personalization

Further examples include:

In the clothing business, the customer is "scanned" in a digital changing room, and his digital twin is then clothed in the items he is interested in, without having to physically put them on. The customer then looks at his digital likeness from all sides and can select the product that he likes best.

In modern dental practices, an artificial tooth is designed on the computer, adjusted precisely and then produced individually and immediately with a 3D printer. For the patients, this means no more troublesome dental appointments and examinations because almost the entire process is handled digitally.

The cases mentioned are only a small selection. Further examples include individual insurance, which is based on the personal behavior of the customer with respect to his style of driving or his health-conscious lifestyle.

Every existing company must therefore consider how the products and services offered can be further individualized through the opportunities of digitization by thinking ahead for more variations, or the customer is involved directly in the design process online.

Start-up companies can consider how they can take on standard products of existing companies through aggressive individualization. The example of mymuesli mentioned at the start demonstrates this route, but the individual configuration of bicycles, insurance services, credit and forms of mobility open up many new business models.

III. Self-control

The next driver of success of digitization is self-control of objects. This means that the control of the objects is largely taken over by oneself and a higher-level control level is thinned out or is even dropped entirely (see Fig. 1.A.04).

In the concept of Industry 4.0, intelligent materials and resources control themselves independently. The machines know their technical skills and their capacities. Intelligent materials know which technical operations they need. Both communicate via the Internet of Things (IoT) and co-ordinate the production process via a type of market place. There is no need for a higher-level production control system, or it only intervenes in special cases.

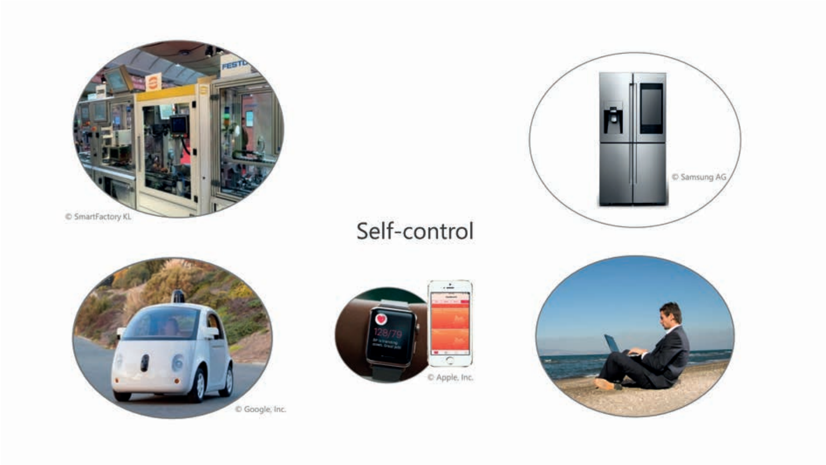

Figure 1.A.04: Self-control

In the household sector, the self-controlling refrigerator is a popular example. Although it was ridiculed at first, it became reality at the Consumer Electronics Show in Las Vegas in 2016 in the form of the refrigerator exhibited there by Samsung. The basic idea is simple: Why should a person open the fridge door and, for instance, open a packet of eggs only to find out that they are needed if the refrigerator already knows what it contains. The refrigerator can then independently fill an order online.

The autonomous car, characterized here in Fig. 1.A.04 by the often-cited Google Auto, is another example of self-control. Why should a chauffeur take over control if the destination and route are known online and the car detects the traffic situation using sensors and can independently select and execute the route? Here too, a vision, which at first seemed futuristic, is already well advanced. The transition from assistance systems to autonomous driving is therefore in sight for road and rail vehicles.

The principle of self-control does not however only apply to devices, and people too are striving for more autonomy through digitization. Several hundred sensors are already contained in the modern vehicle, which measure all possible internal and external conditions. On the other hand, if a patient goes to a doctor for a routine visit, no more than ten indicators about his health condition are generally detected. These include, for example heart rate, temperature, eye response, coating of the tongue etc. Many of these measured values, and many more, can today be recorded by “Wearables”, symbolic of which is the Apple Watch. It is conceivable that the medical conditions of the person as well as his activities will be constantly recorded, evaluated and suggestions for behavior or medical recommendations will be processed using artificial intelligence or medical recommendations. The patient therefore takes more and more responsibility for the control of their own health. The number of doctors making examinations will therefore be thinned out. Of course, a patient also requires a surgeon or at least a surgical robot in the case of a knee joint graft. Nevertheless, here too the artificial knee can be created individually and automatically from the scanned, digital 3D knee model using CAD/CAM processes and then 3D printing.

The Internet allows people to have greater self-control over their professional work. So-called digital nomads offer services independent of location and time, such as app programming, which they over via Internet platforms. They are therefore no longer integrated into companies in hierarchical systems by fixed employment contracts, and instead determine the forms of work, employer, work times and scope of work themselves as a freelancer.

In many sectors, so-called intermediaries are set between the partners in a business transaction, such as a bank in a transfer between two partners. The bank slows down processes and incurs costs. By using blockchain technology, so-called cryptocurrencies eliminate the classic banking system and the partners can execute the transfers directly peer-to-peer. Such decentralized approaches on the basis of blockchain architecture, which will be dealt with in greater detail later, can also make notary and land registry officials largely superfluous as intermediaries, while the acting partners take care of the business transaction themselves and document it using a blockchain application.

These are only a few examples, which should make the broad range of opportunities for self-control clear. What is important is to recognize the underlying principle in order to use it to change existing business models, or to develop new ones.

IV. Products and services with low marginal costs

In his book, “The Zero Marginal Cost Society”, (Rifkin, 2014) Jeremy Rifkin emphasized that more and more material products, but above all services, can be produced and disseminated practically without marginal costs. The Internet demonstrates this already in information-like services. The creation of information does indeed cost money, as before, but it is possible to spread it through the Internet for practically nothing. Fig. 1.A.05 demonstrates this for phoning and the aforementioned example of photography. Through Internet services like Skype, it is possible to make phone calls at almost zero marginal costs, even with convenient video support and over long distances. Photography with smartphones also incurs no marginal costs for the user. Taking an additional passenger in a vehicle is also virtually free of marginal costs. The same applies, for instance, for a guest staying overnight in an otherwise empty room with the aid of Airbnb. In the case of 3D printing, material products are created from simple materials like sand. Here too the marginal costs of production are relatively low.

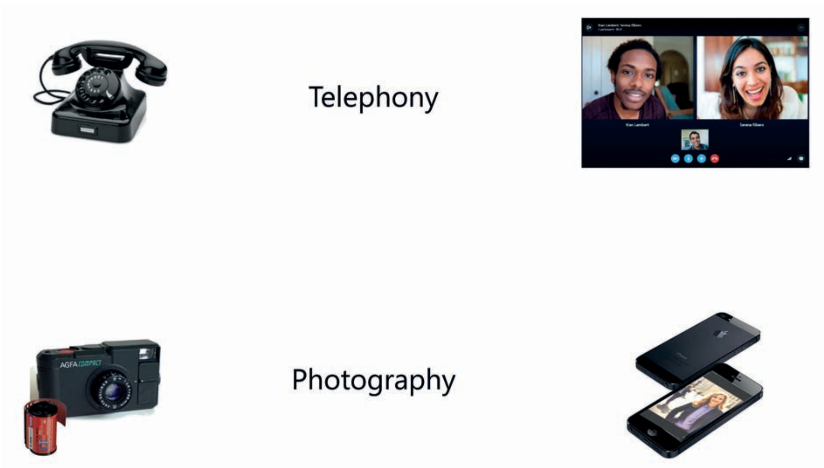

Figure 1.A.05: Zero marginal cost products

This effect has far-reaching consequences. The creation of resources then becomes a common task, as is the development and maintenance of the Internet; use is then largely free of marginal costs. Rifkin calls for new cooperative structures in order to be able to jointly develop and use resources.

Since the elimination of costs and therefore revenues tends to reduce the economic national output, this alone is no longer meaningful as the measure of the well-being of a state.

By using zero marginal cost effects, even start-ups can pose big problems for established companies with cost-intensive variable costs, as demonstrated by Uber or Airbnb.

V. Smart Services

The Internet allows supply and demand for products and services to be linked more easily and in this way opens up new intermediary services. At the same time, new business models for data services can be developed thanks to easy capture of a variety of data (keyword: Big Data) and its intelligent analysis (Smart Data).

Figure 1.A.06: Smart Services

Fig. 1.A.06 presents Internet-based mobility as a service. More and more people, especially younger people, realize that the possession of objects is less important than their availability. As a result, it is no longer owning a car, which is desirable, but rather its demand-driven use. Here, mobility requirements can be easily found via the Internet through car-sharing.

The car then loses importance as a material product and the service comes to the fore. This means that the high number of variants in the fittings of a vehicle will probably become less important and therefore material vehicles will become more standardized. As a result, the manufacturer’s competence to control complexity for the production of a high number of variants loses its significance as a competitive advantage.

In doing so, the principle of individualization must not become meaningless. Rather, more focus will lie on digital services. The autonomous vehicle ordered from a pool then, for instance, recognizes the orderer and independently sets up functions for infotainment, such as favorite stations on the radio, information services, favorite routes etc.

Industrial companies can improve their maintenance processes for their products by recording the behavior of the machines installed with their customers using sensors, and then analyze them using the Internet. Using prediction algorithms for faults, the maintenance intervals can be optimized (predictive maintenance). In this way, the manufacturer can make cross-comparisons of all of the machines installed with many customers in different environments and thereby possesses a more substantial database as compared to a single customer. The “predictive maintenance" business model will be discussed in more detail below in the context of "Industry 4.0”.

New architectures such as blockchain can not only radically change the financial world using cryptocurrencies, but can also influence all industries in conjunction with Smart Contracts. This too will be explained in more detail later in Part 2 “Automation of Business Processes".

The development of Smart Services is one of the most important fields of innovation for new business models by existing companies and start-ups.

VI. Community/Swarm Effect

Community or swarm effect means that the benefits of participating in a group are greater the more members it has, and that easier solutions will be developed in a team than by an individual. Therefore, with product developments and with the aid of the Internet, it is not only a development department established especially for this within the same company that can be used, but instead all interested employees of the organization - but also customers, suppliers or partners all the way to the anonymous community of all interested developers around the world - can be addressed. This effect, known as "Open Innovation" has already led to impressive results. The operating system Linux is a well-known example in software development. The motivation of experts to be involved in the development of a new product or solution to a problem can be supported by incentives, such as the award of prizes or cash-equivalent tokens for successful solutions. Similarly, there is support for the collection of funds for the development of ideas and products via Internet platforms (crowd funding). Platforms like kickstarter.com are awakening the interest of individual customers by making a fixed pre-order, where applicable also with an advance payment on the product to be developed, and then will be served with high priority following successful development.

In the case of cryptocurrencies, an unregulated procedure to issue a new currency is used via an Initial Coin Offering (ICO) in contrast with the regulated Initial Public Offering (IPO) at a traditional stock exchange. The customer will then be given a certain number of coins of the new currency at a preferential rate of an existing currency. Intermediaries, like the classic banks or stock exchanges, are shut out. The participants then finance the development of the currency through the ICO.

VII. Lean Organization and Exponential Growth

A further driver of success of digitization is the simplified and streamlined form of organization to develop and distribute new products and services made possible by the Internet. This difference already became clear from the photography example of the comparison between Kodak and Instagram. While Kodak, as a global company, had factories and extensive distribution organizations at its disposal, in which tens of thousands of employees were employed, the company Instagram was founded by only twelve staff. While many of the classic companies in the automotive, electronics or chemical industry employ several hundred thousand employees, many newly founded Internet companies, measured in terms of their EBIT, turnover and company value, have only a small number of fixed employees, hardly any factories or stationary distribution centers. As a result, the fixed costs of the organization are kept low. At the same time, they can offer their employees particularly lavish support and salaries and create excellent opportunities in the "war for talents".

The Tesla electric car company does not distribute its products through the classic expensive branches or agencies, but predominantly via the Internet. Also new Internet-based banking services, such as those developed by so-called FinTechs or cryptocurrencies, require no glass high-rise buildings or large branch offices, just an Internet platform. The buzzword "asset less organization" vividly describes this trend.

Internet companies gain great competitive advantages thanks to these lean organizations, which creates problems for the classic company. The reaction of big banks to reduce their branch networks, or to promote direct sales in industrial companies, are an indication of the seriousness of the threat.

Successful digital enterprises can therefore grow extremely quickly. Their growth is not tied to the recruitment of staff, but the dissemination of information as part of the business model is carried out almost independently of resources. This explains, for example, the growth of companies in the social media sector, or also companies that place services, such as Uber or Airbnb. This exponential growth has been highlighted and described in particular by the authors Salim Ismail et al. in their book “Exponential Organizations”. (Ismail, Malone, van Geest, & Diamandis, 2014)

VIII. Artificial Intelligence

The term "Artificial Intelligence" (AI) comprises algorithmic processes that take over the cognitive abilities of humans. These are for instance logical reasoning, decision-making and judgment or analysis functions. The term was coined in 1955 by John McCarthy at a conference in the United States. Machines should behave as if they possessed human intelligence. The sector initially had a blooming phase, then receded as a result of excessive expectations and has since taken on a new dynamic thanks to improved computer performance and evolved algorithms. A variety of mathematical methods are included under AI, which at the time were also already known in mathematical statistics and operations research. There are now also new processes. With artificial neural networks (ANN), attempts are being made, for instance, to emulate features of the human brain. Here too, disappointments came after an initial euphoric phase and the subject was not brought back up to date again until recently. This applies above all for methods of "Deep Learning", whereby multi-layered artificial neural networks are used. Astonishing advances have been made here in recent years in the fields of face recognition, games like chess, Go or Jeopardy, machine translation and general pattern recognition.

Since AI and in particular ANN are increasingly being used in many digital applications and business models, the principle of ANN should be explained in more detail. Several concrete application examples will be provided in Part 2 "Automation of Business Processes".

A simplified ANN is represented in Fig. 1.A.07. It consists of an input layer, several intermediate layers and an output layer. The layers are provided with several neurons with their connections to upstream and downstream neurons. These connections are assigned weights, which at the beginning are set as random figures, and then are changed (learned) in the course of the procedure. A vector with the empirical features of the object is entered as input. In the simplified example of face recognition, see Fig. 1.A.07, these features are eye color, nose length and distance between the eyes, which are automatically calculated from the pixels in a photograph.

For each neuron x_j^{e+1}, in each layer l+1 the values of neurons x_i^e of the previous layer l will be multiplied with the weights $w_{i,j}^e$ and added with all the neurons of the previous layer. This provides the output value x_i^{e+1} of neuron j of layer e+1, which is then the input value for the next layer. Here too, the value of a neuron comes from the sum of the products from the output values of the previous neurons with the weights. This process is then continued across the layers up to the output layer. In doing so, the values of the layers are generally standardized in the region from 0 to 1. Other transformations can also be carried out, such as eliminating negative values.

Complex, non-linear relationships can therefore be recorded. The faces recorded in a database, including the face considered, are included in the result set.

As results, they are allocated probabilities with which the input values of the case match the features of the stored faces.

Since both input and result are known during the training, that is to say one of the saved people receives the true Probability of 1 and the others the value 0, the deviations from the output values are also known.

Within the scope of back propagation, these deviations (errors) serve to adjust the weights of the previous layers through a mathematical method and therefore represent the actual learning process (Ertel, 2016, S.291ff.).

The coefficients (weights) of the neurons of an artificial neural network are trained by handling many cases (hundreds of thousands and more), and the model can then be applied in the application phase to predictions (predictive analytics) and decisions. In doing so, each new case in the application phase is also used to adjust the coefficients and therefore to further improve the model. The process is therefore also described as self-learning.

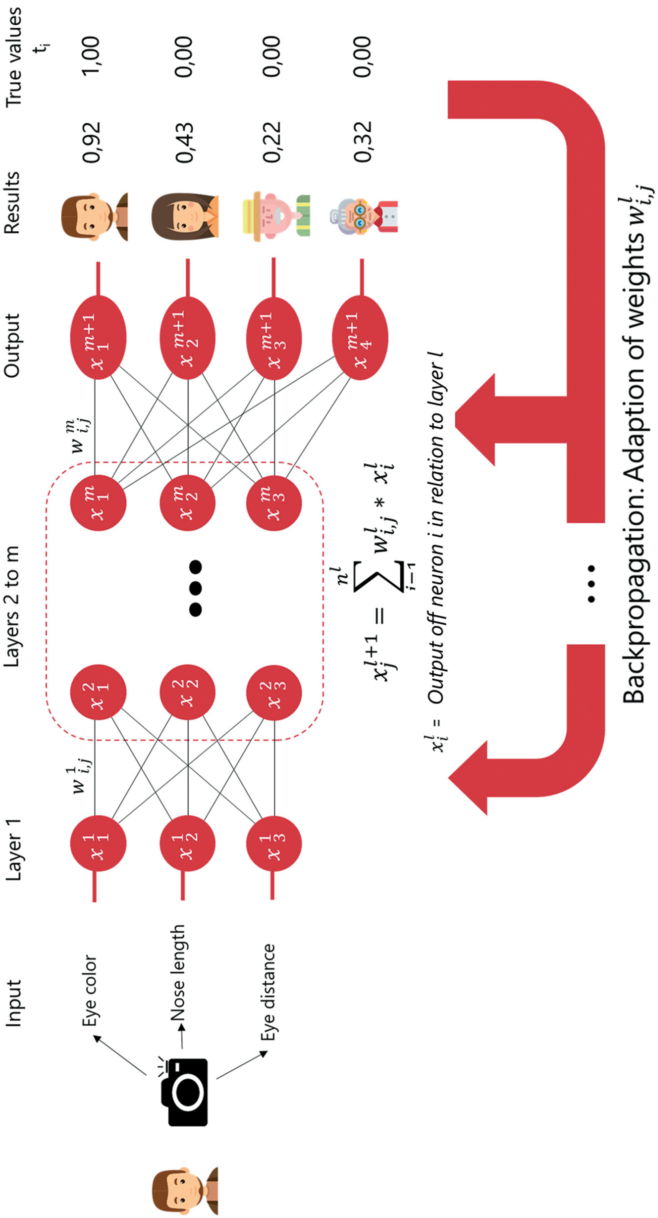

Figure 1.A.07: Artificial Neural Network

The example dealt with is of the type classification models, in which probabilities are output as results. In addition, there are regression models, in which feature values like expected turnover for coming periods, predicted time of a result or the like are output.

The user of an ANN must first determine the model, which includes the input features, the number of layers and the number of neurons per layer. The applicable algorithms also need to be determined. Algorithms to determine the weight as well as back propagation will then be provided in method banks. Through trial and analysis of several models and processes, the user can find the model with the greatest power of prediction.

There are no hypotheses in the approach of Deep Learning. The user is not therefore given a substantive (causal) explanation for a result. This is often cited as a point of criticism against deep learning. Therefore, an attempt should be made to select a model that includes a certain plausibility, e.g. input features, from which a plausible relationship to the result can be expected. It is even suggested to give preference to a statistically accurate model in case there is doubt that the model is plausible, which delivers no clarification in terms of content. In more recent times, attempts are being made to remedy the shortcomings in the explanations, for instance through sensitivity analyses of the input values.

The results of deep learning can then be used for decisions. For instance, if a model to classify customers with regard to their purchasing behavior is used with the features “strong”, “medium” or “low”, then individual marketing measures can be oriented according to this. In this way, one can focus on measures for the individual medium-sized customers because the strong ones are already good customers without having to do anything else and the weak promise little success following any measures (Finlay, 2017).

AI processes are being used increasingly in digital business processes. Mass data from customer contacts or social media as well as sensory data from the Internet of Things can no longer be handled and analyzed by people, meaning that automated processes must be used in order to transform data into knowledge. Companies can therefore analyze their customer relationships to use results for marketing activities or also to make their existing products “more intelligent". IoT data can be used for new services such as "predictive maintenance" or for traffic control. In products that are becoming increasingly material, like automobiles, but also in digital services like navigation systems or search engines, artificial intelligence processes are included. The increasingly important voice control of systems is also unimaginable without AI. Due to the high digital transformation power of AI, it is an essential driver of new business models.

AI systems will not of course replace people entirely, because besides cognitive intelligence we also possess emotional and social intelligence. It has been possible to train football-playing, technical robots to make the double-pass play with great effort, because they were initially trained to look for the shot on goal themselves. To pass the ball to another robot, on the other hand, requires social intelligence.

With his capacity for creativity, recognizing complex situations, holding complex conversation and coping with many daily actions, a human being still has a great advantage. However, artificial intelligence is getting closer to natural intelligence. Features like automatic recognition of handwriting and images, creating forecasts, recognizing patterns in large volumes of data, visualizing results as well as understanding and translating natural language are already highly advanced. Machine learning with ANN plays an important role here.

IX. Infrastructure

Cloud computing and blockchain are among more recent technical developments in IT infrastructures with large organizational effects of digitization. They will be mentioned only briefly here and more detail will be provided in Part 2 of the book.

In the case of cloud computing, data and software will be stored, maintained and operated centrally in server parks and the user accesses their services using simple end devices. Cloud computing opens up simple and cost-effective access to IT resources for start-up companies in particular. It requires no separate investment and a growing demand can easily be met with additional leasing from the provider.

Blockchain architecture has achieved a great deal of attention through so-called cryptocurrencies. Essential features include a distributed database without central control (peer-to-peer), high security of data and transactions through complex encryptions and anonymity of the users.

Besides financial service providers, blockchain architecture is inspiring other sectors to create new business models, while intermediaries are no longer required in business processes and the processes are streamlined through decentralized peer-to-peer connections. Security and trust are transferred from the intermediaries to positions in the decentralized, distributed network and this replaces them.

X. Platform Companies

So-called platform companies have one of the largest market effects arising from digitization. They bundle and use many of the drivers presented and in a short period have developed into dominant players in B2B and B2C markets. They have the highest market values and are taking on classic industrial structures.

Customers and suppliers or general partners can be more easily identified via the Internet in terms of their common interests and can be connected to one another. This applies in particular if there are not yet any individual relationships between them and there is a large number of partners to be connected. Platform companies emphasize this agency as the core of their business model (Baums, Schössler, & Scott, 2015). They push themselves between a customer-supplier relationship (see Fig. 1.A.08).

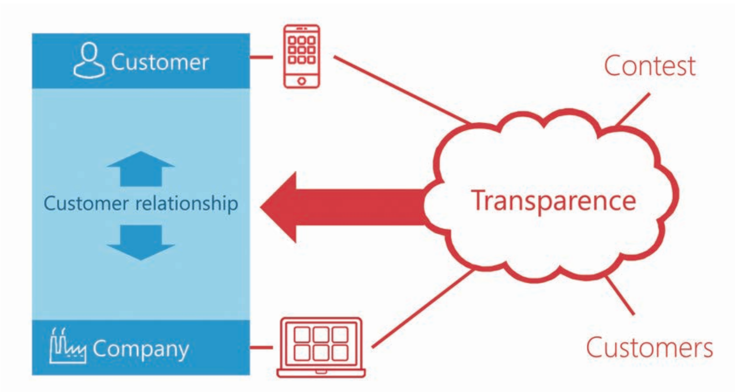

Figure 1.A.08: Platform companies push themselves between customers and suppliers

Organizations, whose business model is the agency between suppliers and consumers, are not new. Goods and securities exchanges have been around for centuries. It is significant that these exchanges have already been extensively digitalized. They largely conserve their given structure and their processes, however. Banks also mediate between people who want to lend money and people who want to borrow money. In doing so, they bundle the deposits and lend them in new tranches. These evolved processes have since been extensively digitized.

Traditional retail companies are also tending towards platform companies if they extend their customer base by opening an online shop across regions and thereby become more interesting for new suppliers. Conversely, they feel greater competition through market transparency if customers can make a quick price comparison with other providers (platforms) online at the till and the sellers are confronted with a more favorable offer (see Fig. 1.A.08).

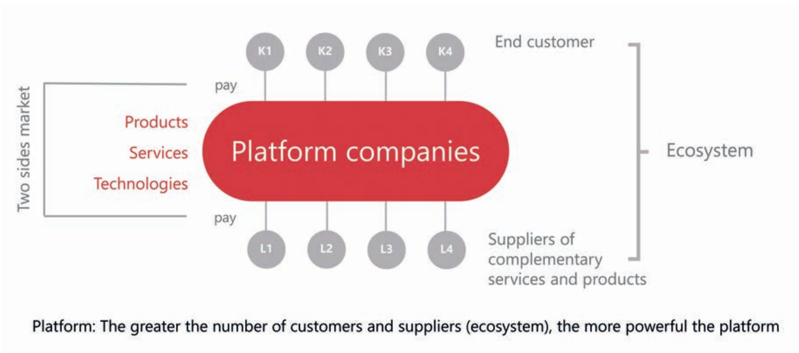

Figure 1.A.09: Platform markets

The architecture of platform companies for a customer-supplier relationship is represented in Fig. 1.A.09. The more customers who make their purchases over the company's platform, the more attractive it is for suppliers to offer their products on the platform. Conversely, the platform is more interesting for customers, the more suppliers who use it, so the greater the offer on the platform is. Successful examples of platform companies of this kind include Amazon, Apple Store, Zalando or Ebay.

Besides the pure agency function (matchmaking), other services like quality assurance, bundling effects or value-added services as well as material products will be offered by platform companies. This creates a large variability in the services.

Platform companies not only want to digitize old structures, but rather revolutionize the business model using new processes. The ride sharing company Uber does not digitize the existing taxi business, but rather opens up a new (private) driver group. The same applies for Airbnb, which does not digitize classical hotel processes, but rather opens up new groups of providers of accommodation options.

The ecosystem of a platform is determined by the customers and suppliers connected with the platform. The platform maintains a market relationship with both customers and suppliers, for which it demands a payment (Rochet & Tirole, 2003). Therefore, from the point of view of the platform, both customers and suppliers possess customer characteristics, while a customer-supplier relationship exists between the external parties regarding the service to be conveyed. The more customers who decide on a platform and the more suppliers who connect themselves with the platform, the more powerful it is. This explains why many start-up platforms initially do everything to get as much traffic, so as many customers and suppliers, to commit to them. This is achieved in part through free use opportunities or even through subsidization. For instance, the providers of computer game platforms subsidize the purchase of gaming consoles in order to then collect high fees for the use of their platform operating system from the providers of games.

In terms of market theory, the success of platform companies can also be explained in that, through the Internet, hierarchical organizational structures tend to loosen and be replaced by market structures (Picot, Reichwald, & Wigand, 1998). The hierarchical principle of an enterprise with local presence of employees and their co-ordination through (hierarchical) instructions are practical when it is a matter of processing complex tasks. Here the work is coordinated through direct personal communication and the project teams are made up of permanent employees.

By using information technology (e.g. video conferencing or groupware), more and more complex tasks can be coordinated while the people executing the tasks are in different locations. The composition of teams is also supported by sharing platforms. This also explains why the concept of digital nomads or geographically distributed software development and the processing of consulting projects are possible by freelancers.

There is therefore a trend to loosen fixed hierarchical structures through market structures, whereby coordination through voluntary agreements between suppliers and demanders is governed.

A platform can even be seen from a technical point of view and therefore provides a software solution, on the basis of which the transactions between suppliers and customers are processed. If this platform is oriented towards content problems, then it will be enriched by contextual references, such as a platform to intermediate financial services, insurance, mobility or entertainment.

An existing company must decide how it wants to be and can be integrated into a platform architecture. If it strives to operate a platform itself, it must use a software solution to do so and enlist as many customers and suppliers as possible. If, on the other hand, it wants to develop complementary products or services for an existing platform, it takes on the role of a supplier. It is obvious that the more difficult part is operating the platform, but, as indicated by naming the most valuable companies, it is also the most lucrative.

Suppliers can strengthen their role vis-à-vis platform companies by bundling suppliers themselves and bringing in their own customers in cooperation with the platform companies. They thereby practically set up their own (simpler) platform enterprise and network themselves with the structures above. This creates networks of platform companies.

An interesting development can currently be observed on the automobile market. The material vehicle stood and still stands as the focal point for the large automobile manufacturers such as Volkswagen, BMW and Daimler-Benz and therefore defines automobile platform companies. The customers are the buyers of these cars. Complementary suppliers include for instance suppliers of components like navigation systems or licensed spare part producers. The vehicle itself is created by an established hierarchy of suppliers. These are not part of the platform concept dealt with here, but rather form a supplier-pipe architecture.

It is well-known that IT companies like Apple and Google are developing operating systems for automobiles. They are therefore pursuing the goal of being the platform for infotainment, so applications like navigation, charging station search, restaurant search, hotel search etc. This could lead to a situation in future where a consumer's decision will be made primarily on the basis of the preferred operating system and the hardware companies (OEM) will therefore be forced into the role of supplier as against the operating system platform companies. This would lead to a significant loss of power by the OEMs.

There were also similar developments in the past, especially in the IT industry. The company IBM was once the largest hardware manufacturer in the world. As IBM and the development of Personal Computers started, they integrated the company Microsoft as a small partner, which developed the complementary operating system MS-DOS. The roles were clear: The hardware manufacturer felt it was the owner of the platform and the small software company Microsoft was a supplier of complementary software. Since then it has been shown that the consumer sees the roles differently. Consumers initially decided upon the operating system from Microsoft and only then for the hardware manufacturer. The result of this is that the global company IBM has since left the PC market as a manufacturer. There was a similar development regarding the company software from SAP. In the 1980s, the small start-up software house SAP in Walldorf offered its business software as a complementary product to the computers from Siemens and IBM. It was proud when it was able to show its software at the large product trade fairs held by these companies. Here too, the roles have reversed. Today, customers first make a decision on their software strategy - that is to say for SAP, Microsoft or Oracle software - and then decide on a hardware solution. The companies Siemens and IBM are eliminated from these markets as hardware manufacturers, while SAP has become a global company.

These developments once again clearly show two effects which arise as a result of using the success drivers of digitization:

Existing large companies cannot be sure that they will retain their supremacy in the context of digitization and can look upon up-coming digital products as merely additions to their services.

With exponential growth, start-up companies can in a short time rock existing global market leaders in their market position, or even displace them.

B. Digital Sector Concepts

In Section A, essential drivers of digital business models of companies were presented, and now in Section B it will be demonstrated how holistic disruptive business models develop for companies in different sectors. Since this concerns perspective concepts, it will be called Addendum 4.0, derived from the concept of Industry 4.0, but which has asserted itself generally as a characteristic of a disruptive and holistic digitization.

Proceeding in this part, different perspectives and therefore different approaches will be presented.

In the case of Consulting 4.0, that is to say, the digitization of consulting companies, the drivers of digitization presented are pursued constantly and it is asked how these can be implemented into digital consulting and what benefits they provide.

In the case of Industry 4.0, which is of particular importance in Germany as an important industrial region, the main industrial processes are followed and it is asked how these are changing as a result of digitization.

For concept University 4.0, the different types of service teaching, research and management are analyzed regarding their digitization options and strategic development opportunities are derived from them for universities.

In total, three different scenarios and procedures will be presented in order to show the breadth of the effects of digitization and to provide the reader with impulses for his own actions.

I. Consulting 4.0

It was already established when dealing with the drivers of success of digitization that companies that create information-like services are among the first wave of digitization of business models.

Since consulting companies create information-like services, they are an obvious candidate for digital transformation.

The market for consulting services is heterogeneous and comprises inter alia legal consulting, tax consulting, auditing, company consulting and IT consulting. Company and IT consulting shall form the focus of the following. There are two starting points:

Firstly, the clients change the consulting company into digital companies and also demand new consulting activities and, secondly, the consulting methods and results of the consultants' work are increasingly digitized (Greff & Werth, 2015).

Some trends of this future consulting market are already visible (Werth, Greff, & Scheer, 2016).

Digitization creates a new scope of tasks for consultants to help companies transform their existing business models.

From a certain size, digital start-up companies need consulting services in order to professionalize their internal structures and processes.

Cloud solutions are increasingly offered as fixed standard solutions without greater individual additions.

Necessary individual additions via apps are created quickly and cost-effectively through new software architectures.

Driver	Analysis	Importance
a. Personalization	Customer-oriented project structure	important
b. Self-control	Self-consulting, freelancer, Internet nomads	very important
c. Marginal free services	Knowledge databases, evaluation algorithms	important
d. Smart Services	Data analysis, combination of industry- and problem competence with algorithms	important to very important
e. Community / Swarm	Flexible involvement of internal and external experts, broadening of competencies at low fixed costs	important to very important
f. Lean organization and exponential growth	Reduction of the number of branches, tendency towards virtual enterprises, less travel costs; knowledge databases, virtual employees	very important
g. Artificial intelligence	Pattern recognition, prognosis, decisions	important to very important
h. Platform companies	Core competencies, project management, industry expertise, algorithms, monitoring	very important
i. Infrastructure	Communication, methods and knowledge database	very important

Figure 1.B.01: Drivers of success of digital consulting

The increasing pace of innovation in many sectors requires of consultants high mental flexibility and expertise in new (digital) business models.

Digital solutions require continuous support through monitoring, analysis and operation (Managed Service).

It is not the introduction of a big data system, which is in the foreground, but an analysis of the data and support for decision-making building on this, up to development of new business concepts, which must be supported.

Technical tools, such as video conferencing, groupware technologies, 3D glasses, virtual reality, augmented reality and evaluation and analysis algorithms of artificial intelligence will become standard instruments in consulting services.

In the following, the drivers of success of digitization developed in Part A in the area of digital companies and IT consulting will be applied.

Analysis and evaluation of digitization drivers are provided in Fig. 1.B.01.

a. Personalization/Individualization

The individualization of consulting services is related to more client-oriented project structures. In future, clients can better consider whether they want to assign a project entirely externally or will undertake services themselves and simply purchase tools or core competencies such as project management and special knowledge from external consultants.

The client-focused configuration of a consulting project leads to forms of consulting in smaller parts. IT projects are currently measured in units of “consulting days”. However, in the future, “nano” services could also be of interest, whereby clients would like ad-hoc issues resolved in a short period of time. Such questions can be billed in units up to hours or minutes. In addition, new distribution systems (Internet consulting shops) and new contractual relationships, such as consulting subscriptions with ticketing are being developed. Overall, the projects are oriented more to towards the clients, from acquisition through to implementation. Consulting companies then think more client-oriented "outside in” than their standard service portfolio "inside out".

These trends are important.

b. Self-control

If the client wants to provide its own services to a large extent in IT projects, he will follow the trend toward self-control. However, consultants too are following this principle.

From the point of view of a consulting company, employee self-control is of particular importance. Many qualified employees want to decide for themselves which projects they want to be involved in to be able to apply their skills in the most effective way. At the same time, new forms of work such as freelancing or digital nomads play a greater role in IT consulting. Through the use of new media, they can provide their services independent of time and place. Here consulting companies must professionalize their ability to hire, integrate into projects and manage competent freelancers, and to ensure the quality of their work.

This development is deemed very important because greater flexibility in terms of qualification and quantity can be achieved through short-term employment of freelancers, fixed costs can be reduced and the company can be developed in the direction of a virtual company.

c. Zero Marginal Cost Services

If databases of experience or knowledge are built up from consulting projects, their creation is associated with significant costs. Their use in subsequent projects, on the other hand, incurs little cost, so it is practically without marginal costs. The same applies for the use of algorithms when analyzing databases in order to evaluate company situations. For example, analyses of distribution data can show weak points of individual distribution staff or make clear any backlog in marketing in particular distribution areas. Here, the development of appropriate, automated analyses procedures can incur significant expenses, but the subsequent application of algorithms has almost zero marginal costs. A simple, but very effective support can be provided by Frequently Asked Questions (FAQ) documentation. Here too, there are costs associated with setting up, but use is almost free of charge (Greff, Winter, & Werth, 2018).

Use of these support options are deemed to be very important for the future. It may even be that the offer of appropriate knowledge databases and analysis tools will be the core business of a consulting company if it is focused on supporting self-consulting for companies or delivering other consulting companies with these tools (Werth, Zimmermann, & Greff, 2017).

d. Smart Services

In the case of Smart Services, the analysis of large volumes of data (Big Data) is in the foreground. By using data analysts with a high level of competence in the sector for particular issues, consulting companies can open up new fields of business. Here it is less a matter of developing algorithms oneself, and instead it is a matter of applying algorithm databases competently to specific issues. This means that the knowledge of how and which algorithms will be applied to answer specific questions is in the foreground. The result of such consulting is then also of a substantive nature and can only be delivered from a mix of algorithmic knowledge and specialist sector understanding.

By analyzing the content of the client's data, the consulting company can also be integrated more into the identification of problem cases of the client. While currently consultants are often first called if the client has recognized a problem, a problem can be recognized pro-actively (Predictive Analytics) by analyzing process data (Process Mining). In this way, the consulting company can extend its value creation chain. By comparing the data of several clients, the consulting company (while observing data protection) can build up its own expertise in assessing individual client cases in relation to the entire sector.

e. Community/Swarm Effect

Traditionally, a consulting project is carried out by a defined team of the consulting company. The same applies to the project group defined by the customer, which processes the project together with the consultants. These teams remain fixed from the start of the project to its finish. Through enhanced, medial communication, this team can be partly replaced or added to by virtual employees. In this way, specialists of the consulting company identified using skill databases, and who are not allocated to the project, can be drawn upon ad hoc for special issues. Likewise, specialists of the client can also be integrated in specific ways.

The consulting company can build a community of user groups, external specialists and experts from the entire world around it and then draw upon them for special questions depending on the situation. In this way, specialist knowledge is made flexibly available at low costs, without having to constantly employ staff at high cost. At the same time, use is made of the effect that judgments by investors from different backgrounds to laymen leads to better estimates than the individual opinion of a so-called expert when their results are consolidated.

This effect is given average importance.

f. Lean Organization and Exponential Growth

The trend to replace hierarchical structures with market structures toward a virtual company leads to a simplification of the organizational structure of a consulting company. Local branches can be reduced and employees living far away can be assigned directly to a head office, because it is easier to coordinate over longer distances thanks to improved technical forms of communication.

A consulting company which builds up a very close medial connection with its clients can reduce expensive travel costs. Easy video conferences - up to the use of 3D glasses or HoloLens - create an atmosphere as if all participants were in the same conference room.

Such n:m communication systems between consultants and clients are in the development stage and will spread quickly. Besides savings on travel costs, which make up a large percentage of the costs in consulting projects, geographically distributed employees will be able to identify more with the company as a whole because branches often have a certain life of their own. The points already mentioned regarding the increased use of freelancers and partners who can collaborate with the company without fixed costs also leads in this direction.

Start-up companies, which from the outset are oriented towards a virtual organizational form, can demonstrate a significant cost advantage compared to traditional consulting companies.

An inhibiting factor is the reduced local proximity to the clients, who often value a regional attachment as a sign of trust. At the same time, a low amount of face-to-face communication between the employees of the consulting company can make it difficult to bind them to the company and prevent the establishment of a standard corporate culture.

Exponential growth is favored above all by the resource-poor possibility of dissemination of information via the Internet. In the case of consulting companies, this is possible if experience databases as well as formalized consulting methods (modeling tools) and AI algorithms are offered as products. Nevertheless, growth through the integration of freelancers and partners up to a franchising concept support exponential growth.

The effect is therefore deemed very important.

g. Artificial Intelligence

Analysis algorithms and methods of artificial intelligence have already been addressed several times and also show their significance for digital consulting.

There are limitations, however. Therefore, as before, human beings are superior in creativity, recognizing complex patterns and holding complex discussions. These are qualities that are required in strategic consulting projects. Defending arguments in a heated discussion is still the domain of human beings, even if it was already attempted early on with the Turing Test to digitally replicate a human conversation. The charisma of a leader with his motivational qualities can still not be replaced by any machine. The hypothesis-free approach of deep learning also raises criticisms because company management, when making strategic decisions, will not support a result which it cannot plausibly explain and which was possibly reached by coincidence or effects of over-fitting (Weißenberger, 2018).

However, it is different for the more operative tasks of a consultant. Here, in a process optimization project, for instance, it is a matter of recognizing redundancies in activities, streamlining processes and adapting IT systems by configuring and customizing software to new processes. The analysis of large volumes of data to detect unusual patterns that, for instance, indicate fraud, is an operative area of application and can be supported by AI.

AI methods are, on the one hand, a rationalization instrument in consulting. Junior consultants, who previously spent days and nights before a presentation analyzing Excel tables and creating numerous PowerPoint images in order to finally detect a surprising result, can now, using automatically detected unusual data patterns, dedicate themselves more to interpretation of the content. Customizing application software can also be supported if defined parameter values for business types can be recognized from many individual cases of completed projects.

Besides the streamlining effect, AI also opens up new types of business models for consultants, who market their knowledge in the use of AI methods and setting up appropriate models. Overall, the author believes there will be a rapid spread of AI methods in consulting, so that these will become a consultant's hand tools in a short time, as Excel and PowerPoint are today (Neuscheler, 2018).

Its significance is therefore deemed important to very important.

h. Consulting Platform Companies

It turned out that all of the digitization drivers developed in Part A are significant for consulting. In doing so, the driver for the development of platform companies earns particular attention. Several drivers are bundled together in this company type. Two different types of platforms can arise:

1. Platforms for consulting companies and users

This type of enterprise offers no independent consulting services, but rather develops software systems that it offers on its platform to support consulting projects. This could be (process) modeling tools, analysis algorithms, monitoring tools or knowledge databases. Special communication platforms and ticket systems to bill consulting services are also interesting. These software systems are offered to classic consulting companies or even application companies for self-consulting. The company can also include other providers of tools on its platform and distribute their products.

This form of company is particularly suitable for start-up companies. They initially begin as suppliers to traditional consulting companies. However, they then implement their methods and tools, dominate the market and are in demand from clients, and can even downgrade substantive consulting companies to suppliers to their platform.

2. Consulting Platform Companies

This type of company focuses on substantive consulting services, but it offers them in a new form, using digitization. To do this, it uses tools developed by itself or standard tools from type (1) companies, enriches them with content and develops an ecosystem of clients and partners. This type uses the following driver of success above all: Personalization through flexible project structures; self-control by explicit inclusion of self-employed consultants (freelancers); smart services through new consulting offers for data analysis and process monitoring; community effects through the use of user groups and expert networks; lean organization through home office solutions and a virtual form of business. It strives for exponential growth by quickly establishing its ecosystem of partners (Werth & Greff, 2017).

For an existing IT consulting company, developing into this platform company is the natural course of development.

The structure of this type of platform company is represented in Fig. 1.B.02:

The platform is characterized by the services offered by the company. These can come from the company itself or from suppliers affiliated with the company. Core services that are offered primarily by the companies themselves include: Organization methods for process optimization, expert knowledge for content-related questions and industry know-how and skills to manage complex projects.

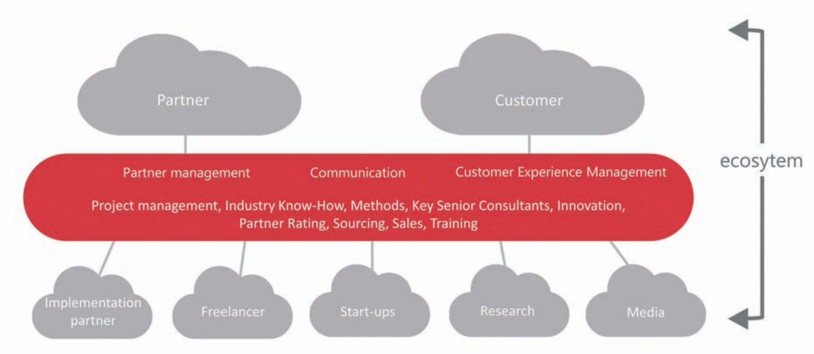

Figure 1.B.02: Consulting platform architecture

The ecosystem of the consulting company then consists of its customer relations, as well as the environment of external specialists, partners, freelancers, research institutes, etc. The larger this environment compared to the knowledge pool of fixed employees within the platform is, the more flexibly the consulting company can react to different issues and resource requirements.

Besides the core of the platform and the ecosystem of customers and suppliers, Fig. 1.B.02 also indicates the embedding of the company into a network of platform relationships using the partner symbol. A consulting company can responsibly manage one project and in another client project, it can be the supplier for another consulting company. In this networking of consulting companies, the economic position of a member is higher if its own ecosystem and on its own core competencies are greater. The company can also charge correspondingly higher prices for its consulting services as against a larger partner.

i. Infrastructure

The developed, digital infrastructure of the consulting company is sketched in Fig. 1.B.03. The structure of the communication infrastructure is provided on the right part. All consultants are supported by Voice over IP (VoIP) and video conferencing systems independently of their location. Likewise, the client's project staff members are integrated into this communication infrastructure in order to reduce travel. In the next step, this infrastructure can also be extended to partner and specialist networks around the world. In doing so, cloud solutions will be given preference. Private blockchain architectures can also be formed for networks of consultants and clients to exchange confidential data.

In the bottom left of Fig. 1.B.03 the structure of knowledge databases to store empirical knowledge from projects and their re-use is provided.

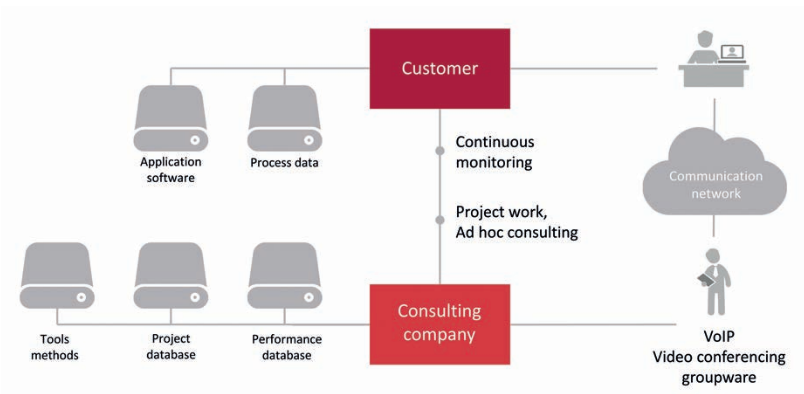

Figure 1.B.03: Digital consulting infrastructure

Smaller consulting units are also offered within the scope of nano-consulting. Using Process Mining tools, the client's process behavior can be analyzed and weak points detected, which are then remedied with a re-organization project. In this way, the value creation of consulting can be extended and begin already from the time the problem is detected - and not first with the solution. Very high significance is also given to this development. Overall, the author expects that in the next 3 - 5 years the consulting market will make a strong change in direction towards virtual and digitized platform companies.

II. Industry 4.0

The term Industry 4.0 (I4.0) describes the fourth industrial revolution triggered by digitization. The counting method is based on the invention of the steam engine, assembly line organization, automatic machine control and now the Internet of Things (IoT). This counting method is not uniform, however; for instance, well-known futurologist Jeremy Rifkin speaks only of the third industrial revolution (see Rifkin, 2014).

Nevertheless, the term Industry 4.0 has spread quickly in recent years and has become a challenge in both academia and in practice. For instance, the large trade associations ZVEI, VDMA and BITKOM, consolidated under BDI, are developing a joint conceptual platform for I4.0. Large companies like Siemens AG, Bosch GmbH and SAP AG are developing their own I4.0 software platforms and in almost every major industrial company, I4.0 is a subject of discussion. In the USA, the subject is handled by the Industrial Internet Consortium (IIC), which the significant major American industrial and IT companies belong to. German companies are also collaborating in the IIC.

Many academic professional organizations and research institutes are working on the topic.

Detailed definitions of I4.0 are varied and complex. Many cover about half a DIN-A4 page and are very technical. In particular, focus is often directed in a biased way towards factory automation. By contrast, the following seeks to demonstrate how digitization affects all essential functions of an industrial operation and leads to new business models with new products as well as services. The challenges for German industry are obvious. Unlike many European countries and the USA, Germany is a heavily industrialized country and must be careful that it does not end up “in the museum of industry” because it misses out on digitization. This was the warning from the German Chancellor Angela Merkel in any case.

It is not only people who communicate via the Internet, but also “things” like materials, products and machines. To do so, Internet conventions are used for communications (Internet Protocol, IP for short), and in particular each “thing” receives an IP address. With the new IPv6 form, 3.4 times 10 to the power of 38 addresses are available, so assigning an address is no hurdle. In this context, one therefore also speaks of the "Internet of everything".

Firstly, an overview will be provided of the main processes of factory control, product management and logistics of I4.0. Then different strategic approaches of companies for I4.0 will be discussed.

a. Main Processes of Industry 4.0

The availability of a new technology alone does not mean that its use also makes economic sense. The economic benefits will only be achieved through the improvement of business processes.

The main processes of an industrial company are presented in the Y-model of Fig. 1.B.04. The model goes back to the author's work in the 1980s on the subject of Computer Integrated Manufacturing (CIM) (see Scheer, 1990). The CIM concept could not be realized at the time due to a lack of IT resources. Nevertheless, many of the conceptual thoughts developed at the time remain useful and are now also helpful when classifying the subjects of I4.0.

The upper parts of the Y-model denote planning activities, the lower part the short-term control and implementation levels in the factory.

The left leg of the Y-model characterizes the order processing process of an industrial company driven by orders. The procurement orders for the required materials and resources and for the parts of the production orders to be produced are derived from the customer orders. The planning and control of these orders is also referred to as logistics. External logistics refers to relations with customers and suppliers; internal logistics refers to internal order processing.

The right leg of the Y-model denotes the product development process. The research and development activities in the upper right area generate the geometric product descriptions through the use of CAD/CAE systems and the production requirements (work plans) through the work planning. Product-related services such as maintenance or financing are also developed. The machine resources required are defined by factory planning.

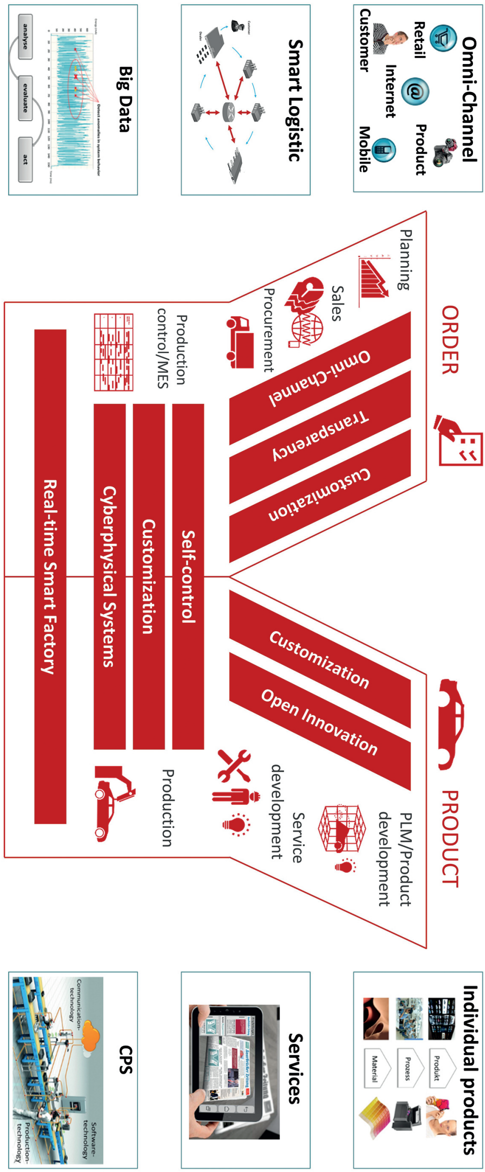

Figure 1.B.04: Industry 4.0: The Big Change

In the production process of the factory, at the bottom of the Y-model, the logistics and product-related processes are closely linked. Here the parts to be produced are allocated resources according to type, volume, time and quality using the production requirements, production is controlled contemporarily and the production results are recorded. The products created will then be handed over to shipping logistics and delivered to the customer.

From a value point of view, financial accounting and controlling support all processes, but are not shown in the Y-model.

The three main processes of factory control, product development as well as logistics are described in more detail below. To illustrate, some functions of the processes are identified by symbols in Fig. 1.B.04: the most important drivers of digitization are given in the bar highlighted in red, and important digital changes are labeled with images to the left and right of the leg.

1. Factory Control ("Smart Factory")

So-called cyber-physical systems (CPS) are an essential new I4.0 technology in the factory. These are software-intensive production systems that are connected to the Internet and communicate with each other and with their surroundings. Materials are termed intelligent if they carry with them their characteristics such as quality and production steps (work plans) required on a data carrier (chip). Using technologies like Radio Frequence Identification (RFID) or image recognition, the materials can then find their way through production independently. The CPS and materials coordinate capacity supply and demand via a digital platform. If a CPS fails, another system automatically takes over this task and the system independently re-organizes the material flow.

The most important digital driver is self-control of the factory. In the last 40 years, there has already been a discernible trend to decentralize factory control, which is now reaching extremes. Until the 80s, a central approach predominated, that is to say that production orders were defined from a central production plan, which should then be "processed" in the factory. Due to the many disruptions in the factory, however, this led to plans becoming outdated immediately and therefore the widespread failure of the central approach. In the next step, the factory was divided into decentralized organizational units (production islands, control station areas, flexible production systems, processing centers), which maintained a certain autonomy of control and could react more flexibly to disruptions.

The continuous self-control of production strived for in I4.0 is therefore the logical consequence of this development. If all elements of the system involved can recognize their condition and the requirements of the task are known, then control is a problem to be solved by algorithms. Operations Research processes and artificial intelligence are capable of doing this.

In a step further, self-control leads to self-optimization. If it is recognized, for example, that a tool in a machine is worn out, production parts can be automatically allocated, for which the condition of the tool is still adequate.

The high level of flexibility of the CPS allows for strong individualization of production, since the system can be re-tooled virtually without loss of time and cost. Therefore, the long-discussed aim of production with a batch size of only 1 at the same costs of mass production can be achieved.

Another essential technology is the cost-effective storage of mass data in production, as made possible by the drop in prices of storage media and new database technologies, such as data storage using internal computer memory instead of in external storage media, referred to as “in memory”. Machine, material and environmental conditions can be measured “real-time” using sensors. Analytical evaluation procedures may not only explain the behavior of the past, but also use the present state for immediate intervention and also provide information about expected future system behavior. A well-known example is predictive maintenance, whereby anomalies are indicated from the current behavior of the system, which advises replacing a component in the near future. This opens a window for new digital services. A manufacturer of machines can record all relevant data using sensors when its machines are being used by customers. Already today, often more than a hundred sensors are used in machine tools to record temperature, speeds, vibrations, qualities, power consumption, etc. In Fig. 1.B.04, this is shown at the bottom left in the record of power consumption of a machine, the analysis of which allows irregularities in behavior to be detected. These can be followed in real-time by the manufacturer online and compared with all systems deployed globally. Using evaluations, maintenance plans based on the individual places of use and conditions can then be drawn up and the manufacturer's maintenance processes can therefore be optimized. Therefore, besides the sale of the machines, there is also a new business model for intelligent maintenance services for it. The business model can be further enhanced by renting. This model is already used in airplane turbines (e.g. General Electric and Rolls Royce), whereby turbines are no longer sold to airlines with the aircraft, but rather remain the property of the manufacturer and use is simply paid for according to the hours flown. The aggregates themselves are continuously monitored via the Internet and the necessary maintenance measures are controlled by the manufacturer. This business model is also referred to as “Build, Own, Operate (BOO)”.

If special aggregates are only used in a company to a small degree, they can be offered to multiple demanders via sharing models. This requires that the aggregates must be mobile. It is conceivable that more and more machines will be brought to operation sites in order to offer their functions as a service there, rather than materials migrating to the fixed operating sites of machines. The coordination of supply and demand as well as the temporal and local control of mobile devices is then a service which is mediated via an Internet platform.

The fineness of the data collection is almost as intricate as needed. Per plant, for instance, 100 to 200 measuring points can be defined for a turbine or a compressor, which are retrieved in real-time. The volume of data to be processed is correspondingly high. As a whole, the “Smart Factory" is driven primarily by data than by predefined processes.

A precursor to the autonomous factory is Manufacturing Execution Systems (MES), which, as a layer between the factory and the overlying planning functions of the Y-model, filters and compresses data. The vision of I4.0 expects, however, that hierarchical approaches will increasingly disappear and all components in an industrial business will communicate with one another directly peer-to-peer. However, this increases the complexity of the overall system, so that the consistent realization of this vision of a Smart Factory should still be considered carefully.

Likewise, more and more methods are available for planning the Smart Factory. The digital factory is of particular importance, whereby the factory is depicted as a digital twin on the computer (see Fig. 1.B.05). All the systems of the real factory are depicted digitally on the computer and use the real master data (Xu, Cabri, Aiello, Mecella, & de Vrieze, 2018). Using the zoom functions, it is possible to look inside the building and any details can be presented. Simulations can therefore be carried out on the computer and used for process planning and product development.

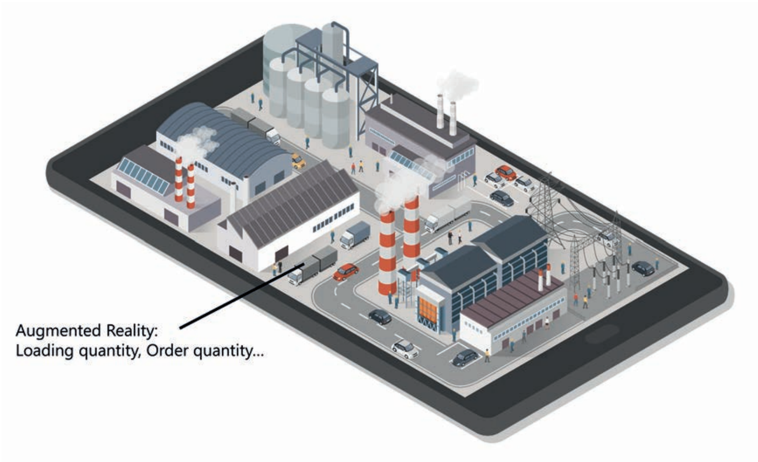

Figure 1.B.05: Digital factory as a digital twin

During operation, the real factory and the digital image behave in sync and production can be traced in real-time from a laptop, independently of location. By entering additional information about quantities, qualities, clients with the aid of augmented reality (AR), the information is much richer than, for instance, if video surveillance is used.

2. Product Lifecycle Management (PLM)

The upper right part of the Y-Model identifies the product development as well as the development of product-like services.

The greater flexibility of production up to a batch size of 1 calls for greater flexibility of product development. In concrete terms, this means that the number of variants of products can be increased - up to purely customized production. This is presented graphically in Fig. 1.B.04 on the right edge by the customized design of a running shoe. This can lead to far-reaching consequences. Since customers generally do not want to wait a long time for their products, individualization demands that production must move closer to the customer's location. To put it another way, a customized design of a running shoe is of little use if the production has to be carried out in Asia and the customer has to wait weeks or months for delivery. New technologies like 3D printing, whereby a product is produced from a geometric 3D model by stratifying material, allow for instant production. 3D printing also increases the production speed of new products thanks to the more rapid development of prototypes (rapid prototyping).

New product ideas can be generated not only from a company's own development department, but also through the systematic inclusion of other staff members in the company, customers, suppliers, even the entire interested world (Open Innovation).

In an I4.0 environment with intelligent materials and machines, all repairs, maintenance, spare part replacements, quality checks as well as the use and conditions of use can be automatically recorded and stored across the entire lifetime of each individual product sold. This creates a digital twin of the product from its development to the day it is scrapped. This leads to the concept of transparent product lifecycle management (PLM) and leads to a wealth of data, which can only be handled using Big Data technologies. Besides the traceability required by law within the scope of warranties, analysis of this data can above all provide suggestions for product improvements and optimization of operating conditions. In doing so, the individual product data can be stored by oneself on a chip or by the manufacturer in its database.

The analysis of data by the manufacturer brings new opportunities for product-related services. Predictive maintenance has already been mentioned in terms of recording machine data in the factory.

If a manufacturer recorded the data of **all** the machines produced by it, then it can make cross-comparisons of the behavior of the machines. If it has concluded maintenance contracts with its customers, then it can optimize the maintenance process by recognizing the measures required before the engineer visits and determines the time of the visit based on needs.

A further development of services is the takeover of the operation of the production plants by the manufacturers themselves. Reference has also already been made to the concept of Build, Own, Operate (BOO). The manufacturer of machinery knows its products best and, using the PLM data, can analyze their behavior depending on all operating conditions and optimize their use. It therefore makes sense that it undertakes the operation of the systems itself at the customer’s premises or at its own production facilities set up by it. The customer then no longer purchases any aggregates, but receives and pays for a service according to use.

Besides manufacturers of aircraft turbines, medical device manufacturers also sell their systems (for instance dialysis systems) not only to hospitals, but also operate corresponding centers themselves, and instead of selling equipment, they sell services, such as increasing the quality of life or cleaned blood. This trend will continue within the scope of I4.0 and more and more industrial companies will assume the character of service providers. Automobile manufacturers therefore understand themselves to be mobility service providers, with which they rent out their manufactured cars within the scope of car sharing. Manufacturers of compressors sell air pressure as a service; manufacturers of measuring instruments for quality assurance sell quality guarantees and decide themselves whether they want to ensure this by using measuring instruments or also through the use of artificial intelligence forecasting methods.

3. Smart Logistics

The upper left part of the Y-model, that is to say the distribution and procurement logistics, is also radically changed by I4.0.

Firstly, a customer can issue, cancel or change an order using multiple channels like standard computers, laptops or smartphones. The manufacturer's order recording and tracking system must act transparently as against the different access channels; it must be omni-channel ready. All channels must be usable out of place, that is to say, the customer can, for instance, issue the order using a standard computer over the Internet, but then change or cancel it using his smartphone. Technically, this means that the user interfaces have to be adapted automatically depending on the medium.

The customer's easy access to the manufacturer together with the individualization of products leads to a greater incidence of changes and therefore to increased requirements for more flexible product design and production flexibility. The customer can then, for instance when painting the bodywork of a vehicle, change the color from his original product definition, practically just before the start of a production stage.

It is only when flexibility of order management, product development and production is achieved that the benefits of I4.0 can be demonstrated to the customer.

The individualization of the products thanks to a greater number of variants up to customized production tends to increase the number of suppliers and reduces the company's vertical integration. This means that the company's logistics network must respond faster. New suppliers for the extra wishes of the customer must be identified quickly and integrated immediately into the network. Disruptions in the supply chain must be recognized early and intercepted by quick measures. Requests for intermediate products and materials are becoming more detailed. The entire network must be transparent for all parties at all times. The information relationships of requests currently encountered between direct suppliers and customers are then no longer sufficient. Rather, the entire supply chain network must be transparent. In the research project RFID-based Automotive Network (RAN) funded by BMWI, this has been created as a prototype through use of a centralized virtual database and RFID technologies for the automobile industry with its suppliers and currently has already been introduced for real by some participants (Lepratti, Lamparter, & Schröder, 2014). In the Y-model of Fig. 1.B.04, this approach is graphically presented by a network in which all nodes are connected via a central database. The RAN concept is presented in more detail in Fig. 1.B.06a and 1.B.06b.

Figure 1.B.06a shows an existing solution, whereby at most the direct partners are connected via Electronic Data Interchange (EDI)

information relationships. Therefore, the OEM (automobile manufacturers) possesses no real-time information if there is a delay in the supply chain. The RAN Project solution is present in Fig. 1.B.06b. Here, all partners are connected with each other via a (virtual) central database and all partners therefore have real-time information about the state of the logistics network at their disposal. The material movements are automatically detected by RFID scanners and propagated to the database. Faults are also passed on immediately. The quality of the materials is monitored and controlled by sensors. Unwanted excess values are communicated immediately.

The basis for the development of the concept is knowledge of the detailed logistics processes. This is gathered by the partners using the author's ARIS methods (on the ARIS method, see the explanations on process modeling in Part 2).

This shows the importance of detailed knowledge of business processes as a basis of digitization.

A private blockchain solution also offers itself for transparent control of supply chains according to the RAN model (for more on this, see below in Part 2 F II).

The three main processes for I4.0, that is to say smart factory, PLM and logistics, clearly show how strongly digitization will change industrial enterprises to new business models and processes.

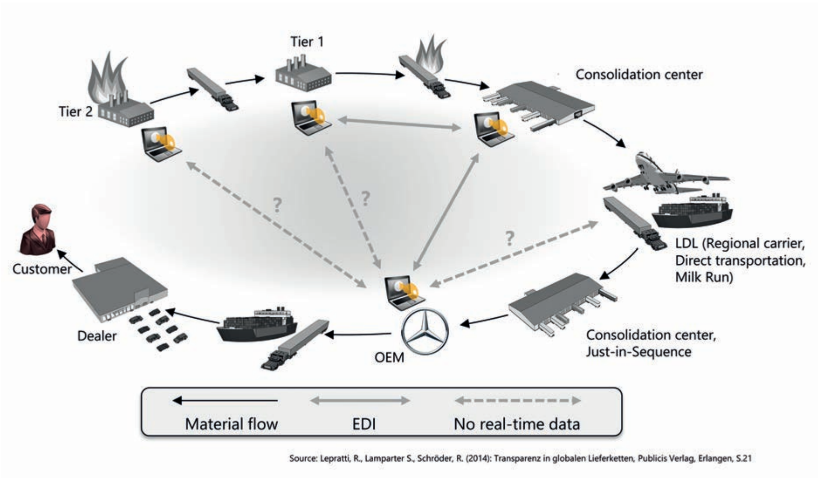

Figure 1.B.06a: Previous flow of information in the logistics network of the automotive industry

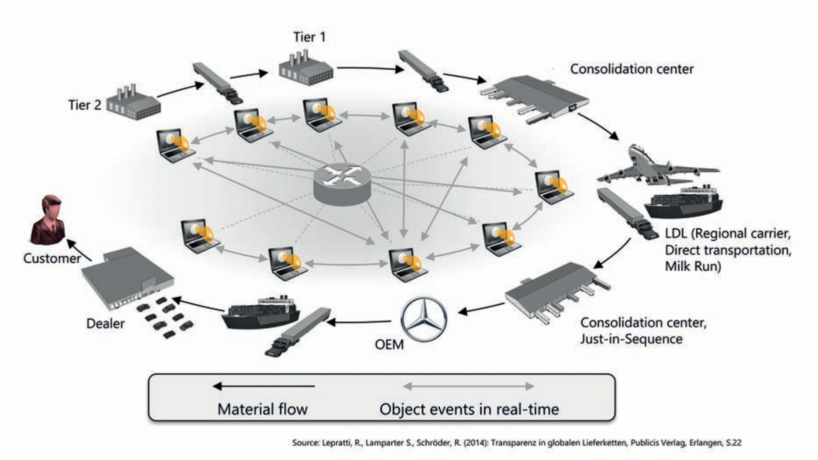

Figure 1.B.06b: Vision of the transparent flow of information using RFID technologies and a central virtual database

b. Strategic Approaches for I4.0

An industrial company that wants to develop in the direction of I4.0, can pursue different approaches. A few alternatives will be developed and evaluated here.

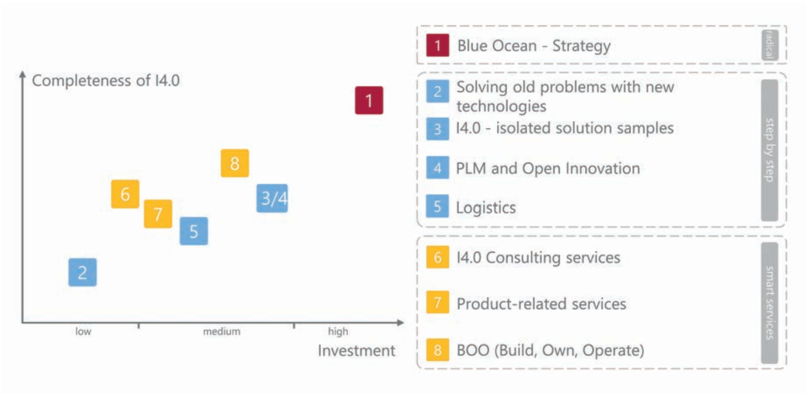

Figure 1.B.07: Strategic Approaches for I4.0

In Fig. 1.B.07, the methods are categorized on the abscissa according to how much investment is required for their realization. The amount of the investment also stands for the degree of complexity as well as the time expenditure required. It is indicated on the ordinate how far away the goal of complete fulfillment of the vision of I.40 is.

Strategy 1: Blue Ocean Strategy

In the Blue Ocean Strategy No. 1 in Fig.1.B.07, a disruptive innovation through I4.0 is strived for (see Kim & Mauborgne, 2005). This means that a complete split is made from the present and a new company with a new business model is practically founded on green pastures. Google Auto is a good example of this. Currently, a passenger vehicle spends 95% of its time unused and is only driven for 5% of the time.

Google Auto intends to reverse this: A vehicle should be driven 95% of the time and only rest 5% of the time. This leads to combining car sharing and driver-less operation to take a vehicle that has arrived at the destination immediately to the next user independently. The principle of access to mobility replaces ownership of a car. Google explicitly propagates the goal 10 x, that is to say that Google does not strive to make gradual improvements with an innovation; instead, it should be 10-times better than the existing concept.

The foundation of the Tesla company, with its uncompromising electric vehicle, can also be classified as a Blue Ocean Strategy. Here too, all functions of the vehicles have been rethought, an Internet-based sales concept has been developed and its own electrical charging organization has been established.

The mobility concept from UberPop also breaks from the concept of a commercial taxi service and follows the concept of a zero marginal cost service, while, for instance, the system *MyTaxi* merely represents digitization of the taxi control center and is rather a continuous innovation.

Disruptive innovations are often connected with a high capital expenditure. It is a foregone conclusion that it is only possible to break even after several years. Financing can therefore come either from a very profitable independent business branch (Google) or from third party investors (Tesla).

Unlike the USA, it is harder to recognize the Blue Ocean Strategy for I4.0 in Germany. This may be due to the fact that German industry is (still) very successful with its traditional business models and therefore shuns disruptive concepts on the basis of the Investor's Dilemma effect. Also unlike in the USA, there is not such great willingness to make very risky investments by venture capital companies and wealthy business angels.

The German automotive industry is also following a more gradual transition to electric mobility, even if commitment has accelerated substantially in recent years.

In Fig. 1.B.07, the disruptive Blue Ocean Strategy 1 is characterized by high capital commitment and a high level of realization for the vision I4.0.

Strategy 2: Solving traditional problems with I4.0 technologies

Individual solutions for known problems can be redesigned by I4.0 technologies. There are already many examples of this.

Using mobile requests for material stocks before production and assembly stages, a machine builder reduces material transport within the company (milkruns), whereby fixed trip plans become trips controlled by demand and empty trips can be avoided.

By using 3D scanners, a manufacturer of agricultural machinery improves the quality of the connection between the body and the chassis (the so-called wedding) and avoids time-consuming reworking.

A manufacturer of screws improves its Kanban system by fitting sensors and cameras in the Kanban containers so that the stocks are constantly recorded without visual inspection by humans.

An automobile supplier improves the incoming goods process by using RFID technologies, whereby counting checks and storage are automated.

In Fig.1.B.07, these approaches are characterized through the use of a comparably manageable capital investment, but because of their specialization have only a low potential for the I4.0 vision.

Strategy 3: I4.0 - Isolated Sample Solutions in Production

An automobile supplier establishes a new production line according to I4.0 principles, which is operated practically as a prototype alongside the existing lines. All processing stations are connected to the Internet and meet the criteria of CPS. Using RFID technologies, the material flow largely controls itself. There are many options for substitution between the production systems in case of disruption. Using sensors, material and plants are monitored real-time and are pro-actively maintained (see Lepratti & Lamparter, 2014). This example is already impressive in itself, but is still in the pilot stages for the entire company.

A medium-sized foundry establishes a Manufacturing Execution System (MES) for its production area, in order to connect production data acquisition (PDA) to the control level and to form a data filter to the overlying planning systems.

Although only partial aspects of I4.0 are pursued, Strategy 3 demands a greater capital contribution and can be the starting point for further steps. However, only factory organization is considered, so that hardly any new business models can be generated.

Strategy 4: PLM and Open Innovation

An engine manufacturer sets up a database for a product memory within the scope of PLM. At the same time, it re-organizes the development area. In addition to the construction data, the production bills of material and work schedules are organized in a new product database and therefore removed from the ERP system. Overall, this indicates a new architecture for the information systems of the company. The generation and management of product-related data come to the fore. The trend toward greater diversity and individualization of products is therefore taken into account. The logistical functions from distribution and procurement as well as production planning are then applications that access the product database, but unlike the current Enterprise Resource Planning (ERP) systems, no longer manage it themselves.

A toy manufacturer includes its customers in product development by issuing rewards for good product ideas. The proposals can be described and submitted via the Internet using a simple CAD system.

In Fig.1.B.07, the first example has been taken as a benchmark. It leads to radical flexibility of product design and opens up new business models. However, high capital requirements are needed for the organizational and technical redesign of the development process. Overall, Strategy 4 is categorized in exactly the same way as Strategy 3.

Strategy 5: Logistics

The radical re-organization of Supply Chain Management also requires that customers and suppliers be included, where applicable across several stages, as was suggested above with the RAN project. From the point of view of an individual company, however, already through the integration of the direct supplier and customer as well as the transport systems, a gain in flexibility and cost savings can already be achieved. The radical use of electronic acquisition technologies as well as real-time tracking of transport conditions provides information at an early stage about the expected arrival times as well as the content according to type, dimensions and volume. Sensors detect particular events on the transport route, such as exceptional temperatures or vibrations, which indicate early on that careful individual receiving inspection is required. The RFID-controlled yard management system regulates transport from the entrance gate until arrival at the warehouse. This includes notification of the means of transport and allocation of storage location.

A manufacturer of technical consumer goods establishes a direct distribution via an online store alongside its retail sales channels. The establishment of an omni-channel access for the customer to issue and track orders poses a large problem for integration. Furthermore, inventory management must be updated to the second as against the previous daily updates. The shipping is detailed and must be processed via new logistics service providers.

While the first example serves more to improve the internal logistics processes, the second example also opens up a new business model.

Overall, the amount of the investment is somewhere in the middle and the strategy opens up medium development perspectives due to its selective approach.

Strategy 6: Offers from I4.0 Consulting Services

Industrial companies which have gathered experience with new technologies and forms of organization as pioneers of I4.0 can pass these on to other companies. To do so, these companies can establish their own consulting company. This could, for instance, be a spin-off of the IT department, which now offers its technical and professional services on the market. The IT cost center then becomes a profit center. There is another benefit in that the company is faced with new customer requirements and therefore a greater speed of innovation is necessary, which also benefits the parent company.

This development can already be clearly observed. In microcosm, such companies become, for instance, specialists for RFID technologies or material flow management. On a large scale, noteworthy service providers can arise for comprehensive I4.0 solutions if German industrial global market leaders from the automobile industry or mechanical engineering bring in their several hundred or even several thousand IT and production specialists to the new services. In this way, I4.0 as a service can also become an export success from Germany.

The spin-off is an organizational and investment problem because IT employees must be hired or re-trained and start-up costs are incurred.

In Fig. 1.B.07, Strategy 6 is allocated average investment expenditure, but a high potential to achieve comprehensive I4.0 concepts.

Strategy 7: Product-Related Services

Connecting produced, complex products like tool or printing machines with the Internet leads to a large gain in information about the global behavior of these products under different usage conditions.

Companies often have several thousand or even tens of thousands of units of their products in active operation by customers.

This knowledge can be used by the industrial companies to offer their customers maintenance contracts under particularly favorable conditions.

However, there are currently still significant difficulties to be overcome. If the manufacturer receives machine data from its customers, then it must adapt to the formats that its customers use and then re-format when using them in its own systems. (Conversely, an industrial company which receives machine data from suppliers for its own production must re-format this in its data organization.)

It is obvious that data standards are crucial due to the large number of data types and the different customers and suppliers. Initial approaches deliver UMCM (Universal Machine Connectivity for MES) from the MES umbrella association and the architecture of the OPCUA Foundation. In any case, additional work is required at the international level, for instance by the IIC. In the end, industrial standards will probably be implemented, which are run by international market leaders from the information technology or supplier industry.

Problems of data security must also be resolved. If machines offer open interfaces to their controls, they can then in principle be used in both directions. In order to avoid abuse, including sabotage, (remember the Stuxnet cyber attack on an Iranian nuclear power plant) complex security measures must be taken.

Therefore, a complex, global infrastructure must be established for the data management concept as well as the services building on it.

A medium-sized investment amount is therefore the focus of Fig. 1.B.07. Since a wide range of information can also be derived about the behavior of the aggregates, for instance about their employment situation, but also about opportunities to improve the products, this Strategy is allocated a good potential for development for I4.0.

Strategy 8: BOO

BOO describes the transition from an industrial company to a service provider. It no longer sells its products to the customer, but merely their functionality as a service with billing according to use.

A manufacturer of agricultural machines then becomes a provider of harvesting services. Its core competence lies in the harvesting machines networked with information technology, for instance to transport vehicles for the harvested products. In the field of Smart Farming, automation is more advanced than in traffic control. The reason for this is that no administrative obstacles, such as traffic regulations, exist out in the fields and therefore satellite-controlled, driver-less systems can be used more easily.

Lucrative business models are produced if use is made of all technical and organizational possibilities. The manufacturer decides when and how it uses its combine harvesters in its customer fields. Besides the optimization of this service, using its knowledge of its aggregates and usage conditions, it can even rent out areas itself and market the agricultural products itself. Using the information about climate and harvest forecasts according to volume and quality available online throughout the world, it can make predictions about price developments. New business models can be developed from this.

Similar opportunities also arise in medical technology. Through the automatic storage of (anonymous) test results in the memories of medical devices, there are evaluation possibilities for manufacturers to detect patterns of illnesses, which are not accessible to the individual physicians. A paradigm shift in analysis technologies in connection with Deep Learning is that analysis is carried out without hypotheses. This leads to a situation where even analysts not familiar with the subject, like computer scientists, can recognize surprising medical correlations. Again, new business models can be derived from this, whereby manufacturers of medical devices, through the use of the AI models together with physicians, offer diagnosis services.

In Fig. 1.B.07, the BOO strategy is allocated a greater investment amount due to the constant change of business model and the transition from sales revenues to performance-related rental income, but which also opens up a large development perspective to I4.0.

c. Road map to I4.0

Pursuing the individual strategies presented does not automatically lead to an overall concept for I4.0.

Therefore, a working group of the company, supported by external specialists, should develop a company vision for I4.0 by asking which products the company will offer in future, how the revenues are to be achieved, which customer groups are to be served, what resources will be needed; in short, how the elements of the business model will look. Then individual I4.0 projects can be categorized in the form of a road map.

This includes decisions about acquisition of companies in order not to obtain existing know-how (for instance about the service business). A manufacturer of electrical control boxes, which previously considered itself primarily as a producer wants to position itself as a provider of building security and management in future and therefore purchases a service company as a germ cell. Alternatively, a company, which previously saw its strengths in the great competence of its development and manufacturing engineers, recognizes that in the future more software engineers will be needed and acquires a software company.

An important organizational issue is also whether new business fields should be executed in the existing organization of the company, or a new company should be established for this, which operates more like a start-up company. Through the spin-off, the new approaches are pursued without looking to the company’s past, thereby avoiding inertia effects of the innovator's dilemma phenomenon.

Suggestions on priorities of the implementation stages can be discussed depending on the level of maturity. If the company is already well advanced in an area as against its competition, it is not really worthwhile to make additional huge investments here if the company is at a disadvantage against the competition in another area. Then one should rather reduce the competitive disadvantage against the competition.

New software architectures are also required to make the strategy a success. From an application point of view, it has already been explained that an I4.0 software application architecture for industrial companies should be more product-centered, that is to say, the product definition should be the focus and the logistical functions should access the product database. On the other hand, ERP systems currently manage the bills of materials and work schedules. A product-based architecture would therefore trigger fundamental changes and weighting between technical and business functions of the Y-model. The technical software architecture will also change. The software must be accessible at all times and allow interventions in the ongoing processes, that is to say it must be event-driven. The hierarchical architectures and the division of logistics, product development, manufacturing and accounting are hereby eliminated. All processes are interrelated. The traditional pyramid models from the technical field level all the way up to the top management lose their significance: With I4.0, the organization of industrial operations will become flat!

The Y-model used here can then be used further to logically classify the processes. However, the legs of the Y-model also come together in the upper area, since the processes meander through all sectors, can be changed at any time and must offer any access points.

These demands lead to a global demand for responsibility of the software. All applications need to be omni-channel-capable, the statuses of all running processes must always be transparent and be accessible for changes.

The technical software consequences are far-reaching. Therefore, only a few fundamental ideas will be provided here.

The high level of flexibility is achieved through a platform orientation on which software services are available. Conscious deviations are therefore being made from the architectural principles of large monolithic ERP systems. Instead, small software units - apps - are formed which can be changed and connected individually and flexibly by the user (see Fig. 2.B.03 in Part 2).

The integration platform allows for easy model-supported linking of different systems. The second level provides function blocks as services. On the next level, services become processes and these are then bundled into the global concept of I4.0.

The idea of the platform enables ad-hoc adaptation of an application or process to the individual requirements of the user (tailoring). Using the platform, processes can be connected with people and things.

With the ADAMOS concept, Software AG is pursuing the strategy of providing industrial companies with a neutral middleware platform with a large number of services. On the basis of this platform, the industrial companies can then develop their software solutions themselves to take control of their products, for instance machine tools, and then sell them to their customers together with the machines.

Although I4.0 is driven by new production and information technologies, people-centered, organizational concepts continue to be important. In particular, lean management, team building and emotional involvement of the employees remain important factors of success even with highly automated production. Training and readiness for life-long learning of employees also promote success. The aim of I4.0 is therefore a synthesis of the use of information technology and classic person-centered forms of organization.

III. University 4.0

In business, digitization has already led to significant changes in the market.

In contrast to these changes, universities in Germany are showing a slower rate of transformation. This is due, among other things, to their understanding of themselves as being based on tradition, a slow generational change of professors, little competition and - in the case of secured state funding - a low level of financial pressure. So today many lecture halls look the same as they did 20 years ago, while bank counters, dental practices, mail order trade and factories have changed dramatically.

Now there is also an upheaval at universities. The new information technologies, like the Internet, cloud computing, big data, social media, smartphones etc., penetrate the service processes of research and teaching and change them. These changes could also have "revolutionary" power, so that it is also possible to add 4.0 to the vision of a digital university. They will become the greatest challenge for the continued existence of universities. The term business model may at first be somewhat unusual for universities. However, it is justified on closer inspection. A university also has a revenue model - be it that it is financed by the state, research organizations, student fees or sponsors. They must prove their performance to these donors, otherwise revenues are put at risk. The other components of a business model, such as resource model, partner model etc. can also apply to universities.

The federal government's digital agenda and nationwide initiatives for digitization meantime provide financial assistance to the digitization of the research and education system. The subject is also currently being discussed on various national platforms. In the "Hochschulforum Digitalisierung" [a forum for the digitization of higher education], about seventy experts are working out recommendations for action for university management, teachers and policy.

One of seven working areas of the federal government's digital summit is the digitization of education and research (IT-Gipfel, 2016). This was a focal point at the Digitalgipfel [Digital Summit] 2016 in Saarbrücken. On the basis of these developments, a great deal more emphasis has been placed on the digitization of universities.

What will a University 4.0 look like? The following scenarios of digital service delivery include the areas of teaching, research and administration. They emphasize again the organizational drivers of success of changes. Because new technologies will only be successful if they lead to organizational benefits for participating students, researchers, teachers, managers and donors.

a. Teaching 4.0

Teaching at universities is currently characterized by the following features:

- Educational services are valued less at universities than research achievements.
- In many subjects, such as law and economics, mass lectures with little personal contact between teacher and student dominate.
- In the MINT subjects (Mathematics, Informatics, Natural Sciences, Technology), there is on the one hand a lack of graduates, and at the same time high dropout rates and a low proportion of female students are complained about.
- In some subjects, such as medicine, there is a narrower numerus clausus and students are looking for alternative study places abroad (e.g. Austria, Hungary).
- Universities focus on initial education and then offer almost no opportunities for further education. Alumni support is also less pronounced as in the USA.

- The university curricula and lecturers are often accused of being impractical.
- A small number of laboratory places or patients per medical student limits practical training.
- In many courses, the selection principle dominates study progress, and not individual support.

The use of e-learning has now been tested for more than 20 years. However, most German universities make use of only a small part of the opportunities of digital learning technologies (Wannemacher, Jungermann, Scholz, Tercanli, & Villiez, 2016). Overall, it can be established:

- Digital technologies for learning (e-learning)/activities were and are rather individual initiatives of lecturers and not part of a university- or country-wide strategy.
- At a single university, multiple IT systems are often used to administer courses and students. Developments by the universities themselves complicate continuous maintenance.
- The creation of digital courses is very cost-intensive and difficult to finance from the department budgets.
- Pedagogic concepts based on e-learning are first to develop.
- Many lecturers have a prejudice against the use of digital learning resources, which they consider too far removed from people.

This situation is now changing seriously:

- The outdated e-learning concept, with its focus on the management of electronic content, is expanding to new approaches focused on the learner.
- New technologies such as the Internet, cloud computing, social media, Big Data, mobile devices such as tablets and smartphones make access to learning materials easier.
- New formats such as e-books, instructional videos, Massive Open Online Courses (MOOCs) or gamification increase their acceptance.
- New tools to create learning materials reduce the cost.
- The digitization programs from the German federal and state governments provide financial resources for the education sector.

In this way, the speed of digitization of teaching at universities will increase.

Drivers of this development are organizational, economic and educational effects, which favor the use of new learning technologies and methods.

In Figure 1.B.08, these factors are grouped around the student and therefore represent his scope of learning. The structure will follow these factors.

1. New learning formats

In the first phase of e-learning, only existing learning materials such as lectures, films and paper documents were digitally processed. Today there are new learning formats available with simulation models, e-books, interactive videos, serious games or MOOCs, the development of which is rapid. Laboratory tests can be carried out with complex simulation models, which in reality are too dangerous or for which no capacity exists. In subjects such as design technology, systems can be designed and crash tests can be carried out without wasting resources or polluting the environment.

E-books offer a format that is closely related to the existing format of textbooks and therefore requires no adjustment on the part of the learner.

Serious Games transfer the application of game design principles and mechanics to non-game applications, to solve problems and to engage participants.

The dissemination of learning materials over the Internet is crucial to the success of digital teaching. The MOOC (Massive Open Online Courses) format has provided a massive boost here.

From the outset, contents are oriented towards a large audience and learners can access it worldwide. MOOCs have become familiar through Sebastian Thrun from Stanford University, who in 2011 offered a lecture on artificial intelligence online and thereby sparked a great debate.

If an MOOC is produced once, for which sizable, technical equipment like video studios are however required, the provider has almost zero marginal costs thereafter. For the provider, it is irrelevant whether a thousand or a million participants "visit" the course. Jeremy Rifkin (2014) sees in this a contribution to a society with zero marginal costs, whereby education is virtually free of charge. For US universities financed by student fees, this is not a simple business model. In Germany, on the other hand, this is not an argument because higher education is financed by the state. Therefore, MOOCs are viewed economically in the USA as more of a marketing tool to attract paying, resident students, or new business models are developed through the use of participant profiles.

Despite its critique, MOOCs have changed the learning world. It has however been shown that only about 10 % of the beginners of a course successfully end it. This has been taken as a counter-argument to MOOCs, but it can also be interpreted as a new learning behavior. For many learners, it is enough to have some information about a field of learning, so they are satisfied with a brief insight or they interrupt the course because they can continue it at any time. Generally, smaller learning units are defined and described as “nano-learners”, which can also be certified as nano-certificates or nano-degrees (Udacity, 2018). In this way, new learning requirements can be reacted to more quickly.

A movement against MOOCs are SPOCs (Small Private Online Courses), which are tailored to small subject units and limited groups and then also provided with payment models.

By recording the user behavior of the students, factors of success for particular learning materials and forms of learning can be analyzed. It is however necessary to comply with anonymity requirements within the scope of data protection.

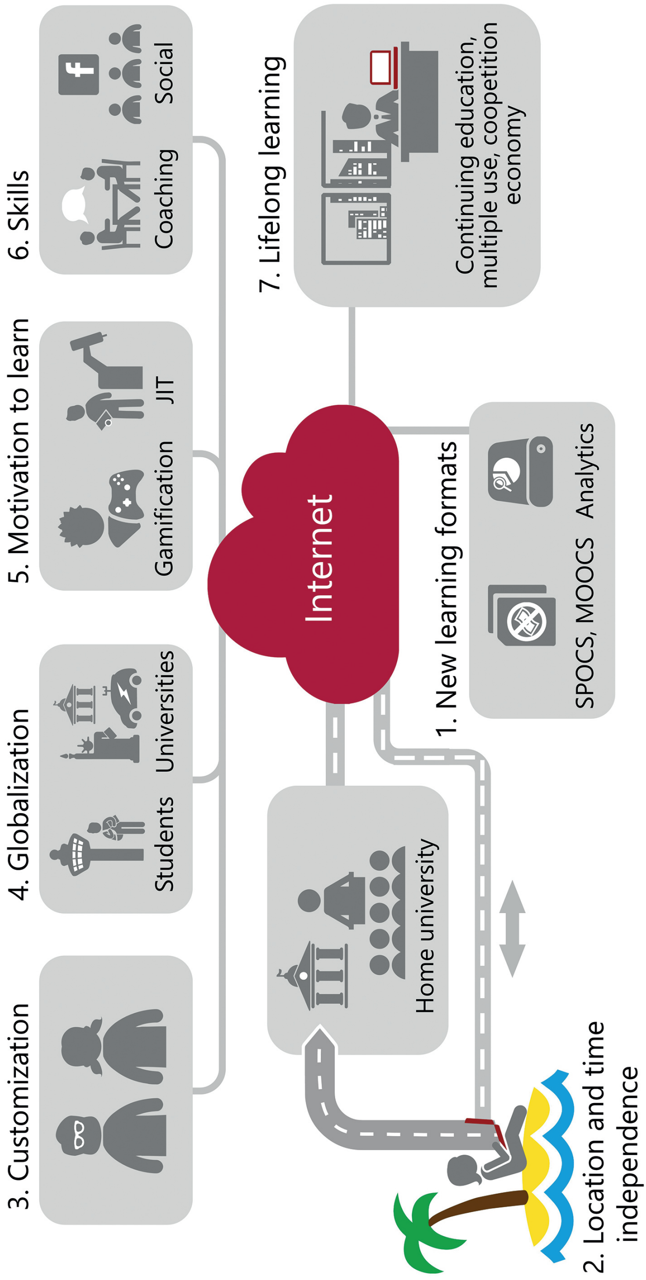

Figure 1.B.08: Teaching 4.0

2. Time and place independence of the learner

Classroom-based events will retain their importance at universities. The student in Figure 1 is therefore also allocated a real home university with lecture halls. He is moreover also connected with it and the entire world via the Internet.

Using a mobile end device, the student can access learning materials or communicate with the university anywhere at any time. This gives him greater flexibility in structuring his life. As a result, he can organize his daily routine regardless of fixed lecture times and coordinate learning better with vocational activities, family duties or hobbies. Students can also remain connected with their home university and their studies while on an internship or course abroad.

3. Individualization of learning (promoting rather than selecting)

On the one hand, a good education promotes different talents and interests of a person, and on the other, it contributes to satisfying different needs of the economy or institutions. In order to take account of different individual characteristics of the learners, universities currently offer elective and compulsory subjects or options to repeat examinations. There are however still fixed hurdles posed by obligatory examinations, for instance to achieve an obligatory grade in math. In this way, students are selected according to defined examination rules - although in later studies or later vocational work much of the knowledge demanded is not actually needed.

Through the use of digital technologies for learning, on the other hand, courses can be structured in much more sophisticated ways. In an extreme case, a student can compile his individual studies in detail from the modulated offer of learning materials. Framework conditions must of course be established, such as the number of credit points to be achieved (points which "measure" the amount of work involved) for a degree - but in a form which is far more flexible than today. The bouquet of professional individual certifications could provide sufficient evidence for applications and not only a formal title for overall performance.

The student can also regulate the speed of learning individually. Using the test questions with immediate evaluation inserted in the learning materials, he gets real-time feedback and can, if necessary, repeat the learning material again immediately and reduce the learning speed. Conversely, the more talented students can increase learning speed individually.

There are further possibilities for individualization, which arise from the choice of different learning formats (video lectures, serious games, e-books etc.) or the use of intelligent analytical methods in order to automatically recommend content to the student according to his preferences and abilities.

4. Globalization

Using the Internet, universities can offer their courses to students all over the world. Each university therefore has the possibility to be a global university. This was already apparent with the success of the MOOCs. At the same time, this offer can also be used for marketing purposes. The university can make itself internationally renowned and then attract foreign students to study in person. The degree of international recognition also influences the international ranking and makes the university attractive for qualified researchers. Conversely, home students can make use of the teaching offers from foreign universities. The result is a global competition between universities.

Recognition of achievements acquired at other universities (for instance through electronic tests) must be clarified. International rules must be defined here. The ECTS (European Credit Transfer and Accumulation System) is a good basis. However, even without formal recognition, the student gains an advantage in terms of later applications. Overall, the question is posed as to what value certifications will still possess in the future. Is a university diploma obtained over several years' worth more than a certificate of completion for current specialist courses?

Cooperation models are beneficial for universities and students, whereby several universities offer and support a distributed course - each university according to their special competences. In this way, each university broadens and deepens its offer. The student receives a quality-assured offer, which is an official part of the course, so that problems of recognition and also the organization of examination is clarified. It makes particular sense to have cooperation between universities if there are fixed standard topics, for instance introductory parts of the course. Here, several universities can develop high-quality courses together, which free lecturers from time-consuming mass classes and therefore allow them more time to provide individual support.

5. Increase motivation to learn

Playful elements are increasingly being used in learning technologies (serious games) in order to convey difficult material in an attractive way. Business plan games and role-playing games have already been used in traditional academic teaching for a long time. However, with new technologies they are gaining a big leap in quality. Online games can be high-quality simulation models in which, for instance, different decision strategies can be practiced. Instant feedback about the consequences of a decision increase learning success.

“Just in time” learning also increases motivation: The faster what has been learned can be applied, the greater the motivation. This can also be promoted by games through other technologies as well. For instance, in case of a real attempt using data glasses in laboratory environments, learning materials and explanations (augmented reality) can be played in so that the learner learns practically "on the job".

In classic academic education, the “stock learning principle” dominates instead. Knowledge is conveyed which should be applied later - carrying the risk of becoming outdated and forgetting. New technologies allow the immediate application of knowledge and skills and therefore train interpretation skills and the interaction of facts (process learning). With ever shortening half-lives of factual knowledge, conveying such skills becomes more important. Currently, lectures, tutorials and seminars only achieve this at mass universities to a limited degree.

6. Convey skills

Learning technologies also offer support when implementing knowledge, not only through simulated application environments such as learning games, but also by creating free spaces for lecturers for face-to-face discussions. Here the principle of individualization, as already addressed regarding the structure of individual forms of learning, continues in face-to-face communication. If the conveyance of the necessary factual knowledge is transferred more and more to the Internet, more communication options arise between student and lecturer.

The combination of classroom teaching and learning technologies is known as "blended learning". The classroom then not only serves to convey factual knowledge, but to exercise skills. For instance, in a course on "Business start-ups”, a business plan for a fictional startup company can be created via the Internet. The student group can then discuss the draft in a physical class and the students then continue to work on the project remotely.

In these models, the alienation from people, which is sometimes an issue held against learning technologies, leads to the opposite situation: Transfer of knowledge that can be standardized will be carried out digitally in order to gain more time for direct human communication. This concept also has consequences for spatial facilities. Instead of large lecture halls, smaller work rooms and meeting rooms must be provided for "one-to-one” discussions.

Social media are also making contributions to supporting communication and collaboration between the students across geographical and time boundaries. It is even possible for students themselves to improve and add to the learning materials easily accessible on the web. In this way, the separation of roles between lecturer and student is reversed (Flipped Classroom or Inverted Classroom).

One desired effect of the greater conveyance of skills instead of factual knowledge could be that students more often found their own companies if they have been entrusted with working out and discussing business plans in their studies. For instance, one in six graduates from Stanford University founds a start-up company.

7. Life-long learning

Knowledge gained in a degree course must be refreshed and expanded during more than 30 years of professional work. Currently in Germany, however, the proportion of universities on the further education market is low (Schmid, Thom, & Görtz, 2016). Further education is not currently a strategic field for universities. For companies, however, the further education of their staff members in the digital shift is increasingly important, and here the opportunities of learning technologies are employed more professionally than in universities. Besides conveying general expertise, current training needs can be dealt with faster and more easily in terms of organization. For universities, greater participation in further education measures will open up opportunities to economically exploit electronic learning materials created for initial education in further education and to enter partnerships with companies as well as to maintain a long-term connection with former students.

In extreme cases, universities can conclude a life-long learning contract with their students and support them individually throughout their life (Student Lifecycle Management). By analyzing the profiles of the participants, education offers can be made to them which are based on their current career situation and which prepare them for the next desired step in their career. By cross-checking with participants of the same peer group, the participants can classify and, for instance, learn where other participants in a similar career situation are currently employed.

On the other side, commercial further education institutions could also compete with universities. They could offer contents earlier for current topics and also compete in certification with other universities using their positive, professional image, for instance as international technology leaders.

Universities are therefore well-advised to work out cooperation models with companies in which common learning materials are created and distributed. This does not only apply to further education, but can also lead to joint courses between universities and companies in initial academic education.

Generally, digitization of teaching leads to more flexible forms of education and further education and then mix with one another. For instance, during a career it will be easier to catch up on fundamental courses. Overall, the education system can be structured more openly and individual bypass opportunities can be created.

8. **Time pressure to transform teaching is increasing.**

When comparing the current state of teaching with future challenges and perspectives, it appears that universities are facing a drastic transformation process. This justifies the addition of "4.0", which stands for the digital revolution. Due to their inertia, the term revolution is now rather uncommonly applied to organizational changes at universities. After all, the central concept of the "lecture" comes from the Middle Ages, when there were no printed books and therefore valuable manuscripts had to be read out by wandering professors. Despite this, lectures are still a central form of teaching today. But if it is considered that universities are in increasing global competition with other universities through digitization, new forms of learning and support are arising, for which a new infrastructure must be established, students can be supported with further education throughout their lives, new universities focused entirely on learning technologies are arising, academies from business penetrate the education market held by universities and weaken their monopoly on certifications, then the term revolution is justified. Therefore, all classic universities are urgently advised to use the opportunities of digitization before others do. On universities which already intensively employ learning technologies and are therefore digital remote universities in Germany, see

www.onlineplus.de (Hochschule Fresenius)

www.mobile-university.de (SRH Fernhochschule)

www.ist-hochschule.de (IST-Hochschule für Management)

It is striking that their sponsors are primarily private foundations. In France, the "école 42" has achieve great importance. It is also supported by a private donor.

b. Research 4.0

Through the close connection between research and teaching, some of the drivers of digitized teaching, like independence from time and place and globalization, also apply to research. Therefore, additional research-specific factors should be dealt with above all, which are represented in Figure 1.B.09 as the environment of a modern researcher.

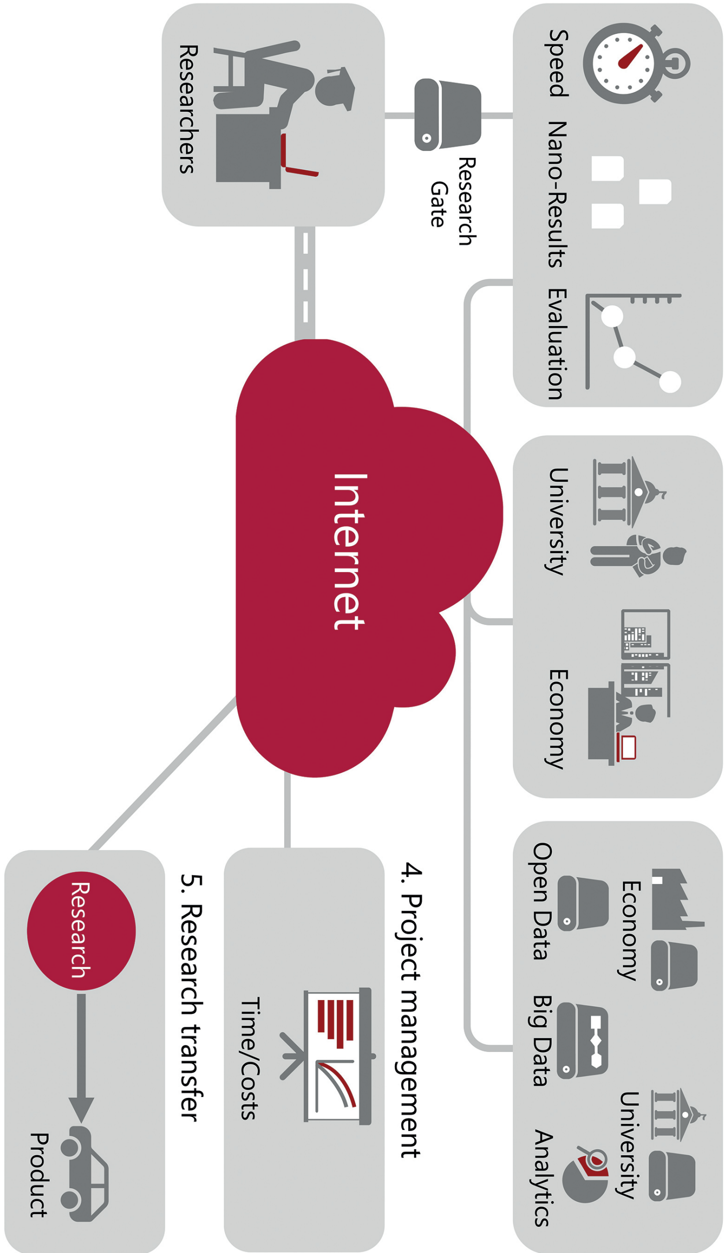

Figure 1.B.09: Research 4.0

1. New research formats

The speed of global communication between researchers is increasing drastically through the Internet. I may well be remembered that the Internet or its success component the World Wide Web (WWW) was developed at the CERN research institute in Geneva for communication between scientists.

Special Internet platforms such as ResearchGate connect global researchers to those with an interest in their research. The researcher himself sets up his research results on these research platforms and thereby increases his visibility. Questions can be posed to the community, which are then answered promptly. This accelerates the research process. Results also no longer need to be published in formal formats like journal articles or books, but rather can be disseminated in small results-based representations (nano-results) via the Internet.

Researchers are no longer instructed to make time-consuming reports for their articles submitted to “renowned journals”, but can instead self-publish their articles on the Internet. Besides text articles, this could also be, for instance, self-recorded videos of specialist lectures. Using plagiarism software, publications can be checked automatically for their originality.

Classic journals and conferences with their reporting procedures retain their place, but here too the processes are increasingly digitized and accelerated. Besides that, new forms of digital evaluation of researchers and research results take shape. The number of views, downloads and citations are indicators of the effectiveness of their work. The well-known H-Index measures the effect that a researcher has on the researcher community on the basis of citations of his publications. In addition, databases with digitized publications are automatically searched and organized by annual figures. Similarly, researchers are also evaluated in social networks, such as ResearchGate.

It is to be expected that when awarding research funding and appointments, these measurements will gain even greater importance. This will influence the publishing strategy of researchers accordingly.

2. Virtual researcher groups

Ministries of research on the state, federal or EU level are increasingly funding joint projects, whereby research institutions and commercial enterprises work together. Therefore, on the one hand, the cooperation between research institutes should be promoted, and on the other, it should be possible to achieve faster implementation of the results in products in cooperation with businesses.

The composition of a researcher consortium for a tender is a complex procedure. Internet contacts help here to find appropriate partners, to match skills, to make applications and later also to execute the project. Video conferences, allocated work on the same subject using groupware simplify and accelerate the process. In this way, there are geographically distributed groups of researchers from different countries and different organizations who coordinate with one another using digital media and therefore form a single virtual unit.

3. Data

Research results are often represented in the form of data. These could be measurement data from natural science experiments, statistical data about patients from medical examinations etc. With the “Open Data” approach, not only summarized data should be published for public access for other researchers, but also the raw data. In this way, analyses can be repeated by other researchers at any time. This concept is relatively easy to implement in academic environments in the case of state-funded research projects and in the case of state databases. When there is collaboration with commercial enterprises, however, problems arise on issues of ownership to data and its protection. Before the start of a joint project, appropriate agreements must be made which govern the rights of the parties to the data and their publication.

New database concepts (inmemory, non SQL) allow for the real-time evaluation of larger data stocks as well.

This opens up new routes for research through paradigm shifts. For one thing, for large series of experiments, the captured data can be stored not compacted and all analyses can be carried out real-time on the raw data; no compact data must be retained. All compacted data will be generated in real-time from the same source as the original data The benefit lies in that in the case of changes to the raw data no compacted interim results need to be rectified.

The second paradigm shift lies in that data can be studied without hypotheses on patterns or correlations using Deep Learning, and so even researchers not familiar with the subject can recognize connections in the data, which subject specialists, due to their limited orientation using hypotheses, had not discovered. This opens up requirements for new analysis technologies and new courses of study as data analysts. Data can be captured from classic experiments on real subjects (patients, technical experiment facilities). The research subjects will however also be depicted digitally and the data will be captured through digital experiments in the form of simulations. For instance, new vehicles can be constructed using CAD/CAE systems, exposed to virtual loads and crash tests using simulations, and then the corresponding data can be analyzed. This saves on resources and costs.

4. Project management

Complex research projects with many participants require professional project management. In order to receive further funding, it is necessary to create deliverables on time and on budget and to give correct accounting for funding. Modern IT tools are available to the project management.

5. Research transfer

Research establishments will be increasingly questioned by their funders about their usefulness. This relates in particular to their commercial exploitability. This does not mean opposition to pure research, but rather an overall view of the innovation cycle of pure research, application research, product development and successful marketing. Universities today apply for the distinction as a founder university to demonstrate their contribution to innovation. They support the foundation of companies and are proud of successful examples. It is precisely digitization that is showing successful company stories. The company Google arose from Stanford University, where it was developed by the development team from a search algorithm created to manage the university library into a general product. Facebook too was initially developed by the student Marc Zuckerberg as a campus solution for Harvard.

In Germany, the successful spin-offs from Prof. Schuh at the RWTH Aachen for electromobility have recently gained a lot of attention. With his spin-offs from the University of the Saarland, the author also showed than spin-offs from German universities can be successful. This is also demonstrated by the technology parks around universities in Berlin, Aachen, Munich or Karlsruhe.

Universities can support this trend by providing their own structure as a testing ground for innovative solutions. At some universities, cryptocurrencies are used for closed campus applications as research and implementation projects.

6. Routes to Research 4.0

Development towards Research 4.0 is already more advanced than for Teaching 4.0. Reasons for this include that research at universities has greater importance and the individual researcher is anxious to organize his working environment as effectively and efficiently as possible in order to distinguish himself in his academic community. Furthermore, the researcher does not need to wait on a digitization strategy by his university, but rather can raise external funding in order to take his own digital research route - also in cooperation with a global academic community.

Despite that, it is important for a university to work out a general digitization strategy for research. Many IT platforms, for instance for data analysis, plagiarism detection etc., can be deployed throughout the university and this reduces costs. A university, which has a convincing digitization concept for research, makes itself attractive for modern researchers and therefore creates an advantage in the international competition for the best research brains.

c. University Administration 4.0

A CIO (Chief Information Officer) has already been introduced at many universities. He is generally assigned to the vice president for administration. In universities that have recognized the strategic influence of digitization, he also even holds the position of a vice president. Within the scope of University 4.0, the CIO can also be referred to as the CDO, the Chief Digitizing Officer. He can then be the driver of digitization by being responsible for developing the entire digitization strategy for the university, providing the infrastructure as well as providing the faculties and lecturers with incentives and impulses.

The four fields of responsibility of the CIO are briefly described in Figure 1.B.10: digital support for teaching, research, campus management and back office. In doing so, the CIO should include the users affected by these tasks in order to achieve the greatest possible level of acceptance.

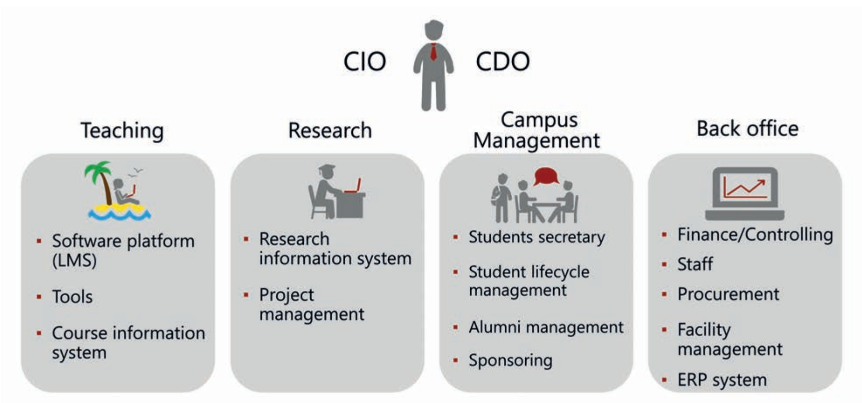

Figure 1.B.10: Administration 4.0

1. Teaching

The CIO determines the hard- and software to be used to support digitized teaching. These include, for example, the operating systems of the students' devices to be supported as well as a possible standard Learning Management System (LMS). The tools to create learning materials should also be determined throughout as much of the university as possible. Moreover, the technical requirements for partners with whom the university would like to exchange learning materials must be determined.

The digital offer from internal and external sources will be provided in a course information system online.

2. Research

Although the digital support systems for research are tailored to the individual research activities of the institute and researcher and are therefore heterogeneous, the CIO can support general systems. All research projects of the university can be captured in a research information system and companies and university researchers can be brought together.

Standard project management software supports processing projects using external funding on time and on budget.

3. Campus Management

Electronic management of student data has already made great advances in recent years through the use of standard software for Campus Management. The waiting lines of students in front of the student secretary's office to register or report have largely disappeared. Many functions can now be carried out by the student independently using the Internet.

New functions, like the university's online presence for student applications, have been added.

Systems for alumni management are also increasingly being used. These are also a link for acquiring sponsors. If the university offers options for further education, students can be supported for their entire lives within the meaning of Life Long Learning (LLL). In this way, student support is developing into a complete Student Lifecycle Management – from application to life's end.

4. Back-office

Standard software, in particular integrated ERP software, has been employed for the functions of Finance/Controlling, HR, Procurement and Facility Management, which exist in any organization and now in recent years also at many universities. At the same time, the transition from cameralistic to commercial accounting has been implemented, so that universities can also draw up a business annual financial statement.

The references to the service processes in the foreground here - teaching and research - are obvious. If students have to pay for particular services from the university, such as the use of parking spaces, canteen food etc., there is then a connection between campus management and finance software. If fees are charged for further education measures, there is a connection between participant administration and the finance system. Researchers are recorded as employees of the university in the HR system. The central procurement system is used for the resources to be purchased for teaching and research. The forecast for building occupancy derived from the analysis of data from campus management and the learning systems is important for facility management.

These few examples demonstrate how closely the research and teaching service processes of a university are linked with management functions.

It is only if the management is innovative that the fields of teaching and research can step into the digital future.

d. Strategy development for University 4.0

Digitization comprises all areas of a university and therefore only an integrated strategy can be successful (see Fig. 1.B.11). By "chasing after" individual components, such as the rapid production of a MOOC for teaching, one can no longer lead in the innovation competition.

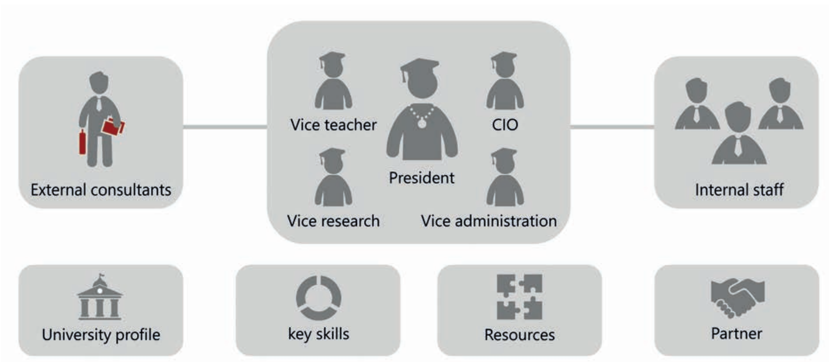

Figure 1.B.11: Strategy development for universities

It therefore makes sense to identify the drivers of success of digitization, to weigh the university's opportunities to use them and to develop the university's profile from that.

1. Learning profile

Different profiles can be formed solely from the perspective of teaching.

A type of university can therefore concentrate both on reference to students as well as the individualization of teaching, the emphasis on skills instead of factual knowledge in education and life-long support.

Another type of university emphasizes internationality, offers its digital learning materials in several languages, acquires many foreign students for its digital teaching offer through its interesting web presence, and as a result is also proud of many international students who physically attend the campus.

A third type of university can concentrate on the development and use of the latest learning technologies and thereby strive for technological leadership.

A fourth type of university cooperates particularly intensively with business and introduces joint courses. To do so, it also uses current teaching material from the businesses and structures education in a way, which is very closely related to its practical application.

An extreme strategy could be to found a start-up university as a subsidiary company, which only offers digital teaching as a digital remote university from the outset. This can also be initiated by private investors as private universities. The bottleneck of state recognition of the certificates can be circumvented by building up a professional image or if prominent and already renowned partners are included. Thanks to the mutual recognition of certificates in the EU, here it is also possible to seek out a partner from a Member State, which grants recognition more easily than one of the traditional countries.

2. Research profile

It is also possible to profile universities in different ways regarding the digitization of research.

Universities can focus on digitization as an area of research and distinguish themselves with new data analysis methods and simulation models in different disciplines as "digitization universities". They therefore get around expensive investments in real, natural science workshops or laboratories and concentrate on the next generation of digital research possibilities. This strategy is of particular interest to entrants to new disciplines.

Another strategy is to maintain international, virtual researcher networks and thereby work on the latest subjects on the top international level.

3. Strategy development

Regardless of which strategy a university decides upon: It needs to develop a concept. Even if one wants to negate digitization, this should be decided consciously and strategically.

Since strategy development is a matter for the boss, the executive committee, and in particular the president, must assume responsibility. A guidance report and an internal staff can help by bringing together facts and working out alternatives. Nevertheless, the university must make the decision itself.

Within the scope of the strategy, in particular the core competences required must be identified and established if necessary. In doing so it is not necessary "to re-invent the wheel" by, for instance, developing course materials or software systems by itself at great expense, and which are already available as standard on the market.

Even if the fundamental decision to use digital courses has been positively made, there are additional alternatives when deciding upon their implementation.

For instance, the entire creation process for a digital course can be taken over by the university, with consistency for all phases: to establish the competences in course design, production, assembly, quality assurance, delivery and certification of the participants with much the same quality as possible.

It can however also decide to simply determine the content of the course (design), have the production of materials like videos, simulations, games or graphics carried out by external partners or to draw on finished components from the market. Bringing the different parts together into a closed course can then be taken over by the university again, while administration of participants and allocation of materials can be “outsourced” via the Internet. Success monitoring and certification can then be taken over by the university again. Consequences for building skills and employing resources result from these decisions on details.

If the entire course including testing is taken over by another partner, then only certification, that is the recognition as student performance, remains with the university.

e. Inhibiting factors for University 4.0

There are also inhibiting factors for any strategic re-orientation. One cannot however be held up by these, and they must be instead removed.

There are always detractors who critically oppose a concept for the future. An argument that is often heard is that the "human factor" comes off badly in digitization and virtualization. It must be argued against this that people have never communicated so much as they do now over the Internet (nothing more need be said about the quality of the content, in particular of social media). The Internet can give thanks for its immediate success largely to the use of the web by American colleges and universities for communication between students and their parents.

An additional argument against digital teaching is that this would lead to downsides when calculating the university's capacities. Here the problem must be shown to the ministries and an adjustment insisted upon. Conversely, ministries of education should reward digitization initiatives.

Strong decentralization at universities with a high degree of autonomy of chairs, specialist areas and faculties can impede any university-wide strategy. Here it only helps to include the most influential opinion leaders in working out the strategy.

The most important inhibiting factor is however the Innovator's Dilemma effect, which has already been mentioned several times. It means that organizations beat back new developments because they are ultimately successful with the current concept. As a result, they miss out on riding the next wave of innovation and fall behind the competition.

Therefore, all classic universities are again urgently advised to use the opportunities of digitization.

Part 2: Automation of business processes

In the first part of the book, the drivers of success of digitization of companies was worked out and then integral, digital commercial concepts were developed for the three sectors of company consulting, industry and higher education. In the second part, methods and techniques to automate the necessary business processes will now be dealt with. This follows from the fact that digitization often leads to new services which are in themselves already business processes. However, new digital processes also need to be developed for material products for development, production and life-long tracking. Overall, the necessary processes for the new digital business model must be defined in detail, implemented and automated.

One can therefore state in short: digitization of companies means the development of disruptive business models and automation of new business processes. The disruptive processes must also be described and are then the basis for automation. “Business Process Management” (BPM) therefore gains a new meaning within the scope of digitization. Building on this, technical procedures to automate business processes will be presented.

A. Business processes as the central focus of digitization

In simple terms, a business process is a consequence of functions to generate an added value for an organization and its customers. Typical examples include customer order processing or product development. Process organization, that is to say the structure of business processes from their starting events to their conclusions, described in the US as "end to end", established the success of the use of IT in companies and resolved the then-existing IT paradoxes (Solow, 1988). This means that in the 80s of the last century a negative correlation was observed between the expenses for IT and productivity. The reason for this was that the existing functional organization for the use of IT had not changed. Individual functions were supported or even automated, but high costs were incurred for data transfer between functions, redundant data retention and double work through the juxtaposition of electronically supported functions and existing hard-copy organization. (Even with the introduction of the electric drive in the 19th century, steam power was at first still used as an energy source. Here too a negative effect arose for productivity because two technologies were employed in parallel.) First, the integral support of processes through integrated databases and ERP systems building on these allowed for processes to be streamlined, different activities at workplaces to be brought together as well as the reduction of data transfers when using IT and have in the meantime generated dramatic increases in productivity. Attention must therefore be paid in the digitization strategy not to take any half-hearted decisions, but rather to constantly veer towards the new business model to avoid friction losses.

"Top down" approaches were initially developed in the 1990s to introduce a process organization (Hammer & Champy, 1993)], in which it was discussed, for instance, whether a radical approach should be pursued "on green pastures", or rather a continuous re-engineering of the processes.

Figure 2.A.01: ARIS Books; 1st Edition 1991; 4th Edition 2002

At the same time, the benefits of integral processes were recognized "bottom up" when implementing IT systems. In doing so, the term process was not yet in common use and was for instance described as a process chain (Scheer, 1984). In addition, specific concepts and methods were developed to model business processes, which the author was able to design with others using the globally applied ARIS concept and the ARIS software building on this (Scheer, 2002) (see Fig. 2.A.01). The abbreviation ARIS stands for Architecture of Integrated Information Systems and emphasizes integration ideas as a requirement for a process organization. The ARIS software was developed under the management of the author in the company IDS Scheer AG. The first version appeared in 1992 and, after the sale of IDS Scheer AG in 2009, is now developed further by Software AG.

The ARIS concept (cf. Fig. 2.A.02) forms the framework to model business processes. A business process using ARIS includes its functions, data, the organizational units involved and the services generated (deliverables) as well as their relationships to one another from the perspective of management. Sometimes the flow of functions (control flow) is already used as an abbreviated description for a process.

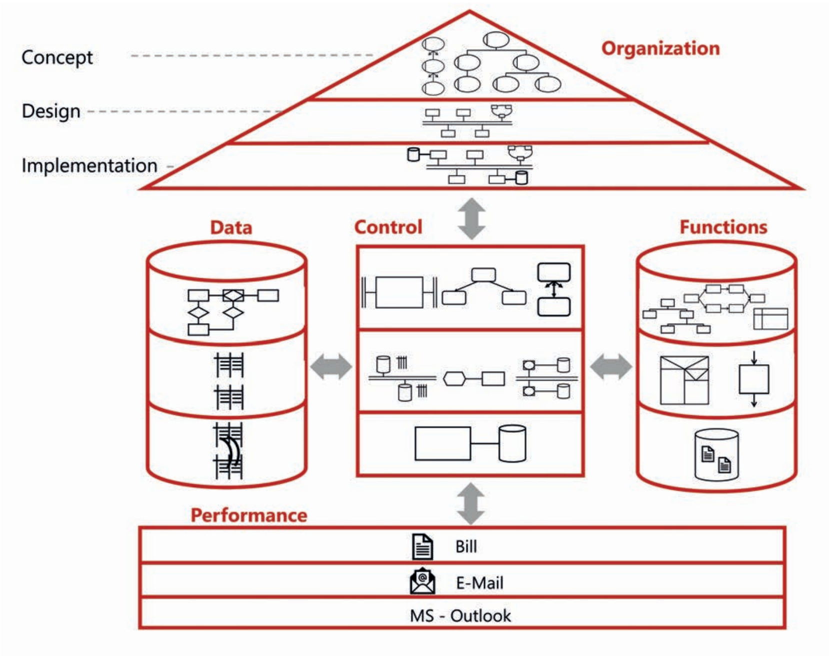

Figure 2.A.02: ARIS – Concept for modeling business processes (Scheer, 1992, 2001, 2002)

Through an IT lifecycle concept, the individual perspectives of the ARIS model are implemented step by step from the organizational specialist level, to the design phase, to IT implementation.

Using the ARIS concept, this permeated in practice to graphic EPC (Event Controlled Process Chain) notation for modeling the control flow for specialist modeling of the business processes. It is supplemented by additional elements of the ARIS concept like data, organizational units, IT systems and output. A simple customer order process is represented in Fig 2.A.03 as control flow.

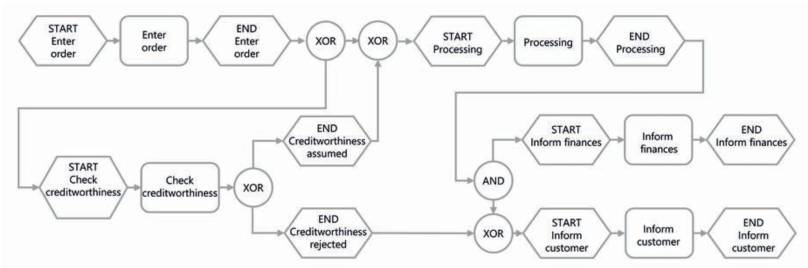

Figure 2.A.03: Process model of a simple order process

The nomenclature is based on the ARIS modeling. The depiction selected is provided in such great detail with the formulation of all start and end results because the example is used again later in Chapter C. Process Mining.

The functions indicated with rounded rectangles transform start results into end events. Events are linked through logical connections (AND, OR and XOR). These can be used both for input as well as output. In Fig. 2.A.03, only the control flow of the process is presented. If decisions are made about which branches to take, they are understood as part of the preceding function and are not formulated separately.

This results in the following situation:

The first function is the customer order entry. After it is processed, there follows either a credit check of the customer or order processing begins immediately. This is determined during the order entry, for instance on the basis of the order amount. Both routes mutually exclude one another (XOR). If the result of the check is negative, the order will be rejected. At the same time (AND), the customer will be informed about this and the process will terminate.

If the result of the check is positive, the processing can be begun, even if the order value is below the decision limit. Both routes mutually exclude one another (XOR). At the end of the processing, the customer and the finance department will be informed for accounting purposes.

The model includes all possible sequences and represents them condensed and without redundancies in the functions. The summary of all individual cases in a model then makes sense if the model is comprehensible and the individual cases cannot be managed by humans due to the large numbers involved. A process model that has been modeled in such a way is now part of the process automation.

The structure of the chapter on process automation follows a lifecycle concept. The chapters are:

- Chapter B: From the process model to the application system
- Chapter C: Process Mining
- Chapter D: Operational Performance Support

The current state and trends of these stages will be explained in the following and a graphic lifecycle model of business process automation will be developed from this.

The explanations will be supplemented with examples from software systems. These originate from companies under the author's sphere of influence.

In Chapter E, the new subject of Robotic Process Automation (RPA) will be dealt with, whereby people will want to be replaced by software robots as the users of software systems and the author's own approach to automation will be presented. In Chapter F, the influence of the infrastructures of cloud computing and blockchain architectures on process automation will be discussed.

The concept of an innovation network made up of large companies, start-ups and research shows in Chapter G how companies can configure themselves to the rapid, technical innovation cycles of digitization.

B. From the process model to the application system

The disruptive business model will be developed in the digitization strategy. This leads to new business processes, which are implemented through application software (see Fig. 2.B.01).

I. Business process modeling

In the first step, an actual process model will be developed. The aim is to obtain a better insight into the problems and options for improvements of the existing organization. The modeling should not be too expensive since the solution should subsequently be changed. The model will be created with the aid of a modeling tool like the ARIS software and stored in the model database. In the case of a disruptive innovation, it is also not necessary to record an actual model.

A detailed target concept will be developed according to the actual model. The target model will initially be created without considering an application software to be introduced.

The target model is a blueprint, according to which the individual forms of the processes (process instances) should proceed later. The model does not describe any individual real sequences, but rather the desired, ideal process behavior on the type level. The attribute levels like time or costs attributed to the functions are therefore average values.

The target model is implemented by configuring parameters of standard software (customizing) or by model-driven software generation in an application system.

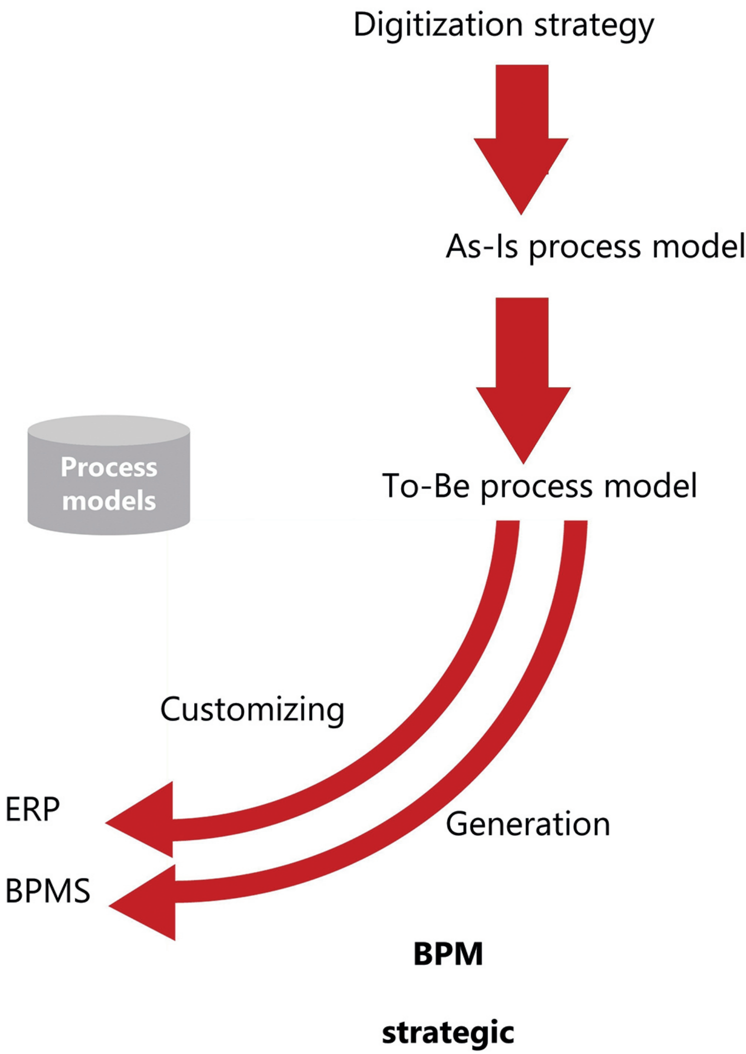

Figure 2.B.01: From the digital process model to the application system

II. Model-supported customizing

If an application software has already been decided upon (for instance an ERP or CRM system), it will be adapted to the possibilities of the software to be introduced. In addition, existing reference models of the software provider can also be used. Standard software manufacturers offer support for customizing whereby the target model is imported into their customizing tools and becomes the basis for the parameters. In particular, comparing the target model with a model of the software documented by the manufacturer is very helpful. Configuration of standard software is increasingly automated in this way.

At the start of the 90s, leading ERP providers did not yet document their software using models. The author had close professional contact with the founders of SAP AG and was able to convince them of the usefulness of data and process modeling following tough discussions. A counter-argument was that competitors could use the models to copy the software. However, in the end, the insight that the users require a content documentation of the software in order to compare it with their requirements won out. At the same time, they could orientate themselves to the best practice contents of the model when defining their requirements, or even learn from them.

Currently, the importance of modeling is increasing for introducing ERP software. The implementation tool “Solution Manager 7.2” from SAP even includes a simple modeling component, but above all possesses an open API interface for third-party modeling tools, to which the ARIS tools can also be docked in order to exchange models (see Fig. 2.B.02).

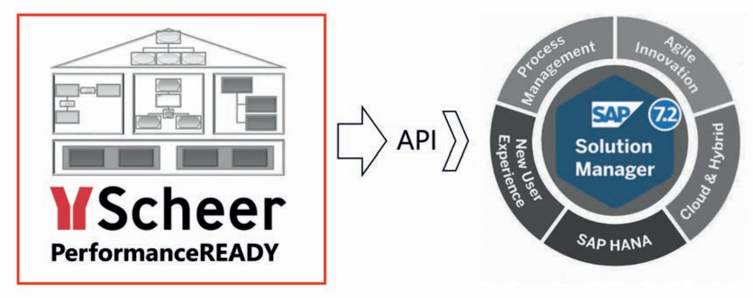

Figure 2.B.02: Connecting Scheer reference model with Solution Manager SAP AG

In addition, in the EPC-modeled process model it can be transformed automatically into the description language BPMN used by the SAP Solution Manager.

Scheer GmbH developed reference models for several industries under the name “Performance READY,” which were adapted by customers to their needs for an individual, SAP-based target model and then further processed using the Solution Manager from SAP. When customizing, the required part processes of the standard software could then be identified from the target model and parameters for decision rules could be taken over, such as value limits for the different handling of credit checks.

The modeling of business processes has now become a standard of BPM projects and the basis of documentation as well as customizing of standard application software. This approach is therefore also of central important for the digital transformation of companies.

III. Model-based software generation

Generally speaking, there is no pre-fabricated standard software available for disruptive new digital business models with corresponding processes. The user must then develop an individual solution themselves. To do so, he can use tools, which almost automatically generate the application software from the target process model. These systems are called BPMS (Business Process Management Systems). They generally consist of a platform with workflow functionality, an integration component to connect various systems, a runtime environment and a rule engine to process decision rules. The specialist target model will be refined further and technical aspects will be added to it. In addition, expanded modeling concepts like BPMN, BPEL and UML have permeated as industrial standards. The constructs - like the control flow, which can be further exploited - arising from the specialist description of a business model, for instance using the ARIS EPC method, can then be transformed into these concepts automatically and further processed.

BPMS includes, for instance, workflow systems and document management systems. The goal is to generate the application system from the process model without programming. Such systems are therefore also called “No Code” or “Low Code” systems.

With the “Scheer Process Excellence” system, the company Scheer GmbH developed a lean and highly integrated BPMS system. Standard software is generally not yet available for new digital business processes, so that developing one’s own on the basis of modern software architecture and software platforms is gaining great importance.

Fig. 2.B.03 shows the software system architecture “Scheer Process Excellence”. The guiding idea is to structure the architecture in a way, which is as simple and clear as possible. It has indeed been devised from the perspective of special software development, but it can also be the basis for the digitization architecture of any other software company or user.

The architecture serves as a guideline for development. External systems are placed on the lowest level, which can be connected with the software. These are initially human users, software robots (“bots”), machine robots and other intelligent things from the IoT, such as lamps, vehicles or washing machines.

Then there is the infrastructure on which the software can be run, indicated here by the cloud and blockchain characters.

As a third group, 3rd party application systems and tools are provided which can be connected with the software.

These elements are connected with one’s own software using a powerful middleware. This include inter alia connections to the elements and workflow functionalities below.

The integration engine is especially important in digitization projects. There are empirical values that show that in digitization projects 70 per cent of expenses are caused by the integration of new and existing systems.

In addition, systems are increasingly data-driven (smart data), so that besides integration, capture and analysis of data are emphasized in particular. Cumulation and filter functions are required precisely for data streams from the IoT. In the graphic, the middleware comprises the upper levels, because these build on their functionality.

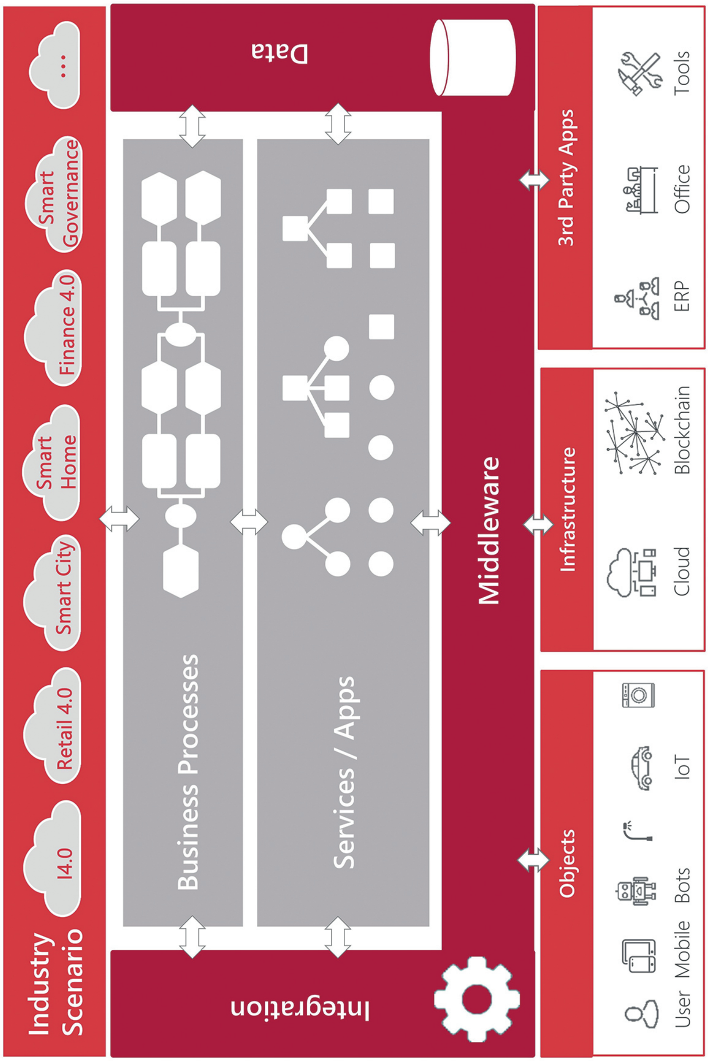

Figure 2.B.03: Digitization Architecture

The service level provides individual technical and application-based software elements (apps). Individual elementary services can be brought together into rougher constructs. The integration engine is used to do this and at the same time, the apps send data to the database.

The term service is not defined with regard to granularity. Generally, a service describes a self-contained software unit like an AI algorithm, an analytical evaluation process or order entry as part of the logistics process.

On the level of business processes, the apps are bound together to a business process. These business processes are modeled within the scope of the company's digitization strategy. Typical business processes on this level include “order to cash”, product development, production or logistics. On the upper level, (digitized) business processes are bundled into industrial scenarios.

For industrial companies, the scenario Industry 4.0 is dealt with in Part 1 and represents the development vision for digitized industrial companies. The same applies to retail with Retail 4.0. Smart City describes the intelligent control of traffic in cities, Smart Home is the digital control of houses, from security to old-age support. Other sector scenarios will be intimated with Finance 4.0 and Smart Government. The concepts of Consulting 4.0 and University 4.0 discussed in Part 1 are included here.

The architecture was previously explained “bottom up”. In the case of a BPMS approach, the layers will be run through from top to bottom, that is to say, that the business process model will first be created from the strategic vision, then the apps generated and connected with the middleware. The required third-party systems and subjects will then be connected to these and linked with the infrastructure.

A specific software development then follows the increasing refinement of the strategic target process description.

In doing so, the desired output formats are described and process apps are generated from this. In the case of simple human-centered processes, the control flow and the user interfaces can already generate a solution. Such applications can then also be developed by the specialist department in a model-driven way, without IT specialists. In the case of complex applications with high integration requirements, in the Scheer digitization platform (see Fig. 2.B.04) a continuous enrichment with technical information is supported by specialist EPC modeling via the transfer to BPMN notation and then to a selection of models in UML language. The result is then an integrated workable system defined by models. No code programming takes place. Changes to the system can only be generated through changes to the models.

In this way, model and software always have currency.

There are two routes on offer to introduce a platform architecture:

(1) If a first new digital solution for a specialist department should first be developed, then it is sensible to begin with a lean platform solution and to build on this by developing other applications step by step into a company-wide architecture. The benefits lie above all in a small initial investment and rapid development of a first solution.

(2) If a digital overall concept for the company already exists, a company-wide platform software can also be acquired

immediately. This is however linked with significant time and financial expense and there is the risk that the solution will later turn out to be too complicated and not fully used by the company. Furthermore, a lot of time and energy is used up establishing the platform infrastructure until the first successes in terms of content become visible.

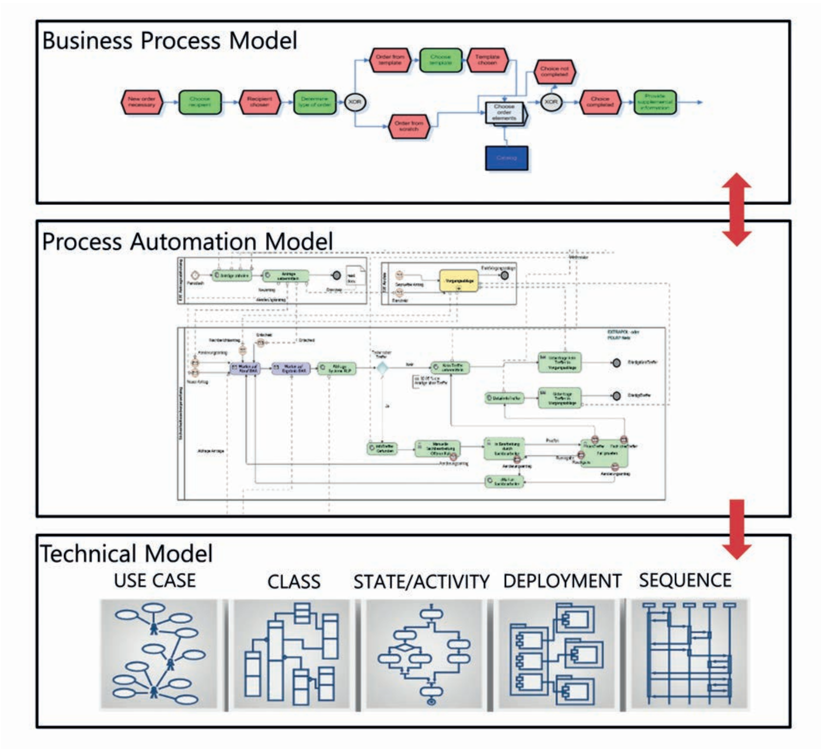

Figure 2.B.04: Model-supported software generation with Scheer Digitization Platform

After customizing a standard application system or generating a system with a BPMS, an executable application system is available and the semi-circle of Fig. 2B.01 of Business Process Management (BPM) is closed.

A transformation project from the actual analysis to the executable application system can take several months to several years depending on the size of the company and the number of business processes to be re-organized and therefore demonstrates the complexity and strategic important of digitization for companies. The model-driven procedure proved itself to be effective and makes important contributions to the great success of the BPM and standard software systems.

C. Process Mining

I. Overview

With the implementation of an executable process solution, the BPM approach is completed from recognition of the problem to the ready-to-run application system. However, it is not clear whether the expected use of a digitization project is created until the processes are carried out.

In both theory and practice, therefore, interest is increasingly shifting away from the strategic BPM approach to the more tactical consideration of the execution of the individual business process instances.

The shift from the type layer of the target model to consideration of the individual process instances is characterized graphically in Fig. 2.C.01 by the shift from the thick lines to three thinner lines.

In theory, the instances should follow the target business process model, or the software developed from it. However, this is only the case if the model includes the logic of all possible real business instances, the software is configured appropriately and no unforeseen deviations occur in reality. All sequences are then predefined and run automatically. This is only the case in theory, however. In reality, however, changes are made to the intended allocations of organizational units, such as of people or machines, to functions or there are disruptions. Humans then interfere and change sequences ad-hoc as against the target model.

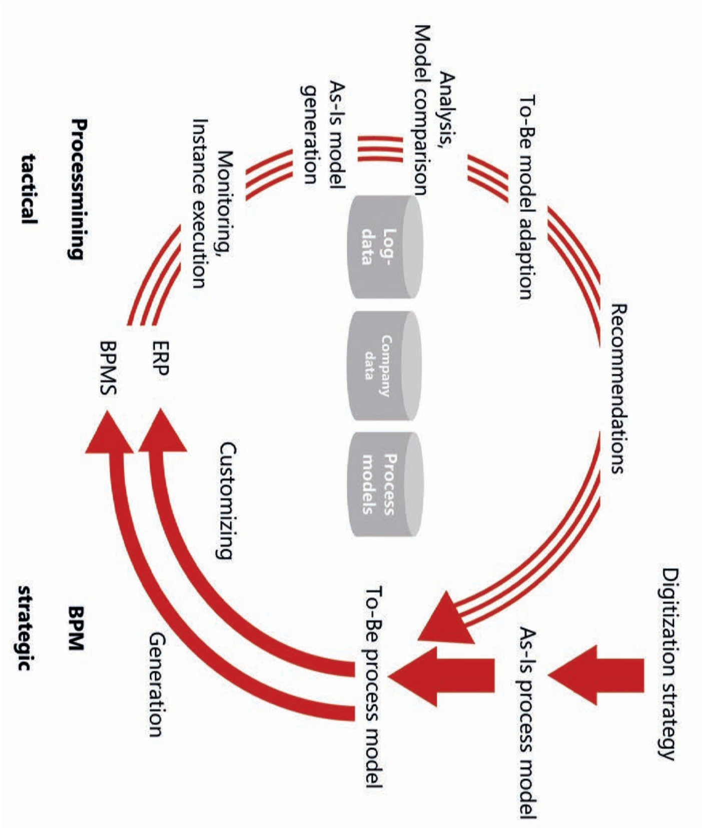

Figure 2.C.01: Process mining cycle

Such deviations justify the interest in the behavior of real process instances. These leave behind data traces in execution systems in the form of incident reports in so-called log files, which are now available for analysis. The management and analysis of these data traces is called Process Mining. While BPM is model-driven from the actual analysis, to creation of the target model, to software implementation, now the analysis of the process execution is driven primarily by data (van der Aalst, 2011).

Automatic searches in data stocks to recognize unexpected patterns and contexts and to process these in an easily understood, often graphic form, is generally called Data Mining and belongs to the field of Data Analytics. If this procedure is applied to business processes, it is called Process Mining. This is firstly a matter of capturing the traces of the business processes during their execution in a log file and observing their behavior (monitoring).

In the next stage, an algorithm then automatically generates an actual process model from the data traces.

Deviations are determined by comparing the existing target model with the data traces of the log file and the generated actual model. These are analyzed to adapt the target model to reality and to develop suggestions for organizational improvement.

Process Mining can provide information about whether compliance rules are observed or breached in execution of the process, at what points capacity bottlenecks arise, whether deviations are made from intended capacity allocations or how throughput times and quality behave.

Drawing upon automatic conclusions to improve the processes requires the use of complex AI methods, in particular machine learning.

The model adapted in such a way is then stored as a new target model in the model database.

The application systems also generate result data, which are called company data in Fig. 2.C.01. These are also available for analysis within the scope of Business Intelligence (BI) and Data Mining.

The log data shall be analyzed at periodic intervals, for instance once a month, or constantly in streaming.

If serious changes in the process' environment occur which give reason to make a fundamental review of the process structure, or should a new application software be introduced, the strategic BPM approach can be started anew.

The addition of the BPM approach to Process Mining, in particular also through the use of AI technologies, leads to a new quality of process management and is therefore called "intelligent BPM" (iBPM).

Process Mining is currently being intensively revised by academics with formal methods (see for instance van der Aalst, 2011).

The objective of this research is to almost fully automate Process Mining by developing algorithms. By foregoing the use of human specialist knowledge, however, this currently leads to an inflated complexity of the algorithms for tasks that an experienced process manager can perform intuitively easily and better. Here a combination of automated processes and specialist knowledge makes more sense.

The academics also often lack a deeper practical experience with marketable systems.

Under the author's management, the system "ARIS Process Performance Manager (PPM)" was already developed at the start of the 90s by the then IDS Scheer AG as one of the first Process Mining software products and since then has been used successfully around the world.

Since then, there is an increasingly broad offer of commercial software systems for Process Mining. In academia, however, the open source product "Process Mining framework (ProM)" with open interfaces for plug-ins (Munoz-Gama, 2016; van der Aalst & Weijters, 2004) dominates, but is hardly used in practice.

Due to the current high level of interest in Process Mining, the individual phases will be dealt with in more detail.

II. Log file

a. Structure

The outcome of Process Mining is the log file from one or more application systems, e.g. ERP, CRM or workflow systems (IEEE Task Force on Process Mining, 2012). During run time, these store event data with their attributes. Depending on the system, these can differ by type, granularity and scope.

Events are time events and describe a change in state of a function in an operating process. Functions are for instance creating an order, credit check or payment. Typical events include the start or end of a function.

In the case of logistics or IoT applications, like Smart City, Smart Home or Smart Car, which are becoming increasingly important, functions and events which can be delivered from sensor, image recognition or RFID scanners will be increasingly incorporated (Soffer et al., 2017). These events can also be recorded in the log file.

An initial task of Process Mining is to harmonize the different event data of a process and to provide it in a standardized file for analysis. Problems can already occur here in that data are false, unimportant or incomplete. This is referred to as noise (Burattin, 2015). It can also be difficult to identify a process instance through several identity numbers and naming in different systems. Special algorithms are being developed to solve these tasks (Munoz-Gama, 2016).

Without going any deeper into the technical details, the structure of a log file is shown in the simple example of the process model of order processing from Fig. 2.A.03.

In Fig. 2.C.02, the three possible instance models are first represented. The start and end events of the functions are explicitly stated.

Instance 34711 describes a case where the credit check is negative, and the order is therefore rejected and the customer is informed accordingly.

Instance 34712 leads to processing without a credit check. The customer and the accounts department will be informed after the conclusion of the processing.

In instance 34713, the credit check is positive, the order is processed and the customer and accounts department are informed about the end of the processing.

As logical connections, only the "AND" links are contained because no alternative processes occur any more in actual instances. In Fig. C.2.03, the log files generated by the order processing system of the three instances from Fig. C.2.02 are entered.

One row is created per event. Each event is allocated an event ID. For better clarity, the instances are arranged by their IDs. Since only two event types are introduced in this example, they denote either the start or the end of a function. For the start and end, time stamps are recorded according to day, month and time, which can be as refined as preferred according to the system, for instance to the precise millisecond.

Many application systems include either only the start or the end of functions. In order to be able to determine the function durations and logical connections more easily, both event types are provided here.

Each event is also allocated the organizational unit or a processor concerned. The final column represents additional descriptive attributes, such as quality information, volumes, costs etc.

With the log file, the starting point for the actual Process Mining is now provided.

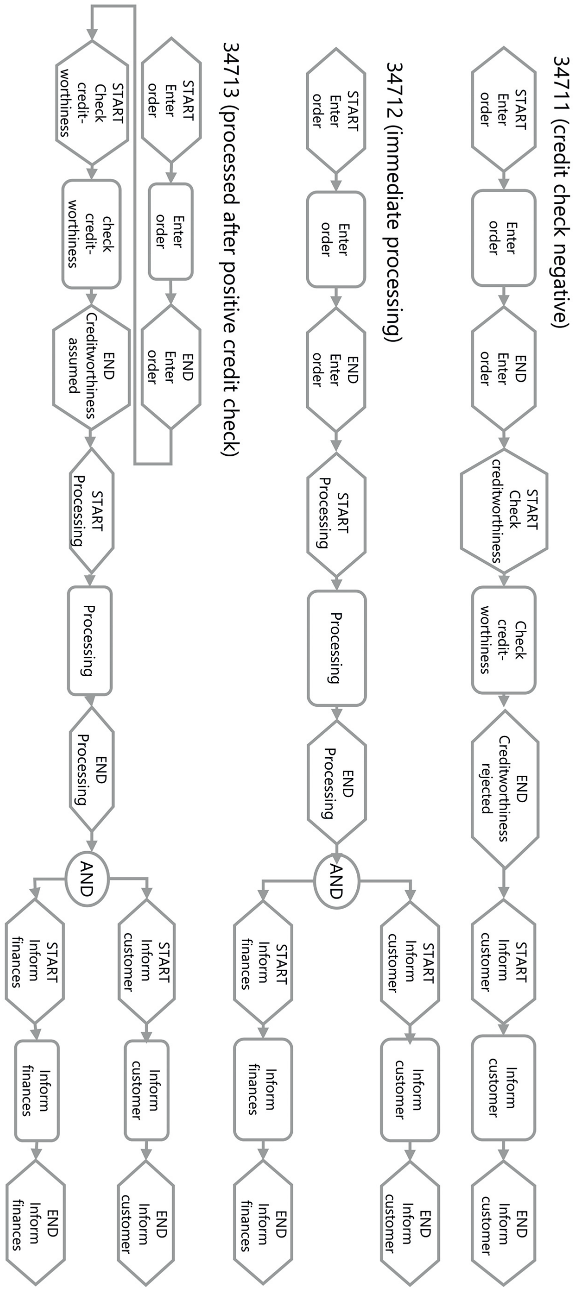

Figure 2.C.02: Instance models of order processing pursuant to Fig. 2.A.03

Instance ID	Event ID	START Function Day, month, time	END Function Day, month, time	Name Function	Organization/ Agent	Further Attributes
34711	...1	5.4.8.02	-	Enter order	M	XX
	2	-	5.4.8.10	Enter order	M	YY
	3	5.4.9.03	-	Check creditworthiness	S	BB
	4	-	5.4.9.40	Check creditworthiness	S	ZZ
	5	5.4.9.45	-	Inform customer	K	LL
	6	-	5.4.9.46	Inform customer	K	MM
34712	9	5.4.8.12	-	Enter order	M	ZZ
	12	-	5.4.8.14	Enter order	M	XX
	13	5.4.8.27	-	Processing	L	XX
	15	-	6.4.10.03	Processing	L	BB
	17	6.4.11.02	-	Inform customer	K	AA
	18	-	6.4.11.14	Inform customer	K	KK
	20	6.4.11.02	-	Inform finances	F	FF
	21	-	6.4.11.05	Inform finances	F	
34713	25	5.4.8.20	-	Enter order	M	LL
	26	-	5.4.8.25	Enter order	M	HH
	27	5.4.9.45	-	Check creditworthiness	S	JJ
	30	-	6.4.11.25	Check creditworthiness	S	FF
	31	6.4.15.03	-	Processing	L	GG
	33	-	7.4.9.28	Processing	L	ZZ
	34	7.4.10.02	-	Inform customer	K	RR
	35	-	7.4.10.08	Inform customer	K	SS
	37	7.4.10.02	-	Inform finances	F	CC
	38	-	7.4.10.15	Inform finances	F	DD

Figure 2.C.03: Log file of order processing

b. Analyses

A log file with the structure of Fig. 2.C.03 already offers a basis for many practical analyses of the real process behavior, whereby for instance the distribution of processing times per function can be statistically analyzed. Likewise, load statistics for organization units and processors can be determined.

The individual instances can be represented graphically according to their start and end times (see Fig. 2.C.04 for the three instances in the example).

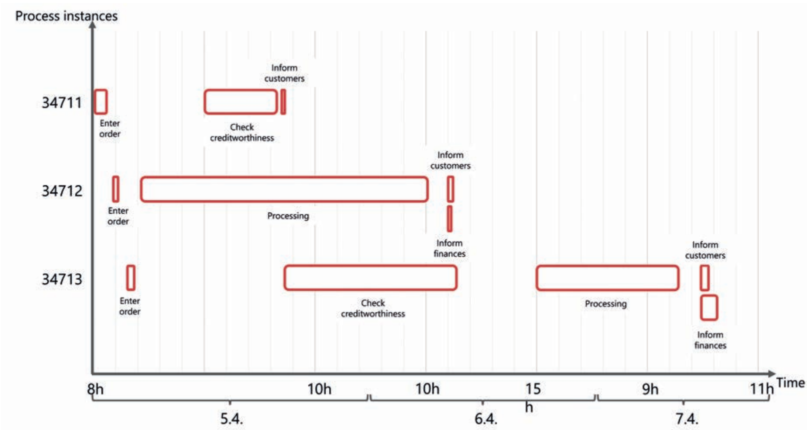

Figure 2.C.04: Temporal sequence of the three example instances

When analyzing a large number of process instances of a period, indications about bottleneck situations can be gained from the steepness of the starting line (see Fig. 2.C.05). The steeper the curve, the more orders arrive per time unit.

Another interesting analysis is fraud detection. It is known that a large number of frauds can be traced to manipulations carried out by staff members. For instance, if in a financial institution there is a sudden influx of transactions on an otherwise rather quiet weekday, this could be a cause for an audit. These cases can be established using the time stamp on the function “transfer” of a log file.

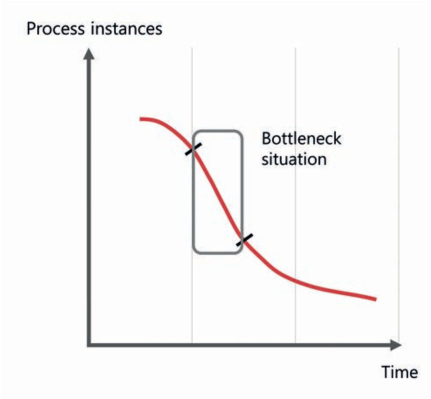

Figure 2.C.05: Starting lines of the instances of a larger log file

These already interesting analyses lack a relation to the entire business model, however, because the control flow of the functions of all possible instances is not apparent from the log file. Therefore, a process model is required in addition for process-related analyses. This can be a target model already manually prepared or an actual model generated from the data in the log file. Since the comparisons of the log file with the two model types are the same, the generation of the actual model will be sketched first. The comparison log file is then analyzed with the models. The target and actual model are then finally contrasted.

III. Generation of the actual model

The actual model is determined from the process sequences actually processed and represents the real situation. It cannot however contain any paths which are possible, but which have not been taken in the period considered.

Very complicated algorithms have been developed to generate models. These are not represented here in detail (but on this, see for instance Munoz-Gama, 2016; van der Aalst, 2011), and instead only a few indications of plausibility are provided.

If, for instance, a function F1 is always carried out before function F2 in terms of time, then the relationship is called F2 AFTER F1. If a function F3 always follows F1 and F2, but if F1 and F2 are carried out in parallel, then there is an AND connection between F1, F2 and the input of F3.

If particular functions new appear together in the instances, then this can indicate an exclusive OR (XOR) relationship.

If functions sometimes appear together and sometimes only individually, then this is indicative of an inclusive OR relationship.

On the basis of such considerations, an algorithm for model generation can be developed (van der Aalst, 2011).

A generated model is only ever as good as the database allows. It is more representative if more instances have been incorporated. Therefore, the calculation is carried out periodically with the largest possible number of instances (several hundred). The time window considered can constantly move further if streaming is used.

A fundamental problem for any model creation, be it manual or automatic, are the effects of overfitting and under fitting.

In the case of overfitting, the model is too detailed and contains too much unimportant information. If, for instance, in the case of an order process, large and small orders, export and domestic orders, standard and tailored individual orders, which are each subject to different processing, are recorded together in one model, then this leads to a confusing model, which is often referred to as a spaghetti model. In the extreme, the modeling then loses any sense.

A generated spaghetti model (van der Aalst, 2011) for the handling process in a hospital is reproduced in Fig. 2.C.06. It has been determined from a log file with 24331 events, which belong to 376 functions.

The complexity can be attributed to the fact that different illnesses are recorded with difference sequences in a common model. This led to the effect of overfitting mentioned.

When the cases are divided according to the different types of illnesses and models generated separately for this, clearer model structures would be produced. Besides the log file, specialist knowledge about separating the cases must also be introduced. It therefore offers to combine algorithmic and context-related modeling.

In the case of under fitting, a model is too rough and therefore of little significance, if for instance only one of three instances from Fig. 2.C.02 is set as a general model. Finding a balance between over- and under fitting is a challenge both for manual modeling as well as for algorithmic generation. In Process Mining, algorithms have also been developed which adjust an existing model, whereby, for instance, functions that are used very seldom are removed from the model, or paths that are very similar to one another are merged.

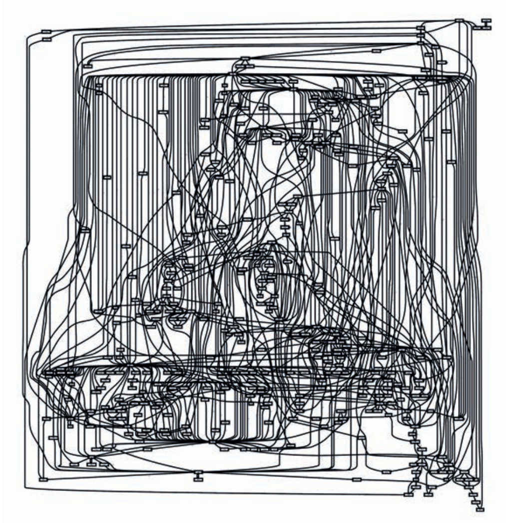

Figure 2.C.06: Generated spaghetti model van der Aalst, 2011

As a result of the generation, there is then a model, which reproduces the control structure of the process instances included in a compressed form.

When applying the above rules, the process model of Fig. 2.A.03 from the log file of Fig. 2.C.03 has been recorded in full because all three possible instances are available as input. This is of course attributable to the simplicity of the example. If there are hundreds of functions and even more instances, this will produce significantly more complex problems.

IV. Comparison of the log file with the process model

By comparing the sequence of an individual instance with a process model, it possible to check whether all functions required by the model have been run through. Depending on the level of detail of the attribute data provided in the log file, content checks can also be carried out by, for instance, determining deviations between costs panned in the model and actually incurred. Using the process model, additional company data of the application systems can also be accessed.

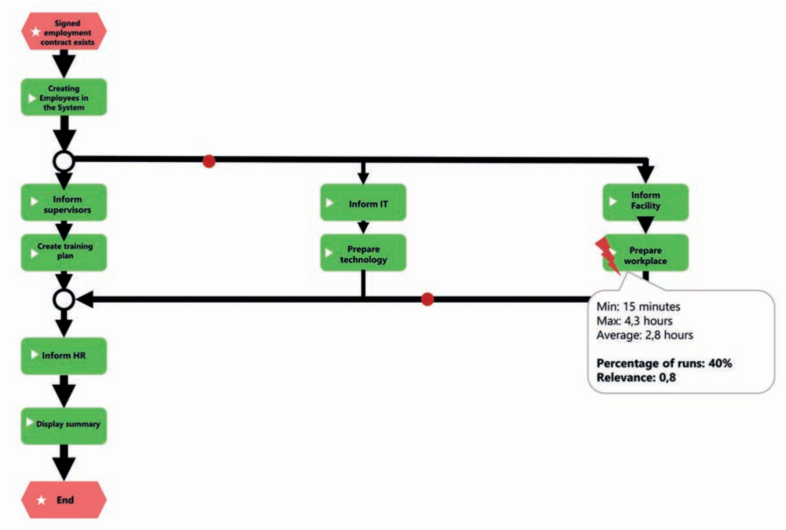

Figure 2.C.07: Dynamic simulation of the log file with preferred lines, time values and relevance of functions

A visually impressive analysis is the animated simulation of the processes processed, whereby the individual instances run through the graphic model in the time lapse. This is indicated in Fig. 2.C.07 in an onboarding process of staff members. Two points show two instances on their path through the model. The dynamic simulation cannot be represented, however.

The regularity with which the different paths of the model are run through is characterized by the strength of the connecting lines as preferred lines of the process (Turner, Tiwari, Olaiya, & Xu, 2012).

The elements of the process model can be allocated actual values for attributes from the log file. Interestingly, for example, the throughput times of individual functions are determined, for the average value and variance from the time stamps of the functions Since the subsequent functions are familiar from the control flow, their logical earliest start times can also be determined, compared with their actual start times and waiting times and unwanted bottlenecks can be recognized.

Based on the regularity with which a function is carried out, its waiting time as well as duration and variance, its relevance for a more detailed inspection is recognized. In Fig. 2.C.07, the function "prepare workplace" is run through in 42% of the cases and shows a high spread in processing time, so it is allocated a higher attention value of 0.8.

If a function is repeatedly processed successively (cycle), this indicates quality problems in the processing.

By analyzing the ramifications, the regularities of the results of decision rules can be determined and their meaningfulness can be reviewed. The communication relationships between employees or organizational units are another automatic analysis (Ferreira, 2017; van der Aalst, 2011).

Refined analyses can be carried out by combining the process model, log file and company data of the application systems. For the individual functions of a purchase process, the following examples of detailed indicators for risks provide information which can be analyzed with process data and data from the purchasing system (Willcocks, Lacity, & Craig, 2015):

- "Order request" function: Request by unauthorized person, multiple requests, unusual volumes;

- “Order” function: Order of sham deliveries, inflated prices, unauthorized suppliers, social connection between suppliers and employees;
- “Order release” function: Order without order request, release by unauthorized person, release outside of defined limits;
- “Incoming goods” function: Deviation from order, no incoming goods inspection carried out, unusual cases of damage;
- “Payment instruction” function: Payment without invoice, discounts not exhausted, excess or double payment, unusual payment recipient.

Automatic recognition of anomalies excludes human influence when making an assessment and thereby objectifies the result. The process sequences recognized as abnormal can then be analyzed further (Bezerra & Wainer, 2013).

At the AWS Institute for Digital Products and Processes in Saarbrücken, an algorithm has been developed which independently discovers different abnormal situations in processes (Linn & Werth, 2016):

- Sequence anomaly: The functions of an instance were carried out in an order that rarely occurs.
- Time anomaly: The duration of a function or the duration of a function sequence is unusual.
- Organizational anomaly: A function is carried out by an unintended or surprising person or institution.
- Data anomaly: Unusual data is transported in the process.

- Multi-dimensional anomaly: An unusual combination of deviations appears, which individually do not represent an anomaly.

The considerations show which powerful content analyses are possible by combining process model, log file and company data.

Many of the analyses have become a standard of Process Mining and are held pre-formulated by commercial tools.

V. Comparison of generated actual model with target model

If a generated actual model and a target model are available, these can be compared with one another. Since models are a condensed representation, the analyses are on a higher level of aggregation than the comparison with the log file. Generally, it must be investigated whether the target model changed in case of deviations or whether the process execution does not keep to the stipulated processing rules.

In this way, dead branches can be discovered, that is to say parts of the process that exist in the target model, but are not throughput by genuine process instances and therefore are not recorded in the actual model. It must then be investigated whether these parts are permanently deactivated and the organization should react to this by redistributing capacities. However, the reverse scenario can also occur, whereby new process arms appear in the actual model that do not exist in the target model.

VI. Improvement of the process model and process management

By comparing the log file with the target model and the actual model with the target model, potentials for improvement can be pointed out.

First, the existing target model can be edited using the findings of the actual process, so that a more realistic target model is available for the next analysis. Specific measures that are taken to improve the process organization are more important.

If attribute values for functions like the average processing times or costs are recorded in both the target and the actual model, suggestions for organizational changes can be gained from the deviations. Employees can be better trained, for instance.

Capacity bottlenecks can be reduced by redistributing resources, processing loops can be reduced by using more accurate technical procedures or better training of staff members. Processes can also be streamlined by eliminating superfluous functions and paths (IEEE Task Force on Process Mining, 2012). The regularities which state how often particular branches are run through help to make the decision rules more precise (van der Aalst, 2011).

A comparison of the actual model of various organizational units like branches or subsidiary companies with the target model helps to identify "best practice" models, from which the other units can learn (Mans, van der Aalst, & Vanwersch, 2015). Learning effects can also be achieved by, for instance, analyzing the best 10 process instances and then presenting them to staff members as "Best Practice".

The analysis of which features of instances determine their throughput times can be used to segment process organizations, for instance, for simple and complex products or domestic and export orders (Mans et al., 2015).

As a result of these multiple adjustments, the target model is improved and brought closer to reality. Finally, the implementing application systems are adjusted. If there is a close connection between the model and the software, as is the case for BPMS software, this occurs automatically. In the case of ERP or CRM systems, this is achieved via the connection to the customizing tools.

Figure 2.C.08: Process Mining dashboard

Commercial Process Mining systems offer convenient dashboards, using which the process manager can access the mining analyses currently (Fig. 2.C.08 or see also (Petermann, 2017; Software AG, 2017).

VII. Alternative approach to Process Mining

An alternative approach to the model-based Process Mining presented is, instead of costly model generation, to support the analysis of the log file more conveniently.

In its compressed form, a process model contains all possible instance paths and should become easier and easier to handle than reality. Process models are however often very complex due to their interlaced logical connectors. The comparison of the model of Fig. 2.A.03 with the three instance models of Fig. 2.C.02 already shows that the individual sequences are easy to comprehend, while the aggregate model is very complex, in spite of the simple example used.

In place of the aggregated model, which is costly to generate, the individual instance models are easily determined from the log file. Convenient search algorithms can be directed at these to filter cases with particular features or to identify similarities using "nearest neighbor" algorithms. As a result, different classes of sequences can be determined, which are represented by typical instance models. These instance models do not contain any more logical alternative branches and are easy to comprehend. The development of algorithms then shifts from model generation to filtering and structuring the instance models derived from the log file.

VIII. Combination of Process and Product Mining

Process Mining, dealt with previously, takes the stock of process instances to be processed in a period for granted. It therefore does not optimize the production program itself, but only the process of how it is processed. The structure variable is therefore only the process model, and not the composition of the tasks to be processed. However, it is precisely here that extended mining can be of service by recording events of process sequences and then re-composing the tasks on this basis.

In a process model, it is admitted that different tasks of the same type are processed, so in the order processing example, orders with low and high order values and orders with positive or negative credit check results. It therefore has to be asked whether there can and should be an influence on their proportions in the mix of tasks on the basis of the mining results.

Product Mining is added to Process Mining, which does not change the structure of the process model, but the way in which what paths within the model are used.

If for instance in a hospital very poor results are achieved when treating particularly difficult cases, one can transfer these cases to hospitals better equipped for them; in spite of this, the process model continues to exist because the illness is still treated for simpler cases. Only the process paths of more severe cases will be throughput less. In a company, too, process results can lead to a situation where the production program must be adapted. That is, the process model is not optimized, but the structure of the mixture of instances to trigger the process is. Process Mining should therefore also be closely connected with Product Mining.

An example case which was worked out at the AWSi (Nalbach, Linn, Derouet, & Werth, 2018) should illuminate this idea.

In a textile company, the defects arising in items of clothing, like seam defects, holes, color defects or stains are recorded from the production processes of cases complained about in quality checks and by customers (returns). At the same time, the cases are allocated feature values of product qualities. These are for instance color, clothing size, country of origin of the material, manufacturing process such as knitting or sewing and proportions of starting materials like cotton or polyester.

Depending on the composition of these features, a process path is produced with another probability of occurrence within the same process model. For instance, processing cycles could be higher in the country of origin of the raw products than in others.

With the aid of a machine learning procedure (2-level Artificial Neural Network) the connection between the defect types and the product features was determined. 2 million data sets of returns and quality checks are available to train the system. The result mask is represented in Fig. 2.C.09. In the upper area, the product features are stated in two rows with their possible criteria for two product alternatives. In the example they only differ in terms of their countries of origin of Bangladesh or Portugal. The other features such as material composition of cotton or polyester, color, size and type of product are the same. In the lower area, the defect types are stated with their possible criteria for the two combinations of the product features. The results are allocated accuracy specifications using color codes.

The correlations cannot be used for product design and the quality of the products can be controlled preventively by determining the product features in such a way when drafting a new product that the particular probabilities of types of defect are accepted. Beside the two alternatives shown, other feature combinations can be automatically tested until a decision is made for one alternative.

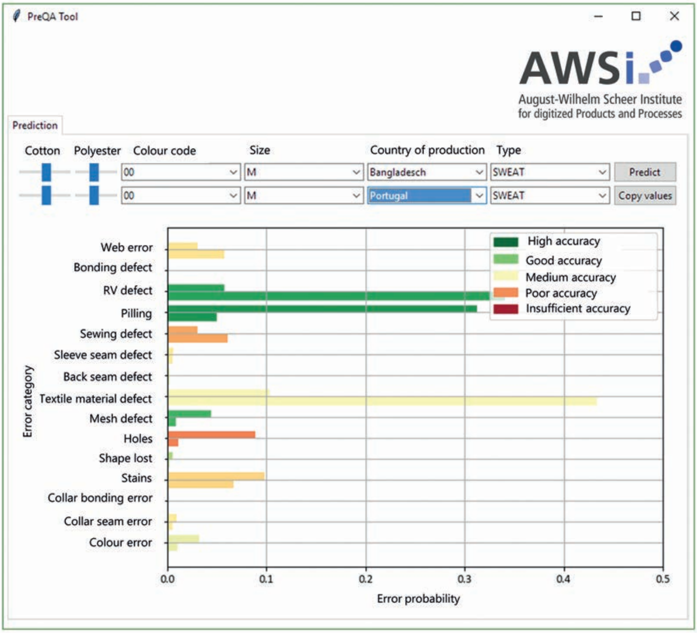

Figure 2.C.09: Combining Process and Product Mining

In this way, the paths will then the determined with their regularities within the process model, which are later analyzed again with Process Mining.

Product Mining and Process Mining therefore mutually influence one another because a multiple throughput of a production process on the basis of quality defects is also recorded in Process Mining. The process stages can thereupon be analyzed as to whether the defects can be reduced further with improved production procedures.

Process and Product Mining both serve to generally increase performance and should be viewed in a larger context.

D. Operational Performance Support

The development and implementation of a digitization strategy is a strategically important and long-term project. The adjustment measures identified during Process Mining are of a rather short-term, tactical nature and change the target and process model only gradually. The operative support of individual process instances during their implementation will now be dealt with using the concept of Operational Performance Support. The implementation loop is added to the model of the process loop in Fig. 2.D.01 on the left side.

Because the individual process sequence is considered, it is marked with an individual line. The aim is to support the implementation of the instances during their processing (pre mortem) in real-time using extensively automated aids. The circle then leads to Process Mining, is collected together with the processes of the period under consideration and analyzed periodically (post mortem).

The operational performance support circle is controlled using real-time data from the implementation of the instances, data from the process environment, through intelligent algorithms as well as using specialist content for user support. In doing so, the implementation data are recorded in the log file already introduced and the company data generated from the application systems are recorded. The real-time process environment includes, for instance, the conditions of the resources employed, temperature or sensor data of a logistics process or the availability of materials required.

Besides the log file and company data, the process models can also be used further.

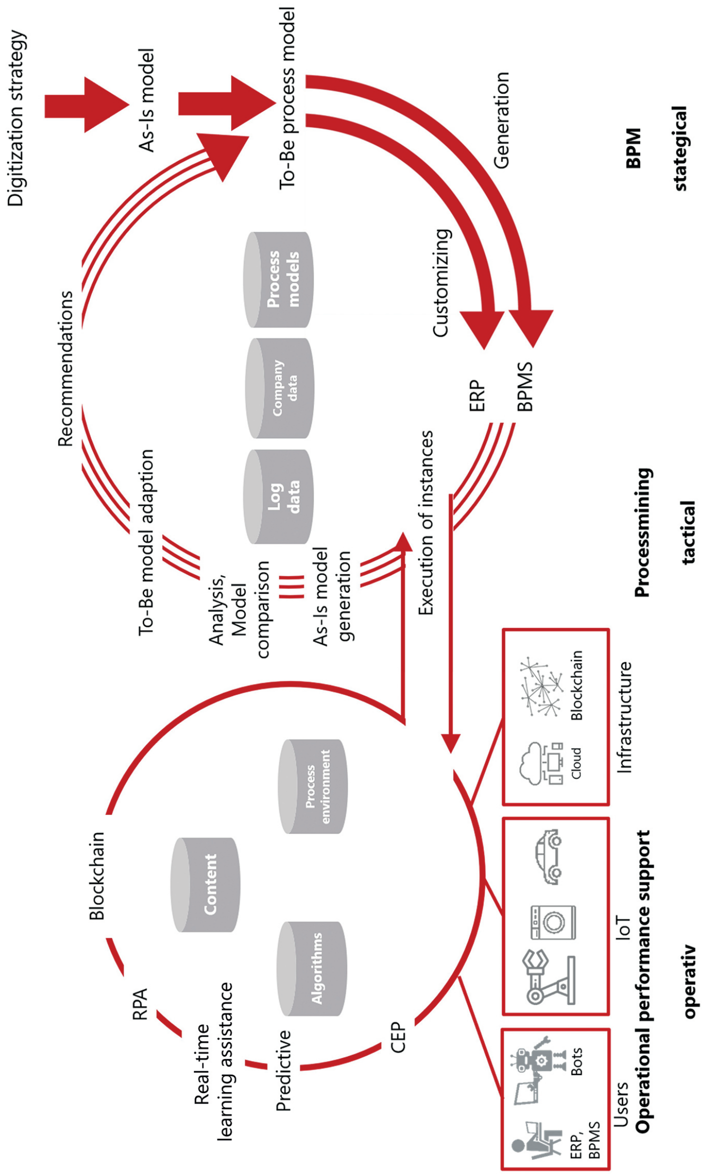

Figure 2.D.01: Entire process loop from strategy to real-time implementation

The functions of the implementation loop include the planning and control of the instance, the event-controlled reaction to particular changes in state of the process, forecast analyses and suggestions for action to avoid unplanned effects as well as online learning aids for users in problem situations.

Fig. 2.D.01 therefore represents the entire process management - from strategy to tactics, to operative management. Because complex analysis algorithms are employed using artificial intelligence, this approach is also referred to as intelligent Business Process Management (iBPM).

I. Process planning and management

Numerous optimization procedures have been developed within the scope of operations research for industrial production management, which can also be applied in a real-time environment. According to optimization criteria - such as minimizing the throughput time or maximizing capacity utilization - the individual work stages of a production instance, that is to say of a production order for a part, are ordered in a sequence and allocated processing places. In doing so, detailed process descriptions are available in the production with the work plans.

The basic ideas behind this production management can be generalized and transferred to all process types. In the administrative department, the process models are available with their function descriptions instead of the work plans. Therefore, in principle the same data basis exists as in production.

Tried and tested control room concepts allow a transparent overview of the operations currently being processed and pending for processing in the production area. The graphic planning board is in the center, as Fig. 2.D.02 shows. In order to optimize the process, stable and proven software systems will be employed in production with MES (Manufacturing Execution System). These can in principle also be used in administration.

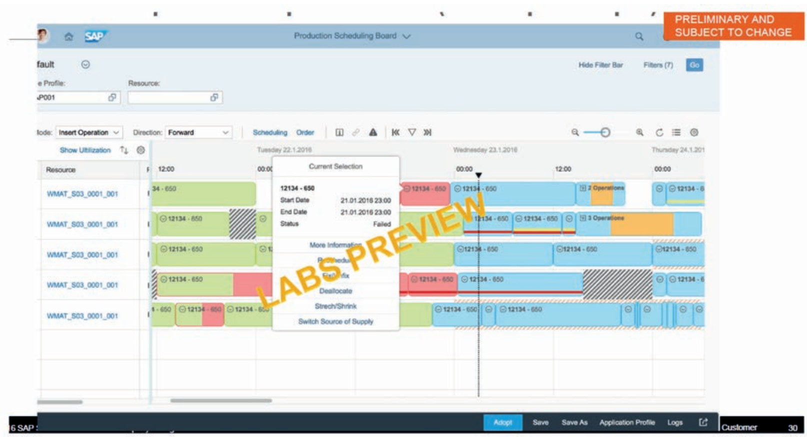

Figure 2.D.02: Control station surface for production management (SAP AG)

The production area therefore holds an advantage in process planning and management because the utilization of expensive and complex technical production plants requires careful management of production early on. In contrast, in the - comparably simpler and more resource-poor - administrative area, more emphasis was placed on the abilities of staff to manage themselves.

However, with increasing complexity and competitive pressure on costs, reliability, quality and speed of processes in modern administrative departments, this is no longer enough. Process management is therefore gaining general importance.

II. Complex Event Processing (CEP)

Using concepts like the IoT, Smart City, Smart Car as well as Smart Home, monitoring and management functions can be supported on the granule level in production and logistics processes by using sensors and actuators. Sensors deliver incidents regarding states and changes in state from the subjects (devices) which carry out the process. These can then be analyzed by a CEP system in real-time and used as the basis for immediate decisions (real-time decision support). The processes will be considered on a deeper and more technical level of detail. It is to be expected that CEP will become increasingly significant in all industries and process types as a result of the increase in the use of sensors.

In the more business-oriented process management, the control flow of the business process, that is to say the sequence of the functions to be carried out with logical connections, comes to the fore. In the case of CEP, the technical subjects and the definition of events of interest, their condensation into more complex patterns and real-time actions to be triggered form the focus. In doing so, the events are subject to stochastic influences in their order and the time at which they appear. Due to the almost incomprehensibly high number of data constantly accruing, the deepest technical levels can be hidden, so that only filtered events with their reactions are dealt with.

Examples for data of a logistics application include the recording of transport goods using RFID, measurement values of sensors for the start of the vehicle, temperature measurement in the loading room, GPS location of the vehicle etc. Because such data can also be tracked continuously, interesting events can be determined using decision rules; not every temperature measurement is interesting, but only if it exceeds a critical value. The definition of limit values can be derived from the existing target process model. Individual measurement values can also be condensed with complex events, such as exceeding a temperature value at a particular time.

Event Based Systems (EBS) provide inter alia constant monitoring functions in order to filter interesting patterns out of the constant event stream.

The more business-oriented BPM and the more technically oriented CEP initially developed independently of one another. Both areas are converging with the influence of the IoT. In doing so, the BPM process description can be more strongly differentiated by incorporating finer and more complex functions and events. The BPM modeling languages must then be expanded accordingly.

The principle of CEP is made more specific following an example from Pnina Soffer et al (2017, S.10).

In the business logistics model, the function "Transport of goods from a warehouse of the supplier to the recipient" is represented as merely a single function within the entire process (see Fig. 2.D.03). Details are provided on the bordered transport function in Fig. 2.D.04. Three actors are involved in the transport: The heavy goods vehicle, the CEP monitoring system and an organizational planning and monitoring instance of the company.

It is therefore accepted that the goods will be collected by the company making the order with its own vehicle. When hiring a third company, the detailed process tracking would be carried out by it and the function “Transport” in the orderer’s process models would remain in the condensed form of Fig. 2.D.03. The example concerns the transportation of pharmaceutical drugs, whereby a maximum trip time as well as particular conditions regarding temperature and shaking must be observed.

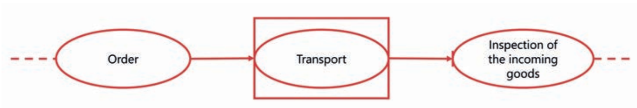

Figure 2.D.03: Business transport model

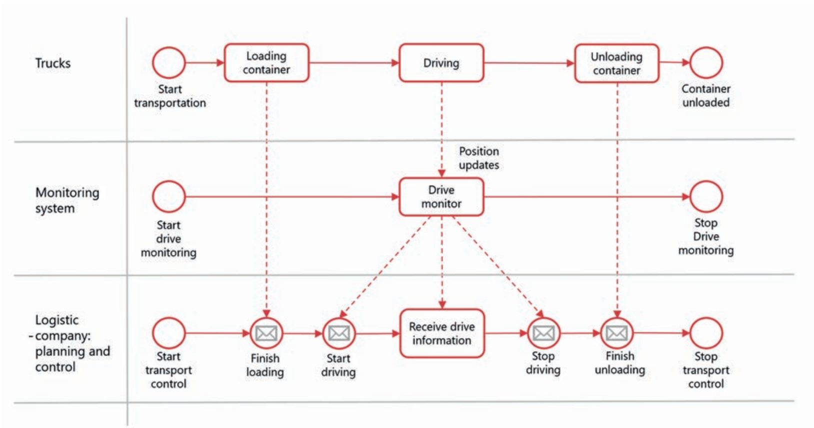

Figure 2.D.04: Refined transport process (according to Soffer et al., 2017)

It is therefore accepted that the goods will be collected by the company making the order with its own vehicle. When hiring a third company, the detailed process tracking would be carried out by it and the function “Transport” in the orderer’s process models would remain in the condensed form of Fig. 2.D.03. The example concerns the transportation of pharmaceutical drugs, whereby a maximum trip

time as well as particular conditions regarding temperature and shaking must be observed.

The monitoring system tracks the trip and sends location information, traffic status, temperature and moisture in the loading area to the planner's system. These data can then be used, for instance, to make (real-time) decisions about the driving routes to be changed. The start and end of the trip are also automatically recorded and sent to the planner.

Status reports are sent directly to the planning instance from the functions "Loading the container" and "Unloading the container". These can also be recorded and passed on automatically, for instance using RFID scanners.

The CEP is a valuable extension to process management both within the scope of Process Mining as well as Operational Performance Support. For Operational Performance Support, empirical knowledge concentrating on the individual instance is important, because there is already empirical knowledge identifying event patterns as well as real-time decision support. Conversely, physical limit values to be complied with under customer agreements are assumed, which are defined in a BPM model.

In the following parts too, interfaces to technical systems will be incorporated via sensors and actuators.

III. Predictive Performance Support

During the processing of a process instance, it is possible to compare the process states with the target process model in order to, for instance, determine the expected end date of the process. The target model is however created on the type layer and represents an average, desired sequence. The later sequence receives more branches from an existing state of a process instance, which are attached to conditions that are not yet known at the present time. To do so, (average) expected values must be set to forecast the later sequence.

Besides the target model, the instances of earlier similar processes of the log file can be analyzed. When processing an order, for instance, access can be made to the stored ordered process for the same customer and/or to processes for the same products ordered by other customers.

The sequences realized there can then serve to assess the later sequence of the present instance. Accordingly, the historical log file must be organized in such a way that it is easy to access. Because such large memories are available today, it is financially justifiable to store extensive historical process instances. In both cases, the objective is to forecast the later sequence for a given state of a process instance and to determine recommendations for its improvement.

This forecast of the sequence to be expected and the decision recommendations derived from this for the later sequence can be compared with the functions of a vehicle navigation system (van der Aalst, 2011). This immediately shows, for instance, in the case of a sudden road block, the changed expected time of arrival and suggests a new route for the given circumstances.

Eyes are therefore looking forward from the instance's processing state in order to set up new situations or to prevent unfavorable developments. For this purpose, appropriate algorithms have been developed in the field of Predictive Analytics, especially machine learning.

Machine learning algorithms “learn” a system behavior from observations in order to analyze it for forecasts. Artificial neural networks are once again the most well-known procedure. These display functions of the human brain. The artificial neurons are linked to one another and they are allocated weights. The weights of the neurons are trained in such a way by entering input/output cases so that the network delivers good output forecasts for new input values.

Today, many sensors are applied to production facilities which constantly measure temperature, vibrations, energy consumption etc. These data streams can be analyzed as input sizes of neural networks and used to make forecasts.

If there is a high degree of automation of software support, bots can be employed, that is to say autonomous working software programs which monitor, analyze and draw attention to expected events or interfere themselves to control the behavior of a facility without human interaction (see more under Chapter E. RPA).

Fig. 2.D.05a and 2.D.05b show an example of pro-active quality assurance by the Saarbrücken start-up company IS Predict GmbH, which is part of the Scheer Holding GmbH innovation network.

An automobile supplier uses 10 of the same type of grinding machine for high-precision machine operations. Although the machines have the same features - they are for instance delivered by the same manufacturer - different quality effects occur.

The aims of the analyses are to identify the disruptive factors of the process and to continually forecast the quality of the operation in order to take control if the quality deteriorates, because quality defects discovered later lead to high reject costs.

Figure 2.D.05a: Quality forecast after 5 seconds

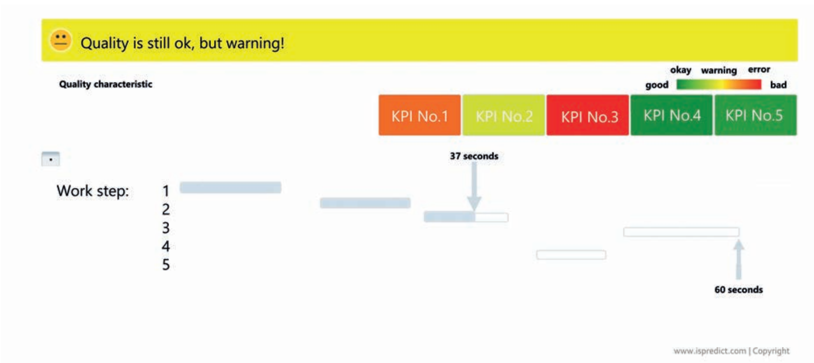

Figure 2.D.05b: Quality forecast after 37 seconds

To do so, 5 key performance indicators (KPI's) such as roughness of the surface, grinding depth, grinding angle, pressure etc. are defined which are measured by sensors in real time. Using the AI algorithm, the connection between these values and the overall quality is determined and a quality forecast is created continually during the operation.

The entire operation process of a workpiece lasts one minute and contains 5 work stages. After an operating time of 5 seconds of the first work stage (see Fig. 2.D.05a), three of the KPI's are in the green area, while one KPI is already red or yellow. Overall, it is forecast that the workpiece will be free from defects. This is shown by the top green bar. After 37 seconds (see Fig. 2.D.05b) two of the indicators are red and one yellow, and the system predicts that the overall quality will still be in order, but gives a warning, as shown by the yellow bar. This can be taken as a reason to re-adjust or replace the machine or the grinding tool after the operation.

Fig. 2.D.06 shows the software architecture of the company IS Predict for pro-active maintenance and quality management. In the meta-model level, generic model structures are managed. These form the output to discover the model for the application case considered. Various data sources (sensors) are connected with the model via interfaces. The model is automatically and continually adapted to new discoveries through learning algorithms. It delivers information about anomalies (for example, changes in the operating behavior of a facility), forecasts (for example, the most favorable time for maintenance of a facility), can be used for what-if simulations (for example, to recognize the effect of early maintenance on the

production plan) and recommends interventions to take control (for example, to reduce production speed or maintenance measures).

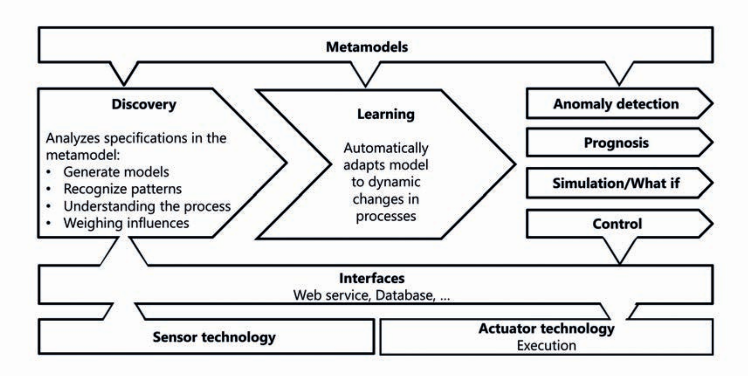

Figure 2.D.06: Software system architecture for pro-active management by IS Predict GmbH

A few examples should help to further clarify the predictive and management approach:

In an automobile factory, the smallest defects in the chassis are discovered already after the pressing and punching process after analyzing sensor data, and which would lead to high subsequent costs if they had been discovered later. If, for instance, hairline cracks are first discovered during final assembly, dealing with the defect will be very expensive.

In a cement factory it is predicted early on using sensor data what quality the ground cement will achieve following the final process step. The machines can be set up pro-actively in such a way (Prescriptive Analytics) that the desired quality is achieved.

In a steel works, the quality of the steel depends on numerous factors; in particular, the liquid steel must be cut off at the right time. By combining the measurement data of several indicators, the temperature can be pro-actively predicted and the correct time determined.

Companies are increasingly producing their own power. If less energy is consumed than is produced, the excess power can be marketed on the power exchange. The system predicts the power required, analyzes the market situation and recommends when and how much power should be offered on the exchange at what price.

Particular emphasis is to be placed on the fact that the development of the predictive approach increasingly includes the management and optimization of the process. The systems considered are then configured automatically using actuators. This closes a control loop from data capture by sensors to management by actuators.

IV. Operational Support using real-time learning aids

Particular attention is increasingly being paid to real-time learning aids during an instance operation. If an operator encounters a situation which he does not understand, direct information can be passed to him which will help him to continue the operation (imc AG, 2017a).

Previously, helpdesks were set up to provide support for IT systems and to which the user could turn, or he would ask his colleagues. However, this then engages other staff members. Approaches were therefore developed to automate such helpdesk functions. New developments of digital learning support were used to do this.

The 70:20:10 rule has been discussed for a long time in the learning environment. It says that 70% of learning takes place by “doing”, 20% by discussing with colleagues and only 10% from formal stockpiling of knowledge. Therefore, motivation to learn is very high in a specific problem case. A system, which passes the particular information required to the user based on the context, must be familiar with the application and the process stage currently being operated, as well as have knowledge (content) about support measures.

The system architecture of the Process Guide by start-up company imc AG in Saarbrücken is represented in Fig. 2.D.07, which is part of the innovation network of Scheer Holding GmbH.

Employees of the application company create micro contents and help texts with external consultants using the “Designer” module, which are managed using the “Manager” module. In addition, they dismantle contents of existing training documents, user handbooks or system specifications into smaller units. Texts, images, screenshots or videos can also be created. The practical knowledge of particularly capable staff members (Champions) is used here. The data stored are kept constantly up to date on the basis of new experiences, which produces learning effects. Multiple authors can create contents in parallel via their own Designer and also see and edit contents created by other authors.

On the user side, the user is taken through the process (navigated) step by step. If there is a problem, the “Guide” module automatically accesses suitable help information depending on the context from the “Manager” module. The information is individualized and adjusted to the user’s level of training. The tasks are geared towards the various end devices. If systematic knowledge deficits are determined for the user, he will be provided with specific support. In order to support compliance, the user will be informed in real-time about compliance with relevant directives.

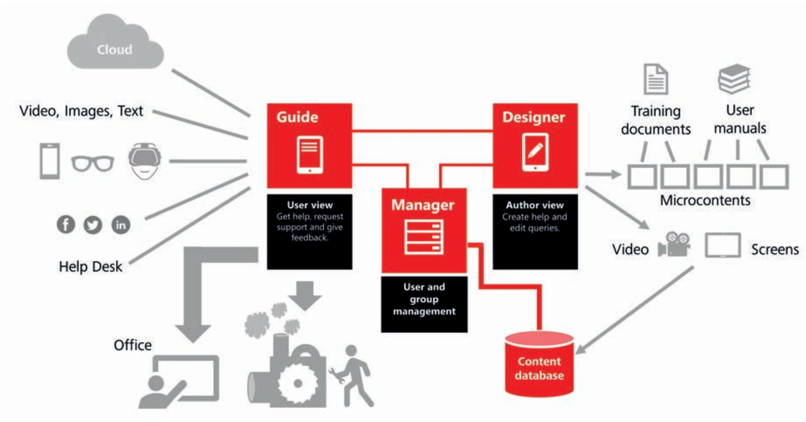

Figure 2.D.07: System architecture of "Process Guide" from imc AG

Where necessary, connections to human experts and the helpdesk will be established via social media functions.

The system supports the processing procedures both in computer-supported offices as well as in production. In the office, it is used in particular to support users of standard application software and has achieved significant streamlining successes there, such as in a large insurance company when introducing SAP software and in public administration when introducing Microsoft software (imc AG, 2017b).

In production, when converting a machine, for example, the staff member is shown an explanatory text about the machine on his smartphone or using augmented reality (AR) glasses. Augmented reality means that the user receives additional information from a database about the reality, which he is observing, that is to say the machine situation in this example.

Figure 2.D.08: Instructions on a smartphone or AR data glasses (imc AG, 2017c)

Figure 2.D.09: VR glasses looking at a drive in operation

Using the camera on his smartphone, he can scan the machine situation and the system determines the most practical aids. AR data glasses are transparent, so that the staff member can still see and his hands remain free for manual work (see Fig. 2.D.08). Another application in production includes repair instructions, which are passed on if there is a sudden machine failure.

Besides augmented reality, virtual reality (VR) applications are increasingly significant. In a VR application, the user is immersed in a virtual world and can move freely within it. Using a 360-degree camera, the user is provided with detailed recordings, using which he can already measure slight material defects. In Fig. 2.D.09, data glasses are represented looking at an actuator drive, in which a mini camera is installed.

He can then carry out maintenance work, even when the operation is on-going. By combining with AR, comments and help texts can also be shown in the images in real-time.

The research institute “AWS Institute for digital Products and Processes” in Saarbrücken carries out intensive research projects into VR applications in Education and Industry 4.0, and the VR representation in Fig. 2.D.09 originates from this (Linn, Bender, Prosser, Schmitt, & Werth, 2017). The use of hologram technology by products like HoloLens by Microsoft opens up other practical perspectives.

E. Robotic Process Automation (RPA)

In the entire process loop of Fig. 2.D.01, human users and software robots (bots) are indicated in the bottom row as the executing "subjects". The employment of bots is currently highly significant in the subject of Robotic Process Automation (RPA) and will therefore be dealt with in detail.

With RPA, a new path to the automation of business processes is taken which opens up a great deal of streamlining potential.

I. Overview of Robotic Process Automation (RPA)

Robots already dominate entire production lines: They work independently around the clock, do not show any signs of tiring, work without errors with consistent quality, can document their work in full and are flexible within the scope of their functionality to be trained for new activities (see Fig. 2.E.01).

These characteristics are also attractive for activities in the office. In the operational functions of logistics, purchasing, distribution, product development, accounting and HR, significant streamlining successes have already been achieved in the last three decades through ERP and BPMS. However, these applications still require a human handler to enter data and to make selection decisions (see Fig. 2.E.02).

The principle of RPA comes into pay in these applications. The operation of the systems should now be taken over by software robots.

Fig. 2.E.03 shows machine robots, but there are in fact "invisible" software programs.

Figure 2.E.01: Robots dominate entire production lines (source: Audi AG)

Figure 2.E.02: Substantive work by humans is still required for the operation of ERP and BPMS systems. (Source: Competence Call Centre GmbH)

Figure 2.E.03: With the aid of software robots (bots), more work stages can be automated. (Source: NDR)

The principle of RPA comes into pay in these applications. The operation of the systems should now be taken over by software robots. Fig. 2.E.03 shows machine robots, but there are in fact "invisible" software programs.

Simple application cases, which are repeated, often, occur in large numbers, are controlled by legal or company rules and only contain a few exceptions, which must be operated by humans, are suitable for their use.

The previously used application systems remain unchanged. Only the operation, which was previously carried out by handlers, is replaced by software. The software robots behave like the handler. In doing so, it employs, for instance, a virtual keyboard or a virtual mouse. Because the application systems are not (or are hardly) changed, the strategic software architecture of the company is not affected and does not lead to any expenditure and a need for a decision by the company's CIO. The robot docks in the user interfaces and surfaces of the systems and carries out the work stages in such a way as the human handler had carried out before. The benefits of using robots in production mentioned, such as 24/7 availability, consistent quality and complete documentation, can then also be applied here.

The market for RPA is defined by the "long tail" of office activities not yet automated and promises a new wave of process automation (see Fig. 2.E.04).

Similar terms to RPA include (Fung, 2014) Information Technology Process Automation (ITPA) or Intelligent Robotic Process Automation (IRPA), if the use of Artificial Intelligence (AI) should be emphasized (Institute for Robotic Process Automation & EdgeVerve, 2017).

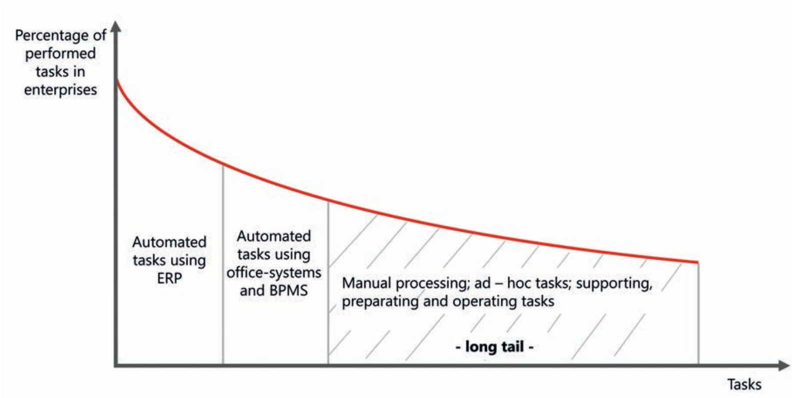

Figure 2.E.04: Long tail of IT application

Using new software architectures, RPA tools are provided which allow the specialist department in a relatively short period of time to define, manage and implement RPA projects itself with the help of consultants and IT experts, without programming expenses.

The streamlining gains to be achieved through RPA are estimated at over 50%. Activities which in recent years have been outsourced to so-called "low-wage countries" can also be retrieved.

Bots can communicate with one another and form botnets. When using artificial intelligence methods, the robots can understand natural languages, recognize and interpret structured and unstructured data (e.g. emails) and possess cognitive learning abilities. With this intelligent IRPA, more complex business processes can also be automated. Examples include customer dialog (chatbots) to agree service times or to identify customer requests.

If several robots are employed in a field of application, which could easily be between 10 and 100 robots, a Robot Controller assigns the individual operations to the appropriate robots. It then analyzes the cases according to content criteria, for instance, in the case of incoming emails, according to indications for complaints, orders, change to service dates or usage support, and allocates the emails for processing to the competent robots.

Increasingly successful RPA projects make it clear that a new software concept for process automation is arising, which will strongly determine the digitization strategies of companies in the years to come.

II. Areas and cases of application

On the one hand, RPA can be used as an add-on to existing standard software, but can also be used for applications previously heavily dominated by simple handler activities. RPA then takes over functions, which were previously carried out with hundreds or even thousands of spreadsheet and database queries.

An important function within the purchasing application of an ERP system is checking the incoming supplier invoices (Fig. 2.E.05a).

Here the diverse data regarding the order, incoming goods and quality checks must be accessed in order to recognize whether the invoice amount is correct. For example, price and volume information for the order must concur with the invoice data.

The authorized cases automatically recognized by the ERP system can then be immediately passed on to the automated function "Payment". If the data do not match, however, handlers must clarify these cases by making inquiries to the supplier and/or internal offices. The number of these special cases depends on how finely the decision rules are formulated in the ERP system. Often, however, there remains a significant need for clarification.

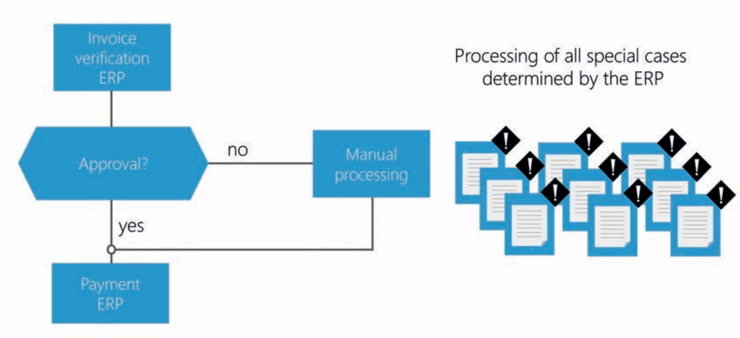

Figure 2.E.05a: Checking the accompanying supplier invoices - manual.

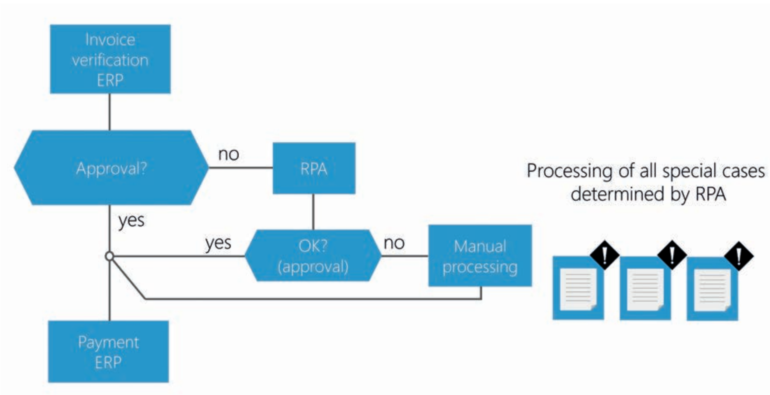

Figure 2.E.05b: Checking the accompanying supplier invoices - RPA supported.

A software robot can take over this clarification process. By observing the handler, the auditing processes can be recorded, the processing rules can be recognized and then transferred to the robot; it is then quasi trained by the best practice behavior of the handler. The extreme special cases not to be processed by the robots must then be dealt with by handlers (Fig. 2.E.05b), but these are still far fewer than before.

In a second example, audit mandates are issued by various state bodies in the case of a police check regarding persons (Rombach, 2017).

In doing so, data are retrieved from various databases (such as state, federal and international databases) and analyzed by the handler. The result is generally negative, so unobjectionable to the applicant. Despite this, each case is processed manually. Only a few cases must then be carefully further processed if there is a positive finding.

With a RPA approach, in the example the robot now takes over the queries to the databases, compiles the information according to rules and thereby filters out the unobjectionable cases, so that substantive work is only required for the less intensive cases to be checked.

Another interesting case is home banking, which has become widespread in recent years. Here the data entered by the customer (for a transfer, for instance) will not be processed directly by the bank's booking system, but rather set as an email in an electronic mailbox at the bank. A human handler processes the cases in the mailbox and transfers the data to the actual booking system. In this way, he also manually checks plausibility rules in order to sort out errors, for example.

In the case of an RPA approach in the examples, the software robot monitors the mailbox, automatically extracts the booking data, starts the banking system and carries out the bookings. The robot therefore processes the exact same steps as the handler - including the plausibility checks, which can be ascertained through programmable rules. The actual booking system is not changed. The few selected special cases will then be further dealt with by human handlers.

Overall, human effort is reduced by 95% and the processes are processed faster and more securely.

Humans and robots work collaboratively together in the examples. If a task is to be described in full through rules, it can also be entirely automated through RPA without human intervention. Another example of this:

In an insurance company, an outdated address management system is being used which still stipulates an IBM Terminal 3270 for data entry. Since these are no longer in use today, the 3270 Terminal is emulated on the new front end systems. A handler receives changes in address submitted from various sources, like email, letters from clients or by mail. In manual processing, a handler takes over these tasks, dials into the application system and carries out the change. This process can be fully automated with RPA. To do so, a self-service portal was set up by the insurance company, in which the changes are set by the client or other address suppliers. The robot monitors the portal, extracts the changes, signs in to the application system using the 3270 emulator, walks through multiple stages up to the system's input mask and fills this out automatically. This can also take place for multiple application systems if they also store client data. Here too, the actual applications are not changed and the change of address can be automated 100 per cent.

As an example of an application which is simple in itself, but which already requires complex artificial intelligence algorithms, Fig. 2.E.06 represents an automatic calculation of travel costs using RPA. Besides storage and calculation capacities, the robot also possesses artificial intelligence functions. It collects and stores all documents accrued, which the traveler photographs using his smartphone.

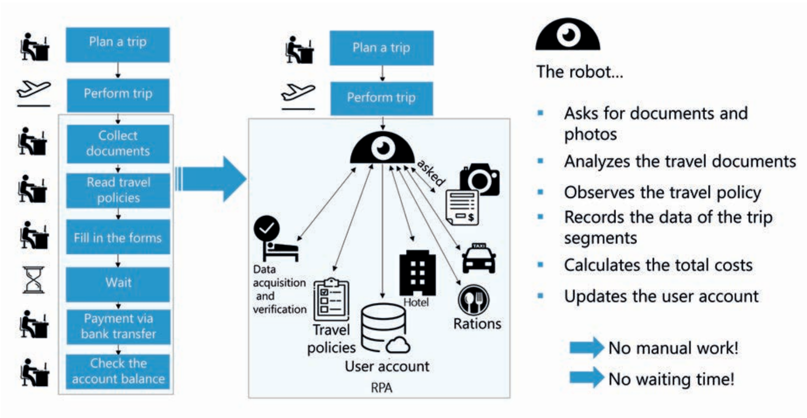

Figure 2.E.06: Automatic calculation of travel costs using RPA.

It recognizes the different types of receipt as well as the payment amounts and forms, calculates the amounts to be compensated to the traveler according to the travel cost guidelines and initiates the transfer procedure. The system accompanies the traveler, tracks all steps of the travel, understands the script as well as the natural language of the traveler and requests expected receipts independently. At the end of the trip, the money is already in the traveler's account.

This example demonstrates that intelligent functions can be demanded of RPA even for such everyday applications as calculating travel costs.

Since a software robot is generally only oriented towards a small spectrum of tasks, a complex RPA task is usually dealt with by connecting multiple robots, like on a production line.

Some impressive examples which demonstrate the breadth of use of RPA applications include:

(1) In a bank in the UK (Institute for Robotic Process Automation, 2015), 11 staff members monitored 2,500 accounts manually every day to see whether particular transactions should be carried out or rejected due to a low account balance. In a few months, this task was transferred to twenty robots and the work, which previously was not completed until 3pm, could now be completed by 11 am. Costs were reduced by 80 % and the staff members could be used for higher value work in customer support.

(2) In a purchasing department (Institute for Robotic Process Automation, 2015) of an auto dealer chain in the UK, the purchasing system was supplemented with robots to automatically detect demand, check availability of suppliers and to process orders.

(3) In the USA (Institute for Robotic Process Automation, 2015; Multiply, 2016) management of a private cloud environment, in particular the flexible scaling of virtual machines, was transferred to robots in an insurance company. The system was developed in 120 days and guarantees 99.99% availability.

(4) In the UK, an outsourcing company had great success in extensively replacing its offers for insurance clients with robots with a team of 20 staff members (Willcocks et al., 2015).

(5) At a European energy supplier, 300 robots were used to perform the work of 600 staff members (Mary C. Lacity, Willcocks, & Craig, 2015). In doing so, work that had been outsourced to India was largely replaced by robots. The robots

were also used to supplement a new ERP system after its introduction, for instance for plausibility checks when measuring energy consumption.

(6) In (Fung, 2014), fields of application within the management of IT systems are mentioned, such as the use of robots to control servers, storage systems, networks, security, password administration and job scheduling.

(7) In Germany, DATEV eG announced it was automating the account assignment of receipts using an AI system (Heeg, 2017).

(8) Deutsche Telekom is successfully employing software robots for customer services to a large extent (Abolhassan, 2017).

Overall, such applications which are structured, occur in large numbers and can be well managed using rules are suitable for RPA. Banks, insurance companies, telecommunications providers, energy suppliers and online stores with customer-based applications are particularly well suited sectors for such applications. Distribution, purchasing, finance, service and HR applications are pre-destined for business functions, irrespective of the sectors involved. This produces a broad spectrum of applications for RPA, so that it can already be deemed the successor to ERP's success.

III. Software functions of simple RPA applications

Robots without intensive AI functionalities are called simple RPA applications. The software robots are assigned passwords that authorize them to access applications. Typical functions which they then carry out include (see e.g. Deloitte, 2017; Roboyo, 2017):

- Log in, log out,
- Fill out masks,
- Read and write in databases,
- Extract data,
- Create reports,
- Log into ERP systems and access their data via APIs,
- Integrate data from different systems,
- Analyze and follow If-Then rules,
- Access social media,
- Execute invoices,
- Open and process emails.

Software components are developed by RPA providers for these functions and provided to the user to configure and customize the RPA.

In a process-driven approach, the robot recognizes the process model of its task and is led by this. Detailed Process Mining is supported by documentation of the operation stages.

When employing several robots, a robot controller takes over allocation of the cases to be processed to different processing robots. The controller is itself a robot. The activities to be carried out by processing robots, including the version management, are described in the Repository.

IV. Intelligent or cognitive RPA

Simple RPA has already reached a professional state of development and can prove its success in practice through cost savings, time reductions and improvements in quality of business processes. Staff members released from these tasks can be allocated higher value tasks and, for instance, customer support can be improved.

By using AI methods, such activities which require abilities, which were previously reserved to humans, can also be supported or even automated. The first impressive examples are already out there, and it is expected that they will make rapid increases in the near future through the development of AI methods supported by high usage of resources.

Intelligent RPA systems are already used in portfolio management of bonds by large banks or to support compliance processes (Deloitte, 2017).

In insurance companies, incoming electronic client inquiries can be analyzed automatically and responded to in natural language.

A large retailer resolved a backlog of 150,000 unprocessed invoices using a system created in three weeks (Institute for Robotic Process Automation & EdgeVerve, 2017).

In customer service, natural language dialogs can be conducted between customers and robots to identify the customer issue, provide help or to pass the issue on to the competent human processor.

In statistical analyses of a file (such as a distribution file), all possible correlations between features such as turnover, item group, sales area, agent, price or volume can be studied automatically in order to single out important correlations and outliers. In Fig. 2.E.07, the result of a sales database analyzed by the Inspirient (Inspirient, 2017) system is represented. This has been developed by the Berlin start-up company inspirient GmbH, which is part of the Scheer Holding GmbH innovation network.

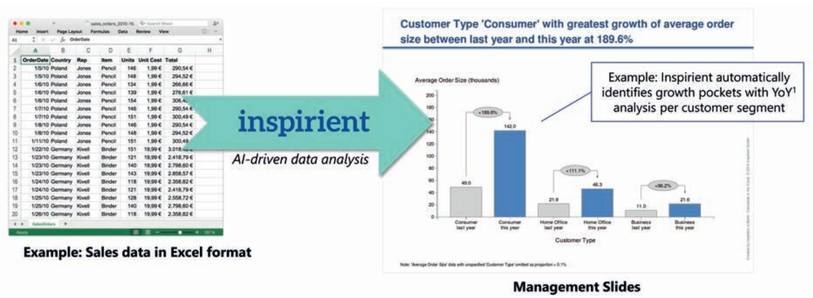

Figure 2.E.07: Automatic data analysis with RPA (Inspirient, 2017)

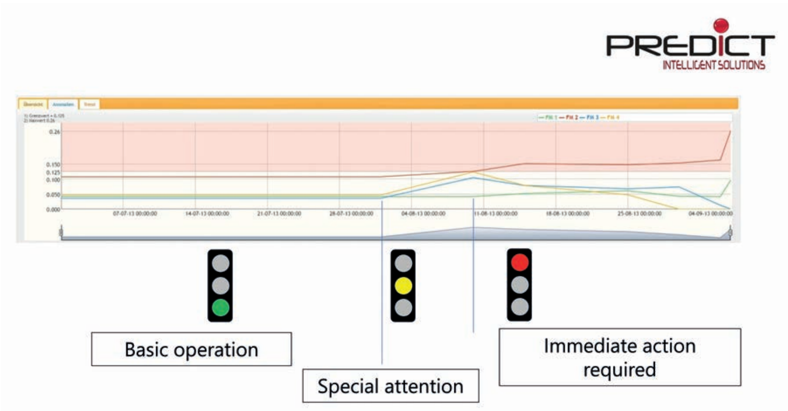

Figure 2.E.08: Predictive Maintenance with RPA from company IS-Predict (IS Predict, 2017)

The system independently recognized that in the year-on-year comparison the largest growth in the consumer-customer segment is recorded with “loyal” customers.

In Fig. 2.E.08, the practical case of a predictive maintenance using the system from company IS Predict GmbH is provided (IS Predict, 2017). The characteristic curves denote indicators that label the operating behavior of four motors of a locomotive. Each indicator already compresses the measurement data from multiple sensors. The self-learning system recognizes when to change the indicators in such a way that a more exact observation is made or immediate action is required. In the example, no intervention is made and the motor finally breaks down with significant consequential losses.

In future, the difference between simple and intelligent RPA systems will fade away because intelligence will increasingly be incorporated into RPA with progressive development of AI, thereby making the differentiation superfluous.

V. RPA and Process Mining

The point of departure of a RPA project should be a process analysis. Only if a business process model is available can the effects of the improvements in a workplace be recognized on the entire sequence. Otherwise, there is the risk that software robots will be employed to reduce time in places which are not part of the critical path of the process sequence and therefore fizzle out. This process model can be generated with the help of Process Mining procedures from the log files of the application software (see above Part C) and describes the actual sequence on the type layer or there is a target model developed within the scope of a BPM project.

The second connection with Process Mining arises from the fact that a software robot processes a detailed process, can store events in a log file and these - just like the business processes dealt with above - can be analyzed with Process Mining.

Process Mining is given a particular and expanded significance in the first step of a RPA project, recording the detailed activities of the workplace studied. This process is called “Desktop Activity Mining”. RPA tools provide support in order to extensively automate this. Recording is carried out on a detailed level, whereby all screen actions are traced and documented on the click layer. These include, for instance, text inputs, program fetches or the opening and sending of emails. Therefore, far more data are captured than in the Process Mining for the BPM loop, in which primarily transaction data are analyzed from ERP or BPMS application systems.

At AWSi in Saarbrücken, a system has been developed together with Deutsche Telekom (DTS) (AWSi, 2018) in which the common recording data from the software systems are initially record on the click layer. From these data, a detailed process model of the activities related to the workplace is generated using process generation algorithms from the field of Process Mining. Fig. 2.E.09 shows the example of a generated process model from the point of view of the operational sequence of the activities and Fig. 2.E.10 shows the fetch sequence of the IT systems used at the workplace.

The numbers on the edges show the number of process instances carried out, which is very low in this small demonstration example. In addition, the stages of screenshots and descriptions of manual activities can be added. This therefore provides extensive informative material for the analysis of whether and how a software robot should be used at the workplace, which rapidly accelerates the development and configuration of the robot.

Figure 2.E.09: Desktop activity mining – Process model

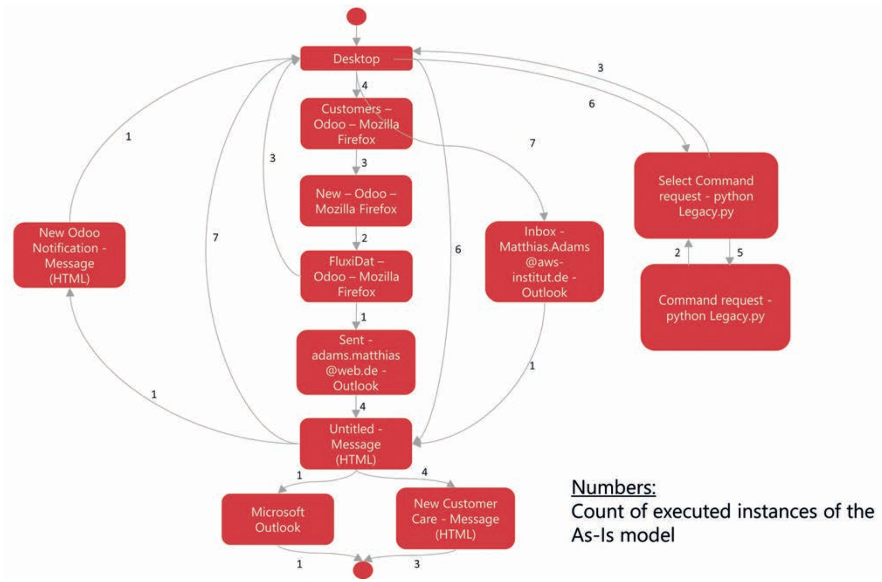

Figure 2.E.10: Sequence of the application systems used

The process analysis of several parallel workplaces helps to recognize best practice processes, which then serve as the basis of the development of the robot.

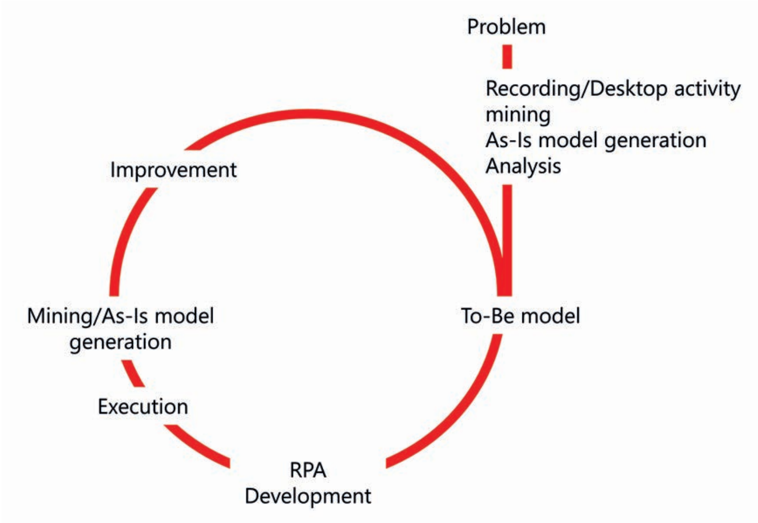

Figure 2.E.11: Development cycle of a software robot

Often, simple considerations can generate significant process improvements. For instance, click results, which occur often, can be bundled into a macro and process times can therefore already be reduced with this single selection.

Following the analysis, a target model will be created and the software robot will be configured building on this. From the execution data captured, analyses can be generated with mining methods as with classic BPM. These can then again provide information for further improvements of the robot.

The sequence of a RPA development is therefore similar to the BPM cycle (see Fig. 2.E.11).

The RPA software architecture of Fig. 2.E.12, as it is pursued by Scheer GmbH, also shows similarities to the general process architecture of Fig. 2.B.03 (Storck & Scheer, 2017).

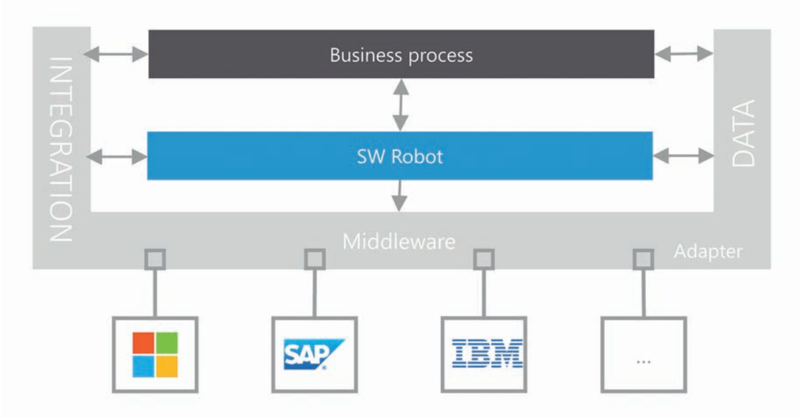

Figure 2.E.12: RPA - Software architecture

On the lowest layer are the application systems encountered most often which are operated by the robots. They are connected with the middleware through adapters. Other third-party services are offered for AI algorithms, such as natural language chatbots or artificial neural network algorithms. Companies like Google or IBM offer extensive libraries for this. The RPA orchestrator in the middleware configures the services in an executable software robot. The robots are then incorporated into the business process.

It is expected that hundreds or thousands of software robots will be employed in the near future in banks, insurance companies and telecommunications companies. Monitoring and optimizing these leads to a new task for specialist departments and IT within the scope of process automation. In particular, the use and correct deployment of robots within general process management are to be traced.

In doing so, an expanded process dashboard can establish the relationship between the deployment of the robot and the overriding business process.

In spite of all the euphoria surrounding RPA, it also has its limits. The approach is in competition with the classic API concept, in which programs open themselves through data interfaces and are then connected to one another through programmed logic. In strict RPA, this should not happen because no interfaces are developed, but instead those available to the handler are used. However, more complex applications also lead to complex integration problems between different systems, which can only be resolved with additional expenditure on development. A mix of RPA and an API approach is therefore practical for complex problems. For this reason, the middleware layer is emphasized with the integration functionality in Fig. 2.E.12.

F. Influence of IT infrastructure on process automation

The processes carried out by application software use an infrastructure comprising hardware and system software. Their features influence the process behavior, like the speed of execution of transactions as well as the IT costs incurred. With the increasing capacity of systems, these sizes are constantly developing “faster and cheaper” according to Moore’s Law.

Going beyond this, disruptive architecture changes could occur which have significant structural and organizational influence on process structure and execution. This was already the case in recent years with the development of cloud computing, and could have even more dramatic effects in future when using blockchain architecture.

Essential organizational changes can be traced back to the influences of stress pairs “centralized - decentralized” and “process optimization - resource optimization”. Here different IT infrastructures provide options to emphasize more of one or the other forms. Without going into the technical details - these can be found in the vast literature available - the organizational effects of cloud computing and blockchain will be represented. At the same time, possible effects of blockchain architecture will come to the fore due to the current intensive discussions on this.

I. Cloud computing

In the era of central mainframe computers, resource optimization of IT was in the foreground. The then very expensive computer core had to be utilized as much as possible, close to 100%, and users were assigned the brief computing power through time sharing. From the point of view of the user, the tasks were processed correspondingly slowly. Central resource optimization was therefore in the foreground

- to the detriment of process optimization. In order to improve processes, the users were then provided with their own decentralized computing capacity with the client-server architecture and personal computers, with which the individual (Office) applications could be processed and at the same time improved central services could be used with more powerful servers. The user's processes were significantly improved as a result. However, with figures at 10 to 20 %, the capacity of clients and server was still far behind the high capacity figures of the previous centralized mainframe concept. Now process optimization dominates the weakened resource optimization. This situation creates space for a re-orientation. This explains the rapid success of cloud computing, despite the initial skepticism. Applications and data are stored centrally in a cloud, which is made up of a network of connected computers from giant server farms. Global providers Amazon, Microsoft, SAP, T-Systems etc. can therefore utilize large benefits from economies of scale.

Standard software manufacturers offer their applications for lease from the cloud. Scheer GmbH also offers the operation of cloud solutions in its Managed Service unit. The same goes for the Learning Suite by imc AG.

From the point of view of process management, in cloud computing there is a trend to more organizational standardization of processes because changes and extensions to applications are associated with significantly higher costs for the user and are also rather averted by cloud providers.

Besides a public cloud, which is offered to all interested parties by a provider (against payment), there are also private clouds created by companies for their internal applications only.

Other characteristics and problems of cloud computing, such as data security/data protection, fundamental features of operation and maintenance outsourcing and the payment model “on demand” will not be dealt with in more detail here.

Cloud computing leads to a high level of data traffic between cloud servers and end devices. Due to limited transfer rates, this can have a negative impact on the application speeds. In particular cases, this already leads to a change in thinking, and applications are migrating back to decentralized systems. This is the case, for instance, for applications of I4.0 and the IoT, whereby the processing intelligence is implemented in the controls of the devices. In this case, the paradigm shifts again from resource optimization to greater process optimization.

II. Blockchain architecture

Blockchain architecture is therefore arousing a great deal of interest because it is not only a technical innovation, but also an organizational innovation, whereby new forms of working together between partners are supported. Moreover, it is also an economic innovation because new business models and companies arise. Particular attention has been paid by the media to the spectacular share performance of the cryptocurrency Bitcoin, which builds on blockchain architecture.

a. Initial situation

Despite the development of integrated application software like ERP, there are still data interfaces between the software systems involved in a business process. This is the case in particular if several external partners are incorporated into a general process such as logistics with different individual systems. Data transfers between systems always hide risks of inconsistencies. One of the first objectives of the blockchain architecture is to avoid this.

In the case of financial transactions, platform companies such as banks or stock exchanges mediate between the sellers and buyers actually involved. This leads to time delays and additional costs.

In Internet trade too, global platform companies like eBay, Apple, Amazon etc. have formed which mediate between customers and suppliers and skim off a part of the value create by the customer-supplier process.

The contribution of these intermediaries (financial service providers and platform companies in the examples) lies above all in building trust in the security of the transactions carried out by customers. They should be carried out more securely than if they were carried out by the participants directly. Security in this regard concerns the secure identities of senders and receivers, the integrity of messages and their confidentiality.

The financial sector has however generally forfeited a great deal of trust as a result of the financial crisis at the start of the century, and the principle which prevails in digital platform companies of “the winner takes it all” with extremely fast growing market values and comparable low creation of workplaces is also discussed critically. Data protection violations by platform companies also show cracks in the trust potential.

Extensively eliminating these intermediaries and making the processes more secure, transparent, faster and more cost-effective, is a second goal of blockchain architecture.

b. Characteristics of blockchain architecture

In contrast to a central system, blockchain architecture is a distributed network (see Fig. 2.F.01) with no central nodes.

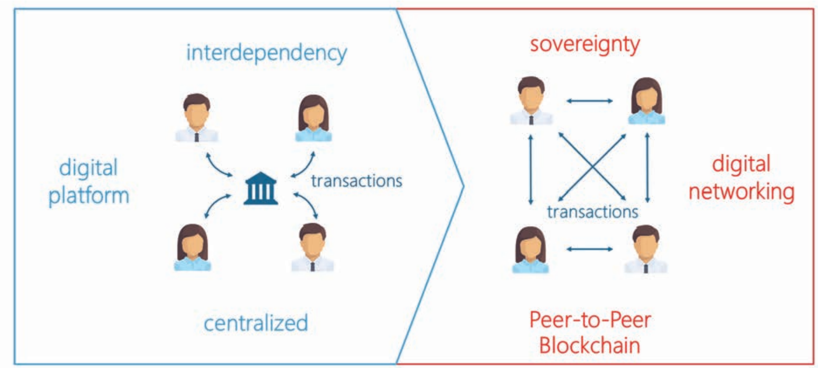

Figure 2.F.01: Paradigm shift of blockchain

In the centralized approach, transactions can only be processed via intermediaries and the users depend on the digital platform. However, if it is distributed, transactions are carried out directly between one node and another node (peer-to-peer) and are therefore sovereign. The security of transaction processing is for one thing guaranteed by sophisticated encryption procedures, and for another by control mechanisms of the network participants themselves, whereby they check and confirm that the transactions are correct. The security function is migrating from a central instance to become part of the competence of decentralized network participants. The network therefore manages itself.

The core element of a blockchain application is the concept of a distributed database, in which all transactions are stored in a way they cannot be changed. The transactions recognized by the network as correct are then compiled into blocks and chained together using hash values. A hash value is a transformation value of the content of a transaction generated by an algorithm, which if changed will immediately produce another value and would therefore be recognized. The hash value of the previous block and the hash value of the block considered are stored in the head of a block (see Fig. 2.F.02). This produces a growing chain of blocks, hence the name blockchain. Each participant (node) receives a copy of this chain so that he can transparently inspect all transactions.

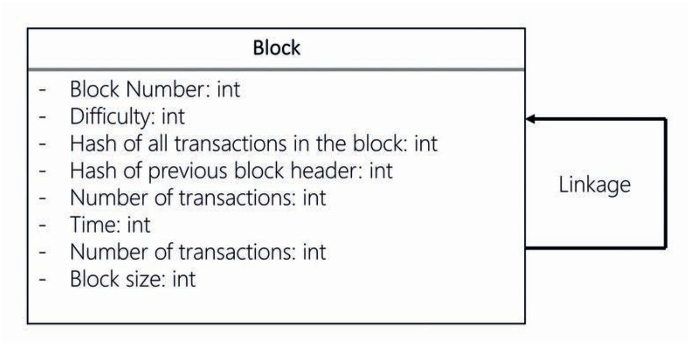

Figure 2.F. 02: Simplified UML diagram from the Bitcoin blockchain

Blockchain is therefore a (redundant) distributed database and if one node fails, the stored transactions are still available at the other nodes. All users access the same data. The content of the transactions can be open or encrypted. Senders and receivers are identified through identifiers, which can be anonymous, whereby the allocation of the identifier to the bearer is known only to it. An asynchronous encryption ensures, using the pair private and public key, that the identity of the participant is guaranteed. Each participant has a private and a public key which match up.

Each transaction is signed by the sender. This signature is generated with the sender's private key and only the sender's public key known to all can check this and therefore authenticate the sender.

The concept of the blockchain database, in which all transactions are recorded one after the other, reminds one of the land register in cadastral surveying or the general ledger in accounting. Blockchain architecture is therefore also referred to as Distributed Ledger Technology (DLT).

The most spectacular use of blockchain architecture includes cryptocurrencies, in particular the currency Bitcoin. Relatively simple payment transactions are processed in it. These applications are therefore also referred to as Blockchain 1.0. A correctly processed payment does not mean, however, that the circumstances which establish the payment are also correct. Therefore, the concept is increasingly expanded, whereby the circumstances can be stored and executed according to the same stipulations as so-called "smart contracts".

With the aid of smart contracts, entire processes can also be automated and the blockchain concept can be significantly expanded. As a vision, a blockchain global database is sometimes cited, in which all processes in the world are stored securely, unchangeably, transparently, unregulated, peer-to-peer and data protected.

Without going into additional technical features and limitations of blockchain architecture, its influence on the digitization of company processes will be intimated in the following. Here, private blockchain architecture is suitable for transactions between different parts of a company and for inter-company processes in fixed partner networks. A good example of this is logistic networks between OEMs and their associated suppliers. A simple example from logistics should therefore demonstrate the principle.

c. Example of application in logistics

The example from the section on “Operational Performance Support” to “Complex Event Control (CEP)” will be used again.

A manufacturer orders the carriage of goods from a warehouse to the company’s head office from an affiliated transport company. Since both companies work closely together and the goods are both valuable and also sensitive, they have established a private blockchain solution (see Fig. 2.F.03).

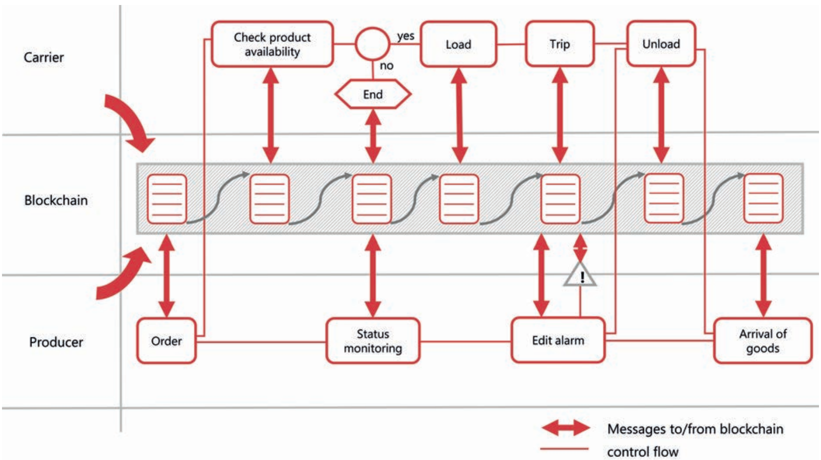

Figure 2.F.03: Logistics process using blockchain

All data and transactions are recorded in the blockchain and carried out with the aid of smart contracts. In Fig. 2.F.03, simple lines denote the control flow of the process and arrows denote data flows from and to the blockchain. Both partners have transparent access to the blockchain. The manufacturer first sends the order via the blockchain as a transaction to the transport company. It obtains the production specifications required for this from the blockchain where the product data are stored. The transport company also manages its vehicle data in the blockchain and checks whether a suitable vehicle is available with a transaction. If not, if informs the manufacturer and the process is over from the start. If the result is positive, the carrier begins loading and sends the loading data to the blockchain. During the drive, events like excess temperatures of the goods etc. are reported to the blockchain. If there is a prohibited transgression, an alarm will be sounded by the blockchain and the processing intended by the manufacturer for the case will be stopped and the blockchain notified.

After arrival, the vehicle will be unloaded, the vehicle's status will be updated and the manufacturer takes over the “incoming goods” function with checks and recording.

The benefit of this processing is that both parties are constantly informed about the process status and all movements are documented indelibly. Disputes about what is owed in case of unplanned deviations, such as the wrong choice of products or damages, are thereby almost excluded.

The example shows a simplified extract from a logistics process.

The fundamental ideas can however be easily applied to more complex scenarios. In this way, automobile manufacturers could establish a private blockchain for their “just in time” logistics chains with their suppliers and transport companies in order to organize synchronized production. In the RAN research project, cited in the part on Industry 4.0, such an approach is strived for using a traditional centralized database. It stands to reason to govern this organizational concept with a blockchain architecture. This would further increase transparency and security.

d. Fields of application for blockchain

Blockchain-supported business processes are discussed and tested for all sectors (see for instance Giese (2016) p. 65; Grinschuk (2017) p.66 et seq.):

In public administration, the land register and civic register present themselves directly.

In finance, one even goes so far as to fundamentally question the necessity of banks.

In insurance, management of contracts and an electronic health file are suitable candidates.

In the energy sector, consumers can in future also become producers with renewable energy concepts. This process can be processed using blockchain, including payment.

In industry, products sold can be transparently traced throughout their entire lifecycle.

This list could go on. Many of the more traditional sectors are therefore drawing up research projects, studies and pilot applications in order to test the options for use of blockchain and to arm themselves against possible intruders from outside the sector.

But the platform companies of the Internet can also be revolutionized. Here, cooperative structures could break the power of the monopolies. Why should the participants in the area of social media not organize themselves in the blockchain and then distribute the advertising revenues earned with their data among themselves, as they cede to the platform company?

With this in mind, blockchain architecture is correctly described as one of the strongest drivers of disruptive process innovations. But this comes with a warning about overblown political effects, in particular the hoped-for democratization and decentralization of digital processes. The Internet was also introduced as a technology for further democratization and decentralization. The result instead is, however, that giant, monopoly-like, globally acting companies have been produced.

G. Digitization innovation network

The use of quick innovation cycles of digitization, as expressed in this work with concepts like Industry 4.0, Robotic Process Automation, blockchain architecture, Internet of Things, Deep Learning, Virtual Reality and Augmented Reality demand a strong culture of innovation from companies. None of these terms were in common use 10 years ago, but today they influence discussions about new business models to company survival. Besides openness to new developments, a company must also be able to sort the wheat from the chaff, that is to say it must be able to recognize what innovations are significant in the longer term and which spark only temporary hype.

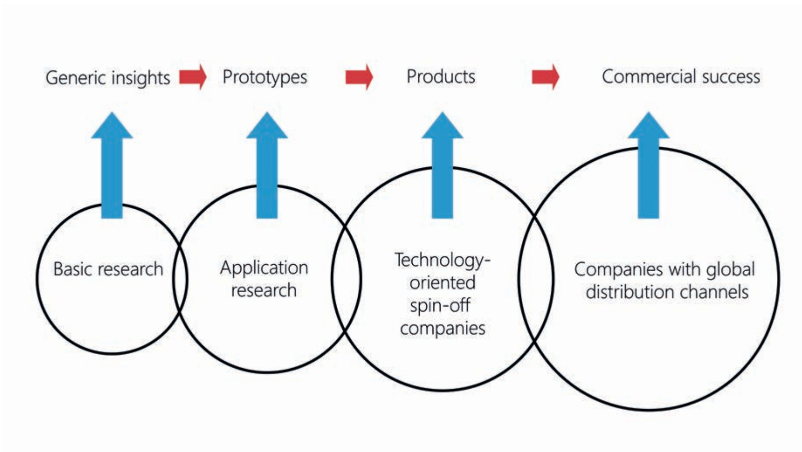

Figure 2.G.01: Sequential innovation process

Several types of partner are involved in the development of an innovation from brainstorming to international market success (see Fir. 2.G.01). Basic research develops generic knowledge which is transferred to application research in application scenarios, for instance, knowledge from physics transfers to new vehicle drives. In research, no products are developed, but rather are developed to the level of prototypes at most. These can be developed further by start-up companies into operational products and made into an international market success through their own growth or cooperation with large companies.

In Germany, there is good infrastructure for basic research with large, publicly funded research organizations, such as the Max Planck Society and university institutes. The institutes of the Fraunhofer Society Institute or the Helmholtz Society provide the same for application research. But after this a gap opens up in the further exploitation of the research results. There is no correspondingly successful company to offer digitization products from Germany to follow up on the billions spent on public research. This market is instead dominated by software from the USA and hardware from Asia.

The climate for founding companies has indeed improved for start-up companies in Germany, with business incubators, state-financed support, investor capital and a great deal of media attention, but there are still too few companies with international significance which have emerged from this. The companies SAP AG or Software AG mentioned briefly only demonstrate there are not many examples of success.

The three structures involved - research, start-up and large company - have different advantages and disadvantages (see Fig. 2.G.02). The (academic) research is flexible when dealing with new subjects. Since they at most create prototypes, they can take on new subjects quickly. The academics are highly motivated and therefore are quick to achieve results. They are incorporated into international networks and learn about the latest trends in research through this.

Research:	+ variety of topics + commitment + prototypes + networks - resources - mainstream
Start – Up:	+ disruptive + outside-in + fast fail - fragil - sales
Large companies:	+ sales + resources - Innovator's Dilemma - not disruptive - inside-out

Figure 2.G.02: Promoters of the innovation process

Start-up companies start on green pastures and therefore avoid the Innovator's Dilemma effect. Due to their limited budget, they learn quickly whether their idea promises success or whether they have to cease the enterprise or change the business model (fast fail). In large companies, on the other hand, those responsible always try to extend development projects drawn up once before, even though the planned objectives were not achieved. However, the founder teams of start-ups are often fragile because after a while they expose different interests which could lead to a break-up.

Large companies possess many resources in the form of distribution structures, customer relations and capital. They are however confronted by the Innovator's Dilemma effect.

It stands to reason to combine the benefits of the three structures. An existing company should therefore establish an innovation network made up of the three different types in order to implement digital transformation.

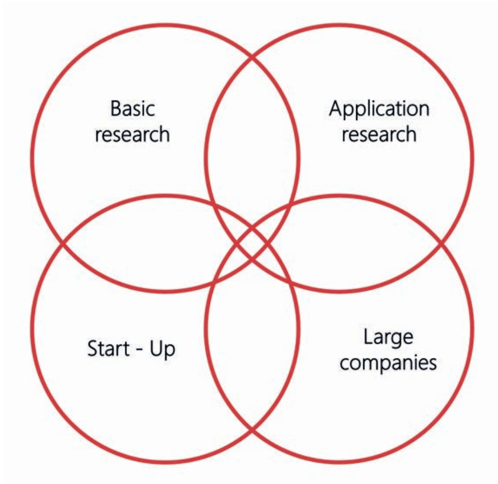

Figure 2.G.03: Simultaneous innovation process

The innovation process presented shows a sequential process. But the increasing speed pushes the circles closer and closer together with the model in Figure 2.G.03. Research, company foundations as well as strong resources and distribution channels of large companies form a network and work closely together in terms of time. The contributions which individual partners can mutually deliver are entered in Fig. 2.G.04.

Such cooperation networks can arise from state-supported collaborative research projects, in which the state project sponsor demands the participation of partners from all three groups. They can however also be drawn up as a strategic concept of large companies in order to surround themselves with an ecosystem of research and start-up companies.

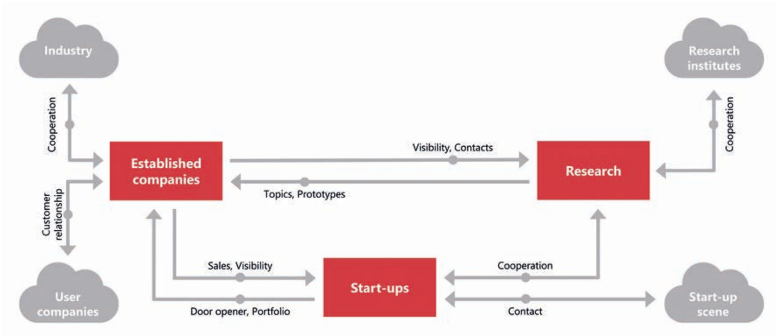

Figure 2.G.04: Significant relationships within an innovation network

Involvement will achieve a closer and longer-term cohesion of the network. Such innovation networks are familiar from companies such as SAP AG, BMW AG, OTTO Group etc.

The author too has in recent years established such an innovation network of companies and the non-profit research institute AWSi (see Fig. 2.G.05). Scheer Holding GmbH or the non-profit AWS Foundation for Science and Art is involved in all companies. These occupy themselves with the digitization of business processes, they develop software products and offer consultancy services.

There are intensive informational and specialist relations between the companies themselves as well as with the appropriate external communities. In Fig. 2.G.06, the network model developed generally in Fig. 2.G.04 is based on this specific case.

Important impulses emanate from the AWSi to the innovative power of the network. Because it is networked with the international research scene, it can bring in information about research trends in all areas of digitization.

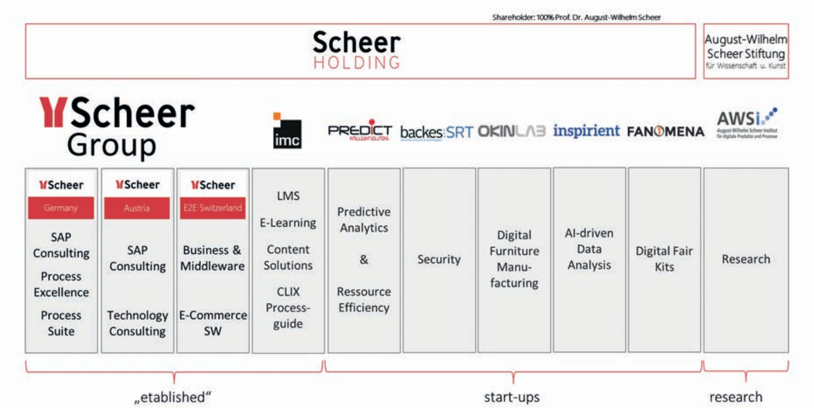

Figure 2.G.05: Organigram of the Scheer Innovation Network

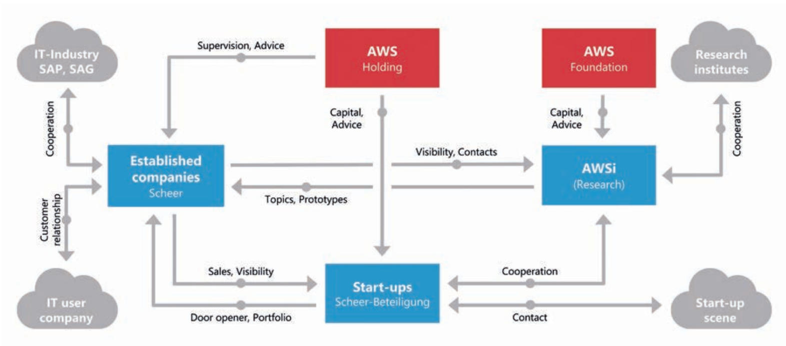

Figure 2.G.06: Significant relationships within the Scheer Innovation Network

Thanks to the cooperation of the "established" company Scheer GmbH with the large software companies, start-up companies are able to make contact with these companies.

Although all companies are of course interested first and foremost in asserting their own interests and independence, synergies are produced from the relationships within the network for all.

The intertwining of research, start-up foundations and established companies is well demonstrated in the author's experience.

The ARIS concept was developed by the author within the scope of his research activities as a university professor at the end of the 1980s and then implemented in products by his young start-up company IDS Scheer GmbH. The BPM modeling approach by ARIS was a disruptive innovation which was not immediately recognized by the established software companies like SAP AG or Oracle due to their focus on further developing their successful ERP products. This was the opportunity for IDS Scheer GmbH to introduce its ARIS products on the market and to establish the partnership with SAP.

The concepts of Operational Performance Support also originate from combining research and start-up companies. The company imc AG was established by the author from a research project at his university institute on e-learning.

Several companies of the network are involved in the further development of the RPA concept. The AWSi research institute deals with, for instance, the link between RPA and Process Mining. The company Scheer GmbH develops its own RPA platform.

Overall, it is the aim of the network to open up great opportunities for success and growth to each individual company, without having to fight along the difficult path from start-up to global success alone.

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MASTER MIND

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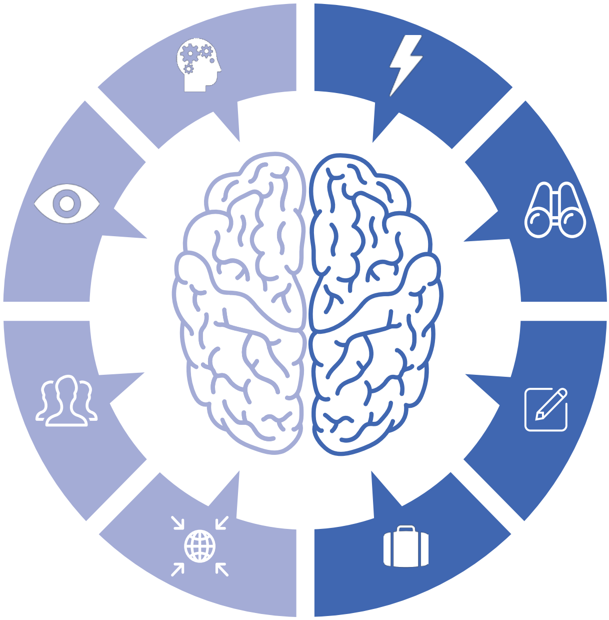


ARTIFICIAL INTELLIGENCE
Smart Office, Smart Retail, Predictive Maintenance – the future of work is intelligent. We guide you there!

DIGITAL REALITIES
Work, train, study and communicate in more than just one reality. We show you how.

DIGITAL SERVICES
Self-Service-Tools or eConsulting Store: we take your business processes to the next level.

SMART ENERGY
Smart Cities, Smart Grid or IoT - Let’s use our earth’s energy in a visionary way!

IDEATION WORKSHOP
Diverse people – diverse perspectives. Together we create next generation solutions you can work with.

TECHNOLOGY-SCOUTING
We identify and assess emerging technologies - the ones that count for you.

FUTURE RESEARCH
How to be successful in three years from today? Let us tell you!

RESEARCH CONSULTING
Independent and objective: we evaluate useful products and services for you.

AWSi
August-Wilhelm Scheer Institut
für digitale Produkte und Prozesse

www.aws-institut.de

How we will learn tomorrow

Our education landscapes are constantly changing

Microlearning is becoming increasingly popular. Short learning nuggets at the point of need, often displayed on smartphones, are bridging the knowledge retention gap. Whether it's financial services, IT or education, Artificial Intelligence (AI) is being integrated into various industries. Using AI, learning content can be personalised to each individual learner. Deep learning enables tailored learner journeys. Immersive learning makes it possible to explore virtual worlds. Due to the abundant possibilities, the adequate use of the individual elements of the learning is becoming increasingly important. Therefore, the challenge for organisations lies in the choice of the right technology, content and its arrangement throughout the journey.

A holistic approach as the bedrock of a coherent strategy

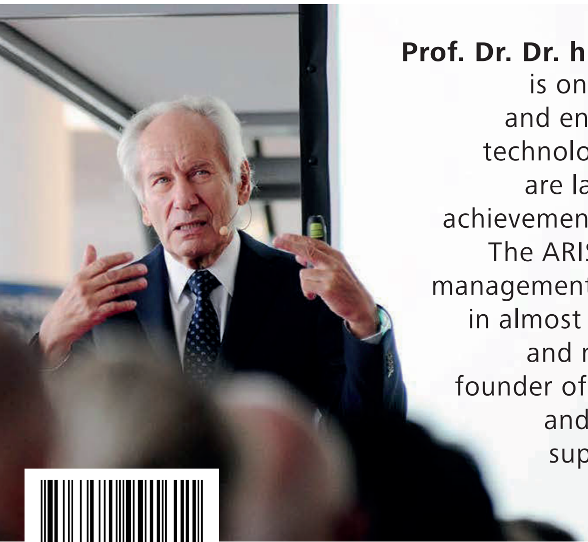
Modern learning technologies can only be fully utilised if they are part of a coherent strategy. With the available solutions, it is possible to create comprehensive learning journeys.

We empower people

IMC supports companies, schools, colleges and educational institutions in designing a strategy that is individually adapted to the needs of the organisation.

Digital companies are seizing entire markets and challenging existing businesses to change their business models. Concepts such as Industry 4.0 are changing entire branches of industry. Only those who know the drivers of success for digital business models can develop their own path to digitization. How can digital drivers of success such as personalization of products, self-control of systems, platform architectures or artificial intelligence be used systematically? Digital business models require new business processes. How do new software concepts and artificial intelligence technologies, data mining, robotic process automation, virtual reality, real-time process control or blockchain help to create and automate the necessary business processes? How do you find a compass in the jungle of new terms and hype in order to proceed safely? The answer to these questions should inspire the reader and lay the foundation for building and converting their own Digital Enterprise 4.0.

The Author



Prof. Dr. Dr. h.c. mult. August-Wilhelm Scheer is one of the most influential academics and entrepreneurs in German information technology. His books on business analytics are largely referenced while his research achievements have received much recognition. The ARIS method developed by him for the management of business processes is employed in almost all DAX companies and many small and medium-sized enterprises. He is the founder of internationally successful software and consulting companies and actively supports multiple start-up enterprises.

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