Chapter 4
Technologies for Digitisation Solutions

This chapter presents technologies and innovative solutions which are available today or in the foreseeable future for digitisation projects in the automotive industry. The purpose of the discussion is to understand their potential applications and potential benefits in order to assess their relevance for current and soon upcoming projects.

The so-called Hype Cycle for innovative technologies, published by Gartner, a leading technology analyst, provides a good first overview on the technologies to come in the industry, Fig. 4.1 [Lev15].

The diagram assigns the technologies to their phases of life, from recognition of the technology, through the phase of excessive expectations to deep disillusionment, followed by initial pilot projects up to the breakthrough. Furthermore, for each technology, the period of time is indicated in which their maturity is reached.

Not all the technologies shown are already relevant to the automotive industry, and some are not yet at all. For this reason, only the fields that have demonstrated a practically relevant degree of maturity and applications at least in the first references are presented below, without entering into the details of the respective technology and thus probably confusing the reader. In addition, solutions and technologies will not be commented on here which are still in the research stage and therefore only available to the industry in the medium to long term. However, when setting up a strategic digitisation roadmap, it is important to also identify and understand these future potentials. That is why Sect. 7.6 looks at these from an innovation management point of view as part of a respective roadmap.

The selection of the technologies detailed here is based on literary research and the results of a large number of current studies. Example sources to mention are [GfK16], [Köh14], [Dum16] and [Man15]. Based on this analysis and taking into

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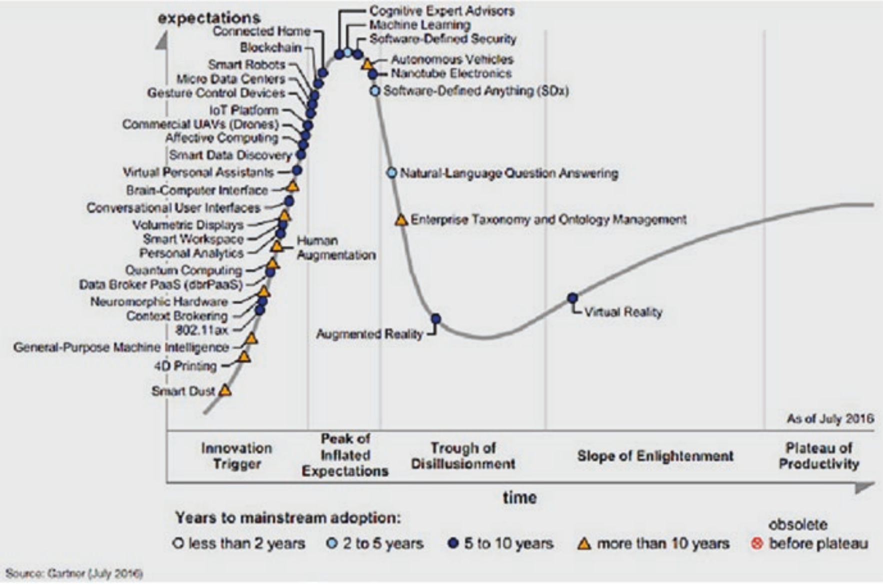

Fig. 4.1 Hype cycle of innovative technologies (Gartner)

account the author's own project and industry experience, the following topics were selected:

- IT solutions
  - Cloud Service
  - Big Data/Analytics
  - Mobility Solutions/Apps
  - Collaboration
  - Machine Learning/Cognitive Computing
- Internet of Things
- Industry 4.0/Edge Computing
- 3D Printing/Additive Manufacturing Processes
- Virtual/Augmented Reality
- Wearables/Beacon
- Blockchain
- Robotics
- Drones
- Nanotechnology
- Gamification

Vehicle-related innovations such as new materials, battery technology and also embedded software, for example for autonomous driving, are excluded here as they do not affect the topic of digitisation directly.

4.1 IT Solutions

As already explained in detail, the driver of digitisation is the information technology, which enables with ever more powerful hardware increasingly efficient software and solutions and expands into many adjacent technology areas. The provision of IT infrastructure in the automotive industry is still to a large extent in its own computing centre. The evolution steps of IT up to the end of the millennium are shown in the lower part of Fig. 4.2.

On the basis of central concepts around the Mainframe, decentralised Client/Server solutions were added in the 1980s and 1990s. Core applications of the industry, for example, from finance, development and logistics, are still running on mainframe systems, i.e. powerful central computers, while newer systems, such as ERP or CAD applications, are implemented on Client server architectures. In this, a Client programme interacts with a server programme installed elsewhere in the processing of transactions. Since the 2010s, a clear trend towards Cloud services has developed along with powerful networks and WEB 2.0 services. This is, in simplified terms, the provision of computing power in any size and of unlimited storage systems for enterprises via a network connection.

The further developments are the relatively new technologies, such as Big Data, Collaboration Tools and Cognitive Computing, which are symbolically indicated in

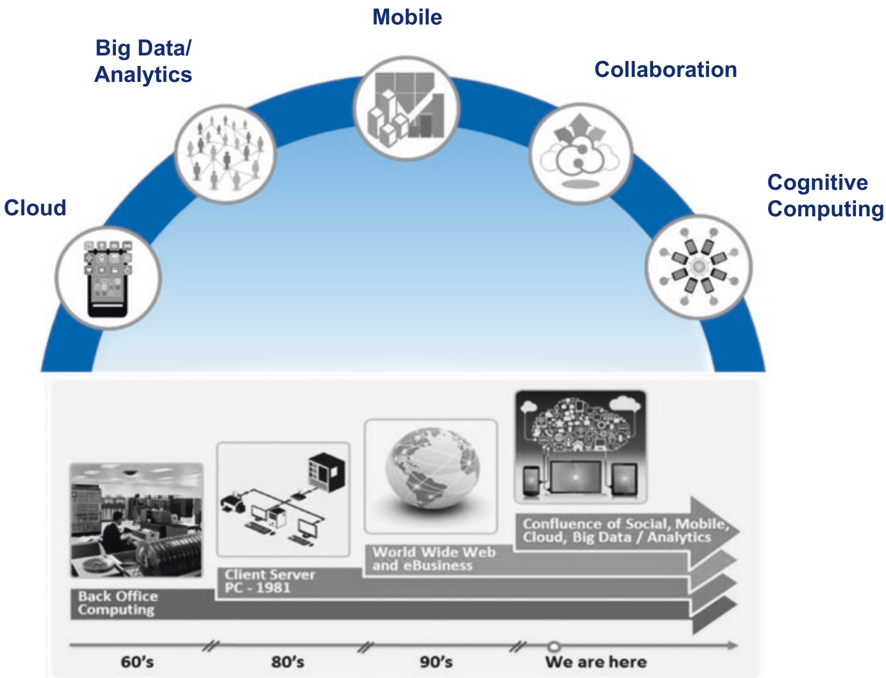

Fig. 4.2 Evolution of information technology

the upper part of Fig. 4.2. The following sections are devoted to these developments which are crucial to the automotive industry.

4.1.1 Cloud Services

Service delivery from the Cloud distinguishes three models. “Infrastructure as a Service” (IaaS) provides the hardware (server, storage, network) including operating software up to the middleware based on service level agreememts [Kav14]. The users install their own software applications on the provided technology and operate them independently. In “Platform as a Service” (PaaS), a development environment is also offered as an additional service, and “Software as a Service” (SaaS) also includes software or application programs, SAP modules for instance, as a Cloud service.

The service models are available on demand in various forms of organisation and security. In the case of the public model (public Cloud), the services are available anonymously from a computing centre network based on the software environment of the Cloud provider. In each case, free capacities are used so that the computing power and data storage are provided from different locations. The service provider can utilise its Cloud environment to capacity due to the flexible usage, so that the prices of this option are relatively low. By contrast, the private model (private Cloud) permanently assigns a certain infrastructure to the customer for the duration of the service provision, and also the software environment may be installed in a customer-specific manner. In this model, the location of the data storage can be determined, for example for the keeping of personal data, in a computing centre in Germany.

This brief overview shows the options and flexibility of today’s service models. The IT performance is delivered according to agreed service quality, for example continuously 7 days/24 h at 99.8% availability, “out of the socket”. The billing is made by consumption, which may fluctuate depending on needs. This flexibility, the speed of service delivery, and the ability to absorb strong demand fluctuations are the main advantages of Cloud services. Companies do not have to invest in large systems to cover peak loads, thus avoiding high investments and depreciation. The alternative of procuring a company’s own infrastructure and building it at the company’s computing centre, may well take several months. Then again, Cloud services are provided via internet-based platforms within hours.

Especially for the new development of applications in a fast-paced agile world, even with strong demand fluctuations, Cloud services thus offer considerable advantages. Obstacles are, on the one hand, the necessary bandwidths for an efficient, secure network connection (becoming available more and more readily and less expensively) and, on the other hand, the “Cloud capability” of the existing applications. Transformation projects with corresponding efforts are often required for this. Another issue is security. Personal data should be kept legally secure in private or dedicated Cloud environments in their own country. A further option is to organise the data maintenance in a way that sensitive data is stored in the company’s own computing centre. This leads to so-called hybrid Cloud architectures, the most common type of IT architecture. These are discussed in detail in Chap. 8.

In conclusion, Cloud services offer great opportunities to make the provision of IT services more flexible. Instead of considerable time and investment, the necessary services are available quickly and geared to the needs of the business. The supply models together with the agreed service levels determine the costs. With a correct overall cost analysis, companies usually achieve significant saving potentials – in addition to the agility gained.

Nevertheless, in the automotive industry there is a heavy backlog in the transition to Cloud services. This is often due to a conservative behaviour of inertia and undepreciated investments. Potential counter-arguments such as data security and availability of power supply are often overstated. Further causes for the delayed Cloud expansion may also be in the existing organisation. Transformation projects to get applications "Cloud-ready" usually require the involvement of several areas of responsibility. In addition to the infrastructure areas, the persons responsible for the usage are required to change the applications and then have these tested by specialist departments.

Such projects bring effort and burdens to the respective teams, while the potential savings may benefit the company but not be adequately advantageous to the project participants. This Gordian knot needs to be cut by all divisional managers agreeing on Cloud conversions as a common objective, and establishing a "Cloud accelerator" as a matrix manager who is responsible for and driving this transformation integrally and across the organisation.

4.1.2 Big Data

A further topic with cross-functional potential is Big Data. This term has experienced a kind of hype which often led to unfulfilled hopes that had been put into the usage. As a result, initiatives were assigned a low priority again. From the author's point of view this is wrong as the topic of Big Data, combined with the corresponding software tools for processing large amounts of data, due to new findings in data evaluation for instance holds significant potential for savings and improvements in process flows through to the development of new business models [Win14].

Big Data is the basic term for large data volumes from different sources and in different structures, but also for their storage, processing, purposeful analysis and evaluation. This term was created in connection with the exponentially growing flood of data. Especially the Internet of Things, WEB 2.0, Smartphone and Apps account for this growth, as Fig. 4.3 demonstrates.

Over the next few years, the worldwide data volume is expected to double annually, reaching a value of 44 zetabytes by 2020 (Zeta equals a 1 with 21 zeros). More vividly: The data volume 2020 is more than 57 times the number of sand grains of all the beaches on earth [Jün13]. A major part of the information will consist of unstructured data, for example in the form of pictures, videos or presentations.

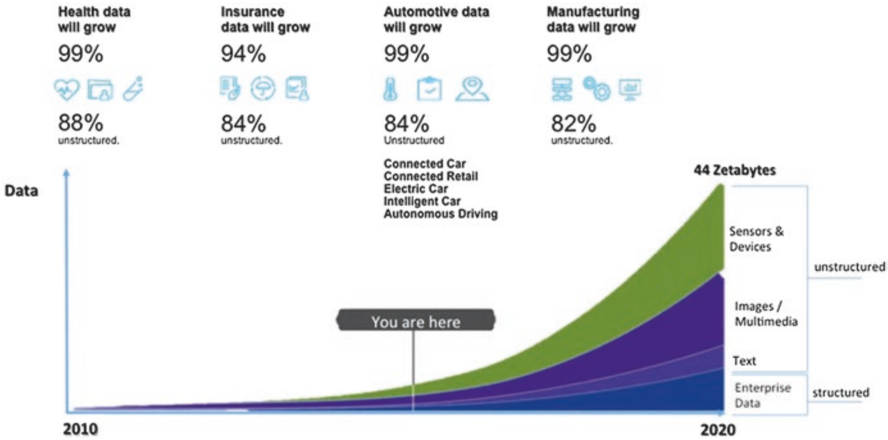

Fig. 4.3 Growth of available data by 2020 (IBM)

Apart from the health and insurance industries, growth will be found in all areas of industry, and certainly in the automotive industry as well. Some topics such as Intelligent Vehicles and Autonomous Driving lead to additional growth.

The technical literature usually distinguishes between the three "V's":

- Volume … ever more expanding data pools
- Variety … different formats, sources, types
- Velocity … processing speed, real-time

As additional parameters there are often added Veracity, Trustworthiness, i.e. seriosity of the data source, and Value.

In order to handle these extremely high data volumes and different characteristics, a large number of technologies are available, which go far beyond the performance of classical data tools such as relational databases or spreadsheet-oriented evaluations. A good overview on the new tools is included in a guide to Big Data by Bitkom (Bitkom is the Digital Association Germany). Authors from different companies and technology providers have been involved, and the entire field of tools has been reviewed in a structured manner. The summary is shown in Fig. 4.4 [Web14].

The topic field is structured into six function clusters, to which available technology components have been assigned. This results in a modular system that can be used to configure the required solutions. For example, streaming tools could access data in so-called Hadoop stores, analyse these data with appropriate mining tools, and visualise the results in a dashboard. In the further process, encryption and the integration of adjacent systems are carried out. There are also offerings from different software providers for the technology elements, which are also listed in the Bitkom study. The technical details will not be discussed further. Operational and architectural aspects as well as new methods such as "Data Lake" are explained in Chap. 8.

Big Data projects offer significant potential to businesses, as the efficiency of today's software provides powerful tools for aggregating and evaluating data from

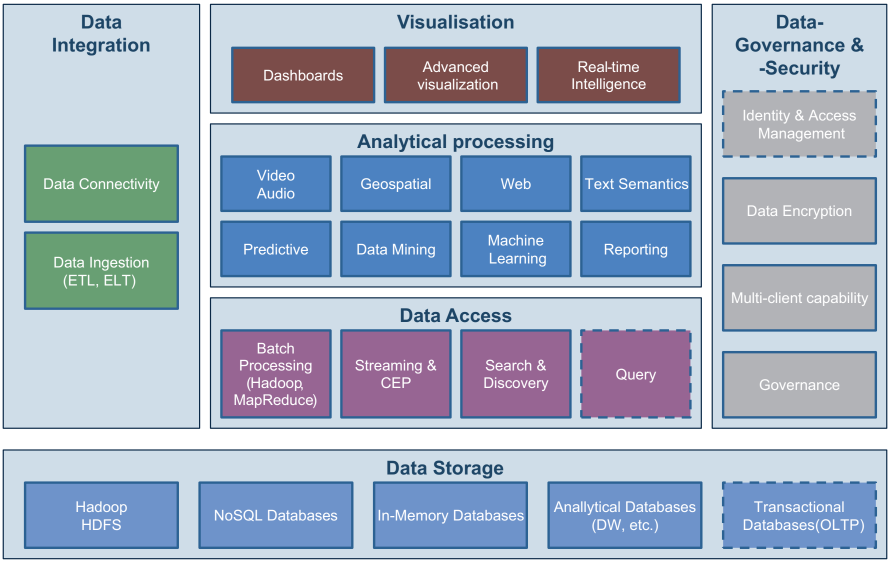

Fig. 4.4 Modern tools for data processing (Bitkom)

multiple sources, both within and outside the enterprise. These technological options go well beyond the tried and tested structured evaluations which have been used with Excel, Business Objects or Cognos until now.

Modern Big Data tools can process very performantly structured and unstructured data in a combined manner, independently extract patterns from data sets, and suggest new insights and options for action on very appealing graphical surfaces or prepared in apps on the smartphone. Typical applications for Big Data projects in the automotive industry are, for instance:

- Early detection of failures in body-in-white manufacturing
- Segmentation of customer interests and definition of the “next best action”
- Understanding of stock movements to reduce inventories
- Recognition of warranty patterns
- Increase the reuse of common parts
- Recognition of bundling potential in purchasing

These are examples of realised Big Data projects with very short payback times. Chapter 9 presents specific projects in this context.

Finally, the question arises here as well as to why the implementation of Big Data projects in the automotive industry is rather sluggish despite the fact that the technologies are available and the benefits are proven in many references. Similar to the Cloud subject in the previous section, an obstacle lies in the distributed responsibility for the data pools.

If, for example, the retrieval of spare parts is combined with the age of certain vehicles and their service and maintenance history and this information linked with the quality of the supplied parts, new patterns of early fault detection could be discovered, and preventive maintenance measures based on these failures could reduce vehicle breakdowns. Technologically, such an overarching data analysis would be relatively easy to carry out. Organisationally, such a Big Data project turns out to be problematic as various parts of the company have to act in concert. Expenses in the individual organisational units achieve benefits for the company which can not be offset against the expenses directly though. Due to this problem, unfortunately such projects often remain undone, and there is a lack of overarching motivation for change and improvement. It is this readiness to transform which the change in corporate culture needs to address – a topic in Chap. 7.

4.1.3 Mobile Applications and Apps

Another established technology, being available as the core element of digitisation projects, are mobile applications, the so-called Apps. Smartphone and Apps are mutually dependent; both have achieved massive growth rates. At the launch of the iPhone in 2007 and the Android smartphones in 2008, mobile applications were initially offered in the areas of games, news, weather and entertainment. Very soon, Apps were added as user interfaces to established Internet platforms such as eBay, Amazon and social networks. Due to their great success and the customer interest, apps from companies, initially from the areas of marketing and communication came to the market soon. On the two best-known store platforms of Apple and Google more than 2 million programmes are on offer, of which approximately 20% are fee-based. The following categories are on top, according to their proportionate number of apps: Education, Lifestyle, Entertainment, Business, Personalisation and Tools [App16], [Ipo6]. Many companies also offer Apps on the established platforms, and an increasing number of platforms from other providers are developed directly in companies.

The Apps are not developed by Apple or Google, rather by a global developer community. So-called store operators take care of the quality assurance and distribution of the apps through the store environment, and for this they receive a fee from the developers posting their Apps on the stores. A direct installation of Apps on iPhone or Android-based smartphones is possible only through unofficial or unsupported paths, so these are closed systems. The principle is similar with other providers.

The massive crowdsourcing for the development of Apps leads to an extremely high pace in the provision of new applications and adjustments, at low cost to the customers. Key to the success of the Apps is the easy installation and operation of the programmes, which do not require any special training. The Apps are available, specifically for the smartphone technology in use, in the respective stores to download by clicking. After downloading or installing the application, these are usually opened and tested immediately. Applications that convince the potentially interested user through functionality, stability and response times normally remain on the smartphones for later use. The entire App environment is characterised by very high dynamics, which is very much in line with the behavioural patterns of the digital natives as was covered in detail in Chap. 3.

The App environment is thus known to all users from daily use and is accepted despite all criticism for instance with regard to data security, terms of use and the filter of the store operators. Therefore, this type of IT usage is shaping the expectation of users in the company. Instead, many enterprise applications are still used by complex user menus on stationary workstations. With the progressive spread of the smartphone, more and more users in the companies want a simple and flexible App-oriented IT environment. Similarly, the customers of companies are looking for marketing or product information for instance or to ask questions via mobile applications.

The challenge to the companies in the context of these expectations is to connect the established IT structures with its proven applications and enormous data pools with the mobile App-oriented world. This is also referred to as integrating the so-called Systems of Record and Systems of Operations, i.e. the proven IT world, with the Systems of Engagement, the mobile, App-oriented world [Moo16]. Figure 4.5 illustrates this situation.

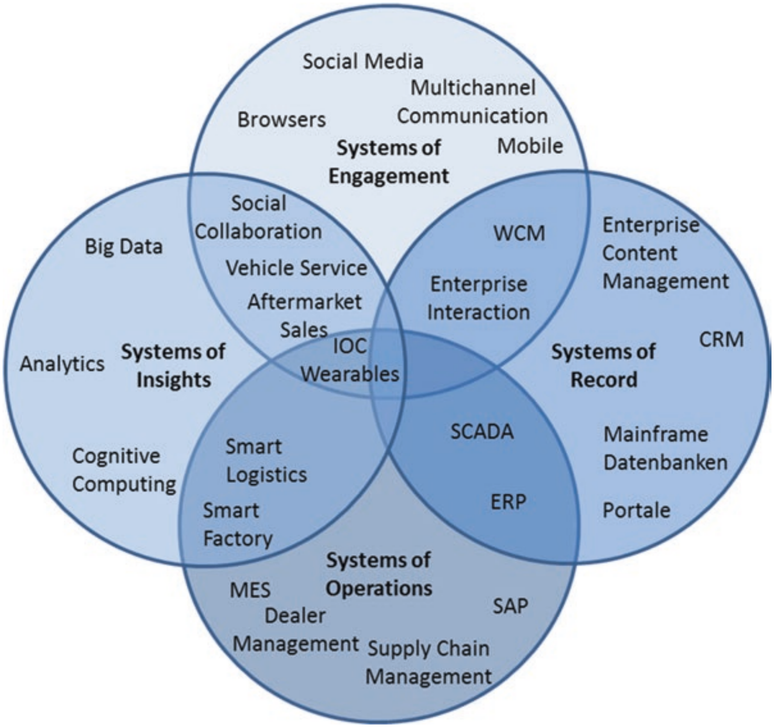

Fig. 4.5 The new IT structures in times of digitisation (Moore)

"Systems of Insights" are added here. They pursue the goal of gaining new insights from the huge data stocks within and outside companies [Whe15]. This is served by the Big Data technologies already explicated, as well as new solutions from the areas of Cognitive Computing and Collaboration, which will be discussed in the following.

New insights result from the combination of different data sources. For example as for the customer behaviour regarding a product, derived from company data of the CRM environment (Customer Relation Management), after-sales information and product discussion of user groups on Internet platforms. The findings are then available as up to date information to customer service representatives through a mobile sales application in the sales talk. This results in the integration of the established IT-world with the mobile capabilities and the Big Data and Cognitive Computing Technologies.

The direction and also the potential for a comprehensive integration and use of the new technologies are shown by this example. These opportunities must be developed quickly within the companies. For this purpose, the enterprise IT should provide a secure environment, which makes it easy to specialist departments and users to establish themselves in the mobile application world. This can also prevent an "uncontrolled growth" which is generated when each department establishes its own path to App development and to the hosting of solutions, as is quite common within the companies. Chapter 8 introduces appropriate approaches to an adequate IT environment.

It is important for the business departments not to simply transfer existing applications from the stationary IT world into the mobile world. Rather, the Apps should be used as bearers of transformation initiatives. On the basis of customer interests, existing processes are to be queried with the application systems supporting them. For which business purpose are specific processes and information required, and which customer value do they create? What is the overall process chain, and how do upstream and downstream organisational units work with the information and with which IT solutions? Section 8.4.4 provides answers to this context.

The questions raised are intended to give thought-provoking impluses to methodically use the Apps, for example in so-called design thinking workshops, to start overarching digitisation initiatives. The development of the solutions should then follow through an agile approach in the App development in which a first version of the App is available to the users very quickly, so that the user feedback can already be taken into account with the first update. This cross-organisational approach with overarching objectives, which can be implemented swiftly with new methods, should for successful digitisation become part of a new corporate culture. This is why Chap. 7 is devoted extensively to the subject of the transformation of corporate culture.

4.1.4 Collaboration Tools

An important element for supporting cultural changes are collaboration tools. Telephone and e-mail are currently the established communication standard as the basis for cross-departmental and transnational cooperation in companies and also across corporate boundaries, for example, with partners. However, these technologies currently reach their limits, e-mail due to the pure flood of daily messages, and the telephone due to acceptance problems. Digital Natives prefer the group-wide exchange of information, for example, in social networks or even messaging services in interest groups, instead of communication in direct contact between communication partners. Thus, established technologies such as e-mail, calendar, video conferencing, document management and project management tools are increasingly being replaced or supplemented by:

- Social Networking
- Workflow Systems
- Wikis, blogs, bots
- e-Learning
- Messaging systems
- Whiteboarding, Desktopsharing, Teamrooms
- RSS feeds, tagging.

These technologies are by no means new yet rather tested in reference projects, and there are comprehensive offers available on the market. A good overview of application examples is provided, for instance, by a Bitkom study [Eng13]. This underlines the importance of these tools for communication and collaboration in teams. To understand the fundamentally different ways in which traditional communication and collaboration tools work, they are contrasted in Fig. 4.6 with the new WEB 2.0-oriented world.

The comparison shows that the new tools emphasise an open collaboration in the team, flexible fields of application and the integration of different tools and processes. The traditional communication applications were aimed at direct dialogue. Electronic calendars, project and document management as well as special software solutions for developers supported the collaboration. The new world is characterised by flexibility, openness and integration capability and thus transparency for entire business areas. Mobile Apps are used on mobile devices in the same way as the established private applications, so that no special training is required.

This results in a wide range of applications for collaboration tools, such as software development projects with distributed teams at different locations in Teamrooms, company-wide communication and opinion-forming on strategic initiatives via social networks, and documentation of work experiences with a new tool in Wikis. If necessary, examples of solutions and references can be found on the Internet. It is important to recognise the opportunities to shape new forms of communication and cooperation with IT tools in a timely and appealing manner in order to use them for digitisation projects specifically.

Consideration	Traditonal Collaboration Tools	Web 2.0 Collaboration Tools
Focus	Clear-cut Structure	Open-minded Structure
Governance	Command & Control via Direct Dialog	Social Collaboration
Core Elements	Electronic Calendars, Project & Document Management	Wikis, Social Networks, Unified Communication & Collaboration
Value	Single Source of Truth	Open Forum for Discovery & Dialog
Performance Standard	Stability, Controllability	Flexibility, Openness, Transparency
Content	Authored	Communal
Primary Record Type	Documents, Structured Data	Conversation (Text-based, Images, Audio, Video), Unstructured Data
Searchability	Easy	Hard
Usability	User gets trained on systems and has access to follow-on support	Intuitive handling due to resemblance of enterprise systems to social networks
Accessibility	Regulated, Contained, Workplace-restricted	Ad hoc, Open, Always On
Engagement	Top-down, Management-driven	Intrinsic, collegially-driven
Policy Focus	Closed System (Knowledge Retention)	Open System (Knowledge Spillover)

Fig. 4.6 Comparison of traditional and modern collaboration tools (Source: Author in reference to [Moo16])

4.1.5 Cognitive Computing and Machine Learning

A still young IT technology is the focus of many research projects, and increasingly in innovative industrial projects: the so-called Cognitive Computing, often equated with machine learning. Both topics relate to the field of Artificial Intelligence.

For machine learning, algorithms are programmed that recognise patterns and laws in large quantities of data and, on this basis, derive forecasts of events. These findings or these algorithms can then be transferred to new, comparable data and improve through further cases of operation. The software does not optimise itself independently, but appropriate rules must have been provided and programmed in advance. Fields of use of machine learning are, for instance, the assessment of user behaviour on internet platforms, the detection of credit card fraud, the optimisation of spam filters and handwriting recognition [Shw14].

In contrast to machine learning, the learning algorithms are not preselected in Cognitive Computing, yet open algorithms are used at a higher, more abstract level, similar to the functioning of the human brain. In simple terms, the systems form hypotheses on structures and statements from the recognised patterns in the data sets which are then validated with probabilities or hypotheses, similar to the human thinking process. These sequences are programmed on a meta-level.

Systems based on Cognitive Computing develop in the course of operation time, in dialogue with human experts, autonomously in the focussed topic area, which means they keep learning. Due to the immense performance of today's IT systems, which is growing exponentially, cognitive methods from increasingly large data sets with more complex algorithms can produce impressive results in an acceptable time.

A well-known example of the potential of Cognitive Computing is the Watson solution [Kel15] used by IBM for the first time in the US television show Jeopardy! in 2011. This was based on high-performance hardware. The system understood the human voice of a quizmaster in real-time, analysed the background, context and words of questions, and then, using the cognitive algorithms, sought in extensive data sets with factual knowledge, images and documents for solution hypotheses to answer the question. Ultimately, Watson was more successful in the competition than two previous champions.

Since the presentation of this system in 2011, the area of Cognitive Computing has developed rapidly. In general, they are now able to access, analyse, and process various problem situations independently, using extensive heterogeneous data sets. Conclusions and proposals are compared with expert knowledge from specialists. The system sustainably acquires the new knowledge and also refines it. The following aspects are common to all cognitive systems:

- Flexible, open algorithms – trainable and self-learning
- Updating of experiences – without human input
- Flexible fields of application and trainability in different subject areas
- Interaction with people – also with speech control; multilingualism
- Processing of large data volumes, both structured and unstructured

As Cognitive Computing is able to be used in a wide range of tasks and to continually improve in working on the subjects, flexible possibilities of use are created with immense potential. Namely the handling of administrative processes and the merging and updating of information can be completely automated with procedures from this environment and, after learning phases, replace jobs in these areas. The following examples are already implemented as fully automated operations:

- Processing of the granting of small loans
- Answering questions at the customer helpdesk
- Analysis of radiographs and patient records
- Invoicing
- Assignment and planning of logistics tasks
- Handling of procurement processes in web shops.

These are just some relatively simple reference projects. The technology, as well as the underlying IT systems, will become even more powerful, the algorithms more comprehensive, and especially the voice-controlled user interfaces more secure.

This gives the automotive industry a wide range of opportunities for using this technology in the areas of autonomous driving, voice-controlled user guidance, vehicle diagnostics and vehicle configuration. The personal assistant, both in the workplace and in the private sector, is also foreseeable, accomplishing some of the pending tasks automatically and supporting the remaining subjects. Overall, Cognitive Cumputing will play an important role in the development of a vision for the automotive industry and the development of a roadmap for digitisation, as well as in the case examples in the coming chapters.

4.2 Internet of Things

In addition to IT technology, sensor technology also continues to become less expensive and more powerful. As a result, more and more items of everyday life, such as clothing, kitchen appliances, heating systems and weather stations, have components for status detection and communication. This is all the more true of the properties and facilities of manufacturing companies, where the sensor system for control is often already available however is now becoming smarter and able to communicate.

The term “Internet of Things” (IoT) includes the integration of sensory data from different “things” via web-based applications. They aim to support users, improve processes, intervene to control, or gain new insights. Some examples of applications are the turning on of a heating system in the house when the homeowner has almost arrived, the automatic selection of the correct washing machine programme in the case of delicate clothes, or the follow-up delivery of groceries which the refrigerator has previously ordered after the user at the start of the journey home had been asked in the car what food was preferred.

The topic of the Internet of Things is seen as a megatopic because of the diverse fields of application in all industries as well as in the public and private sectors. Figure 4.7 gives an overview on the possible applications [Man15].

The overview highlights that the topic of IoT is present in many areas and acts as a driver of digitisation projects there. The economic potential is also considerable, which is due to, on the one hand, the transformation and thus the improvement of existing processes and, on the other hand, new business models. Different studies assume a potential in Germany of at least €20 billion, some of which anticipating much higher values [Wis15].

For the automotive industry, the topic of IoT is of central importance since this industry is involved in almost all the areas which are shown in Fig. 4.7. Examples are solutions for vehicles, in order to recognise emerging problems prematurely and to plan maintenance services to avoid failures. Furthermore, it is possible in cities for instance to connect the vehicle sensor system with traffic signals or parking space sensors in order to design the route according to the driver’s wishes. In the industrial environment, information from logistics vehicles about delivery situations can be used to control the supply chain according to demand. Due to the breadth and importance in many business areas, IoT is certainly also becoming a driver of digitisation in the automotive industry.

Setting	Description	Examples
Human	Devices attached to or inside the human body	Devices (wearables and ingestibles) to monitor and maintain human health and wellness; disease management, increased fitness, higher productivity
Home	Buildings where people live	Home controllers and security systems
Retail environments	Spaces where consumers engage in commerce	Stores, banks, restaurants, arenas—anywhere consumers consider and buy; self-checkout, in-store offers, inventory optimization
Offices	Spaces where knowledge workers work	Energy management and security in office buildings; improved productivity, including for mobile employees
Factories	Standardized production environments	Places with repetitive work routines, including hospitals and farms; operating efficiencies, optimizing equipment use and inventory
Worksites	Custom production environments	Mining, oil and gas, construction; operating efficiencies, predictive maintenance, health and safety
Vehicles	Systems inside moving vehicles	Vehicles including cars, trucks, ships, aircraft, and trains; condition-based maintenance, usage-based design, pre-sales analytics
Cities	Urban environments	Public spaces and infrastructure in urban settings; adaptive traffic control, smart meters, environmental monitoring, resource management
Outside	Between urban environments (and outside other settings)	Outside uses include railroad tracks, autonomous vehicles (outside urban locations), and flight navigation; real-time routing, connected navigation, shipment tracking

Fig. 4.7 Application areas of the Internet of Things (Manyka)

4.3 Industry 4.0

The term "Industrie 4.0" was created in Germany on the basis of a political initiative to further automate production in the sense of safeguarding workplaces and improving competitiveness. Compared to earlier concepts such as CIM or Lean Production, the new element is the continuous digitisation of product and production at maximum flexibility of the order structure and the supplier connection up to batch size 1. For this purpose, IT, sensor system and production technology must be linked in such a way that an integrated IoT solution is created.

"4.0" emphasizes the positioning of this phase of digitisation as the fourth industrial revolution, following the previous three phases of steam drive, assembly line and programmable controllers. In order to achieve the desired smooth interaction between technology, people and computers, a working group has developed recommendations for architectures, technical standards and norms [Kag13]. The work of the panel is being continued, and research projects and pilot projects are driving the implementation on a sustainable basis.

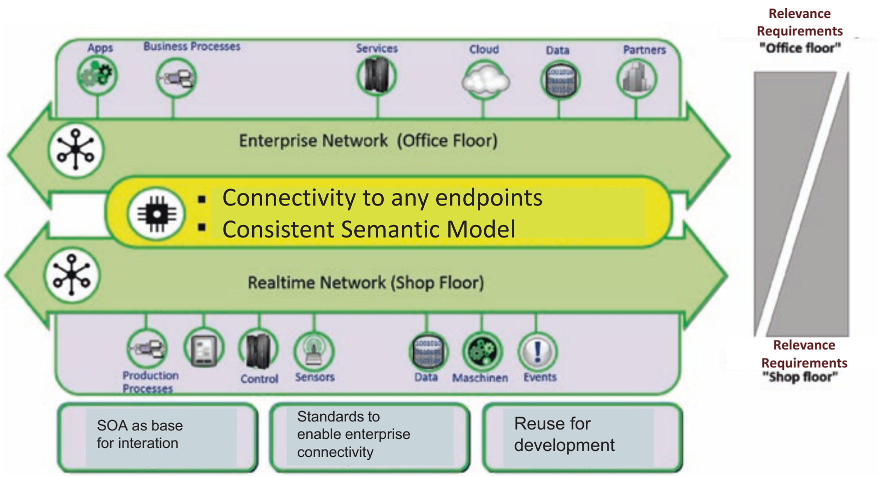

Fig. 4.8 Component model Industry 4.0 in office and shop floor layer (VDI/VDE)

The Industry 4.0 reference architecture is documented in a VDI/VDE status report [Ado15]. Figure 4.8 shows the component model with the distinction between Office and Shop Floor layers. While business processes in the office area are transaction-oriented, the shop floor area near the sensors and actuators is operated in real-time.

In the office or enterprise sector Cloud solutions establish themselves. Due to the required real-time capability, these can not simultaneously also provide the IT services in the shop floor area because the transmission speed is insufficient. For this reason, an architecture is establishing which provides for a separation of the two environments. For the production environment with sensors, actuators, control, field bus systems, etc., special Cloud solutions according to the principle of the so-called Edge or Fog Computing are applied [Rie15]. The connection with the Cloud environments is achieved via so-called edge gateways. These connect the special real-time Shop Floor protocols with the superimposed enterprise Cloud applications. Depending on the size of the IoT or Shop Floor environment, one or more gateway instances are required. Based on the idea of using several smaller edge servers on the shop floor, a load distribution is performed, which allows processing of real-time applications independent of the enterprise Cloud. As a result, Edge Computing also enables the implementation of machine-to-machine applications and the local preprocessing and handling of mass data. From Shop Floor, the concept of Edge Computing is also spreading into other application areas, such as connected services for cars, smart grid in the energy sector and in the field of Smarter Cities.

The topic of Industry 4.0 is in Germany in the many manufacturing companies in its implementation phase, and a large number of references are known. These often come from the areas of maintenance and services, where preventive measures help avoid the breakdown of production equipment by using Big Data concepts. A comprehensive implementation example for IoT/Industry 4.0 is shown in Fig. 4.9 [Man15].

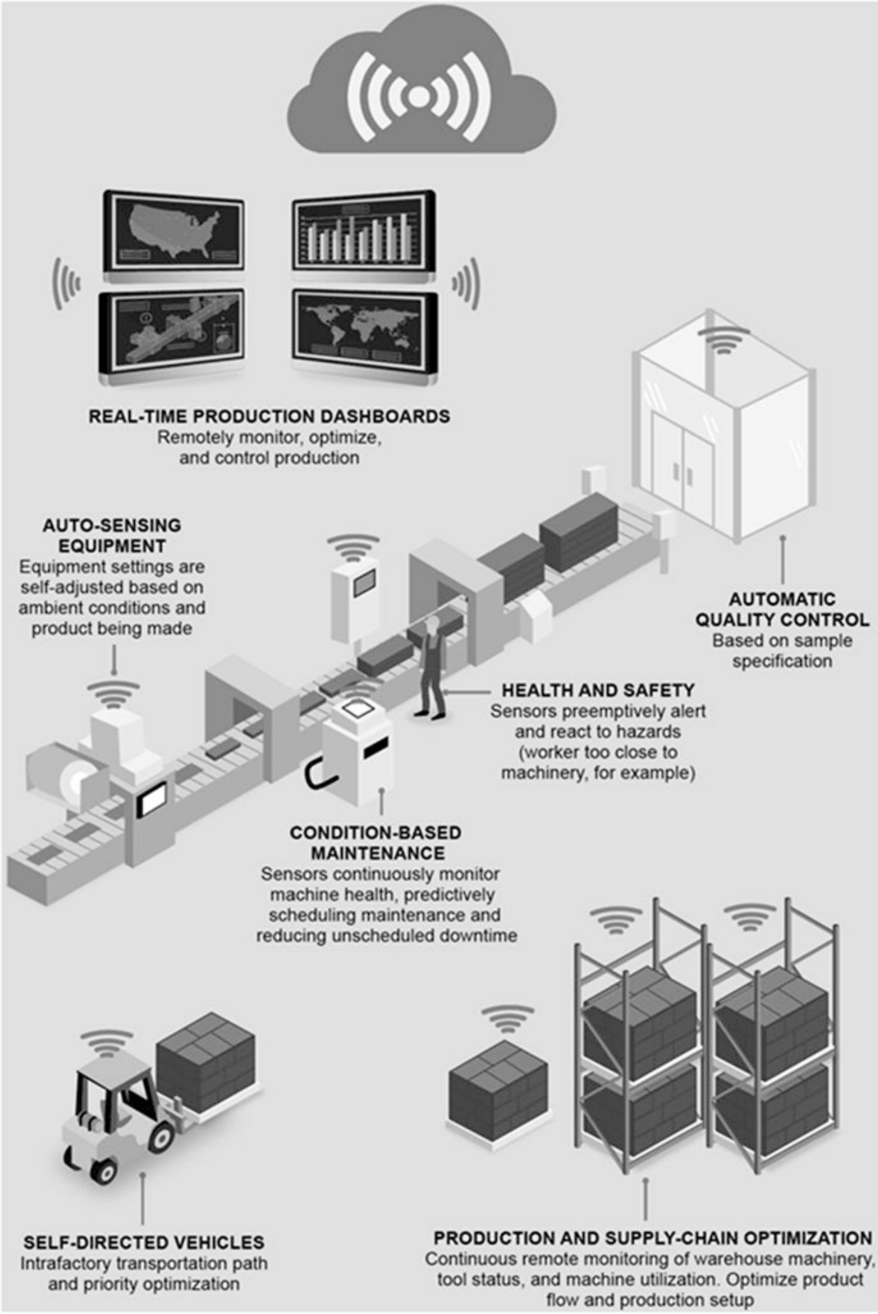

Fig. 4.9 Implementation of IoT/Industry 4.0 solutions (Manyka)

In a central control console, all information on current orders, machine statuses and logistics information for the supply of parts are combined on large displays. Preventive maintenance measures are derived from the entire data stock, and a continuous quality control takes place. Forklifts drive autonomously between warehouses and supply points. Sensors with corresponding application solutions ensure safety at work.

This scenario, allowedly, is a comprehensive and fictive, visionary example. There are, however, already many references from the area of flexible utilisation planning of plants that are integrated into the logistics concepts of the suppliers. This makes configuration flexibility of products possible right up to production start, as well as precise customer individualisation up to batch size 1. A good summary of reference projects, research projects and also providers can be found in a report of the German Federal Ministry of Education and Research [BMBF15].

By now, comparable initiatives such as Industrie 4.0, launched in Germany in 2011, are developing abroad as well. More detailed information on these initiatives can be found on the Internet, for example:

- USA: Industrial Internet Consortium (IIC)
- Japan: Industrial Value-Chain Initiative (IVI)
- South Korea: Smart Factories
- China: Five-Year-Plan initiative "Made in China".

All of these activities aim to increase the efficiency and process quality in production through digitisation projects, thus ensuring the competitiveness and sustainability of the national industries.

4.4 3D Printing

The 3D printing process can also be attributed to the subject of digitised production. By now it has outgrown the research and pilot project status and moved into industrial production. Gartner considers these processes in the Hype Cycle for future technologies as ready for production (see Fig. 4.1). Particularly in the automotive industry there are a wide range of possible applications, ranging from prototype construction and the printing of spare parts on demand, through to the production of special tools and the manufacturing of a customer-specific interior. Because of the anticipated further increase in the performance of the process and the improvement of the materials used, 3D printing with its entry into serial production has the potential of a "disruptive technology", i.e. a revolutionary change of previously established production processes. The growing importance and further development of this technology is underpinned by the appraisement of the related market volume, which includes the costs for printers, materials, software and services. In 2016 the total volume was around $7 billion, and at exponential growth a volume of approx. $21 billion is expected in the year 2020 [Ric16].

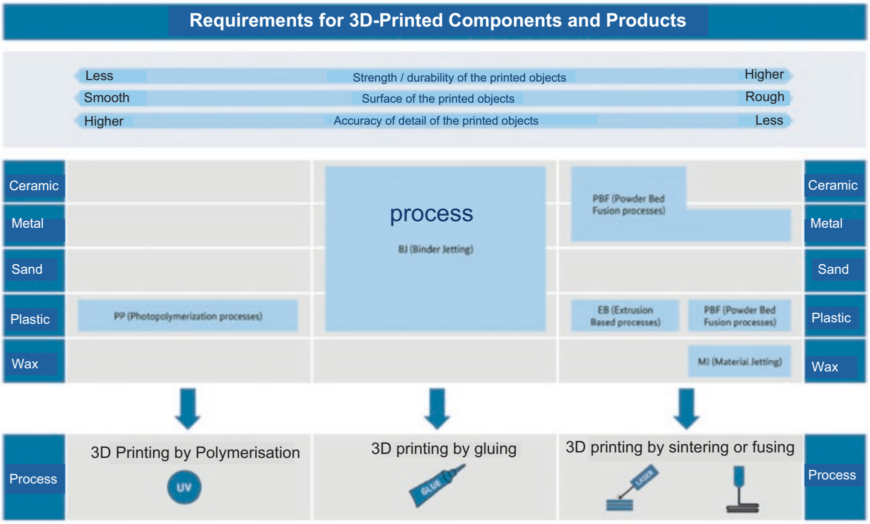

Fig. 4.10 Process models of additive production (Richter)

Under the generic term of 3D printing, different processes from the field of additive manufacturing are summarised. These methods have in common that in contrast to traditional abrasive methods, such as turning and milling for instance, in additive production, the target product is gradually built up from material layers. Three methods can be distinguished according to Fig. 4.10 [Ric16].

In the so-called PBF (Powder Bed Fusion) method, a thin material layer of plastic or metal is applied to a working surface and then melted or sintered with laser beams. After solidification, this process is repeated in layers until the target shape is achieved. With the EB or Extrusion-based processes, thermoplastic synthetic materials are placed down by means of a heated nozzle in strips or layers. The PP or Photopolymerisation process uses liquid materials, which are solidified in layers by UV radiation for example. In the BJ or Binder Jetting process, material powders and binders are alternately applied in layers, similar to inkjet printing. The component then consists of a multitude of powder and binder layers. It achieves high strength in this composite and is particularly suitable for large objects. Further methods are known, often also derivatives of the presented approaches, which are not dealt with in detail here and are instead referred to the specialist literature [Geb13], [VDI14].

The automotive industry has long since used additive manufacturing processes, and the degree of maturity is very advanced. Powder based technologies and the extrusion process are most frequently used. However, application fields are not large series with high batch sizes, which will continue to be dominated by traditional manufacturing processes, but rather products with many variants in smaller quantities. In addition to prototype construction, the production of special tools and spare parts are established fields of application, which take advantage of the high flexibility and short throughput time. This allows complicated component geometries to be manufactured economically [Hag15]. With the increase in performance of the technology, further fields of application are sure to emerge.

A pioneer of 3D printing in vehicle manufacture is the company Local Motors in California for instance, which introduced its first vehicle in 2014, being produced entirely using this technology. Subsequently in 2016, the company introduced an autonomously driving mini-bus, called Olli, all of whose parts are produced by means of 3D printing [Tri16]. The bus accommodates 12 passengers. Olli picks up its customers independently at their location when they have requested it through an App. The intelligence of the minibus is based on methods of Cognitive Computing (see Sect. 4.1), in this case the IBM WATSON Suite. The example is deepened in Sect. 9.2.

Since the production of the bus is based entirely on 3D printing processes, Local Motors has plans for interesting production concepts. Instead of mass production in central large factories, it is planned to have local 3D printing workshops near the customer. The vision is to establish a global network of these mini-factories in a market-oriented manner, which are flexibly able to integrate local requirements directly into the products.

In the light of this idea, a vision that was expressed some time ago could at least come true in facets. According to this, no more production lines would be used in the Wolfsburg Volkswagen factory by the year 2035, at most as museum pieces. Instead, there would be a tightly coordinated network of many small production plants with more than 10,000 3D high-speed printers, 100 design offices, 500 marketing companies and 300 assembly and test centres [Eck13].

There is of course still a long way to go to implement this vision. Traditional production processes are still superior to additive technologies, especially in the case of high quantities. However, in the fields mentioned above which require flexibility and speed at low number of pieces, 3D printing is already competitive today. With further performance expansion, the entry into series production is foreseeable, namely since the series will reduce in size due to the further increasing customer individuality and high segmentation. Especially in the area of the new electric drives, characterised by less and simpler components and smaller series, 3D printing will play an important role.

4.5 Virtual and Augmented Reality

In the following, a further technology area will be presented, which is to be classified as a core element of digitisation projects in production, but also in many other areas, such as sales and service, as well as development. “Virtual Reality” and “Augmented Reality” are often used as synonyms, but they are quite different. Virtual reality (VR) is an entirely computer-generated 3D representation of objects without a link to the real, physical world. The viewer is able to move in a virtual world, for example in a street or in a factory hall. Typical applications are 3D movies, computer games or even animated manuals. The user is limited to the role of a consumer, and the interaction takes place in the programmed environment via consoles or input devices.

Augmented Reality (AR) means the projection of a computer-generated scene into the real world. An interaction takes place in real-time and in high-resolution graphics, often in 3D representations. There are mixed forms between the two technologies in which, for example, real situations are reflected and virtualised by simulation, or alternative solutions are looked into. In this way, the virtual and the real world superimpose one another, possibly supplemented by relevant information. Augmented Reality is a technology which intelligently connects different data sources with heterogeneous data types and high data volumes with powerful output possibilities such as animations, text and speech. These solutions use techniques from Big Data, Analytics and Cognitive Computing and can thus be applied in many areas. Possible applications in the automotive industry are described in [Teg06].

Figure 4.11 illustrates the basic structure of a virtual reality application with the required system components by the example of a worker's place [Teg06].

The total solution consists of hardware and software components. In principle, the following must be distinguished: input systems for recording the real scene (in this case a camera), processing systems for tracking the situation, integration of virtual elements and further data for the preparation of the integrated overall scene (scene generator). Display devices show the user the overall scene (in this case with the help of a data glasses). The solution components may be configured in various technologies. The processing power for the execution of the AR task is available via Cloud solutions or special appliances, depending on the specific application or

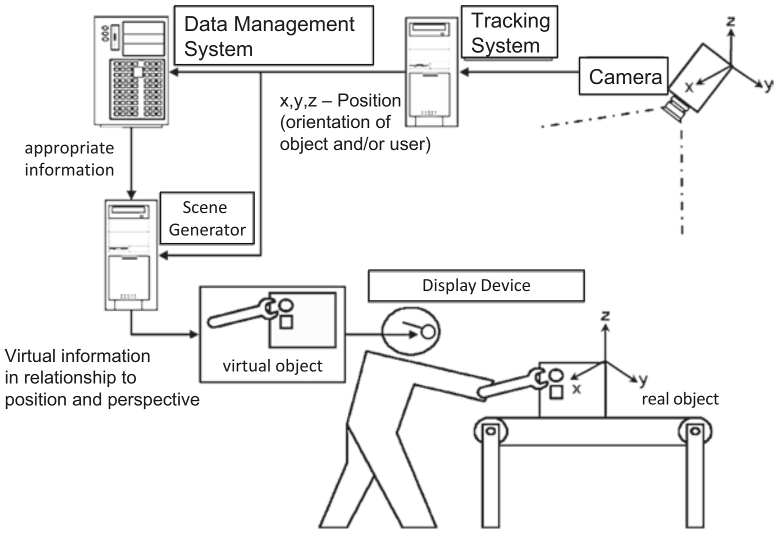

Fig. 4.11 Conceptual virtual reality application example

power demand on dedicated computers. The definition of appliances in this case means integrated devices, which for a particular application contain both the hardware and the required software, for example for the rapid analysis of large amounts of data or also for secure data transmission.

Besides the keyboard, touchscreen and mechanical devices, all types of sensors and cameras are also being used for the input. For the output or display, different devices are available, for instance:

- Monitors … traditional screens, displays of smartphones
- Videoprojections …. Display on large monitors or projection screens
- Video glasses or Head Mounted Display (HMD) …. Glasses or a special data helmet
- Data glasses … partial glasses, which allow to view the real scene in parallel
- Contact lenses with display …. Contact lenses with integrated displays
- Retinal data frames … direct projection onto the user's retina.

There are numerous applications in the private sector and for companies, especially in the automotive industry. Examples for the AR deployment there are:

- Display of working instructions via data glasses during the execution of complicated assembly sequences
- Virtual test of assembly processes such as installation of the drive train
- Simulation of material flow concepts on virtual factory models
- Presentation of vehicle configurations as 3D models in a showroom in interaction with exhibits of different interiors
- Joint work of designers on the 3D model of a vehicle on a large screen to refine concepts
- Showing road surface information on the windscreen of a vehicle
- Voice-controlled interaction with an intelligent driver assistant
- Gesture control in the vehicle operation
- Interactive training of service staff during the execution of repair work.

For almost all examples, one can find on the Internet experience reports of the manufacturers who use Virtual and Augmented Reality. Due to the great benefits, the acceptance and further continuous improvements to the performance of the solutions, a massive increase in the spread can be expected. Thus, a large market growth is forecast for VR/AR solutions. Coming from approx. $2 billion in 2016 almost exclusively for VR solutions, a market volume of $150 billion is predicted by 2020, of which $120 billion for AR and $30 billion for VR solutions [Gor16]. The large proportion of VR is expected in films, computer games, marketing and distribution solutions, while the AR sector is growing significantly stronger by applications in the industrial environment. Other studies predict somewhat lower values of the future market volume, although on a considerable scale as well, so that these technologies are also to be considered as disruptive.

4.6 Wearables

The input systems are an important element of all AR solutions. Keyboards, sensors and camera systems are already established techniques. The following section briefly presents two relatively new technologies, which are receiving much attention as innovative and strongly growing solutions.

Wearable Devices, also being referred to by the short name of Wearables, are intelligent, small, body-worn devices such as data glasses, fitness belts, smart watches and sensors that are incorporated into clothes, as well as data gloves. Along with the growing interest and business potential of the Internet of Things and Augmented Reality, rapid growth is also forecast for the Wearables sector. Basically, Wearables are connected to the Internet, and there are two different versions. On the one hand, devices which assume a pure input/output function (I/O), such as clothing sensors or data glasses, and on the other hand devices which, in addition to the I/O capabilities, also have their own computing power in order to directly execute applications, such as smart watches.

Wearables are also becoming more popular in the automotive industry. Examples of using the data glasses were given in the previous section. Further options are to equip workers' clothes with sensors which measure their physical load in the work process. Using the data, workflows are then improved or even health-damaging processes are avoided by the use of suitable tools for the workers.

Further examples stem from the area of customer service for automobiles. The service employees call the next service request via their Smartwatch. Then, they are guided by "point to pick"-solutions to install the right spare parts and supported in the execution by instructions through data glasses. Further possible applications can be found during Sales activities. For example, many car dealers have established virtual sales areas. Interested customers can test selected vehicle configurations in a virtual environment. Powerful 3D glasses incl. loud speakers for the driving noise provide a comprehensive driving experience. The equipment can be changed in an interactive manner, and the bonnet and doors of the virtual vehicle can be opened by means of gesture control in order to inspect details.

Also namely in trade, a further technology allows to expand interaction with the customer and provide a personalised experience. So-called Beacons are used for this purpose. These are battery-operated transmitters with the size of a matchbox. These transmit signals at short intervals with their device-specific ID. Data transmission is done, for example, via the so-called Bluetooth low-energy technology, which operates very energy-efficient within ranges of up to 30 m [Stro15]. The signals are received using corresponding Apps. By analysing the signals from the Beacons in the showroom, the exact location of a potential customer can be recognised and used to provide information precisely about products in their field of view. In addition, the prospective buyer can also be guided through the showroom by relevant hints to offers that are relevant to his or her interests.

There are already many references in Apple Stores or at Starbucks for the mentioned application of Beacons in trade. The area of trade is certainly a suitable business field for this technology. In addition, many other areas open up interesting application opportunities as well, such as in logistics in the management of scheduling staff [Bvd16]. The use of Beacons in the automotive sector is just at the beginning.

4.7 Blockchain

The subject of Blockchain is positioned as a disruptive technology within the finance industry. As an idea published for the first time in 2008, more and more users and providers are turning to this approach with corresponding solutions. Many start-ups have been established around this topic, and a rapidly growing community is emerging. Starting from the financial sector, the basic approach is now being tested in many other process and business areas in the automotive industry in first pilot applications [Wil16].

The purpose of the Blockchain architecture is to enable direct and secure business relationships between two parties without intermediaries, for example, a money transfer from A to B without a bank being involved. Before and after a transaction, transfers have already been made, which may at least affect the parts of the transaction. The basic idea behind Blockchain is to transparently store a network of these transactions for all parties involved and to update these in a chronological way. In order to make the process tamper-proof, a multi-layered architecture was developed in which the changes of the transactions are filed in a block of the data set in encrypted form. The basic structure is shown in Fig. 4.12, taken from the public developer guidelines for Bitcoin, the Internet currency which is also protected by Blockchain methods [Bit16].

Throughout the process, verification mechanisms ensure that the payer is in fact the owner of the funds at the time of the transaction. Each new transaction is stored in a new block and appended to the previous blocks. This creates a chain of data blocks, which explains the name of the procedure.

Blockchain solutions suggest many advantages. Further to the security aspect, there are the cost advantages from avoiding the need for an intermediary organisation, and the transparency of the transactions. The disadvantages are in the effort and the processing time for the complete handling (storing, sending, updating) of the transactions. For this reason, the procedure is currently better suited for applications with individual business content and a small transaction volume, rather than for standardised mass processes. These are more cost-effective with specialised and optimised IT solutions. However, the application possibilities of Blockchain are of a universal nature and not restricted to the sphere of finance. The possibilities of use are characterised by any business relations between partners, which in turn are part of a chain, or the existence of predecessor and successor relations.

In the automotive field these are for example logistics processes in the supply chain, services in the field of warranty handling, vehicle control or handling of short-term loans in the area of mobility services, as well as payments in the area of

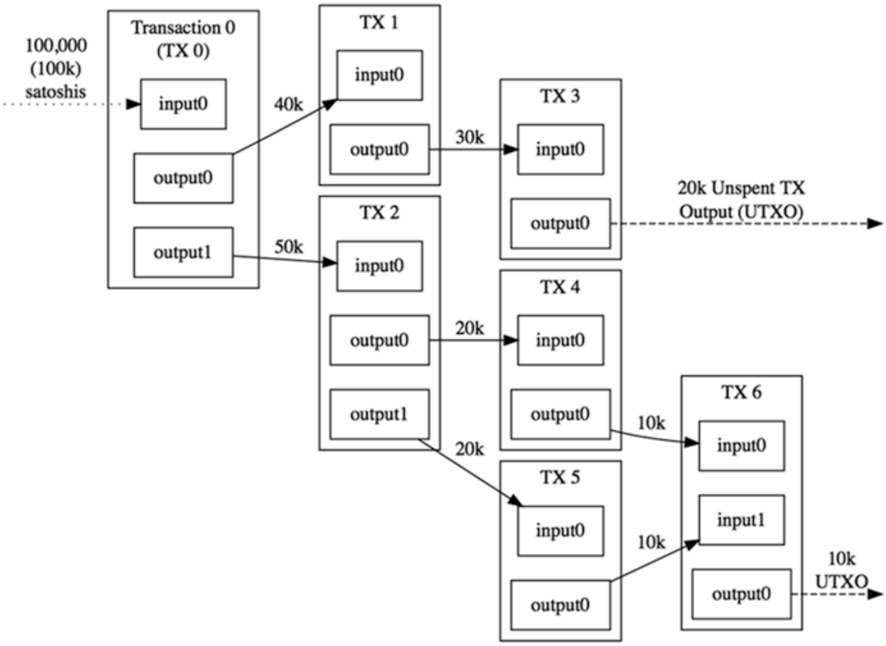

Fig. 4.12 Basic structure of the blockchain method (Bitcoin)

connected services. These examples demonstrate the flexible potential applications. A case example is explained in Sect. 9.3.

The spreading of Blockchains could accelerate if, with appropriate transaction volumes in the companies, general platforms were also established by third parties, which would offer the processing in a standardised and efficient way. On this basis, the importance will continue to grow. It remains to be seen whether a disruptive trend will develop from this, perhaps along with the digital Bitcoin currency. Potential cost, security and transparency benefits are the drivers.

4.8 Robotics

A long-established automation technology in the manufacturing industry are industrial robots. They have been used by the automotive industry in production for more than 50 years. Application fields are heavy and clocked activities which are physically exhausting to employees, such as in welding lines or assembly. Currently, the so-called robotics density (number of robots per 10,000 employees) in the automotive industry in 2014 averaged in the USA, Germany and South Korea at approx. 1100, while Japan has the highest density with 1400 and China is far behind at 300 [Har16]. Even if extensive experience is gained in the use of robots, this technology field nevertheless belongs to these fields of innovation which deserve a high level of attention as the possible uses for Robotics are currently greatly expanding.

Drivers are changing needs and application fields along with the extended capabilities of the devices. The high and further increasing computer performance, simple programming methods and the growing mechanical performance of the robots drive the spread of robotics into new business segments. The application is therefore also interesting with small batch sizes. Manufacturing of vehicles is more and more tailored to the customer and in small numbers. Hence it is foreseeable that in future fewer and fewer assembly lines will be used in production. Instead, autonomous production cells are created, in which the workers work flexibly without fix cycle times together with robots.

Robots are also increasingly used in areas still untapped by robotics so far, for example for the assembly of complex parts and also for work in the service sector. In addition to the established industrial robots, lighter collaborative systems and service robots will also be used in the future. The robots will have more sensor technology which is necessary to ensure safety in human-robot cooperation (HRC). With the help of sensors, the robots detect whether humans are dangerously close to their action radius and stop the movement immediately. Due to this sensitivity, robots will no longer be surrounded by safety fences in the future, called “Fenceless Production”. The service robots also work without a safety fence, which means that robots are already in use in the care of the elderly people or in the cleaning of vehicles.

Furthermore, powerful innovative programming methods support the further spreading of robots. While in the past special programming methods and tools were required, the graphically oriented programming facilitates the use of robots. In the Teach-In process, experienced workers lead the robot directly and thus train it. In the future, gesture- and speech-controlled programming will be used to improve the possible applications and lower the costs for the introduction.

In addition to the technical feasibility, a comparison of the expected unit costs is an important decision criterion for robot use. Volkswagen has published a detailed analysis, summarised in Fig. 4.13 [Dol16]. Depending on the investment costs for the robot, cost per hour is below one and twelve Euros in the sample scenario. Comparable hourly costs for workers, as also stated in the study, are at full cost at around fifty Euros. Thus, the economic comparison also speaks in favour of the application of robots.

Against the backdrop of these advantages, Volkswagen plans to expand the use of robots in production, not only in established fields, but increasingly also in more complex areas and workplaces, for example, in the interaction with workers, i.e. human-robot cooperation. This strategy is also intended to counter the emerging shortage of skilled workers.

Due to similar drivers and advantages as in the industrial sector, the use of service robots continues to grow strongly. Completely new fields such as care services, concierge services, as well as cleaning work will be taken over by robots. Especially in these applications, Cognitive Computing (see Sect. 4.1) facilitates that robots become teachable, available for open dialogues and thus also fulfill social functions.

Assumptions Business Case	
Duration in operation	7 Years
Uptime	250 Working days/Year with 20 hrs/Working Day ➔ 5000 hrs/Year * 7 Years = 35.000 hrs
Operating Costs	Electricity(1 - 13 KW) * 0,10 € * 35.000 hrs
Maintenance	5% of robot basic structure cost

Fig. 4.13 Overall cost comparison of different robot types (VW)

One example is the so-called humanoid robot "Pepper" by the company Softbank with IBM's cognitive base "Watson" [Wan16]. This autonomous robot is used in Japan as a concierge service in banks. After welcoming customers in the counter room and inquiring about the customer requirement, Pepper leads the customer to an advisor desk. Meanwhile, the analysis of public social media data and the existing customer data held in the bank are used to prepare the customer's profile and make it available to the consultant for the conversation. As a result, the conversation is conducted from the outset on a secure information basis. This example illustrates future possibilities in the field of Robotics, especially with the use of further digitisation technologies in the automotive industry (see also Chap. 9 with a practical example on "Pepper").

4.9 Drones

Drones are considered a further technology with high potential for innovation in many industries, and this is discussed below from the perspective of potential applications in the automotive industry. Drones are unmanned aerial vehicles which are operated by computer or remote control. They have long been seen in the military environment. As early as 1931, the British Royal Air Force used unmanned aerial objects as target drones [Pap17]. For some years now, drones have been spreading at a high rate of growth both in the private and the industrial environment. The devices come in many forms, ranging from a few centimeters in size to load carriers with spans of more than 30 m, such as the "Aquila" drone used for experiments by company Facebook. The flying apparatus which weighs over 400 kg, is powered by a solar engine and is able to remain in the air for 3 months. With the aid of this drone, people in remote regions shall be given access to the Internet. Google is working on a similar project [Han16].

This example illustrates the innovation potential which drones can have also for the automotive industry. There are many possible applications. In logistics, the delivery of parts could be carried out with such “flying robots”, as well as the support for performing an inventory check on the stock in high-bay warehouses [Bmw16], and also traffic monitoring, which is already being tested in pilot applications. Further possibilities of use could be in service and also in the internal parts supply, so that this technology will play a role in the digitisation as well.

4.10 Nanotechnology

Nanotechnology is a topic area that deals with the research, production and application of structures which are smaller than 100 nanometers (1 tenthousandth of a millimetre) in at least one dimension. This technology has been rapidly developing since the 1980s and established as a cross-sectional topic in many industries. In addition to naturally occurring nanoscale materials, there are many artificially produced nanomaterials. One differentiates between carbon-based materials, metallic materials, dendrimers and composites [Wer16]. The effect of nanomaterials is essentially due to the fact that the ratio of surface area to volume is much greater compared to conventional materials, and thus the surface properties dominate the volume properties. Furthermore, the finely structured nanomaterials have fundamentally different chemical, physical and biological properties compared to coarser substances. The fields of application of nanotechnology can be roughly divided into the following fields:

- Nanoparticles … “mini-materials” made of metals or composites
- Coating … surface coatings such as paints or non-stick coatings
- Biology/Medicine … special drugs and also implants
- Tools/Devices … mini-sensors; mini-devices for medical or industrial areas.

In the automotive industry, nanoparticles are now an integral part of many vehicle components. For example, nanoparticles lead to better properties of car tyres and allow for more efficient catalysers and air filter systems. Even car wash facilities offer “nano treatments” in which special dispersions provide the paint surface with dirt-repellent properties. Further examples for use in the automotive industry are:

- Petrol additives to improve combustion
- Adhesives that replace welding joints
- High-strength materials as a substitute for traditional body parts
- Sensor systems in plants and also in the vehicle
- Coatings against corrosion
- Light-emitting diodes/LED for vehicle lighting

- Photochromic glass or mirrors
- Paints with a dirt-repellent surface or special colour properties.

The examples show the wide-ranging possibilities of nanotechnology. In terms of digitisation, future developments in the field of devices are of particular interest. In research projects, nano-devices are equipped with microelectronics, sensors and actuators. This creates quasi microscopically small “nano robots”, called Foglets [Stor01]. Each of these foglets has its own computer power and can communicate with its neighbour or even with control devices.

For the foglets, many possible applications are conceivable. For example, in medicine, foglets could be injected into the bloodstream. They could remain there, monitor the state of health in situ and take preventive measures to maintain health, for instance by removing calcifications or even diseased cells. Similarly, “service foglets” could be used in cars while driving and, for example, stop wear problems in the oil circuit at an early stage.

Another example of use, which may be of interest also to the automotive industry, is that the foglets keep each other with their actuators, so that masses of foglets connect to solid material. This could lead to the development of programmable bodies or components, which is an application certainly still far ahead in the future. Nevertheless, in case of further progress in the relevant technologies, it can be assumed that this vision will also become a reality within the next 50 years.

4.11 Gamification

Since this chapter so far has described mainly engineering-oriented areas of innovation, the next section is devoted to new methods which increase the efficiency of processes and also the usability of new procedures and applications. One way of achieving this, is through so-called gamification. This means the approach to use gaming principles outside games, to transfer them to entrepreneurial interests and thereby to engage and motivate employees. The basis is an appealing game idea with the interests of the employees involved in mind. The game takes place in competing teams, whereby progress reports with ranking lists, special tasks in the game process with game-related bonuses, as well as transparency of the game advances and task fulfilment, are motivating elements.

Numerous project references for the use of gamification in companies namely are in human resources, in qualification, but also in change management. PwC Hungary, for example, uses the “Multiploy” game, which, with the help of Monopoly approaches and structures, helps new employees to get to know the company in a playful way, thus reducing their familiarisation phase. Walmart uses Gamification in security training of its employees, while company Qualcomm uses the method to improve its technical support [Mei16]. Gamification will also play a growing role in the automotive industry. Digital Natives in particular welcome the use of modern methods in companies. In addition to the direct benefits, the attractiveness of the work environment also increases.

The examples mentioned above show possible fields of application. A large number of other fields are foreseeable. Why not do the budget planning according to the principle of the show "Lion's Cave", or the qualification for a new application program as "Memory" in combination with "Activity" elements? Gamification certainly offers the potential to support the transformation of the corporate culture towards digitisation. Chapter 7 elaborates on the necessary cultural change.

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