Chapter 8
Information Technology as an Enabler of Digitisation

Information technology as a company function plays a key role in digital transformation. It is not only required as an advisor and supporter of all specialist departments in the implementation, but also has to operate the existing technical IT environment in a cost-effective and secure manner and to develop itself comprehensively at the same time. The established architectures and technologies have constantly to be modernised or replaced by new solutions in order to meet the requirements of the specialist departments flexibly and efficiently. But not only new architectures and infrastructures have to be implemented, yet also the organisation and the internal processes of IT must change, along with the development of the knowledge and the behaviour of the IT staff.

This situation is covered in the following with a focus on the business IT, while the IT installed in the car with control devices for various functions, such as air conditioning or distance control as well as the factory IT with its field bus systems, plant and robot controls, are left out at this point. Firstly, the challenges of IT as a supporter and enabler of digital transformation are explained, followed by the approach to the development of a holistic IT strategy based on the digitisation roadmap and, finally and briefly, a method for assessing the usefulness of IT for the business processes. The detailed elaboration of an IT strategy is not the subject of this book. Extensive approaches to this can be found in the respective specialist literature and standards such as COBIT, ITIL and ISO, e.g. [Joh14], [Cox16], [ITG08]. Instead, the focus is on typical initiatives and thematic areas, which based on the author's experience, are upcoming in the IT organisation of the manufacturers and must be implemented urgently. Two examples finally support the discussion.

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8.1 IT Transformation Strategy

The IT organisation is in a balancing act between the traditional application landscapes and computing centres on the one hand, and the new world of digital natives, characterised by Apps and smartphones on the other. For decades, computers in the automotive industry have been used for a wide range of tasks, and specific solutions have been implemented for the specialist departments. For example, the vehicle developers use systems for drafting and parts list management, the commercial sector uses so-called ERP systems, and the production works with control stations for monitoring the production lines. The systems are either functionally specific in-house programming solutions, so-called legacy systems, or standard packages such as CATIA from Dassault Systemes or SAP. They are partly more than 30 years old and continue to support a large part of the business processes with high reliability.

The usually highly customised and sophisticated applications are widely regarded as business-critical and require high quality of service. Due to the programme scope and the complex, often poorly documented process/technology integration, an adaptation of the processes and the IT systems is very complex. Also the complete replacement of these solutions by Apps is not foreseeable. At the same time however, the specialist departments demand modern Apps which run on mobile devices. As used to in the private life, these applications should be available quickly and flexibly. Thus, there will be a long-term coexistence of both approaches.

The current situation in the companies and the required orientation of IT is summarised in Fig. 8.1. The business processes are to be reviewed and made lean, and the IT systems and the IT infrastructure have to be transformed and consolidated hand-in-hand. The established systems are often referred to as monolithic, because the applications are created as a closed block in a technology, aligned to an application area and adapted to new business processes only with great effort. The solutions run on dedicated infrastructures, whereby the technology is defined by the applications.

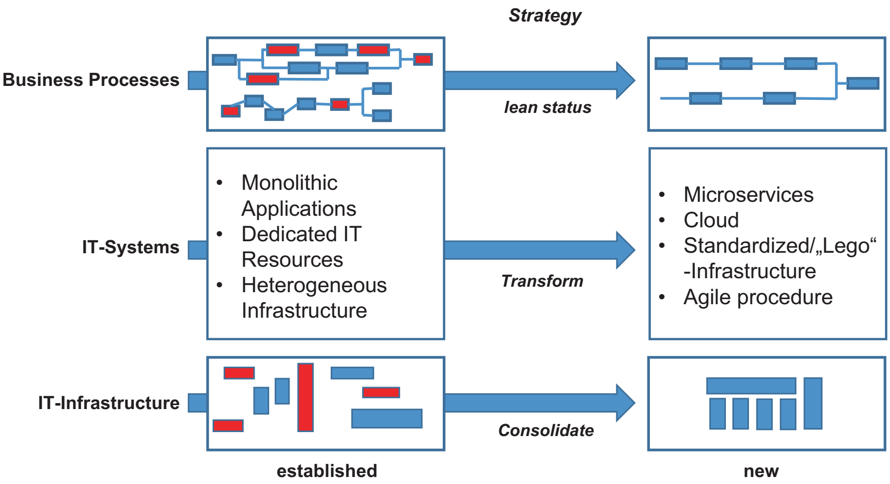


Fig. 8.1 Integrated IT strategy (Source: author)

As a result, a tremendous infrastructure diversity, a “technology circus”, has emerged in the computing centres, which can only be operated safely with great effort. According to new studies, the operation and the application support of these areas often require more than 70% of the available IT budget, while for innovations only 14% are available [Kur16]. Standardisations and consolidations help to improve this cost situation, but there is still a significant budget ratio of the legacy systems.

The development of the “new IT world” is characterised by Microservices as solution elements for applications as well as by standardised hardware components whose capacity is easily expandable by connecting “Lego blocks” which are connected in Cloud architectures. Projects are characterised by agile procedures. The necessary investments must at least be partially financed through savings in the established sphere in order to be able to provide the required modern applications in support of the transformed business processes.

8.2 Building Blocks of an IT Strategy

In order to tackle the new challenges in a purposeful way, an IT strategy is needed that combines old and new technology areas and is sustainably geared towards achieving the business objectives. Transformation initiatives and optimisation projects build on this, which lead to programme planning. It shows the individual projects on a time axis with implementation priorities. The strategy describes, for example, the sourcing strategy, the target architectures, the technological IT standards and the programme to implement the required transformation.

The classic approach to strategy development is based on corporate objectives and the derived business processes, and subsequently defines the goals and basic architectures of the IT. This approach is proven in relatively stable processes and established IT environments with an existing process and application landscape. At the same time it is important though to take up the selected initiatives of the digitisation roadmap in close consultation with the specialist departements and to include them in the IT strategy. The particular challenge is that disruptive new business models and structures may become necessary in the short term. IT needs to be prepared for that with flexible structures that can quickly meet the new requirements. For example, the platform concepts proposed in Chaps. 5 and 6 for mobility services, administrative functions and sales management as well as for new digital products should be covered by the IT strategy in order to provide the necessary services quickly and efficiently.

When formulating the strategy, it must also be taken into account that the role of IT as a powerful enabler of digital transformation must change dramatically in the future. In the past, primarily technical expertise was required in order to develop applications, build the necessary infrastructure and operate it securely. The IT experts often were like within “a world of their own”, partially isolated also by the use of technical terms, which created reserve in the users. Business processes were described in the definition phase of implementation projects according to the technological requirements. A continuous exchange with the specialist departements rarely took place.

However, this situation is changing fundamentally now. Through the use of modern IT technologies also in the private sector and the rejuvenation of the work force through the entry of the digital natives, the knowledge about the fields of application and use of IT is growing in the specialist department. There are hardly any more fears of contact, and the expectation towards the internal IT services is increasing to provide modern solutions quickly and flexibly. In return, IT is called upon to build more process knowledge and business orientation in order to expedite the ideas and projects of digital transformation in future together with the specialist departments, for example, in design thinking workshops. IT must also build this knowledge in order to be an accepted advisor and driver in the digitisation. Should this fail, there is a risk that the specialist departments will decouple and independently create own Cloud solutions and App developments. This "shadow IT" is to be avoided in any case since such isolated solutions certainly generate additional costs and often also constitute a security risk.

An IT strategy must therefore illustrate how the jointly developed objectives are to be achieved, taking into account the initial situation. The path should be clearly described, responsibilities should be assigned, and clear measurement points and key figures must be defined for progress monitoring in the work packages. The following topics are to be dealt with in an IT strategy:

- Architectures/standards
  - Architectures derived from corporate architecture
  - Standard applications/development planning
  - Concepts for handling of data and acquisition of information
  - Technology standards
- Applications/Microservices
  - Strategic services: Big Data, Analytics, Cognitive Computing
  - Application strategy
  - Software development … Tools … Methods … Open Source Software
  - Concept: Microservices/PaaS … API management
  - DevOps
- Infrastructure
  - Platform strategy, operating systems, integration technology
  - Cloud strategy
  - Communication technology, network concepts
  - Operating strategy … SLAs
- Sourcing
  - Core business vs. Commodity
  - In-house vs. Outtasking/Outsourcing

  - Nearshore/offshore
  - In-house factory concepts: software development, testing
  - Partner concept
  - Supplier strategy/-consolidation

- Mobile devices … "Bring your own device"-concept
- Security concept
- Innovation management
- Computing centre concept … site consolidation
- Training planning
- Organisation, internal processes, governance
- Investment planning, personnel planning, controlling.

For a detailed elaboration of an IT strategy, as already mentioned, please refer to the relevant specialist literature. It is important that the strategy integrates both IT worlds holistically. It should be noted that the development of an IT strategy is a dynamic process, especially with regard to rapidly evolving technologies and the changes in the requirements which accompany the transformation. The strategy and the implementation programme derived from it should therefore, together with the specialist departements, be validated and revised about biannually in parallel with the review of the digitisation strategy. A regular external benchmark is also useful to identify where new measures may be needed.

8.3 Cost and Benefit Transparency

An IT strategy will also have to be measured against the envisaged and achieved efficiency by clearly defined goals. In the past, the automotive industry evaluated its IT organisation at quasi natural service quality almost exclusively based on costs, while the benefit of IT support was not an issue in the execution of business processes. The goal was usually to achieve the lowest possible value in pure cost benchmarks. For this purpose, the ratio of the summarized IT costs to the company turnover as a percentage value has established itself as a standard parameter. As a general rule in the industry, volume manufacturers in Europe should achieve values below 2%, and in higher-quality vehicle segments, up to 4% are considered acceptable due to the smaller vehicle volumes. To be able to use this characteristic value for meaningful comparisons, it is necessary to define exactly which cost types of IT are involved. For example, there is a need to define the extent to which the IT costs are included in the production lines, the extent to which the costs of the in-car IT are taken into account, and which communication costs to include.

The main disadvantage of the exclusive cost focus is that the benefits generated by the IT are not assessed, and also the development of the digital maturity of the companies and thus the development of the competitiveness is not measured. It is therefore recommended to define together with the specialist departements parameters which, in addition to the costs, also describe the intended business benefit and

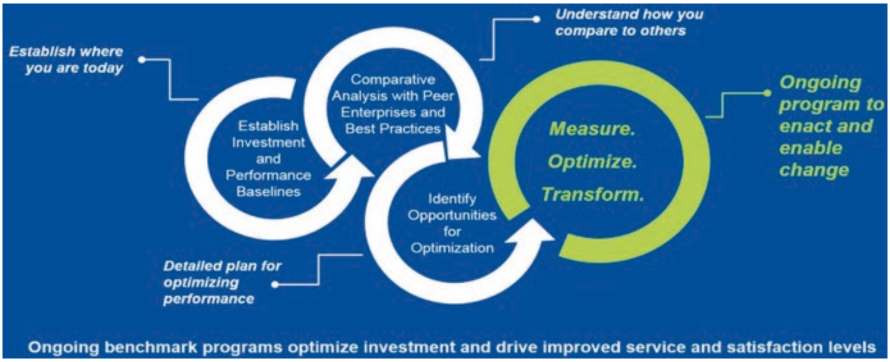


Fig. 8.2 Initial situation and direction of an IT strategy [Gue16]

the support of digital transformation, without neglecting measures to increase efficiency. A procedure for setting such characteristic values is shown in Fig. 8.2.

Firstly, the current IT costs must be recorded with an adequate level of detail. This includes the costs for personnel, hardware, software, delivered services, communication and also buildings. This rough view is then to be refined functionally, and as a basis for the progress control as well as external benchmarks performance, key figures are to be added, such as the costs per terabyte memory by service class, Linux costs per instance or also MIPS costs (million instructions per second) in the mainframe computer area.

On the basis of this classification, it is possible to identify IT areas in which improvements are possible and optimisation measures are useful in a cost comparison between the brand organisations of the manufacturers or also by comparison with benchmark indices of a comparable industrial sector. This procedure has been established, described many times and is therefore not to be deepened here [Tie11], [GadA16].

Furthermore, it is recommended to allocate IT costs as much as possible according to their causes to the main business processes of the specialist departments. A suitable basis for this is, for example, the segmentation described in Sect. 6.2.3 as per the SAP Value Map or the Component Business Model. Together, process areas with potential for improvement can be identified, also considering IT costs, and transformation initiatives be established.

The allocation of costs in line with their origin is relatively simple for specific application solutions, such as CAD program licences, whereas distribution keys are to be specified for cross-company IT services such as firewall solutions or server operation. This should be done in coordination with the specialist departements in order to create a common basis also for future cost tracking. The specialist functions should then asign benefits to these IT costs, for example the IT costs for the execution of a sales transaction, or the share of the IT costs in the construction of a vehicle component. Although the method proposed here is initially rather effortful, it is recommended in order to bridge the gap between IT and special departments, since this approach is particularly useful in digital transformation [Fre16].

8.4 Transformation Projects

On the basis of the corporate objectives, the corporate organisation is defined with the necessary business processes, and the objectives and the strategic requirements for IT are derived from it, which in turn becomes the basis for the IT overall architecture to be defined as the framework for action. It encompasses the thematic areas listed in Sect. 8.2, such as applications, data, security and technology. In addition to the requirements and needs, namely technological trends and innovations as well as resulting utilisation potentials must be included in order to ensure the sustainability of the IT solutions. In the following, essential aspects of the IT transformation are deepened.

8.4.1 Development in the Status Quo

Modern IT applications should be cost-effective, secure, and scalable, even with strong demand fluctuations, yet also easily adaptable, expandable when business needs change, and also function with adjacent applications. Furthermore, they should provide App-oriented appealing user interfaces that allow intuitive operation, and control should be via smartphones, voice, or gestures.

When migrating the existing applications to the target scenario, three options are available, summarised in Fig. 8.3.

The upper part of the picture shows the requirements for modern IT applications which have already been covered in the introductory explanations. In the implemen-

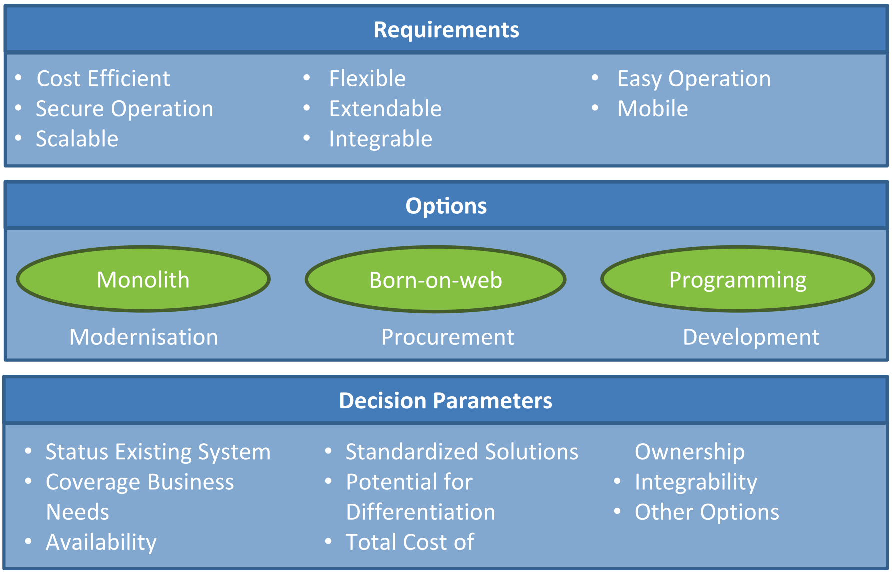


Fig. 8.3 Migration options for IT applications (Source: author)

tation of the development planning, the options listed in the centre of the figure range from the modernisation of existing applications, and the procurement of software solutions based on the latest technologies, effectively “born on the web”, through to new development using innovative technologies and methods. In the lower part of the image, the key decision parameters are listed to choose between the options. The most important influencing factors are the status of the legacy system with regard to security and operability, the coverage of the business needs by the chosen solution and the total cost of ownership.

With stable business needs and safe and economically viable applications, modernisation is a good option. If an old system is to be replaced for lack of functionality or permanent instability, it is recommended to get a system according to modern standards. If this is not available in the required functionality on the basis of new technologies and also operable in Cloud environments, a new development is the remaining option, using innovative development tools and implementation methods.

The existing and traditionally developed applications include all the necessary programme modules, libraries and interfaces required for smooth operation. Because of this architecture, even small adjustments are already very complex, since comprehensive tests, compilations and deployment of the overall application are necessary. This explains why modernisation, in order to reconfigure these applications for example for operation in Cloud environments or to create new user interfaces, is very complex. The extension of functions and the transition to access via mobile devices require extensive works.

In order to improve this situation and, in particular, the agility of the application in the long term, a replacement of the application or a fundamental renovation is recommended with the modularisation and conversion to a modern, open architecture [Old15]. In order to support this work, methods and tools are available and make the process economical if migration factories in offshore centres are used. With this option, further to the pure project costs, the implementation risks and the costs for testing and rollout of productive operation need to be assessed. The transformation risk is manageable if the legacy system is encapsulated by a software layer, for example, for the handling of accesses and the control of the sequence integration, an architecture based on the concept of so-called strangler patterns. These allow a mixed use and the stepwise transition to the new system [New15]. A further option is to connect the legacy system to be preserved to the integration layer of a business platform in order to enable through this an App-based, up-to-date operation, the integration of new functions in form of mobile function modules, or the use of innovative solutions for data analysis (cf. Fig. 6.27 in Sect. 6.2.3.1).

In addition to the individually programmed legacy systems, many manufacturers are using standard applications. SAP solutions have been very common for years. A major advantage of this off-the-shelf software is that the provider ensures the continuous further development and modernisation of the application. For example, in-memory technologies (programmes and data are in the main memory during execution) provide high-performance data analysis, the operability in Cloud, and latest SAP releases offer high modularisation, a new user interface and mobile access options. In this regard, a challenge for automotive manufacturers is that the

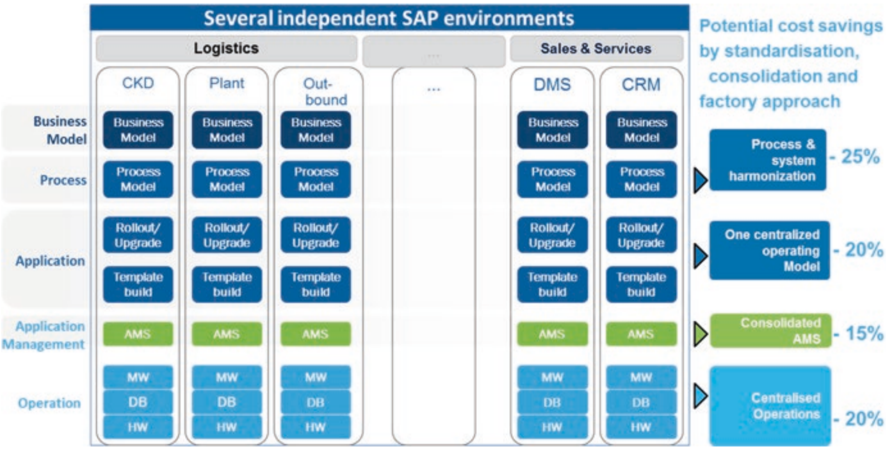


Fig. 8.4 Example of a developed SAP environment (Image IBM, author's experience)

standard software in many cases has been changed by parametrisation, customising or complex additional programming. Thus being far away from the standard, the release updates often cause considerable efforts and expenses.

Furthermore, many manufacturers are using not only one single SAP system, but rather special systems in different organisational units, which have grown as isolated solutions. These changes are often maintained as sector-specific standards, so-called templates, in order to achieve a reuse during the rollout into comparable organisational units at home and abroad. To do this, the required local adaptations in the templates must however be maintained up-to-date as a standard, also a complex task. In addition, SAP systems consist of three independent individual systems each for development, test and production, and operation respectively. Figure 8.4 illustrates this situation.

The picture shows the established SAP landscape of a manufacturer. The columns each represent an organisational area, for example, in logistics the sections CKD (exports in the Completely Knocked Down concept), the internal plant logistics, and the outbound logistics for the supply of parts. Also, in Sales & Service there are the units DMS (Dealer Management Systems) and CRM (Customer Relationship Management). The areas are shown here in part. There are further fields, for example, in the financial environment or procurement.

The lines are for the different project and operating phases and include the three-level system structure (development, test, production) of an "SAP island", e.g. the plant logistics. To start an implementation project, the business units define the system requirements for IT support in the form of a business and process model. The customising of the system is performed in the development system and then checked in the test system by the specialist departements. In rollouts, local extensions of the template are preferably added as standard to the "template build", often even by special development and test systems.

The systems are further developed and maintained in the application management area where so-called Application Management Services (AMS) are provided. In the IT operation, alongside the SAP applications also the middleware (MW), databases (DB) and the hardware (HW) are running, in addition to other technologies, for network integration and security for instance. The image illustrates the complexity of a developed SAP environment which in large companies may well cover several hundred different SAP systems.

Such IT landscapes offer significant savings potential if the systems are first returned as close as possible to the software standard. This must be done in close cooperation with the specialist departments since an absolute prerequisite is the adaptation and cross-organisational standardisation of business processes, which must be adhered to in a disciplined way on the basis of strict requirements management also in future changes and extensions. In addition, efforts should be made to reduce the number of SAP templates and to consolidate these across all areas. Depending on the company size, an ambitious consolidation goal is to be defined in order to significantly reduce the number of systems without too much restricting the agility of rollouts and extensions due to overly large application monoliths.

As a result of the reduction and standardisation of the applications, the number of hardware systems and through the unification of the application also maintenance and operating costs decrease. The standardisation also reduces the effort required for release changes, so that innovations are made available to the specialist departments substantially faster. Also, development and operational tasks can be carried out with considerable synergy gains by teams across the organisation, set up in several regions in 7 × 24 h modus operandi "follow the sun". These teams should be uniformly organised globally and collaboratively according to "factory concepts", using modern tools for problem analysis, knowledge management and automation in order to further reduce costs while at the same time improving service. Against this backdrop, the savings potentials shown on the right in Fig. 8.4 between 15% and 20% annually are a rather conservative estimate and often much higher, depending on the initial situation.

In many cases, the application inventory of legacy and SAP systems thus has significant potential for improving service, increasing the ability to innovate, and especially achieving savings. The latter should be used to further standardise applications and develop them towards the target architecture in order to finance innovation projects.

8.4.2 Microservice-Based Application Development

With increasing digitisation, the need for software continues to rise. IT becomes the core element of business processes and products. As a result, the importance of software development in companies is growing and becoming an integral part of the core business. The expectations of the specialist departments towards the IT to provide fast and flexibly scalable applications which can be further developed in

Monolith Architecture vs. Microservice Architecture

	Monolith Architecture	Microservice Architecture
Architecture	A monolith architecture represents a single logical program unit. All functions, libraries and dependencies are located within one "application block".	A microservice architecture consists of a series of small services that work independently and communicate with each other. Each service can be used in more than one application.
Scalability	The entire application scales horizontal behind a load balancer.	Each service scales independently and on demand.
Agility	Changes to the system lead to the compilation, testing and deployment of the entire application.	Each service can be changed independently.
Development	The development based on a single programming language.	Each service can be developed in a different programming language. The integration happens via a defined API.
Maintenance	Very long and confusing source code.	Many pieces of source code that are easier to administrate.

Source: Crisp Research AG, 2015

Fig. 8.5 Comparison of monolithic and microservice-based application architectures [Büs15]

short cycles, can hardly be fulfilled with traditional software development methods, technologies and the architectures for monolithic applications.

As an alternative, so-called Microservices are becoming increasingly important [Ste15]. As an evolutionary development of object-oriented programming or SOA (service-oriented architectures), microservices are small, standalone functional modules that can be created in different technologies. More extensive application programmes are created by coupling many microservices. The individual objects are executable independent of each other, tested as individual module and scalable, so they can easily be adapted to changing requirements. This concept is called a Microservice Architecture and offers many advantages over monolithic applications [Fow15], Fig. 8.5.

The first line of the listing compares the architectural approaches. Closed programmes stand as monoliths in contrast to a connection of independent individual modules which are also usable in other applications. The scalability of the microservice-based applications is very high, since heavily loaded modules can be given additional computer, memory or data transfer capacities. The availability of the entire system is also high as the failure of a single microservice does not necessarily cause the failure of the entire application. Agility and maintainability of the microservices are very high as well since only the modules concerned are to be tested for the deployment of adaptations and extensions, rather than the entire programme.

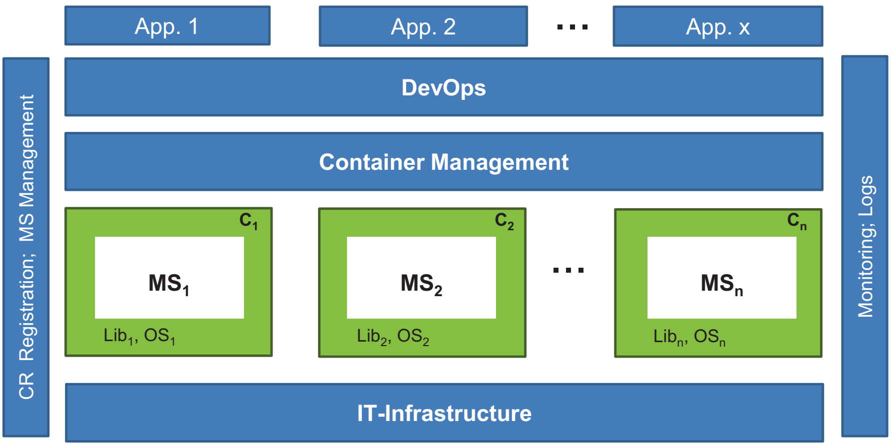
The development of the modules can be carried out by different developer teams, and interconnection of the modules is via predefined APIs (Application Programme Interfaces). Due to the parallelisation, the concept is well suited to work in Scrum teams. The low test effort and the flexible possibilities for the implementation facilitate rapid response to the demands of the specialist departements. These advantages of the microservice architectures can be enhanced by the use of further technologies and concepts such as Container and DevOps.

In logistics today, standardised containers are a common means of transport for all kinds of goods. The standardisation of the containers gives considerable advantages in the transport process since cranes and vehicles worldwide are adapted to the handling in ports, railway stations or transfer points. In line with this concept, the IT container technology encapsulates Microservices together with the required operating system services and runtime services by a surrounding software, thus quasi packing them into a container that can be run on any kind of infrastructure and operating system environment [Pre15]. The implementation of this idea takes place for instance via the Open Source project Docker and has enjoyed increasing popularity since then [Kri16]. The “packaged microservices” which can run on any server enable a very convenient infrastructure utilisation, and the transfer of the application, for example between development teams and computing centres, becomes very flexible. For traditional applications, extensive effort was needed to ensure that the infrastructure, including the system software, was set up completely identical between the systems.

Multiple Docker containers can run independently on the servers, without the need for further installations or virtualisation measures. The necessary resources are assigned to each container individually. The growing complexity from increasing container numbers can be mastered in this way even in running IT operation. Figure 8.6 shows an overview on the use of microservices with additional services.

In the centre of the figure are, placed on the IT infrastructure, containers C_1 to C_n, each of which encloses Microservices (MS_1 to MS_n) with the individually required libraries (Lib) and operating system components (OS). The orchestration of the microservices to applications is done via a separate MS management system [MSV16]. Resource allocation is done through container registration, and this level also manages releases and areas of use of the microservices. Monitoring and logging functions which log internal processes for example, support the operating teams. This means that comprehensive tools are available throughout the entire lifecycle of microservices-based applications. These are offered by different firms, so that the use of the architecture across the corporate is secured.

Apart from the considerable benefits, a number of challenges must be considered when deciding on this architecture. In addition to technology knowledge, develop-



App. Application, C Container, CT Container-Registration, Lib Library, Logs Log-Functions
MS Micro-service, OS operating system component

Fig. 8.6 Orchestration and operation of microservices in containers (Source: Author) ers also need Cloud know-how in order to avail of the advantages of hybrid hardware architectures, which are discussed in Sect. 8.4.4. It is in this context that latencies, i.e. delays in data communication, have to be taken into account in the operation of the distributed services, which must be absorbed by powerful communication concepts. Furthermore the developers should have knowledge in the topic fields of DevOps and APIs since both are vital for the full use of microservice-based architectures.

DevOps models are methods and tools which bring the areas of development (Dev_elopment) and operation (Op_eration) closer together in order to enable fast release cycles and short implementation times [Bos15].

What is important here is that a culture of close, open cooperation also establishes itself through the sharing across locations and organisations. It is important to create in an agile project approach as efficient processes as possible together, which are also increasingly automated in certain phases, such as testing and production roll-out. The use of containers, in particular, reduces the effort required since no application-specific infrastructure environment is needed any longer.

Another advantage of microservice-based architectures is the ability to easily also integrate external microservices. Especially in the Open Source environment, there are a variety of offerings, in many cases free of charge on sharing platforms provided by developer communities. Services from other companies or external suppliers can also be used. It is also possible of course to provide one's own microservices, programmes or even data via APIs for use by interested parties outside the company. For example, vehicle-related data could be sold to insurance companies or marketing organisations, or providers of services can be given access to the vehicle for displaying offers on the infotainment unit (cf. Sects. 5.3.2 and 6.2.1). To pursue this business strategy, an API management system is to be established not only in the microservices environment yet also for interaction with other application technologies.

8.4.3 Data Lakes

"Explosions" of data volumes in the enterprises, social networks and the Internet of Things open up opportunities for greater transparency, new insights and additional business. For this purpose, future-oriented data architectures and the targeted utilisation of the information from these data through the use of high-performance technologies are essential. Previous evaluation and reporting applications worked with a defined temporal grid via hard-coded interfaces with access to data in also defined structures. Reading the data from different applications and preparing the reports takes a lot of time. Ad hoc queries were not possible, and deviations from the report structure or the integration of further data sources were complex.

To avoid these disadvantages, so-called Data Warehouses (DWH) have been developed. A DWH imports data from different source systems, transfers them into a target data structure and stores them in the DWH. Reports and evaluations are fed from the target data of the DWH, while the output data in the source systems are overwritten [Dit16]. In situations with precisely defined analyses and stability of the data sources to be integrated, this concept is still reliable and widely used.

Aside from the effort for processing and storage, the main drawbacks of data warehouse architectures are the limited flexibility in reacting to spontaneous queries, the fixed data structure and the loss of the raw data after storage in the target system; also, evaluation directions must be specified in advance. It is not possible to gain new insights through modified queries or a new combination of raw data. However, modern solutions for the processing of information must offer flexible evaluation possibilities of most diverse data formats and efficiently work “near real time”.

In response to these demands, the concept of the so-called Data Lakes has proven itself [San15]. The approach is to store all types of raw data without further processing in a flexible system at low cost. This may be, for example, structured data from established application systems, data from vehicles, machine-generated information, social media data or also audio and video files. The summary in Fig. 8.7 contrasts DWH and Data Lake solutions according to various criteria.

First, data storage is compared in both concepts. While in Data Lake the raw data remain unchanged, including the link to the source data, and are acquired in almost “near time”, various technologies are available for data storage, whereas in DWH the data are stored in a target structure without the raw data being kept. Relational databases are used, and the data is transferred in a fixed rhythm, often at the end of a working day (EOD, end of day).

	Data lake	“traditional” DWH
Data storage	• Technical 1:1 data storage to original system • Technical mapping can be reconstructed in original system	• Technically harmonized and technically standardized data storage • No availability of original data in persisted target data model
	• Long-term persisted source data • Logical integration of source data possible	• Temporarily persisted input data (“staging area”)
	• diverse technologies for user-oriented provision (e.g. Hadoop, NoSQL-DB)	• usually relational mapping
	• Near-time data transfer possible	• Data transfer usually EOD
Query	• Individual access rights (e.g. HiveQL, JAVA, PHP, SQL); partly complex	• Simply structured query option via SQL
	• Preparation of data (e.g. harmonization of field versions) “on the fly”	• Preparation / standardization / harmonization already completed in target data model
Performance / scaling	• Available technologies developed for very large data amounts (“big data”) • Linear scaling based on “standard” hardware	• Relational DBMS usually designed for large data volumes • Scaling partly only possible based on special hardware
Development	• agile / iterative procedure • Environment under development (div. technologies, models under setup)	• target image-oriented procedure • established environment (tools, models, etc.)

Fig. 8.7 Comparison of data warehouse and data lake [San15]

Retrievals in Data Lake are more complex, since the data processing only takes place in the course of the query. Date Lake solutions scale their need for large amounts of data by using flexible technologies and based on standard hardware better than DWH solutions, which often require special hardware. For standardised queries with predefined evaluation direction and regular consistent reports, DWH's continue to have their strengths. Data Lake concepts, on the other hand, offer flexible analysis options and fit well into the agile, digital world because of the possible gain of new knowledge. Big Data technologies from different providers are available for the technological implementation of the Data Lakes as well as for the definition and processing of the queries [Gad16]. Through the use of flexible tools, specialist departements can independently carry out all kinds of evaluations without the involvement of IT and therefore welcome the new flexibility and independence.

Both concepts can also be combined, for example, if a Data Lake is connected to a DWH as a front-end system [Mar15]. Therefore, both DWH and Data Lake should be integrated as a core component in data architectures.

The following trends and technologies in the field of Big Data are to be considered in the architecture definition:

- Data Stream Management Systems (DSMS)
- DSMS systems process data streams that occur continuously and at short intervals [Ara04]. Search algorithms are permanently extracting desired results from the data stream and make them available for processing. Examples are vehicle motion data or data from camera systems during autonomous driving.
- In-Memory Data Management
- With in-memory data management, data is stored in the main memory of servers rather than on separate storage media and thus is available to processing in a high-performance manner. To efficiently use the available memory bandwidth, the data are read sequentially in the flow. This technology is often used when analyses of current data are required. Examples of use are complex reports, evaluation of sensor data and also real-time evaluation of social media data [Pla16].
- Appliances
- Appliances are integrated turn-key systems, optimised for a specific application. In a casing there are servers, memory, system software including visualisation, and partially software for data management as well. Examples of use are high-performance Big Data analyses via a distributed infrastructure and applications.

In order to deepen the technologies, which are only briefly mentioned here, and which are gaining in importance in the automotive industry in times of growing data volumes, for example from vehicle motion sensors and the Internet of Things of Industry 4.0, reference is made to further literature [GSM16], [Mar15]. Overall, a growing number of products are available for information processing.

8.4.4 Mobile Strategy

As was explained in detail, mobile devices and Apps are gaining ever more importance. In continuance of the private habits, employees, business partners and also customers expect new applications such as from the area of Big Data and Analytics to be available as Apps on mobile devices such as smartphones and tablets. This modern operation should also be available for established in-house applications. It places the use of workstation PCs in the background and will namely be for “power users” or programmers and testers. The use of mobile applications should be done through appealing graphical surfaces that are intuitive and easy to use without training.

Furthermore, users expect at any time and from anywhere access to the company applications used by them and the relevant data. In order to be able to address the rapidly growing needs in a structured manner, clear specifications for mobile terminals and mobile applications must be defined. This mobile strategy is particularly important because it defines the interface to digitisation and the move towards innovative usage models for all employees and customers. Also the agile handling of requirements from the field and the fast provision of solutions must be possible by powerful technologies, defined in the strategy.

Firstly, the device standard for company-internal equipment must be defined and also decided whether to offer the employees a BYOD option (bring your own device) to allow them the use of their private devices in the company as well. Next to commercial considerations on the basis of a comprehensive TCO (total cost of ownership), the safety aspects play an important role in this (see Sect. 8.4.7). Due to the worldwide customer acceptance and the resulting market shares, with Apple and Android devices two essential technology directions are dominant. For both platforms, architectures and solutions for secure integration into the enterprise IT are available so that many companies support both platforms.

Based on the device standards and the safety architecture, the application strategy has to be defined. Particular challenges arise from the fact that mobile devices are subject to very short innovation cycles, and the applications must therefore be able to run on several device and system software generations. The integration of mobile applications into the existing enterprise applications, the so-called back-end integration, also requires a viable architecture and specifications in order to generate synergies in the development and to facilitate operation and backup.

Also, criteria are to be defined in order to decide in a comprehensible manner on the type of implementation of the applications. There are three options. Native Apps work directly on the device operating system and use device functions such as camera, sensors and communication interfaces with high efficiency and safety. Programming, maintenance and operation in this case are more complex compared to the second option, the web applications. At this, the application development is independent of the device, and their use is done via a web browser. This means that special device options are not used, so that the user-friendliness often is diminished. The development and operating costs are lower though. A further option are so-called hybrid applications, which are a mixed form. All three routes are proven and have their benefits of use.

Namely the field of App development is particularly well suited to bring together specialist departments and IT in digitisation initiatives as a team and to make joint decisions on design and implementation. The App is wrongly much-underestimated and partly dismissed as just "a few colourful pages for mobile phones". These applications are however just the right tool to drive the transformation of business processes and to make them easily accessible and tangible to the users. They are, in a sense, the user interface of the digitisation. In this way, IT can position itself as an innovative, agile organisation, which also understands the business processes and realises fast implementations and adaptations. IT should avail of this opportunity and not only handle the technology and security aspects of Apps. A potential sequence of this cooperation is shown in Fig. 8.8.

In Design Thinking workshops, the team develops initial ideas by clarifying the business situation of the area, analysing disruptive trends and elaborating potentials for process improvements through Apps. The prioritised ideas are collected and, in the following concept phase, the processes (user story) have to be mapped and interfaces (user interface) are discussed, in order to then agree upon the scope of a first prototype (MVP, minimum viable product) (see also Sect. 6.2.3 and 7.2.1). This also includes an accompanying requirements management.

Development, testing and deployment should be based on developmental environments, the so-called mobile development platforms MDP. These support different device types and implementation paths also with the integration of microservices. The finished Apps are made available on company-owned App Stores for easy download.

The devices are managed using an MDM (Mobile Device Management) solution, with reliable architectures being available for safe integration regarding connectivity (network capability) and security. These technology kits support agile procedures especially in the test phase, so that feedback can always be given to the

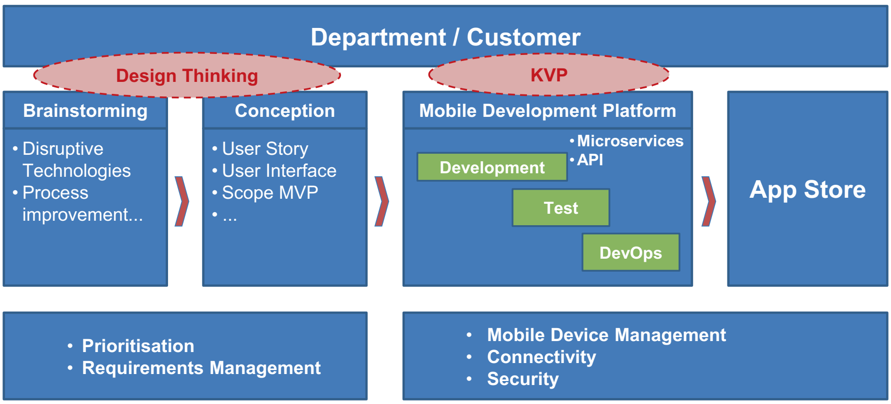


Fig. 8.8 Agile App development (Source: author)

specialist departments in order to continually improve the product and further releases. DevOps methods ensure fast release changes. The procedures and requirements for the user interface design as well as colour concepts to ensure a certain branding or "look and feel" should be described in addition to the mobile strategy in an online manual. Examples can be found in the relevant specialist literature and also on the Internet [DHS16].

A structured description contradicts at first glance the agile approach required in the field of mobile applications. Nevertheless, some rules are needed to avoid a sometimes occurring uncontrolled development in this rapidly growing area of solutions, and in order to achieve high quality and operational efficiency. On the basis of a well thought-out mobile strategy, the IT should therefore create the technical and organisational preconditions to surprise the specialist departments by implementation speed, flexibility and quality and thus be accepted as a partner in the development of mobile solutions. Implementations outside the IT which unfortunately happen frequently in this area, can thus be avoided.

8.4.5 Infrastructure Flexibilisation Through Software Defined Environment

The preconditions for high reactivity and efficiency are created in the computing centres. Challenges such as in the area of applications the integration of legacy standard applications and container-based microservices in a single target architecture, are similar in the IT infrastructure. In this context, infrastructure means a combination of all the technical facilities required to run applications, store data and transfer them for utilisation.

In the past, for each major application special hardware packages were installed, often with specific system software. In this way, complex heterogeneous infrastructure environments have developed over the years. System operation was in technology clusters such as Linux servers, storage systems and networks. These often ran without any reference to the applications, let alone any customer reference. The provision of system environments for new applications or projects lasted months. Deployment of solutions or the provision of minor software updates required long-term planning and special maintenance time windows in the business process.

This structure and serviceability were sufficient in times of stable business processes, stationary workplace systems, without Internet and at "manageable" data volumes. In this day and age, isolated server, storage and network structures have served their time. In times of digitisation with demanding requirements in the areas of mobility services, autonomous driving, Big Data, IoT, blockchain and social media, new solutions are imperative.

As a vision and a sustainable response to the requirements of digital transformation, the concept of the Software Defined Environment (SDE) has established itself with intermediate steps through consolidation, virtualisation and partial automation

[Qui15], [Bec16]. In this approach, the entire technical infrastructure is controlled by a special software without human intervention or changes to the hardware. There is a control layer above the computer nodes (i.e. computer units without further subsystems such as I/O units and power supply) and the storage and network units. Their software recognises the system requirements of the applications and automatically implements them through adaptations in the connected infrastructure, avoiding the previous complex manual work. The hardware technology fades into the background. This concept is further characterised by the following features:

- Automatic real-time adaptation of the technical infrastructure to the needs of the applications
- Automatic deployment initiated by software request
- Continuous dynamic optimisation of the configurations to achieve the definable target service levels and resource utilisation
- Highly scalable and “breathable” at load fluctuations and modification of operating parameters
- Fail-safe and self-healing if needed
- Hardware-independent
- Modular, open concept without “vendor lock-in”.

The challenge on IT is to define a target architecture that ensures full coverage of the business requirements, takes into account the existing infrastructure, and allows a coexistence of the established and new world. For example, the following will have to coexist for several years:

- Monolithic applications/Microservices
- Virtualisation/Container
- Commercial software/Open Source
- Hard drives, tape drives/flash memory
- Mainframe technology/standard server (“lego bricks”)
- Dedicated own hardware/multi-Cloud solutions

For this purpose, a transition road map towards the Software Defined Environment is to be specified and implemented. Figure 8.9 gives an overview on a target scenario with the technological components and their coupling to the applications.

A precondition for implementing the SDE concept is a complete virtualisation of the technological infrastructure consisting of computers, storage and network [Men16]. This refers to the complete logical representation of the hardware in software-based logical units. Virtual servers, storage systems and network components, so-called images, are managed in a way completely decoupled from the details of the hardware versions. A further element of SDE concepts is the integration of Cloud services in both manufacturer-specific (private) and publicly distributed (public) solutions; (cf. Sect. 4.1.1).

To implement the so-called hybrid Cloud architectures, many companies rely on OpenStack technology. This is a comprehensive software portfolio for building open Cloud solutions, developed by the OpenStack Foundation and made available as an Open Source solution. The open community includes more than 600 compa-

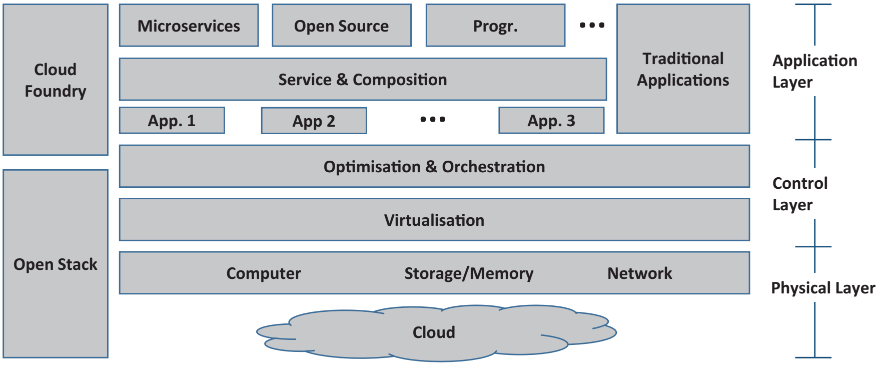


Fig. 8.9 Overview on the software defined environment (Source: author)

nies and its over 50,000 members are from more than 180 countries [Buc16]. A fast-growing number of large companies such as Walmart, Disney, Volkswagen and SAP rely on this technology to build and use Cloud environments. The manufacturer-independence, the openness of the architecture and the rapid further development of the technology with the opportunity to contribute their own input and to influence trends, all are motivators. Due to the active designing in the open environment, it is also possible – by contrast with closed, manufacturer-specific solutions – to ensure the control over own data.

Building on full virtualisation, based on the detected infrastructure requirements of the applications, the control layers automatically adopt the orchestration of the resource allocation and its optimisation. For this purpose, cognitive solutions are integrated. The avoidance of failures is based on preventive maintenance technologies, which in turn require a continuous analysis of the operating parameters and the operating logs (log-on and log-off).

The software layer in the SDE concept also adopts the automatic deployment of both traditional standard packages and new applications which are traditionally programmed, based on Open Source software or configured as microservices. As a development environment in this setting, CloudFoundry has established itself with considerable growth. This is a Cloud-based software environment for developers, a so-called PaaS (Platform as a Service) solution, for example, with services for development, production, and test, provided by the CloudFoundry Foundation as an Open Source. The foundation includes many major industry players, such as SAP, IBM and Cisco, which help to establish the solution as a standard [Sch16]. The full compatibility with Open Stack and thus the possibility to integrate into Software Defined Environments support a decision to also include this technology in a mission.

In SDE concepts, IT technology loses much of its importance. While previously specific performance and configuration parameters of servers or storage systems were important in order to run certain applications as efficiently and securely as possible, the SDE software now recognises the requirements and assigns the required number of virtual resources. The applications then run distributed on any server and are optionally saved on storage systems to enable the desired service level. The physical IT layer consists of standardised units, which are sufficiently available in a manner comparable to a Lego concept. In the event of a failure, the respective units are automatically discarded. In order to replace or extend the capacity, the installation of such "Lego bricks" is implemented, which are adapted by the virtualisation layer.

Apart from these hardware-independent applications in Software Defined Environments, there still remain a few islands that require special technology.

These include, as briefly described in Sect. 8.4.3, so-called appliances, which efficiently process very large amounts of data through high parallelisation of computer units. Furthermore, neuromorphic chips can be foreseen, which map neuronal structures directly in silicon circuits (cf. Sect. 2.6.4). This technology is particularly strong in the recognition of patterns and images. Another emerging trend is quantum computers. After stabilising the above-mentioned technologies and increase in the business requirements, the control software of the SDE architecture is expanded so that these systems can also be integrated in the future.

8.4.6 Computing Centre Consolidation

With transformation projects in the area of application and infrastructure, it is in both cases necessary to establish a target scenario as part of the IT strategy and to transfer the current inventory step by step. By consolidating and optimising the growing heterogeneous environments, costs are saved which are available for innovations. Similarly, the consolidation of the existing computing centre structure provides significant savings potentials. Large manufacturers often have well over a hundred computing centres, ranging from smaller computer rooms at importers and dealers, special IT rooms in the plants, to computing centres in the brand organisations. As recently as in the 1970s, local requirements necessitated special server and operating software installed there because the networks at that time did not have the bandwidth and security to hold the required infrastructure in a central computing centre. Also, hosting and Cloud solutions were not available. As a consequence, at many manufacturers a heterogeneous computing centre structure has developed over many years, Fig. 8.10.

The left side of the figure shows the typical computing centre structure of a manufacturer, as was already described briefly. In addition to the large separate computing centres each per brand or financial sector, there are often smaller computing centres (CC) in the plants and also at the importers, at least shielded server rooms, and even the dealers have their own IT areas. In many cases, local operations teams run the respective infrastructure with local applications. The utilisation factor of the infrastructure was estimated by the author to be less than 50%. The high energy consumption due to this low utilisation, but also due to the partially aged computing centres, certainly holds improvement potential.

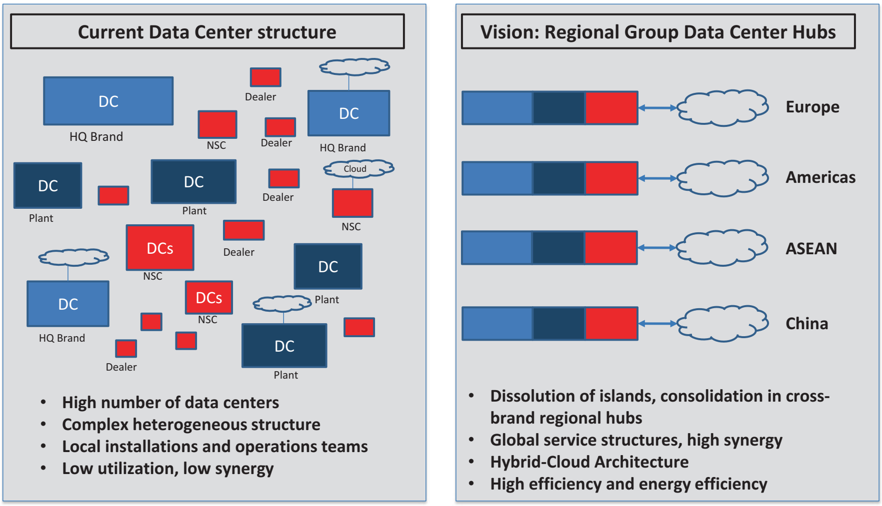


Fig. 8.10 Consolidation of a computing centre structure (Source: author)

In addition to this current situation, a possible target scenario is shown in the image on the right. In order to achieve significant savings and reduce the complexity of the structure, the primary goal should be to minimise the number of computing centres and maximise the use of the Cloud instead. Today, the technological developments in the network sector and the infrastructure allow very ambitious consolidation targets [KriS16].

For this reason, the author suggests that manufacturers completely refrain from local computing centres and rather build regional CC hubs, for example in Europe, for the Americas and for Asia. Due to the specific security issues, a separate hub in China makes sense, as well as in Africa if there is a market presence. The hubs then serve brand organisations, plants and also sales organisations of the respective region on the basis of hybrid Cloud architectures. These are implemented in the hubs as private Cloud environments, which in turn are linked to public Clouds in compliance with security concepts. Clear goals should be implemented to massively expand Cloud components outside the manufacturer environment in order to keep the previously used productive CC area as constant as possible despite the significant increases in demand due to the foreseeable digitisation and the growing data and storage requirements. The operation of the infrastructure is organised globally and is based on standardised processes. The hubs are interlinked and safeguarded by backup and emergency solutions so that in the event of a disaster situation, a region can jump in for another region and continue the operation of this failed region.

The implementation of such scenarios is technologically manageable, and the advantages in terms of costs, complexity reduction, securing options and flexibilisation are considerable. The road to implementation is quite demanding, and many manufacturers are moving in significantly smaller steps, with no overriding big goal in mind. However, this should be defined as part of the IT strategy and approached according to the concept “think big, start small, move fast” [Low16]. Prerequisites for implementation are, for instance:

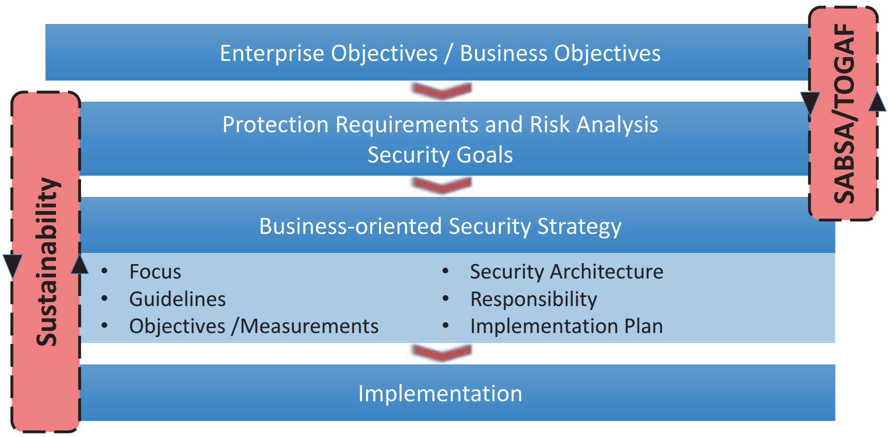
- Powerful networks with high service levels
- Regional computing centres for the hubs with sufficient space availability and high energy efficiency
- Strong global governance and enforcement opportunities for the dissolution of the local and organisational “kingdoms”
- Global integrated service structures
- Global IT strategy with future-oriented goals and transformation targets for applications (especially: standardisation, “Cloudification”, microservices) and infrastructure (especially: software defined environment, virtualisation, standardisation)
- Partnerships for Cloud services and project implementation
- Leadership and entrepreneurship

The above emphasises that it is not a lack of technological possibilities which bars the way to ambitious consolidation, rather the challenges are in the breakup of customary procedures and the establishment of global, overarching organisational structures.

8.4.7 Business-Oriented Security Strategy

Another very important topic of the holistic IT strategy is security. Almost daily there are reports on hacker attacks, the theft of company data and the intrusion into company software by viruses, partly dormant in Trojans as a latent risk. The integration of nearly all business processes with application solutions which is further increasing in the digitisation, the penetration of the cars with IT, the direct coupling of dealer applications with the manufacturer’s backend, or the implementation of Industry 4.0 initiatives along with the “Internet of Things” at the plants, give more and more opportunities for attacks. Also the open agile project processing methods with temporary integration of experts, partly involving badly secured Internet communication, increase the risks.

This is why many companies have established CISOs (Chief Information Security Officer) who are in charge of security in the company. However, in many cases their area of responsibility does not include the plant and vehicle IT, which is carried out independently by the specialist functions. The security of the dealer and service network remains a topic of minor importance even in companies which belong to the manufacturer, and it is addressed by independent dealers even without manufacturer integration. Security measures are primarily regarded as technology projects there, at best loosely linked to business objectives and specific security requirements, such as protection from intruders or restarting a plant.



SABSA: Sherwood Applied Business Security Architecture
TOGAF: The Open Group Architecture Framework

Fig. 8.11 Development of a business-oriented security strategy (Source: author)

These exemplary problems illustrate that in many cases there is a need for action to approach the issue of security with the appropriate focus, sustainability and business orientation. The recommended major development steps of a business-oriented security strategy for traditional IT are shown in Fig. 8.11.

It is recommended that IT and specialist departements jointly define and implement the security strategy in order to achieve acceptance of this topic, which is often seen as a nuisance. The starting point is the company strategy and the business targets derived from it. On the basis of protection requirements and risk analyses, the team identifies the potential risks and defines the specific security objectives. This should be done in a pragmatic way so that IT security is not perceived as a hindrance to business and the acceptance of the subsequent measures is already developing at this stage.

To ensure the completeness and for the structuring of the cooperation, it is recommended to use the SABSA and TOGAF methods proven in the industry in the areas of security and corporate architecture [Kni14]. SABSA (Sherwood Applied Business Security Architecture) is a framework for the structured recording of security requirements as well as for the development and implementation of security architectures. The focus here is on the security aspect, but there is no link to the business processes. This gap is bridged through the use of TOGAF (The Open Group Architecture Framework). The combination of the two approaches provides a suitable approach to record safety requirements from a risk and business perspective in a structured manner and to transform them into a target frame for a business-related security strategy.

In the security strategy, the essence of security is described for instance, and the general guidelines for achieving security are defined with objectives, standards and

Infrastructure	IT Operation
Vulnerability Management	Information Security Process
Patch Management	Access and Authorization
System Hardening	Asset Management
Remote Access	Employee Security
Software Development	OPS-Demands: Malware Protection, Logs, Back-Up, Network
Cryptographic Solutions	Change Process
Documentation	Security Incident Management
Reporting Security Breaches	Physical Security, Access Control
Non-technical Security	Security Outsourcing Process

Fig. 8.12 Work areas information security (Source: author, following [KRIT16])

responsibilities. Concrete targets and key figures are the basis for the implementation plan. In line with sustainability, security planning should be continuously monitored, and a change in the business objectives be reflected in the adaptation of the protection requirements. Within the scope of the implementation, there are a number of topics. Some typical work areas, derived from "best practices" experience, are shown in Fig. 8.12.

The areas are grouped according to infrastructure and IT operations. Vulnerability management, for example, is the continuous surveying of all components of the infrastructure for vulnerabilities as well as the identification and removal of detected problems. Firewall gaps may occur or a lack of protection at the server BIOS level for instance. These are eliminated within the framework of patch management, which covers all software components of the infrastructure. Further areas of work are the use of encryption techniques and namely also remote access for technicians and service staff from outside the company. In IT operations, many fields concern the secure handling of processes, such as change management and incident management, which includes problem management within the service management, but also the regulation of access rights and personnel security.

A further detailing of the implementation of the strategy for information security of the business IT is left out here, as well as an explanation and deepening of the large number of relevant standards, norms and guidelines of the German Federal Office for Information Security. Rather, reference is made hereby to extensive literature and sources as well as to explanations on new requirements derived from Cloud services and open architectures, e.g. [BSI16], [BSI09], [NIS17].

It is important to understand that the issue of IT security cannot be managed and implemented by a CISO or the security department's staff alone. The topic is rather to treat it top-down by all business areas with appropriate care. In the company's management meetings the subject has to be on the agenda time and again, the more since various laws provide for the personal liability of executives in case of failures or negligence.

8.4.8 Security of the Factory IT and Embedded IT

The procedures and security measures described so far relate to securing of the business IT. In addition though, all manufacturers are required to also secure the IT directly at the production lines in the plants as well as the embedded IT in the vehicles. Both fields require special measures, which are briefly discussed below.

During the implementation of Industry 4.0 projects, a massive penetration of relevant business processes with IT is taking place. The production and assembly lines are equipped with additional sensors and the line sections are linked via IT solutions based on fieldbus systems in order, for example, to assign individual measured values from the work operations to orders during the manufacturing process, or to flexibly control subsequent stations. The production planning system forwards order data to the lines via the Shop Floor system, so that pick-and-place robots automatically change the correct gripping device using their programmable logic controller (PLC). Data from the line monitoring is compared with the information from lines of other plants in order to derive proposals for preventive maintenance measures. The examples illustrate that traditional IT and plant IT are more and more converging and thus the security risk is increasing. This also explains why the plant IT is to be integrated into a holistic security strategy and should therefore be included in the responsibility of the CISO.

The IT security procedures presented above do in many cases however not meet the requirements of the plant IT. For example, the use of anti-virus software in control computers is problematic since the scan process consumes computing power and thus results in performance losses in the near-real-time sequence control. Also, common measures of the anti-virus software when tracing a virus, such as setting up in quarantine and shutting down the computer, are contraproductive to the desired uninterrupted production operation, and so are regular updates of the signature database with corresponding runtime as well. Therefore, if the use of anti-virus software is not possible, other security measures must be taken, such as swapping out the unsecured components into a special network segment protected by an additional firewall. Detailed advice on securing information in the Industry 4.0 environment can be found in the relevant specialist literature [Bac16].

Just as with the plant IT, special procedures are applied to secure information of the embedded vehicle IT, different from the usual measures of information security. Although, the protection of the vehicle IT also has other aspects with respect to the security objectives. At this, the focus is not "only" on corporate objectives, but on the interests of many persons and parties concerned. The security risk of the vehicle IT is increasing with the rapid expansion of the IT in the cars, indicated by the rise of computer units, the so-called embedded control units (ECUs) (cf. Sects. 5.3.3 and 5.3.5). In the premium vehicle segment, more than one hundred ECUs are often used to control procedures and driver assistance systems. Details on this were also given in Sects. 5.4.5 and 6.2.1. To implement these functions and also as part of the future mobility ecosystem, the vehicle has to become part of a comprehensive communication, as shown in Fig. 8.13.

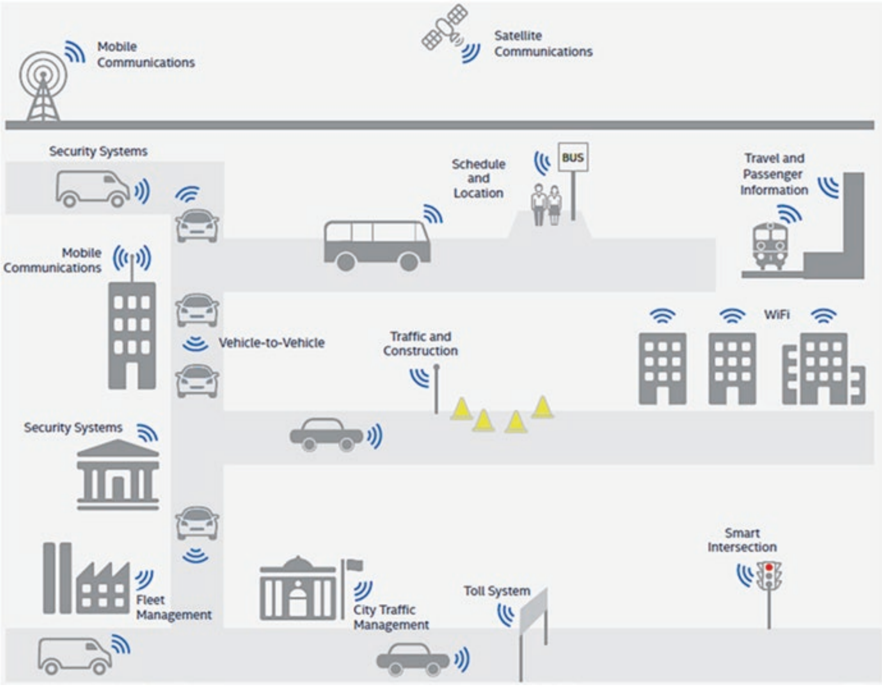


Fig. 8.13 Communication in the ecosystem of mobility [Bro16]

In intermodal transport, cars are used in order to reconcile the passenger changeover points with other mobility services such as regular buses and other means of public transport. "Vehicle-to-Vehicle" communication, also including sensory data from the infrastructure, is used, for example, to warn each other of dangerous situations in the course of the road. Mobility providers record vehicle information to increase the utilisation of their fleets or to dynamically adjust routes as needed. Traffic control in cities and the online handling of toll payments also requires a vehicle connection. Beyond the examples shown, further communication needs will arise in the future with autonomous driving and the growing number of driver assistance systems, as well as for remote maintenance and software updates "over the air".

The numerous communication channels and the high number of ECUs in the vehicles, combined with several fieldbus systems, are widely open to hacker attacks. These follow a recurring pattern [Mil14]. Initially, intruders attempt to enter the vehicle IT via one of the established communication channels and then use malicious software to generate false data in the vehicle network, which are then read by safety-relevant or sensitive ECUs, depending on the objective of the attack. Their interpretation leads to malfunctions, such as the unintentional triggering of braking processes, malfunction of the engine electronics or blocking steering movements. The intrusion can also take place via other weak points such as, for example, remote control of the door lock, sensors for tire pressure control, Bluetooth mobile phone connection or downloaded Apps in the infotainment unit.

These examples of security issues and possible points of attack illustrate the need for special measures by manufacturers and their suppliers to secure the vehicle IT. They start with hardening the IT technology used in the vehicles. In the ECUs, identity management, encryption and active memory protection should be programmed for instance. Furthermore, safeguarding the applications and also the onboard wiring systems is needed, also with identity management, segmentation of the network areas and authentication [Bro16]. The basic principles of identification, authentication and authorisation with secure handling in a protected, tamper-proof environment have a very high protection function – and this holds true in the vehicle IT as well [Bon16]. One way to implement this is to create a security gateway, as shown in the solution overview in Fig. 8.14.

Within the security gateways, the identity management of each IT component is handled, as well as the secure storage namely of personal data and the entire communication with the vehicle. The integration of the back-end and thus the integration with the enterprise IT is encrypted and also done via the gateway. In the backend, identities, access keys, and authorisations are managed. Intelligent safety solutions detect anomalies and trigger preventive measures. These can, for example, be initiated and monitored in a so-called security operation centre, a service organisation at the manufacturer.

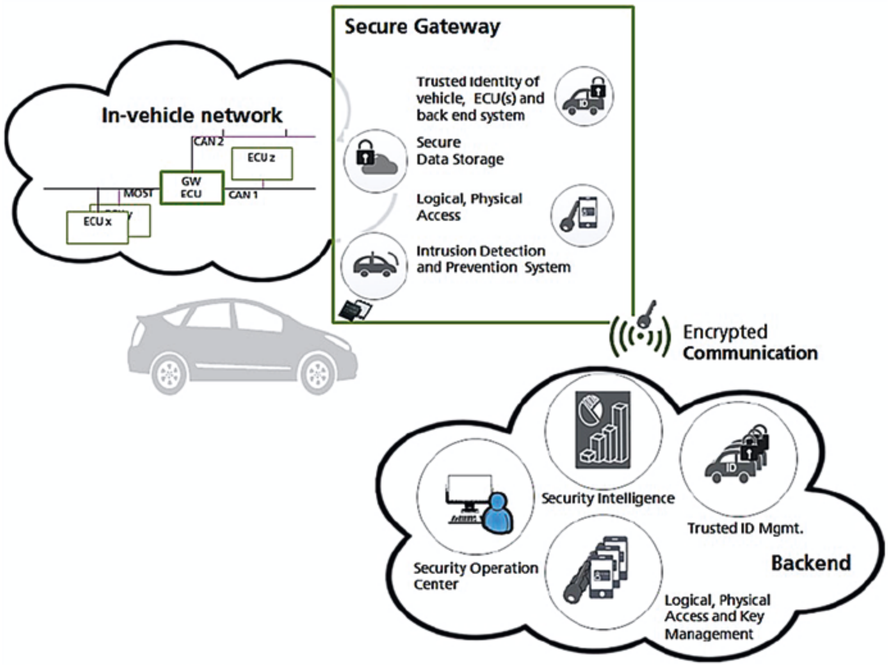


Fig. 8.14 Securing the vehicle IT [Bon16]

These explanations on the safety aspects in the areas of factory IT and vehicle IT illustrate the special challenges on these sensitive areas. Due to the constant data exchange with backend systems, hacker attacks and the penetration of malicious software can continue over this path too. Both areas therefore require special protection measures which are based on the principles of traditional IT security though. Also for this reason, vehicle safety has to be part of a holistic security strategy and the responsibility of the manufacturers.

8.5 Case Studies on IT Transformations

This explanations round off the description of some important topics on the transformation of IT from a developed structure towards more innovation and agility. In the following, two case studies show how companies outside the automotive sector have met these challenges and achieved their goals.

8.5.1 Transformation Netflix

Netflix, although not being related to the automotive industry, is chosen as a transformation example here, because even though this company operates extremely customer-focused now, it had to adjust its business model massively three times within the short period of its existence. During this time, modern IT was a key enabler for this transformation and for implementing higher service and customer orientation. These experiences are also of interest to the automotive industry as the transformation is particularly needed on the sales, marketing and services side.

Netflix was founded in 1997 as a rental service for DVDs with mailing as a competitor to videotheques, ergo a rather traditional business model. In order to differentiate itself in the market, the company relied on good customer service and attractive prices. On this basis, the business grew steadily, and in 2007 with a portfolio of 35,000 films more than one million DVDs were shipped per day [Kee16]. During this time, the technological possibilities and bandwidth of the networks had also improved, so that precisely in this year a so-called “tipping point” was reached from which on the download costs of a film were cheaper than postal dispatch. The Netflix CEO recognised the threat at an early stage and urged his team to adapt the business model and become a highly efficient download provider.

This transformation was successful, but with streaming a new technology with disruptive potential and entry opportunities for competitors was soon establishing itself. Netflix also successfully adapted this swing and mutated from a download provider to the leading streaming provider.

But then another business model adjustment was required. In response to the incessant increase in the costs of screen rights for films, shows and other content, Netflix itself became a successful producer of films and series such as House of

Cards [Kee16]. At the same time, further adjustments were made, especially in the IT, in order to create the basis for growth and competitiveness. In the fiscal year 2016, Netflix achieved with approximately 3700 employees, sales of $8.8 billion. Earnings increased, and analysts see a good orientation of the company with growth potential through expansion into new markets [Fin16].

The key points of this successful transformation combined with massive adjustments to the business model are:

- Management with Leadership and Entrepreneurship
  - Early adaptation of disruptive technologies
  - Courage to adapt the business model
  - Consistent implementation of change
  - Corporate culture with a willingness to change
  - Screening of technology trends
- Uncompromising customer orientation
  - Focus on “experience” with a high level of service
  - Intensive evaluation of social media, feedback and market trends, early recognition of customer requirements by innovative IT solutions
  - Attractive offering which lives up to expectations: very comprehensive range of films, flexible use (rental, download, streaming), own content
  - Active “near-real-time” social media-based marketing (Facebook, Twitter, Instagram)
  - Attractive price structure: no shipping costs, no late fees, subscription model
- High-performance staff base [Kno16]
  - Hiring top performers (“A-Team”)
  - Open performance assessments and result-orientation
  - High fixed salary (market benchmark); no bonus payments
  - Minimisation of internal regulations – e.g. no rules on holiday or travel expenses
- Use of IT as an enabler for innovation and transformation
  - Microservice-based application landscape; API opening
  - Complete Cloud orientation; no own IT infrastructure
  - Innovative analytics of Big Data to identify customer needs
  - Adaptation of new technologies
  - Crash tests to ensure availability

Further details on the aspects mentioned can be found in many contributions on the Internet, and it is certainly interesting to follow the further development.

Due to the thematic focus of this book chapter, the topic of IT is deepened in the following. Netflix has migrated the entire hosting of the applications into a Cloud and operates over 10,000 virtual instances spread over several time zones and regions [Tot16]. In the hosting structure, security concepts are active, whose performance is time and time again tested by specific scenarios. In doing so, virtual servers or even entire hosting regions are switched off for the exercise, while the responsiveness is checked in order to ensure a high availability of over 99.99% for the customers. The many terabyte data are therefore stored redundantly with a second Cloud company.

Netflix does not maintain any own servers for application operation. However, the company still operates in-house the network to the customer, its so-called Content Delivery Network (CDN). The aim is to maintain the know-how of a core technology for streaming and also to independently exploit analytically recognisable options to bundle products for commercial reasons. At peak times, Netflix uses one-third of the Internet bandwidth in the US.

Another core know-how of the company is Big Data Technologies and its own algorithms to forecast customer requirements. For example, the proactively communicated recommendations for shows and movies achieve very high hit rates. Analytics and prognostics are also used in marketing. By analysing social media data, one can recognise customer trends there and posts, for example in Facebook, regional information tailored to the region. In this way, IT supports agile and closely segmented appearances in the social media, which, in addition to up-to-date information, also show different images or extracts from new episodes. Decisions on which films and series will go into production and which content orientation they may take, are based on detailed analyses of customer expectations. The selection is not made by the Netflix executives, yet by the respective content managers.

The complete application landscape of the company is based on a microservices-based architecture and includes more than six hundred solution modules, for instance to handle the processes of registration, evaluations, recommendations and rental history. An overview on the architecture is shown in Fig. 8.15.

Customers can use any devices such as smartphones, web browsers or game consoles for access. In total, there are more than one billion hits per day, orchestrated by load balancers to distribute the loads, and managed via APIs published in the Open Source community. The APIs run via an intelligent buffer layer, which intercepts any errors and smooths them without failures. The administration of loosely coupled individually installable and upgradeable business services, as well as the system services, are provided by a processing system, a service registry. Data access to the distributed data storage is done via an access level. The technology base consists essentially of Open Source products, such as HTTP servers or Tomcat; Java, Ruby, Python and Go are used as programming languages, and for data management Casandra is employed [Tot16].

Also interesting is a look at the environment and the working conditions of the development. The services are created in parallel by many teams. These bear the complete responsibility for their solution modules, from development over deployment through to operation. There are no general guidelines for quality assurance for instance, release management or the defining of standards. Which technologies are used, is decided by the teams, and the optimal problem solution is in the foreground. The technology-fit stands above the demand for standardisation; innovative power and growth have priority over planning capability, and status statements and speed

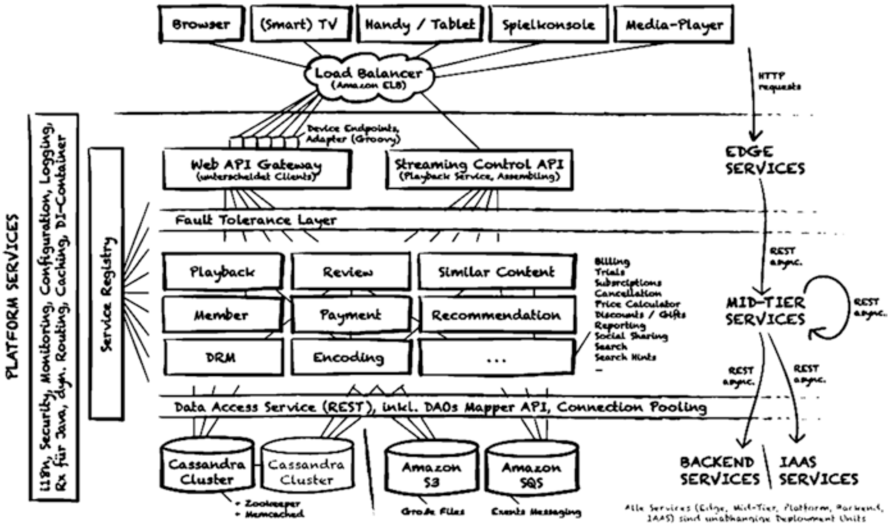


Fig. 8.15 Application architecture Netflix [Tot16]

of delivery are more important than being error-free. The work environment is aptly described with the heading of "freedom and responsibility". This approach and the microservice-based modular architecture founded on Cloud services provide many advantages. The entire application landscape is fault-tolerant due to the modularity and provides a very high availability. With the Cloud in the background, the scalability is secured, and innovations are available to customers very quickly. Currently, there are one hundred deployments on average per day.

The innovative environment is very attractive to young talents. The disadvantage is that the teams need to build up an extensive knowledge of the Netflix application landscape and the specific frameworks and tools used, and thus require a longer training period. Also, a heterogeneous technology portfolio is used. Furthermore, the independent services require comprehensive monitoring and logging. However, these disadvantages are compensated for by the described advantages of thorough customer orientation. The aspects of the Netflix approach are certainly worthy of note for manufacturers and can be implemented in the construction of new Connected Service and digital products.

8.5.2 Transformation General Motors

As a further case study, the IT transformation of General Motors (GM), a leading volume vehicle manufacturer, is being presented hereinafter. Of particular interest in this reference is the transformation of the IT from an operation which was characterised by third-party services into an orientation towards innovation, self-competence and agility. This type of reorientation is now a subject at almost all manufacturers and suppliers.

First, some basic data of the corporation: General Motors is an internationally active US company present in more than 140 countries with over 170 production sites spread over ten brands with a total of 215,000 employees. With more than ten million vehicles sold per year, the turnover is well exceeding $150 billion with a 10% target return [GM16]. The main markets are the United States, China and Europe, with the focus for further growth being on the emerging countries.

Following the severe crisis in the automotive industry with its peak in 2009, the measures taken to increase efficiency and realign the company were effective, so that continuous increases in sales and earnings were achieved over the last few years, albeit with some backlog in certain regions and areas. The current strategy, summarised, is divided into four main areas:

- Earn customers for life
- Customer-relevant innovations such as connectivity and Connected Service at an early stage in the desired functionality in the market; strong focus on safety and quality; social communities
- Lead in technology and innovation
- Leader in 4G LTE (mobile radio standard of the 4th Generation); comprehensive mobility services (investments in Lyft, Maven); autonomous driving (investments in Cruise); e-vehicles
- Grow our brands
- Strengthening of Cadillac as an "iconic" luxury brand with focus on the USA and China; Chevrolet as a global volume brand; specific brand management
- Drive core efficiency
- Safe implementation of a program to increase efficiency with ambitious savings in administrative processes, production and development; lowering of break-even limits

In the implementation of this program, the IT is involved in all fields as an enabler with many projects and is also required to provide direct contributions, for example to the provision of innovations with simultaneous savings. To achieve this goal, IT has undergone a fundamental transformation. Key figures for this are shown in Fig. 8.16.

In line with many other companies, General Motors had almost completely outsourced its IT up to the year 2009. Essentially, there were only employees left in the company for supplier control, and the in-house competence in this thematic field faded. With the growing importance of IT as a driving force for innovation and digitisation, GM has since 2012 completely aligned the strategy in the direction of an insourcing concept, and hired 3000 IT employees of the previous outsourcing service provider [Sav12]. To further strengthen the in-house competence, a large number of additional experts and career starters from renowned universities were added, so that GM in 2016 employed a total of 11,500 own IT staff.

In order to keep the in-house knowledge up-to-date, comprehensive training programmes are available, and up to 500 university graduates enter the IT every year. With this consistent expansion of the own competences and "depth of IT production", the ratio of external service providers to own employees has become reversed, so that today 90% of all services are provided in-house. The work contents also

Metric	2009	2016
IT Staff	1.400	11.500
Performance Ratio External / Internal	90/10	10/90
Work Load, ratio Run / redevelopment	80/20	20/80
Number of main Data Centers	23	2
Number of core applications	4.000	3500 Target: 1500
Data Management	Distributed, heterogeneous	Central, EDWH
Governance	Decentralised Local interests	

Fig. 8.16 Key figures of the General Motors IT transformation (Source: author, following [Pre16])

fundamentally changed towards process improvements, global operation teams and focus on automation. In 2016, 80% of the capacity was used for new developments and innovation, while the operation of the existing IT landscape needed just 20%. Global governance with corporate-wide responsibilities and synergy in the service teams across brands is certainly also a basis for this change. This avoids duplicated work as not every brand maintains a server operation team for instance, rather there is only one team in the world.

Along with the establishment of the GM IT team, the computing centres, formerly 23, were consolidated into now two main computing centres in mutual backup. The number of central applications shrank from 4000 to 3500, always moving towards the goal of 1500 applications. At the same time, a considerable number of applications from the "shadow IT", i.e. IT solutions operated in the specialist departments, were transferred to IT responsibility and thus to safe operation. Data management is now fully centralised, and in the central computing centre a global data warehouse (EDWH Enterprise Data Warehouse) is located first for North America, where all structured and unstructured data are stored and are available for evaluations. As an example, on this basis it is possible for the first time to carry out detailed cost analyses on specific vehicle models in individual markets in order to determine contribution to margins in advance or to simulate measures that increase profitability. A few further summarised innovations go here:

- Consolidation of social media applications; central service centre for centralising 30 separate applications and providing an application in the service centre; a

customer view for enquiries or also sales activities → Increase customer satisfaction
- Expansion of high-performance computing to increase the use of simulations in the development, for example, to optimise the consumption and material use of the vehicles → Shortening the development time
- Use of predictive analytics in paint shops and robotics → Increase output and availability
- Real-time inventory in the central spare parts warehouse in Brazil → Increase service level
- Innovation Centre for Connected Services; for example remote access to vehicles via an App for tire pressure control or operation of the air conditioning system or heating; onboard diagnostic solutions → Increase competitiveness

These examples demonstrate how the IT and its projects contribute directly to the implementation of the company strategy. Overall, GM has succeeded in aligning the ability to act and the possibilities of the IT with the expectations of the specialist departments and customers. Requirements are taken up competently and solutions are developed within a short time in an agile approach in close cooperation with the specialist departments. The IT provides up-to-date solutions that can be used on mobile end devices via graphical user interfaces. The benefits of IT and the role of enabler and moderator for innovation and digitisation are more and more recognised. The precondition for this success was the establishment of a change culture among the employees and on this basis the transformation along a clearly communicated roadmap.

8.6 Conclusion

Overall, IT plays an important role in digital transformation. It provides the platforms for new digital business models and the use of new technologies such as 3D printing and augmented reality as the basis for new learning methods. It also becomes a consultant to the specialist departments on the possibilities of the latest IT solutions, for example in order to achieve savings through the automation of business processes and the use of Apps.

At the same time, IT has to renew itself technologically and, for example, switch to Microservices, Data Lakes and Cloud, all of this financed by consolidations and optimisations in the legacy system. In this transformation, the matter of security is of new importance, not only in the company IT, yet also in the factory and vehicle IT. Successful case studies show that it is crucial to promote entrepreneurship and leadership, to establish a change culture, and then to move forward together with the specialist departments in both the existing and new fields, employing agile project methods [Gen 14]. The following chapter explains some successful digitisation projects that have been made in the light of these success criteria.

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