3 To manage risks: as networked e-business scenarios can get complex in terms of functions and processes and large in terms of the number of actors involved in a scenario, it is often hard to identify and manage risks (such as fraud). Business intelligence can be used to construct typical usage and transaction patterns, such that current business can be compared against these patterns to avoid risks before they appear or manage them after they appear.

Business intelligence technology is used to analyze business data. To store this data, often warehousing systems [Inmo01] are used. These dedicated systems enable business intelligence processes to proceed freely without disturbing primary business that runs against operational databases. Business intelligence technology is closely related to the *big data* development that we discuss in the next section.

8.6 Technology in the Big Five

In chapter 2 we have introduced the Big Five developments in e-business: social media, mobile computing, cloud computing, big data, and the internet of things. In this section we revisit the Big Five and discuss how these developments are related to the technologies that we have discussed in the previous sections of this chapter. We discuss each of the Big Five in the following subsections.

8.6.1 Social media

The current development of social media relies on most of the technology classes that we have seen in this section. Obviously, social media applications make use of the basic infrastructure technology found in the internet and the web. Less visible for the end users of these applications is the use of advanced infrastructure technologies by the social media operators. Given the size and complexity of modern social media, use of these technologies is a strict requirement.

Most aspect-oriented technologies that we have discussed are highly relevant for social media. Given the vast amounts of data managed in social media applications such as Facebook, advanced data management technology is a technology cornerstone of these applications. Human communication technology and mobility technology are important for obvious reasons. Security technology is of utmost importance to guarantee the privacy of the users of social media applications. Performance technology is important to guarantee smooth, fluent interaction between users and social media servers. Poor performance would have a negative effect on customer retention. Note that end-user social media applications are highly interactive, such that short response times must be guaranteed. The only discussed aspect-oriented technology that has a less clear link with social media is process management technology. The reason for this is that the use of social media mostly does not follow predefined business processes.

[redacted]

Most discussed function-oriented technologies are also relevant for social media. Catalog technology is important, but basically for another reason than in e-retailing: in social media, catalogs of social contacts are important to manage personal networks. Certificate technology is important to correctly identify parties involved in social media and enhance trust (even though the use of certificates is typically not very visible to the end user). Payment technology is gaining importance, as social media applications are moving into the e-retailing domain. Business intelligence technology is highly relevant to operators of social media to understand the overall behavior of subsets of their customers or to find closely linked clusters of customers. For the latter, techniques such as social network analysis [Wik14n, Golb13] can be used. Contracting technology does not (yet) play an important role in social media.

8.6.2 Mobile computing

As we have discussed in chapter 2, mobile computing has a profound impact on networked e-business. Mobile computing (obviously) relies on mobility technology, as discussed in section 8.4.6. Advances in both hardware (such as advanced screen technology and low power processor technology) and software (such as dedicated mobile operating systems like Android [www.android.com] and IOS [www.apple.com/ios]) have made mobile computing one of the fastest developing technology markets. But of course, mobile computing does not rely only on the mobility technology class.

Basic and advanced infrastructure technologies are important for mobile technology to enable the connection of mobile devices to server-side functionality. The advanced infrastructure class may not be visible at the 'mobile end' (i.e., the client side) of mobile computing, but it plays an important role in enabling the 'central end' (i.e., the server side). Connection of mobile devices to server-side functionality is more complicated than connection of stationary devices for two main reasons. First, mobile devices typically rely on less reliable wireless connections (such as cellular networks). Second, mobile devices can be *roaming*; that is, change their physical connection point to a network on a frequent basis.

For the aspect-oriented technology classes, mobile computing largely follows the same pattern as social media (which is not surprising, because social media applications are often used on mobile devices). As mobile computing is increasingly used to perform business transactions, security technology for mobile applications is of utmost importance [Dwiv10]. Note that data-management technology and performance-management technology are mostly relevant at the server side.

For function-oriented technology, the emphasis in mobile computing is on certificate and payment technology. Certificate technology is required to authenticate parties in mobile e-business scenarios. To enable adequate levels of trust, this technology relies strongly on security technology. Where payments are made from mobile devices, integration with payment technology as discussed in section 8.5.3 is essential.

[redacted]

8.6.3 Cloud computing

Cloud computing brings virtualized, flexible information processing facilities to parties in e-business scenarios, as we have seen in chapter 2. As its basis, cloud computing requires the application of basic and advanced infrastructure technologies, as discussed earlier in this chapter. To allow dynamism in the relationship between cloud users and cloud providers, an important aspect with respect to the advanced infrastructure class is support for the portability of e-business applications across cloud providers. Adequate support for portability allows cloud users to move their applications from one cloud provider to another, if market circumstances dictate so, and prevent lock-in with a specific service provider. Automated deployment frameworks such as the *topology and orchestration specification for cloud applications* (TOSCA) [OAS13, Binz13] play an important role here. These frameworks allow the specification of cloud computing configurations at an abstracted level that can be reused across providers.

In the aspect-oriented technology classes, as discussed in section 8.4, security and performance technology are of utmost importance for cloud computing. Security technology is important to make sure that cloud users can run their applications as secure in the cloud as on local systems (or perhaps even more secure). Security is important not only to shield unwanted parties that are external to the cloud provider but also to shield other parties that use the same cloud provider. Shielding other parties that use the same provider becomes more important when these parties share the same computing infrastructure. A number of small parties may, for instance, share the same database server in the cloud – with obvious risks for data privacy. This situation of sharing resources in the cloud is referred to as *multi-tenancy* [Mutc11]. The importance of performance technology is obvious: one of the reasons to use the cloud is to obtain flexible, high performance.

In the function-oriented technology classes, as discussed in section 8.5, we find few direct relations to cloud computing, because cloud computing is applicable to very diverse applications. Contracting technology may become important when relationships between cloud users and cloud providers become very dynamic and therefore have to be formally arranged in a quick and cheap way. In this case, cloud service contracts may be established effectively and efficiently using electronic contracting technology.

8.6.4 Big data

We have introduced the development of big data in section 2.2.4. The use of big data is becoming increasingly important for business intelligence in networked e-business. Big data technology relies on basic and advanced infrastructure technology as discussed before in this chapter. Internet and web technology are important for the transport of data from the data sources, where the data originates, to the big data repositories, where the data is stored for processing. Likewise, the internet and web are used for the transport of information distilled from big data to decision makers.

[redacted]

In the aspect-oriented technology classes, the emphasis is (of course) on data management technologies. Advanced data management schemes are required to effectively and efficiently deal with the huge amounts of data generated in e-business scenarios.[13] Take, for example, large e-retailers (see section 5.6.1) that may store not only transaction histories for millions of customers for accounting reasons but also their browsing history for marketing reasons. Security technology is important for guaranteeing the security of data transport and data storage in big data applications – certainly where privacy-related data or business-sensitive data are involved. Performance technology is important to guarantee high-performance data processing over very large databases: big data applications may run on large server parks, where effective load balancing technology is required.

In the function-oriented technology classes, business intelligence technology (as discussed in section 8.5.5) is strongly connected to big data developments. Business intelligence is not so important for the creation of large databases, but to extract relevant knowledge from them. Here, technologies such as data mining [Prov13], online analytical processing (OLAP) [Thom02] and process mining [Aals11] play important roles.

8.6.5 Internet of things

Like the other developments in the Big Five, the development of the internet of things (IoT) relies on basic and advanced infrastructure technology. Basic infrastructure technology is required to couple the 'things' to central information systems that process their state signals. For example, information from RFID scanners in logistics e-business scenarios is sent to central transport management systems [Yee12]. These central systems use advanced infrastructure technologies.

Nearly all discussed aspect-oriented technologies are relevant to the IoT, with human communication technology as the exception: communication in the IoT is centered at things, not at humans (although humans can be treated as 'things' to be automatically tracked – see the discussion of the TraXP case at the end of this chapter). Process management technology is relevant to the IoT to enable adaptive automation of business processes in which the 'things' are manipulated. Here, the IoT generates state change signals of things, which are fed to business process management systems used for controlling the enactment of processes [Zhao09]. An example application domain is logistics, where IoT technology is used to track the movements of goods and control business processes related to these movements.

In function-oriented technologies, the emphasis in the IoT is on certification technology to certify the identity of things (or of the systems that deliver identity information) to the central information systems and on business intelligence technology to distill decision management information from the real-time information generated by the things.

[redacted]