In Chap. 1, we introduced the basic principles of cloud computing, on-demand self-service, broad network access, pay-per-use, resource pooling and rapid elasticity. In Chaps. 2 and 3, we used a pattern format to describe workloads experienced by cloud applications, the hosting environments they use, and the cloud-specific properties of different cloud offerings in an abstract, vendor-neutral view. Chapter 4 covered patterns on how to deal with these properties in application architectures followed by best practices for managing cloud applications in Chap. 5. Chapter 6 covered compositions of the patterns described in previous chapters to create cloud applications.

Readers are now familiar with the principles and the properties of cloud offerings making cloud computing different from traditional computing. However, we have not explicitly reviewed how the cloud computing properties defined in Sect. 1.1 on Page 3 that are displayed cloud offerings influence the behavior of applications built on top of them on different levels of the application stack introduced in Sect. 2.3 on Page 42. Especially, we have not explicitly discussed how these properties of lower levels of the stack can be mitigated on higher levels so that an application can, for example, display required properties to its users and customers without necessarily requiring the same properties to be displayed at the middleware or infrastructure level. In this chapter, we discuss properties of cloud offerings that can be changed through application design and cloud-specific properties that cannot be mitigated within applications. As a result some properties can be changed and some propagate up to the business level where they have impact on how applications support the business processes and, thus, these properties have impact on the business itself. We will see that it is often unnecessary to mitigate cloud-specific properties on the application level. This is the case, as the impact on the business is less profound than it may seem at first glance.

In this chapter we examine more closely the impact that the cloud-specific properties of cloud offerings have on the levels of the application stack that build
upon them. We do so by more closely inspecting the properties that are assumed and expressed by the patterns introduced in the chapters before.

Knowing the impacts of these properties and how to mitigate them is important for a range of scenarios:

- **Selecting the right cloud provider.** In this scenario, knowing the impacts of properties abstracted by the patterns enables customers to classify cloud providers and select the right one based on the business needs. Business needs can be mapped to cloud properties that cannot be changed and application architectural patterns can be evaluated to mitigate other properties to support the business needs.

- **Building a cloud infrastructure or platform.** In the private cloud scenario knowing the impacts that are produced when selecting different implementation patterns will steer private cloud providers to offer the right selection of infrastructures and platforms.

- **Rethink business requirements.** In case a cloud provider offers significantly lower prices while assuring only certain properties that do not directly meet business needs, it may be beneficial to rethink the impact these properties have on the business and if it is feasible to live with them.

- **Build cloud native applications.** Knowing the impact of properties on the infrastructure and platform levels and how to mitigate them on the application level enables application architects and developers to build cloud-native applications that make use of the full potential of the underlying cloud offerings by respecting offering properties in their architecture.

### 7.1 Cloud Computing Properties on Levels of the Application Stack

Having introduced patterns as a vehicle to describe the properties of cloud offerings and how to deal with them in application architectures, we can now use these patterns to deal with the cloud computing properties on all levels of the application stack. When using a cloud offering it important to understand the key properties that influence the upper levels of the application stack depending on the properties of the chosen lower level implementation. In software engineering for custom on-premise applications, requirements are traditionally propagated top-down the application stack as shown in Fig. 7.1.

During this propagation of requirements the requirements of a business usage scenario and its business processes are iteratively refined into application software requirements, middleware requirements and infrastructure requirements. In IT environments, where the whole application stack is fully controlled by the software architect and can, thus, be created in a custom fashion for each application, this approach leads to middleware and infrastructure layers that are very unique and diverse but well suited for the respective applications as they are optimized to meet the specific requirements of the business usage scenario.

In the cloud, however, when using existing *-as-a-Service offerings this approach tends to be less successful, as the properties of the cloud offerings to be used can typically not be modified as freely as in an on-premise usage scenario.