and higher thresholds are defined to rule out trivial cases of migration. A simplified variant of this method can be presented as a balanced scorecard-oriented decision making. An example of that approach to the adoption of cloud is found in Dargha [10].

2.3 THE SEVEN-STEP MODEL OF MIGRATION INTO A CLOUD

Typically migration initiatives into the cloud are implemented in phases or in stages. A structured and process-oriented approach to migration into a cloud has several advantages of capturing within itself the best practices of many migration projects. While migration has been a difficult and vague subject—of not much interest to the academics and left to the industry practitioners—not many efforts across the industry have been put in to consolidate what has been found to be both a top revenue earner and a long standing customer pain. After due study and practice, we share the Seven-Step Model of Migration into the Cloud as part of our efforts in understanding and leveraging the cloud computing service offerings in the enterprise context. In a succinct way, Figure 2.4 captures the essence of the steps in the model of migration into the cloud, while Figure 2.5 captures the iterative process of the seven-step migration into the cloud.

Cloud migration assessments comprise assessments to understand the issues involved in the specific case of migration at the application level or the code, the design, the architecture, or usage levels. In addition, migration assessments are done for the tools being used, the test cases as well as configurations, functionalities, and NFRs of the enterprise application. This results in a meaningful formulation of a comprehensive migration strategy. The first step of the iterative process of the seven-step model of migration is basically at the assessment level. Proof of concepts or prototypes for various approaches to the migration along with the leveraging of pricing parameters enables one to make appropriate assessments.

These assessments are about the cost of migration as well as about the ROI that can be achieved in the case of production version. The next process step is in isolating all systemic and environmental dependencies of the enterprise.

FIGURE 2.4. The Seven Step Model of Migration into the Cloud. (Source: Infosys Research.)
application components within the captive data center. This, in turn, yields a picture of the level of complexity of the migration. After isolation is complete, one then goes about generating the mapping constructs between what shall possibly remain in the local captive data center and what goes onto the cloud. Perhaps a substantial part of the enterprise application needs to be re-architected, redesigned, and reimplemented on the cloud. This gets in just about the functionality of the original enterprise application. Due to this migration, it is possible perhaps that some functionality is lost. In the next process step we leverage the intrinsic features of the cloud computing service to augment our enterprise application in its own small ways. Having done the augmentation, we validate and test the new form of the enterprise application with an extensive test suite that comprises testing the components of the enterprise application on the cloud as well. These test results could be positive or mixed. In the latter case, we iterate and optimize as appropriate. After several such optimizing iterations, the migration is deemed successful. Our best practices indicate that it is best to iterate through this Seven-Step Model process for optimizing and ensuring that the migration into the cloud is both robust and comprehensive. Figure 2.6 captures the typical components of the best practices accumulated in the practice of the Seven-Step Model of Migration into the Cloud. Though not comprehensive in enumeration, it is representative.
Compared with the typical approach to migration into the Amazon AWS, our Seven-step model is more generic, versatile, and comprehensive. The typical migration into the Amazon AWS is a phased over several steps. It is about six steps as discussed in several white papers in the Amazon website and is as follows: The first phase is the cloud migration assessment phase wherein dependencies are isolated and strategies worked out to handle these dependencies. The next phase is in trying out proof of concepts to build a reference migration architecture. The third phase is the data migration phase wherein database data segmentation and cleansing is completed. This phase also tries to leverage the various cloud storage options as best suited. The fourth phase comprises the application migration wherein either a “forklift strategy” of migrating the key enterprise application along with its dependencies (other applications) into the cloud is pursued. Or perhaps using the “hybrid migration strategy,” the critical parts of the enterprise application are retained in the local captive data center while noncritical parts are moved into the cloud. The fifth phase comprises leveraging the various Amazon AWS features like elasticity, autoscaling, cloud storage, and so on. Finally in the sixth phase, the migration is optimized for the cloud. These phases are representative of how typical IT staff would like to migrate an enterprise application without touching its inners but only perhaps at the level of configurations—this perfectly matches with the typical IaaS cloud computing offerings. However, this is just a subset of our Seven-step Migration Model and is very specific and proprietary to Amazon cloud offering.

2.3.1 Migration Risks and Mitigation

The biggest challenge to any cloud migration project is how effectively the migration risks are identified and mitigated. In the Seven-Step Model of Migration into the Cloud, the process step of testing and validating includes

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8 http://aws.amazon.com
efforts to identify the key migration risks. In the optimization step, we address various approaches to mitigate the identified migration risks.

Migration risks for migrating into the cloud fall under two broad categories: the general migration risks and the security-related migration risks. In the former we address several issues including performance monitoring and tuning—essentially identifying all possible production level deviants; the business continuity and disaster recovery in the world of cloud computing service; the compliance with standards and governance issues; the IP and licensing issues; the quality of service (QoS) parameters as well as the corresponding SLAs committed to; the ownership, transfer, and storage of data in the application; the portability and interoperability issues which could help mitigate potential vendor lock-ins; the issues that result in trivializing and noncomprehending the complexities of migration that results in migration failure and loss of senior management’s business confidence in these efforts.

On the security front, the cloud migration risks are plenty—as addressed in the guideline document published by the Cloud Security Alliance [8]. Issues include security at various levels of the enterprise application as applicable on the cloud in addition to issues of trust and issues of privacy. There are several legal compliances that a migration strategy and implementation has to fulfill, including obtaining the right execution logs as well as retaining the rights to all audit trails at a detailed level—which currently may not be fully available. On matters of governance, there are several shortcomings in the current cloud computing service vendors. Matters of multi-tenancy and the impact of IT data leakage in the cloud computing environments is acknowledged; however, the robustness of the solutions to prevent it is not fully validated. Key aspects of vulnerability management and incident responses quality are yet to be supported in a substantial way by the cloud service vendors. Finally there are issues of consistent identity management as well. These and several of the issues are discussed in Section 2.1. Issues and challenges listed in Figure 2.3 continue to be the persistent research and engineering challenges in coming up with appropriate cloud computing implementations.

2.4 CONCLUSIONS

While migrating into a cloud has a lot of challenges, many migration projects fail to fully comprehend the issues at stake—with the key sponsors and management either trivializing it or committing to migrating a piece of code and/or data into the cloud. There are significant opportunities and success factors for a well-designed cloud migration strategy leveraging the Seven-Step Model of Migration into the Cloud. Primary amongst them is a comprehensive understanding of the cloudonomics of the migration as well as the underlying technical challenges.

Developing the best practices in migrating to the cloud is unique to every class of enterprise applications and unique to every corporate practice group. Some of the key best practices include designing the migration as well as the
new application architecture or design or code for failures when in reality most assume that cloud computing service environments are failsafe. In fact most cloud computing data centers use commodity hardware and are routinely prone to failure. Approaches not reflecting this reality results in several performance penalties. Another best practice is the application and enforcement of loose-coupling between various parts of the target enterprise application. A key best practice has to been to build security at every level and layer of the migration. Finally the most important of the best practices has been to fully leverage the cloud computing service features while not being constrained by the baggage carried by the enterprise application in its traditional deployment in the captive data centers. Migrating into a cloud is a nontrivial activity. It is challenging given the complexity of comprehending the various factors involved for a successful migration. The proposed Seven-Step Model of Migration into the cloud helps structure and organize one’s efforts in putting together a plan of action and process to successful complete the migration without problems. Of course best practices are accumulated through migration project executions, and the seven-step model of migration is reflective of this.

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