An assessment tool for establishing *Infrastructure as a Service* capability maturity

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About the authors

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Abstract

The concept of using IT services ‘out of the cloud’ is relatively new, let alone having an entire infrastructure in that same cloud. The technological advancements in virtualization technology have brought organizations to the point where they have the opportunity to outsource their entire IT infrastructure and use it as a service, out of ‘the cloud’. This phenomenon is known as a specific form of ‘cloud computing’ called ‘cloud architecture’ or Infrastructure-as-a-Service (IaaS). Adoption of IaaS has a massive impact throughout all layers in the entire organization.

This research is focused on examining where the adoption of Infrastructure-as-a-Service, as it is defined in this research, might impact and what factors pose an important role for successful IaaS adoption. It presents an assessment framework that measures the maturity of these factors, which are grouped together in seven different aspects (referred to as Adoption Capability Aspects in this research) and were identified by explorative expert interviews combined with a literature study. The framework consists of around 80 statements derived from several established frameworks and assessments. The purpose of the framework is to identify the maturity and state of readiness of an organization with regard to the adoption of IaaS, thereby aiding in the decision making process.

The concept of IaaS architectures is yet to gain more attention and maturity, but will also prove to be interesting and show its potential in the near future. The

framework proposed in this research will contribute to the IaaS adoption maturity of organizations and attempts to increase awareness of IaaS as an emerging IT infrastructure architecture, as well as its most influencing aspects.

Introduction to Service Systems and Infrastructure-as-a-Service

To relate the subject of this book to the subject of this research, we go back to the 1980's. Since the introduction of Personal Computers, they have become ever increasingly important within businesses and have gradually replaced many tasks previously done by man. These tasks can be seen as *services* and the Personal Computers as individual *service enablers*, effectively making them part of a *Service System* as a 'physical enabler' (Karni & Kaner, 2007).

The next major revolution in the history of *Service Systems* after the introduction of the PC, was the rise of the internet. It is a development that changed the way we live and we have become dependent on it. The same applies for businesses all around the world as the internet opened the doors for fast, cheap and generally reliable and around-the-clock information exchange. Not surprisingly, a lot of companies took advantage of the opportunities this relatively new medium offered and so the "internet-boom", caused by the extremely rapid increase in availability of internet providers and web-browsers, soon enabled the following "offshoring-boom" in the mid-90's which enabled companies to do their business 24 hours a day, save costs and focus more on their core-businesses. This concept is described in (Gupta & Seshasai, 2007) as the "24-hour knowledge factory". A direct consequence of offshoring part of your company is that process streamlining to allow working in a uniform way, worldwide, is difficult to achieve due to the large distances between offices (Metters, 2007). Of course, the internet

acts as an enabler when it comes to solving this issue (Gupta & Seshasai, 2007) and many companies already use various web-based applications to synchronize their work on a global scale. However, the amount of data that needs to be shared and synchronized is ever increasing and as a result, internal information networks tend to grow large, inefficient and require a lot of maintenance.

In the meanwhile, technology also evolved and concepts such as desktop virtualization, cloud computing and Software-as-a-Service (SaaS), emerged as answers to these growing issues. By separating software possession and ownership from its use, these technologies follow an entirely new software paradigm focused on describing and delivering a service (Turner, Budgen & Brereton, 2003).

A "service" can be described as the following definition:

"An act or performance offered by one party to another. Although the process may be tied to a physical product, the performance is essentially intangible and does not normally result in ownership of any of the factors of production" (Lovelock et al., 1996).

Software-as-a-Service is often seen as the first major step towards what in 2004 was already described as 'service based computing' (Shipley, 2004). The SaaS concept is receiving widespread attention with Salesforce.com and IBM establishing themselves as major providers and market leaders. With bandwidth ever in-

creasing as a result of rapid advances in hardware virtualization, IT automation, and usage metering and pricing, the SaaS concept later evolved and extended to include infrastructure components like storage and computational resources, cleverly coined ‘Hardware-as-a-Service’ (HaaS) by Carr (2006). The term HaaS has since been superseded by Infrastructure-as-a-Service (IaaS), which has been introduced by the first emerging providers offering this concept (e.g. Bluelock.com, Tier3.com).

Lack of awareness and fear of implementation failures result in that even today there are still not many organizations making the decision to adopt these technologies and analyst firms state that a distinct market and market leaders will not emerge for at least another year in the IaaS market (Fenn et al., 2008). This is the reason that there is little scientific information available about the IaaS concept, let alone knowledge on how to deal with the adoption and integration. This research attempts to provide some of that information. It focuses on IaaS as a strictly defined cloud computing environment (see definition on page 9). The mission of this research is to increase awareness of the factors that play an important role in the adoption process and provide a tool to aid in the decision making progress by identifying the state of adoption readiness to ease the (perhaps inevitable) transition to an IaaS architecture in the future.

The research attempts to fulfill this mission by accomplishing a number of goals:

- identification of factors that pose a significant risk to the adoption and implementation of IaaS
- identification of factors having specific requirements with regard to IaaS
- identification of processes in existing frameworks covering these risks
- mapping of risk factors to adoption aspects
- development of an assessment tool measuring aspects of adoption readiness
- development of a matching maturity model covering the most important aspects

Research approach

The first step in conducting this research is the determination of the research method. Because the subject of the research is new and there is little to no literature at all available to extract information from, the first stage of the research conducted in this thesis, the definition of the Adoption Capability Aspects, can be classified as explorative (qualitative) research as described in ‘t Hart & Boeije (2005), amongst others.

The second phase, the actual construction of the assessment framework, can be classified as design science. The choice for this method is that ‘*design-science research addresses important unsolved problems in unique or innovative ways or*

solved problems in more effective or efficient ways.' Design science is a problem solving process in which problems are considered to have the following characteristics (Hevner, 2004):

- *unstable requirements and constraints based upon ill-defined environmental contexts*
- *complex interactions among subcomponents of the problem and its solution*
- *inherent flexibility to change design processes as well as design artifacts (i.e., malleable processes and artifacts)*
- *a critical dependence upon human cognitive abilities (e.g., creativity) to produce effective solutions*
- *a critical dependence upon human social abilities (e.g., teamwork) to produce effective solutions*

One might argue that most, if not all of these characteristics apply in this research and thus making it a justified research approach for designing an assessment construct for Infrastructure-as-a-Service adoption capability.

What is Infrastructure-as-a-Service?

In order to begin with the research as proposed in the previous section, a proper definition for the concept of Infrastructure-as-a-Service had to be established. Available literature does mention that Infrastructure-as-a-Service is an emerging development based on the service delivery paradigm (like e.g. Software as a Service, Platform as a Service, etc.). It is sometimes also referred to as *cloud computing* or, more specifically, *cloud architecture*. However, as there is no standard terminology (yet) to strictly define Infrastructure-as-a-Service, this research defines the Infrastructure-as-a-Service as:

An entirely virtualized information technology infrastructure with scalable storage on demand, in combination with either database(s) or computing capacity on demand, or both.

These services are limited in terms of available database-versions, CPU types, etc. Additional generic services such as internet access, monitoring services, network security (e.g. intrusion detection systems) are optional as well as integration with the customer's own generic services. Application and OS (Operating System) hosting is managed by the provider, where the applications are provided and maintained by the customer for optimal configurability. The provider is not responsible for functional or technical management of hosted applications but solely provides the OS environment. Furthermore, end user support responsibility remains with the customer.

Access is possible via public networks by a variety of hardware (thin clients, desktop and laptop computers, mobile devices, explicitly not using its own local storage but solely operating via a virtual environment provided by the IaaS architecture).

A visual representation of the Infrastructure-as-a-Service definition as described in the previous section can be seen in Figure 1.

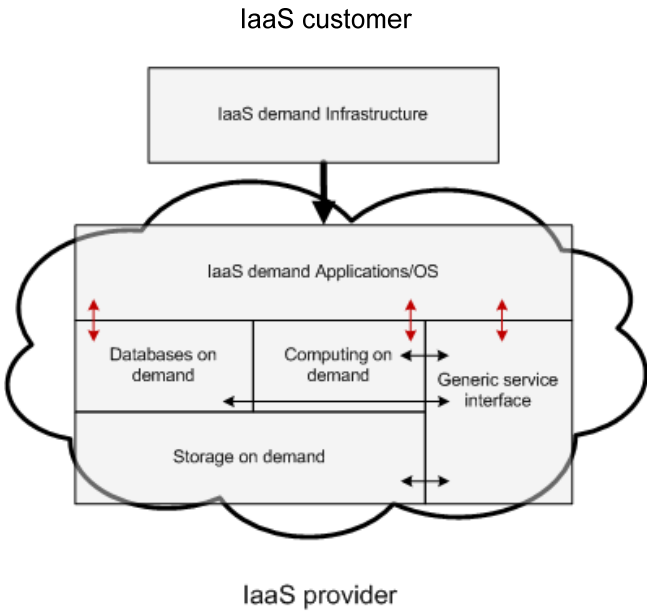

Figure 1: IaaS visual representation

Research execution and framework development

In this chapter the research approach and the subsequent development of the framework will be described in detail.

Phase one – Literature study and explorative interviews

The first research phase was twofold, a literature study was conducted to identify risks, requirements and characteristics of technologies closely related to Infrastructure-as-a-Service (IaaS); and explorative interviews with eight experts, functioning in the financial services and communications & high tech business segments, were held to identify risks and requirements directly related to IaaS.

For the literature study, technologies such as desktop virtualization, Software as a Service and IT outsourcing were studied to determine what benefits these technologies have to offer and, more important, what challenges they have overcome or still face. This was done to identify potential challenges that IaaS may inherit through the evolution of these technologies. This literature study thus resulted in the theoretical perspective of potential IaaS challenges.

The goal of the expert interviews was to gain as much information about IaaS adoption in practice as possible. A semi-structured approach was chosen as inter-

view strategy to leave room for improvisation when the opportunity would arise to gain more detailed information about the subject. The structured part of the interviews consisted of questions about the current trends of infrastructure outsourcing, success rate of previous IaaS initiatives, and most importantly, risks and requirements that would apply to IaaS implementation from their business point of view, resulting in the practical perspective of potential IaaS challenges.

Originally, experts from two different business segments were interviewed to examine if there was substantial difference in the answers or if business specific challenges would be mentioned. Interview results did not provide suggestions that this was the case, hence the assumption was established that the assessment framework could function for both the financial services and the high tech business segment, and could possibly also function for other business segments.

The two perspectives combined provided a base of information to identify certain aspects of an organization that have an essential role in the adoption of an IaaS architecture. Interview results were listed, made consistent, sorted, compared to- and supplemented with the information gathered during the literature study. This process eventually resulted in the seven Adoption Capability Aspects (ACAs) that form the dimensions of the assessment framework:

- IT Infrastructure Complexity

  measures current state of IT infrastructure complexity

- IT Infrastructure Health

  measures current state of IT infrastructure health factors such as hardware age, performance

- Cost & Benefit

  identifies current control over IT costs to measure the ability to achieve ROI

- Governance

  measures the condition of the governance function

- Capacity Management

  measures the ability to effectively monitor and forecast capacity usage

- IT Service Management

  measures the condition of several IT service management related processes

- Security & Compliance

  measures the condition of security & compliance processes and regulations

These ACAs would form the seven dimensions of the assessment tool to be constructed. In the later stages of the research the ACAs were validated during a second interview round and considered useful and satisfactory complete by experts within the IaaS provider market. The identification of the ACAs concluded the first phase of the research, they would be given mass in the development phase.

Phase two – Assessment development

For the development of the assessment framework, the *design science* method described by Hevner (2004) proved to be a suitable research method, as the situation complied with most of the characteristics mentioned earlier.

To provide the Adoption Capability Aspects with units of measure that would accurately reflect the state of maturity for the concerning aspect, several well established frameworks such as the IT Infrastructure Library (OGC, 2007) and the COBIT best practice framework (ITGI, 2007) were consulted to study process descriptions that were directly or indirectly relevant to the identified aspects. The ITIL and COBIT process descriptions proved to contain detailed information including a description how the process should look like in an ideal situation, process metrics and maturity level descriptions. This information was used to establish measureable statements that cover the ACAs. Additionally, the Infrastructure Assessment Toolkit was used to derive statements and maturity descriptions.

In Figure 2, the derivation method is visualized. This method was used to provide the ACAs with metrics.

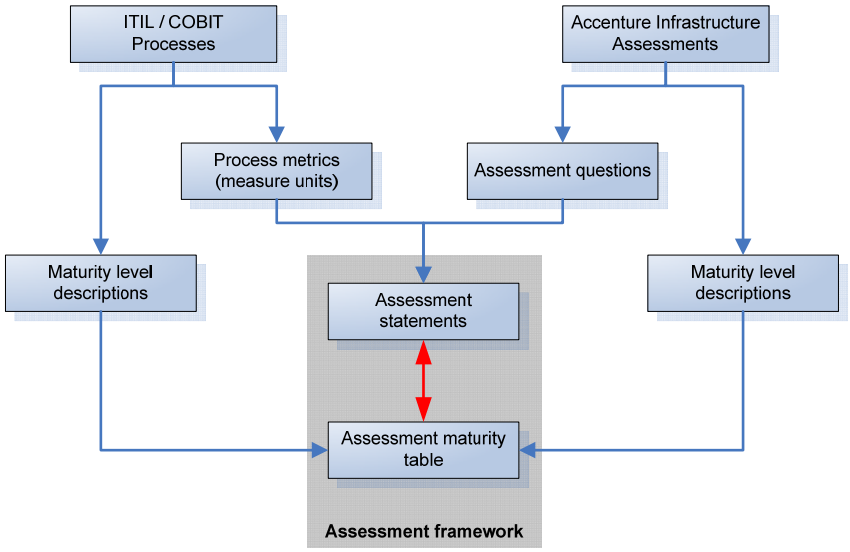

Figure 2: Assessment framework compilation

The Infrastructure Assessment Toolkit (IAT) consists of predefined assessment questions instead of process metrics so these questions were derived from the IAT directly rather than interpreted from the process descriptions in the ITIL and COBIT frameworks. Therefore, the derivation method is slightly different and is visualized apart from the ITIL and COBIT framework.

The IAT was used to incorporate Accenture's existing view on how to assess IT infrastructures in the framework, although it must be stressed that the final framework is absolutely not restricted to internal usage.

Adoption Capability Assessment framework

The Infrastructure-as-a-Service (IaaS) adoption capability assessment framework is the primary result of this research. The framework consists of seven Adoption Capability Aspects (ACAs) which were identified through expert interviews. The ACAs form the dimensions of the assessment framework and were given mass by means of analyzing existing frameworks and technologies and deriving measurable statements from the process descriptions and assessment questions from these frameworks. The maturity level descriptions in the assessment maturity model are derived in a similar way as the assessment statements, as the frameworks from which the statements originate, all offer accompanying maturity descriptions with its process descriptions.

ACAs are subdivided into factors which in their turn contain a varying number of five point Likert-scale based statements. Each statement has a 1-5 output score which will be used to determine the maturity level for the concerning aspect. The maturity level outcome resembles a state of maturity described in the maturity table and for each ACA there is a minimum state of maturity concerning IaaS adoption. Using a spider graph to visualize the assessment result, an organization is able to identify which aspects are sufficiently mature for the adoption of an IaaS architecture, and which aspects still need attention.

An overview of the ACAs and factors, along with the original sources that were used in the derivation of the assessment components is provided in Table 1.

Table 1: Overview of sources used for assessment factors

ACA	Factor	Source
IT Infrastructure complexity	Integration	IAT
	Compatibility	IAT
IT Infrastructure health	Legacy	IAT
	Performance measurement	COBIT
Cost & Benefit	TCO	Gartner TCO
	ROI	Explorative interviews
Governance	Control	COBIT
	Outsourcing	Explorative interviews
Capacity Planning & Mgmt.	Monitoring / Availability	ITIL
	Forecasting / Planning	ITIL / IAT
IT Service Management	Support	ITIL
	Changes	ITIL
	Third Party Management	ITIL
Security & Compliance	Security	IAT / COBIT
	Compliance	COBIT

IAT = Infrastructure Assessment Toolkit[1]

COBIT = Control Objectives for Information and related Technology framework

ITIL = Information Technology Infrastructure Library framework

Gartner TCO = Total Cost of Ownership method by Gartner

To further clarify the derivation of the assessment statements and maturity descriptions from the sources mentioned in Table 1, see **Figure 2** in the previous chapter. An excerpt from the actual assessment is provided in Figure 3.

[1] Infrastructure Assessment Toolkit developed by Accenture for internal use

	Applicability	1	2	3	4	5
	Integration					
1	Open standards (e.g. open file formats such as PDF, XML) and interfaces are used extensively within the organization					
2	The organization makes extensive use of directory service(s)					
3	The organization makes extensive use of (a) Wide Area Network (WAN)					
4	The organization makes use of a Storage Area Network (SAN)					
5	OS virtualization is extensively used within the current infrastructure of the organization					
	Compatibility					
6	The organization limits the number of database vendors to a minimum					
7	The organization limits the number of database versions to a minimum					
8	Dedicated hosting is used for all databases					
9	The organization limits the number of server vendors to a minimum					
10	The organization limits the number of server versions to a minimum					
11	The organization limits the number of vendors of operating systems to a minimum					
12	The organization limits the number of operating system versions to a minimum					
13	The organization limits the number of vendors of storage infrastructure to a minimum					
14	The organization limit the number of storage infrastructure versions to a minimum					
15	The organization only uses commercial off-the-shelf applications					

Figure 3: Contents of the IT Infrastructure Complexity ACA

Figure 3 shows the contents of the IT Infrastructure Complexity aspect. This ACA consists of the factors **Integration** and **Compatibility** which are measured by five and ten statements, respectively. The statements are designed so that position 5 on the Likert scale always resembles the most ideal situation, and thus a positive score on Infrastructure-as-a-Service adoption maturity. For each specific

factor, five maturity descriptions are described in the maturity table. To determine the maturity score on the factor, the average score resulting from its statements is used. The maturity score on the ACA is subsequently determined by the average score of all of its statements.

Upon completing the assessment, all ACA maturity scores are plotted into a spider graph, clearly indicating the organization's maturity in contrast to the minimum maturity score required for proper IaaS adoption. An impression of the spider graph result is provided in **Figure 4**. This result will help organizations to identify the factors that need improvement before an IaaS architecture can be adopted.

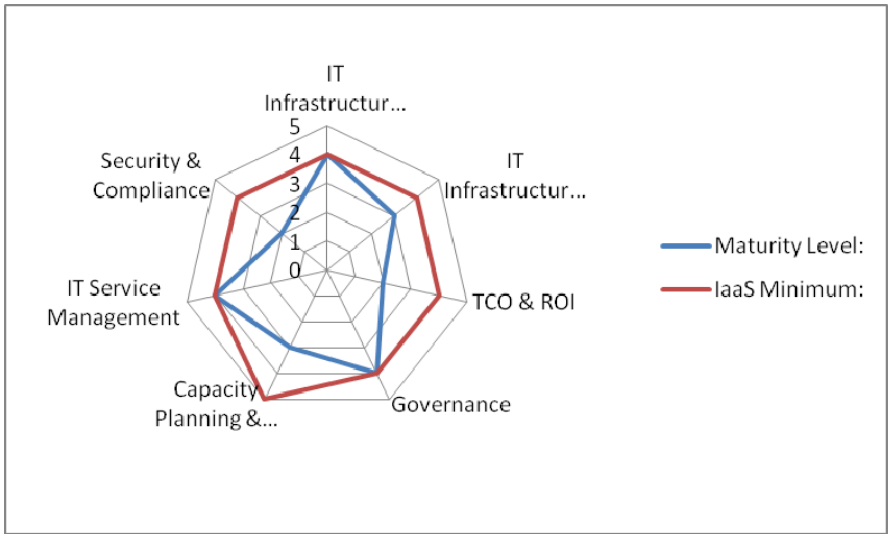

Figure 4: Assessment spider graph result (impression)

Conclusion

The Infrastructure-as-a-Service (IaaS) Adoption Capability Assessment framework is developed to provide a quantifiable way of identifying the state of readiness of organizations for the adoption of an IaaS architecture. It identifies the maturity of seven aspects within an organization, exposing its strong and weak points concerning the adoption of an IaaS architecture, contributing to the organization's long term (IT) strategy.

While the concept of IaaS is still in its infancy and widespread adoption at least a few years away, the assessment framework contributes in creating awareness of the factors that influence the adoption of this emerging technology which may very well be the future of IT infrastructure.

Future research

Although this is a start in identifying challenges and influential factors that have to be faced and taken into account when adopting an Infrastructure-as-a-Service architecture, there are several opportunities for further research.

In the first place; a case study is desirable for the validation and completeness of this research. Due to the worldwide economic crisis, organizations are not eager to release sensitive information needed to execute the assessment, thus validation opportunities are scarce. It is for this reason that a case study could not be exe-

cuted for the validation of this research and a less desirable method (a second round of expert interviews) was chosen for validation purposes instead. Nevertheless, a case study would still be an interesting addition to the research and would provide the opportunity to fully validate the developed assessment tool.

Secondly; quite early in the research an observation was made that there was no significant difference between the interview answers of personnel from financial services and the communications / high-tech business segments concerning specific risks and challenges of IaaS adoption for their department. An assumption was made that the assessment framework did not need to include business-sector-specified statements and could thus be used to assess organizations from different business segments. Future research could further examine this assumption by extending the case studies to other business segments to validate the claim that a 'universal' IaaS Adoption Capability Assessment framework would suffice for every sort of organization.

Thirdly; it might be interesting to extend this research with a second hypothesis examining the relation between the assessment maturity scale and IaaS adoption capability. It was assumed in this research that adoption successfulness was related to the maturity descriptions derived from the varying sources. Further research can examine how adoption successfulness relates to the identified levels of maturity as they are currently described in the assessment framework, and how *individual* statements impact IaaS adoption.

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