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Towards the Development of a Cloud Service Capability Assessment Framework

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Abstract: Considering the complexity of today's service environment, Small-to-Medium sized Enterprises (SMEs) cannot afford to accept the status quo of service operations and therefore must have some clear business analytics objective to reach. Without clear metric objectives, organisations are almost destined for disaster since the allocation of resources may not have responded to the demand exerted from outside of the organisation. This is particularly true within a complex and rapidly changing cloud computing environment. The cloud dynamic ecosystem is moving towards a collection of services which interoperate across the Internet. This chapter offers a discussion on an approach to assessing cloud capabilities through Cloud Service Capability Assessment Framework (CSCAF). Service metrics plays a critical role in CSCAF and presents managers with a practical framework to carry out cloud capability assessments. The process may be simply described as publishing, retrieving, and managing cloud service descriptions, service publications which are matched with descriptions of consumer's requirements and service matching.

Keywords: Cloud Computing, Service Capability, Cloud Assessment, Cloud Service Capability Assessment Framework (CSCAF)

1.1 Introduction

Considering the complexity of today's service environment, Small-to-Medium sized Enterprises (SMEs) cannot afford to accept the status quo of service operations and therefore must have some clear business analytics objective to reach. Without clear metric objectives, organisations are almost destined for disaster since the allocation of resources may not have responded to the demand exerted from outside of the organisation. This is particularly true within a complex and rapidly changing cloud computing environment. The cloud dynamic ecosystem is moving towards a collection of services which interoperate across the Internet. This chapter is motivated by the findings of a literature review to assess the experiences of SMEs as they provide and/or try to avail of cloud solutions. More specifically, the initial research phase of a literature review identified the lack of capability assessment practices for cloud computing readiness and capabilities within SMEs. This chapter offers a step towards a solution to assess cloud capabilities.

This chapter presents the Cloud Service Capability Assessment Framework (CSCAF). The chapter discusses the development of the CSCAF and how is can support organisations gain a thorough insight on their ability to migrate towards providing and/or availing of cloud solutions. Thus, service metrics plays a critical role in CSCAF and presents managers with a practical framework to carry out cloud capability assessments. The author also adopts Universal Description, Discovery, and Integration (UDDI) as a platform to develop a cloud capabilities registry (CCR). The process may be simply described as publishing, retrieving, and managing cloud service descriptions, service publications which are matched with descriptions of consumer's requirements and service matching.

1.2 Literature Review

> *The interesting thing about cloud computing is that we've redefined cloud computing to include everything that we already do. . . . I don't understand what we would do differently in the light of cloud computing other than change the wording of some of our ads.*
>
> **Larry Ellison** (Oracle's CEO), Wall Street Journal, September 26, 2008.

This section draws on the current literature and discusses some the main themes which have emerged from the evolution of cloud developments. The objective of the literature review is to provide a platform for both academics and industry practitioners to gain an understanding of the current trends and issues surrounding the adoption of the cloud.

The influence of information technology (IT) continues to alter our understanding of the business environment. It continues to shift computing paradigms to afford greater accessibility to business capabilities. This is yet again evident through the emergence of cloud computing. Cloud computing allows various key organisational resources to become more efficiently available, for example, software, information, storage, and business processes. Cloud computing allows organisations to gain access to sophisticated services through Internet channels. The fundamental benefit of cloud computing is its ability to share resources 'on demand' at considerably reduced costs. This has led to the explosive uptake of cloud computing. According to the latest Cisco report, "*Cloud is now on the IT agenda for over 90% of companies, up from just over half of companies (52%) last year*" [1]. However, availing of services through a systematic manner can become a very complex entanglement of business processes. Understanding the complexity and value of 'the cloud' offers immense opportunities through service analytics (i.e. measuring performance). Thus, understanding and organising how cloud resource are exchanged while assessing organisational ability to provide services on-demand requires a capability maturity framework to assist in strategic business and IT alignment. If organisations are to enjoy the benefits of cloud developments, it is important to strategise how they can assess the business and technical factors to transform their cloud capabilities. This is particularly true for the survival of Small-to-Medium sized Enterprises (SMEs). While the author anticipates that cloud computing will revolutionise the way SMEs operate and compete on a global scale, there is little literature on SMEs assessment capabilities. This literature review offers a state-of-the-art in cloud computing across SMEs and examines methods of how cloud initiatives could be assessed. The author identifies a number of key factors for assessment and highlight significant gaps particularly in the realisation of cloud readiness and assessing 'cloud value'. The emphasis here is a change in organisational architecture and support how managers reengineer cloud provisions by orchestrating their capabilities to optimise return-on-investment (ROI). The chapter offers a discussion on

addressing the literature gaps by introducing the Cloud Service Capability Assessment Framework (CSCAF) to support cloud computing assessment.

1.2.1 The Service Environment

The service industry continues to play a critical and dominant role within the global economy [2, 3, 4, 5]. A service may be defined as "*a means of delivering value to customers by facilitating outcomes customers want to achieve, without the ownership of specific costs and risks*" [6]. Nowadays, services are wrapped up in a complex business and IT environments. For example, the Internet offers a distributed platform to port services across the world and has become one of the most significant industrial drivers in recent years, referring to the networking and connectivity of objects. IT is described as the third wave of the world's information industry. It captures the importance of Internet tools and technologies to support computing utility. This has also led to the realisation of cloud computing. Cloud computing is considered to be the next 'technological revolution' [7] which will transform the IT industry [8]. The National Institute of Standards and Technology (NIST) [9] define cloud computing as "*a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction*." Thus, understanding an organisations capability to adopt this paradigm has become increasingly important as part of their strategic planning. Cloud readiness is one of the emerging concepts which support organisations ability to take stock of their resources and their capability to adopt cloud solutions. Cloud readiness is a critical assessment strategy which examines the organisational ability to adopt a cloud service infrastructure to support service provision. However, while much of the literature is primarily concerned with large organisations and MNOs, the author has identified the gap and need to examine cloud readiness of SMEs.

1.2.2 Defining Cloud Computing

Cloud computing has resulted in a number of technological and business shifts which provide an opportune period to promote the adoption of cloud initiatives. However, due to the explosive uptake of the cloud [10], there has been some blurred concepts as to what constitutes as cloud computing. In fact, according to Cohen [11] it is the "lack of understanding" which has held many organisations back from adopting the cloud. In effect, there is a resistance amongst managers with the expectation for organisation to swiftly move from a traditional business model which has served organisations well up until now to one which has yet to be proven. This section attempts to clear up the meaning of cloud computing as we examine what the literature defines as cloud computing (see Table 1).

Although Table 1 demonstrates the various understanding of what constitutes as cloud computing, they do share common characteristics. For example, this chapter defines cloud computing as an enabling effort and overarching philosophy which exploits Internet technologies as organisations provide or avail of resources and competences through flexible and economic IT-enabled infrastructures. Buyya et al. [12] highlights the economic promise of cloud computing and explains that it is "*a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements*". This may be

achieved through a number of service models. There are generally three main categories of the cloud computing models:

Author	Definition	Macro Characteristics
Buyya et al. [12]	"…parallel and distributed system consisting of a collection of interconnected and virtualised computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers".	• Distributed system • Interconnected • Virtualised • Dynamic • Negotiations • Provider • Consumer
Armbrust et al. [8]	"…both the applications delivered as services over the Internet and the hardware and systems software in the data centres that provide those services"	• Applications • Delivery • Internet • Hardware • Software • Data centres
Gillett [13]	"A form of standardized IT-based capability – such as Internet-based services, software, or IT infrastructure – offered by a service provider that is accessible via Internet protocols from any computer, is always available and scales automatically to adjust to demand, is either pay-per-use or advertising-based, has Web- or programmatic-based control interfaces, and enables full customer self-service."	• IT capability • Internet-based services • Software • Availability • Self-service
Cearley [14]	"help enterprises improve the creation and delivery of IT solutions by allowing them to access services more flexibly and cost-effectively".	• Improvement • Create IT solutions • Deliver IT solutions • Accessibility • Flexibility • Cost-effective
Wang et al. [15]	"set of network enabled services, providing scalable, QoS guaranteed, normally personalized, inexpensive computing platforms on demand, which could be accessed in a simple and pervasive way"	• Network services • Scalability • Quality of Service • Guarantee • Personalised • Inexpensive • Platform • On-demand • Pervasive
EC Expert Report [16]	"…an elastic execution environment of resources involving multiple stakeholders and providing a metered service at multiple granularities for a specified level of quality (of service)."	• Elasticity • Resources • Multiple stakeholders • Metered services • Quality

Table 1: Cloud Computing Definitions

- **Public Cloud**: a cloud is made available through a metered agreement for the general public [8].
- **Private Cloud**: internal data centres of an organisation or other organisation, which is not made available to the general public [8];
- **Hybrid Cloud**: a combination of public and private cloud developments.

These three categories may also be described as micro characteristics of cloud models. For example, see Table 2:

Model	Micro Characteristics
Public	• Flexible • Distributed users • Elastic • Freedom of self-service • Pay-as-you-use • Secure • Metered
Private	• Internalised business processes • Restricted access • Scalable • Accessible • Elastic • Shared
Hybrid	• Elastic • On-demand • Abstracted locations and equipment from the user • Combination of restricted and open access to services

Table 2: Cloud Model Characteristics

The adoption of these models is largely reflected in the service environment (i.e. the industry) and manager's confidence in their ability to become cloud providers/users. It is expected that as organisations become more accustomed to cloud capabilities they will become more tentative with experimenting with a combination of these models [1].

1.2.3 The Emergence of the Cloud

The exponential growth of technological developments has provided modern society with the expectation of rapid accessibility to services [17]. We have grown accustom to 'on-demand' services to meet our daily routines – making accessibility an essential requirement [2]. This had a significant impact within the business environment and how we now view services. IT has experienced the same phenomenon but at a much faster pace, i.e. utility computing. This was predicted back in 1969 when Kleinrock envisaged that we would witness

the evolution of computer utilities similar to that of electricity [18. 19]. This coupled with increasing demands for greater mobility and customised software at reduced costs has allowed service providers to become more competitive regardless of organisational size [20, 21]. In this sense, there is an apparent paradox with enabling greater competitiveness and shrinking market size. However, while more organisations choose to deliver and/or avail of the cloud opportunities, this adds greater complexity to the business environment, often making it difficult to assess the 'true value' of cloud developments [22]. Thus, cloud computing promises increased capabilities with little guidance as to how one can assess their capabilities within the cloud. In fact, it is suggested that cloud computing promises to transform the strategic value of an organisation through 'incremental and evolving objectives, competencies, and value measures' [23]. The question remains, *how can SMEs assess the value of cloud capabilities*? Therefore, at this stage, the attraction of cloud computing is exploratory in nature but some of the key benefits include the financial reward, ability to leverage existing investment, establish and defend a service franchise, leverage customer relationships, and to become a cloud platform [8]. Table 3 summarise the main advantages and disadvantages [24] of cloud computing. The disadvantages of cloud computing are often considered by CSPs as opportunities and we will invert these and argue they can provide a service that improves upon each of these through what the author describes as 'plug-in capabilities'.

Advantage	Disadvantage
1. Enhanced service accessibility (greater access to resources)	1. Often an unknown fit for the needs of the organisation (reliability, availability, accessibility, robustness, resilience, recoverability).
2. Backup and recovery (increased storage capacity)	2. Integrity (software functionality)
3. Increased competitiveness (faster access to markets) through improved access to resources	3. Maintainability (remoteness, priorities, SLAs) suggesting a limited scope of solution.
4. Scalability	4. Contingent risks (high impact on service operations)
5. Greater flexibility	5. Major service interruption (service survival, data survival)
6. Collaboration (sharing resources)	6. The need to support a flexible business operation
7. Lower investment / up-front cost	7. Security risks (service, data, authentication and authorisation, denial of service attacks)
8. Lower operational costs	8. Risk management strategies (compliance and usage)
9. Lower IT staff costs	

Table 3: Advantages and Disadvantages of Cloud Computing

The disadvantages of cloud computing have been identified as 'opportunities' by several large cloud providers an area which we will revisit later in this report. The advantages listed in Table 3 have resulted from a number of important shifts in the service ecosystem. The growth of the cloud computing is due to a number of key technological delivery factors (hardware and software) which came together over the last decade (Figure 1).

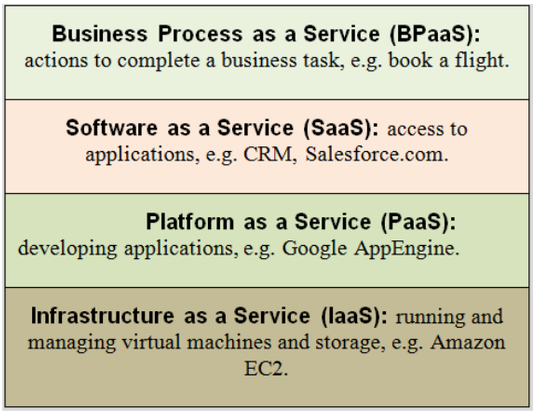

Figure 1: The Cloud Stack

Cloud computing comprises of four main layers and an overarching management layer which, in a real world scenario, would operate in most of the layers. Due to improved technological hardware capabilities, organisations can enjoy the benefits listed in Table 3. However, understanding how we can measure these cloud computing capabilities remains unclear. In addition, Armbrust et al. [8] list what they describe as the three main hardware aspects which are considered 'new' to cloud computing:

- **Agility**: creating the illusion of endless computing resources available on demand;
- **Reduced cost and increased competition**: eliminates end-users up-front commitment and thereby costs;
- **Resource efficiency**: supports short-term concept of "pay as you go" usage of computing resources.

This offers an immediate insight on the primary drivers behind cloud computing, i.e. greater access to computing economies of scale to generate greater business value, for example *cloudonomics* [25]. Considering the promise of cloud computing, it is critical that organisation can evaluate the opportunities presented to organisations. This is particularly important in the context of core business solutions, drivers and business initiatives to sustain 'value-added' activities.

1.2.4 Cloud Computing: Drivers and Trends

Over the last two decades we witnessed two important key cloud computing developments: 1) increase in technology capability and accessibility, and 2) the emergence of new business models. Similar to the growth in IT throughout the 1990's [26], combined these developments opened up new opportunities to apply technology to address business needs. The cloud computing paradigm promises greater accessibility to computing capacity from domain expertise providers allowing consumers access (anytime-anywhere) to resources via Internet connectivity. The availability and low cost of large-scale commodity computing infrastructure and storage enabled the emergence of cloud computing. This was also timely with the emergence of cost of electricity, growth in broadband, and economies of scale in hardware and software

development [8]. These factors also influence the location of data centres. According to Gillett [13] of Forrester Research, the main drivers which support the adoption of cloud developments include:

- Internet-based services (including social media);
- New IT infrastructure architectures and the availability of very high speed networks over extended distances;
- New business models which cater for flexible technology usage;
- Integrated service and product offerings.

Other trends which are often considered to be 'unwritten' [27] include:

- Low-cost access and computing devices (cost of devices continue to decrease);
- Parallel programming (increasing the number of CPU cores);
- Communication networks (Cloud-based applications);
- Open Source Software (allowing users to customise SaaS);
- Cloud access to high performance computing (utilisation of global e-infrastructures through Grid computing);
- Green computing (becoming more environmentally-friendly computing and make efficient use of electricity).

Therefore, as suggested above, the main rationale for adopting cloud computing may be summarised as opportunistic, cost, production, and catalytic. From a research perspective, we are reminded of Mooney et al. [28] where they suggest that there is a difference in the value drivers in the pre- and post-adoption of IT-enabled management and operational processes. Their framework examines the typology of business processes and impact of IT on processes. In addition, they suggest that by examining the impact of IT on processes, we can derive a 'business value' of IT. This research proposes the need to examine this in a cloud computing context. While there is much hype about the promise of cloud computing, industry analysts (for example, Gartner, Forrester, and Morgan Stanley) predict how it will transform our understanding of the 'organisation' where boundaries continue to erode. However, there is no '*one size fits all*' approach [29]. The consumption of service varies drastically and influences the derived benefits from their requirements and application. The cloud does not represent a shift in how IT services are produced or even managed but rather it shifts our understanding on how IT is valued and accessed to deliver services. For example, pricing is a hot topic across cloud computing literature. Armbrust et al. [8] explain that one of the key drivers of the cloud is the elasticity of resources adding to the competitive armour of an organisation. While one of the benefits of the cloud is the 'anytime-anywhere' factor, this also causes concern, particularly regarding the 'anywhere'. The physical location of the data centres are often influenced by the laws which govern that area and the techniques used to protect data. Buyya et al. [12] highlight how Amazon EC2 has introduced the concept of 'availability zones' (i.e. a set of resources that have a specific geographic location) which appears to have set a trend regarding cloud storage and security. Service provision is also protected through service level agreements (SLAs). SLAs establish the terms and conditions upon which a service is provided, for example, pricing mechanism and Quality of Service (QoS). Thus, many of these factors influence the decisions in the transition towards cloud computing.

1.2.5 Transition towards the Cloud

The transition towards the cloud is often considered a daunting process. It can be a time consuming process and is often hindered by the fear of 'unknown' financial investments coupled with security risks (for example, see the Open Group, 2009; 'Risk Taxonomy' [30]). However, prior to cost assessment, it is also important to gain an understanding on whether the service ecology is 'ready' to make the move. This places emphasis on the need to incorporate a capability assessment tool. There are two key questions which managers must ask clearly answer regarding their motivation to adapt cloud computing [22]:

1. Are you trying to reduce cost or add value?
2. Who will benefit from the use of cloud computing – the IT group or business units in the enterprise (including clients or customers)?

The transition towards the cloud is also influenced by the presence of existing technological capabilities, for example, service orientated architecture (SOA) environment. The benefits of the cloud are similar to SOA. For example, some of the main characteristics of SOA are its flexibility in processes, its reusability of services, and its ability to reduce the complexity in service execution [31], making the transition more informed. Cloud computing and SOA may be viewed as complementary activities since both play critical roles in IT planning and management. Cloud computing presents a value-added offering to SOA but does not replace SOA initiatives. SOA components can leverage software over networks using standards-based interfaces which can benefit from the platform and storage services as a less expensive scalable commodity. Cloud computing and SOA share similar drivers such as cost reduction. As illustrated in Figure 2, there are significant overlaps in cloud computing and SOA [32]. However, we must be mindful that they have different focus to address problems within the organisation.

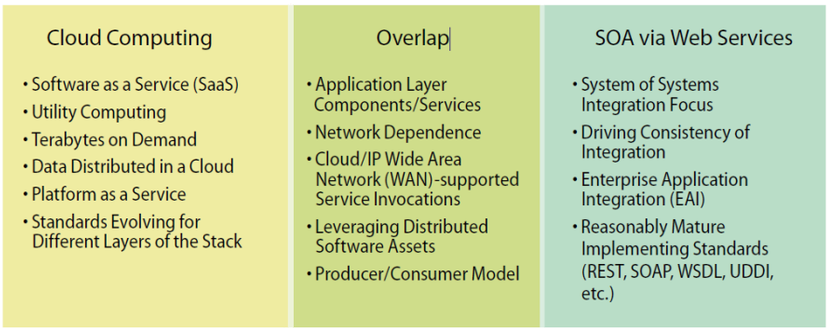

Figure 2: Overlapping Concepts from Cloud Computing and SOA [32]

For example, SOA is primarily concerned with enterprise integration technologies to efficiently exchange information between systems. SOA implemented technologies include Web Services standards which support greater integration across different development languages by providing a language neutral software layer. This allows organisations to maintain a certain level of consistency across enterprise architecture for additional integration. Cloud computing, on the other hand, focuses on using the network to outsource IT functions as commodities where it may be considered a more viable option than supporting the IT function internally. Therefore, cloud computing provides on-demand access to virtualised IT resources across the

Internet. Thus, while SOA and cloud computing share many characteristics, they should not be considered synonymous [32].

In most cases however, managers require some form of guidance to support their ability to decide on their readiness for cloud strategy and enrolment. We examine some of the prominent assessment models which are used to assess IT-enabled business strategy. Assessment models have always been greeted with enthusiasm and criticism. For example, Mettler [33] explains that Capability Maturity Model Integration (CMMI) assessments are too forward-looking from a maturity assessment perspective. In addition, Gefen et al. [34] warns that one of the most common criticisms of CMMI is its excessive documentation which may "*lead to a loss in motivation and creativity*". Thus, we must design assessment strategies which allow SMEs to easily explore and examine their cloud capabilities. This is critical as according to the EC Expert Report [16] one of the open research issues is that "*cloud technologies and models have not yet reached their full potential and many of the capabilities associated with clouds are not yet developed and researched to a degree that allows their exploitation to the full degree, respectively meeting all requirements under all potential circumstances of usage*". Thus, this forms part of the author's motivation towards the assessment of cloud computing environments.

1.3 Assessing the Cloud

Cloud readiness is associated with service improvement. In order to assess process improvement Humphrey [35] suggests that one requires four key components:

1. A framework to measure the improvement;
2. Advice on the approach to take;
3. Guidance on the methods to use;
4. The way to benefit and build on the experience of others.

Assessing the cloud steers this research effort towards understanding cloud service metrics. Brooks [36] cautions that we must be careful when selecting service metrics. Just because a measure may be easily available does not ensure that we are making the correct choice of measures. He suggests some key principles when choosing metrics. IT Service Management (ITSM) practice recommends adopting the philosophy of the following principles [36]:

- **SMART** (Specific, Measurable, Achievable, Realistic, and Timely):
  - Metrics should be realistic and concise within a specific timeframe.
- **KISS** (Keep It Simple Stupid):
  - Metrics should be explained well in a simple format.
- **GQM** (Goal-Questions-Metrics-Method):
  - High-level goals which are used to decide what metrics to employ.
- **MAPE** (Mean Absolute Percentage Error):
  - A statistical technique used to establish reliability.
- **Customer Relationship Diagram**:
  - A mapping method of the most immediate customer relationships which identifies the processes between the organisation and customer in a simplistic manner, e.g. customer satisfaction.

While adopting these metric principles, Brooks [36] also suggests that a process should be designed to monitor appropriate status from the beginning. In addition, if changes occur, communication and training should be provided to develop a thorough understanding as to the impact of this change. Brooks [36] advises that we should not implement a "*catch-all statuses or categories*" as metrics in service management making it is important to monitor and manage these statuses and categories, particularly in assessing cloud readiness.

According to Orand [37], the main issue associated with IT is the inability to improve service provision due to a lack of 'proper' measurements. There is often a mismatch in IT personnel's ability to address the business needs as business demands more for IT support and functionality. The alignment of IT and business is often only experienced as an organisation matures [38] to support evolving strategies (if organisations survive to that point). While there is often a lot of discussion surrounding business and IT capabilities, consider for a moment that business do not 'want' IT but rather, they want the 'service' which is provided by IT (Figure 3). This research describes this as cloud value co-creation [56], i.e., the alignment of business objectives and IT capabilities to supports organisations ability to generate value. IT is a cost, and yet it enables business value. Thus, we ought to be interested in the output of a service and the capabilities employed to reach the desired output. What is of immense interest here is the ability to assess cloud capabilities in delivering the desired output.

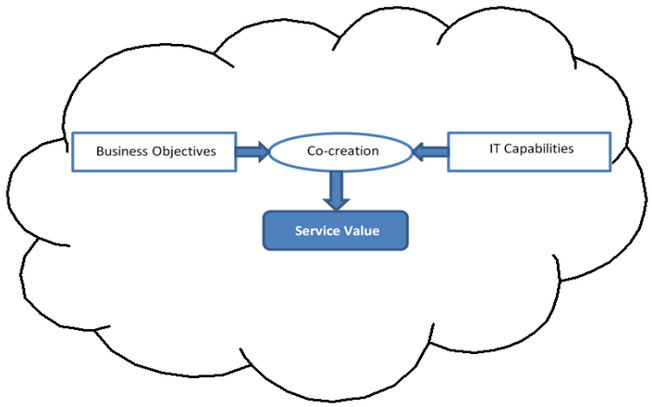

Figure 3: Cloud Co-creation

Organisations rely on the alignment of business objectives and IT capabilities to create value. However, what if organisations identify a niche market which they can provide a solution but may lack one or two essential IT capabilities to be successful in this space. SMEs can view this as a hindrance or an opportunity. Consider the opportunity of SMEs offering 'plug-in capabilities' to support external organisations ability to avail of greater cloud solutions. The author examines this in light of existing service management standards. Several efforts have surfaced as world leading standards in IT Service Management and IT Quality initiatives for governance, quality, and operational guidance. These include (but not limited to):

- Capability Maturity Model Integration (CMMI);
- Control Objectives for Information Technology and Related Technology (COBiT);
- Open Group Architecture Framework (TOGAF);
- IT Service Management;
- The IT Infrastructure Library (ITIL, ISO 20000);

- IT-Capability Maturity Framework (IT-CMF);
- Service Management Index (SMI).

There have been a number of efforts to access cloud computing environments. It has become increasingly difficult for customers to decide on a cloud service provider based on their individual requirements [39, 12]. Garg et al. [39] propose a framework which suggests that service quality may be matched with service requirements. However, this is once again from a technical (software) perspective rather than a business-oriented view (focusing on the business value of cloud 'as-a-Service' components). The research focuses on how one could dissect service capabilities to improve capability assessment methods.

1.3.1 Capability Assessments

Capability assessments have been well documented throughout literature, particularly in the information technology (IT) field. However, due to the explosive growth in cloud computing, efforts to assess the organisational capabilities of SMEs to adapt 'the cloud' are almost non-existent. This presents a significant burden of SMEs to understand the benefit of cloud computing or to optimise their existing cloud operations. Therefore, to address this problem the author began to structure the capability assessment process following traditional approaches such as the Capability Maturity Model (CMM). There are five factors which must be considered in the assessment including:

1. **The maturity levels**: presents a scale of one to five, where five is the ideal maturity state.
2. **Key process areas**: clusters specific business process or activities which are considered important to achieve a business goal.
3. **Goals**: goals of individual processes and to what extent they are realised indicates the capability and maturity of an organisation.
4. **Common features**: describe the practices which implement a process centred on performance mechanisms.
5. **Key practices**: the infrastructure and practice which contribute to the process.

While this chapter adopts this structure and based the development of CSCAF, one must be mindful of the need to examine cloud capabilities from a management level (i.e. business-oriented metrics rather than IT-oriented metrics). Processes are measurable and are therefore performance-driven. The main objective of developing a capability assessment is to provide some level of measurement which can generate data to support decision-making. These measurements can support managers determine process status and effectiveness being executed by their cloud strategy. It can also allow organisations identify where opportunity exists at various levels identified by CMM (discussed later in this chapter). Therefore, the initial step to assessing capabilities is to have a clear and concise understanding of how one can:

- Determine organisational goals of cloud computing initiatives;
- Identify the organisational objectives of how they set out to achieve the goals;
- Define specific measures which influence decision-making:
    - Determine individual process goals
    - Determine individual process objectives
    - Determine individual process measures.
- Establish a cloud readiness and capabilities assessment framework.

The assessment process is a significant contribution to both practitioners and academia. This work is also influenced by previous works such as Sycara et al. [40] and Paolucci et al. [41] who examine the semantics of matching engines. The author attempts to simplify this approach in a business context.

1.3.2 IT Infrastructure Library (ITIL)

In order to achieve some level of consistency, good practice must be established and become a commodity of achieving desired results. The IT Infrastructure Library (ITIL) is an example of this approach which defined best practice and became 'good practice' (see Figure 3). One of the prominent ITSM practices which guide the alignment of IT service with business needs is the ITIL. ITIL describes specific procedures, tasks and checklists which may not be organisation-centric but is employed to examine service compliance and to measure improvement. The ITIL was initially designed as a library of defined best practice (i.e. tried and tested in industry) which dates back to 1986. Nowadays, ITIL v3 presents a holistic view of the service lifecycle with particular attention on IT which support service delivery. Orand [37], describes ITIL as "*documented common sense*". While ITIL does not prescribe how to do things, it merely highlights what ought to be carried out in order to reach a desired outcome. Thus, ITIL has become the de facto for over 20 years of IT Service Management. The author identified the potential of examining cloud readiness through this cyclical approach (see Figure 4) while recognising the need to adopt ITIL to suit a cloud computing context. For the purpose of this chapter, the author examine the promise of ITIL in cloud computing.

Figure 4: ITIL Service Lifecycle V3 ([52])

As illustrated in Figure 4, the service lifecycle comprises of five stages:

- **Service strategy**: guidance to developing an overall strategy (for example, markets, customers, capabilities, resources, financial) to align business needs with IT capability. The main components covered within service strategy include:
  - Strategy management
  - Service portfolio management
  - Financial management of IT services
  - Demand management
  - Business relationship management

- **Service design**: guidance to balance design and service constraints for example, requirements vs. financial resources) to streamline automated processes. The main components covered within service design include:
  - Design coordination
  - Service catalogue
  - Service level management
  - Availability management
  - Capacity management
  - IT Service Continuity Management (ITSCM)
  - Information Security Management System
  - Supplier Management

- **Service transition**: guidance in transitioning a service into operation (i.e. technical and non-technical) through enterprise architecture. The main components covered within service transition include:
  - Service Level Management
  - Service level management
  - Availability management
  - Capacity management
  - IT service continuity management
  - Information security management system
  - Service asset and configuration management
  - Release and deployment management

- **Service operation**: guidance on effective and efficient operation of the service, i.e. aligning strategy and objectives with service execution and technology.

- **Continual service improvement**: ensuring continual improvements throughout the organisations lifecycle, not just a service (e.g. people and governance).

These stages play a fundamental part in our assessment of cloud readiness and capabilities and the development of the CSCAF. The author considers these stages to play a role in the assessment of organisational macro capabilities within which more detailed assessment may be carried out to pinpoint areas of weakness.

1.3.3 Control Objectives for Information and Related Technologies (COBIT)

The Control Objectives for Information and Related Technologies (COBIT) is a framework [53] which supports the management and governance of IT. It supports managers' ability to identify business requirements, risks, and technological issues within their organisation. COBIT was launched in 1996 to establish an international set of standards in the day-to-day operations of an organisation directed towards managers and IT staff. This section examines how this offers an agile support tool to provide cloud services. The COBIT framework consists of 34 core processes to manage IT, and validated from "*41 international source documents*" [42]. The processes identify the objective, input, output, and performance through a maturity model. These processes are also aligned with the business objectives, thus creating a better linkage between business and IT. In doing so, there are shared metrics and responsibilities of process owners within four main categories:

1. Plan and organise;
2. Acquire and implement;
3. Deliver and support;
4. Monitor and evaluate.

COBIT is also known to act as an umbrella framework for a number of good practices including, ITIL, ISO 27000, CMMI, and TOGAF. Within the COBIT 5 framework (see Figure 5), users can benefit from its process descriptions, control objectives, management guidelines, and maturity models. However, from a SME perspective, adopting COBIT can become a very time-consuming and cumbersome task guideline to support SME cloud operations. This motivates the author to establish an easily adoptable framework which integrates the benefits of COBIT.

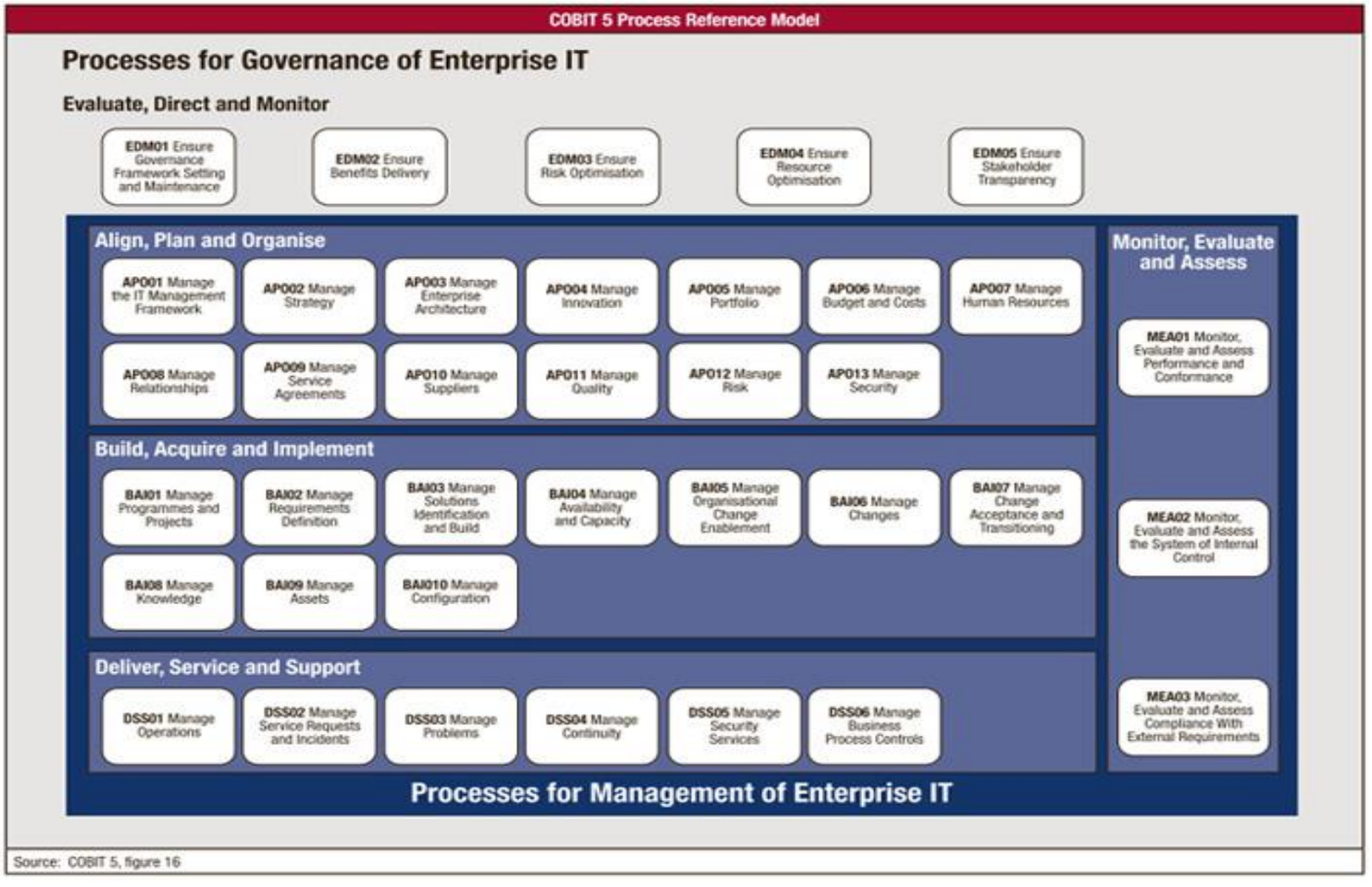

Figure 5: COBIT 5 Framework ([53])

As illustrated in Figure 5 the latest version of COBIT (COBIT 5), provides and end-to-end view of enterprise IT governance. This highlights the important role that information and technology plays in the creation of value within an organisation. The principles and practice of COBIT 5 can also provide a valuable lens in cloud computing particularly in business and IT governance. COBIT 5 provides five key IT management and governance principles:

1. Meeting stakeholders needs;
2. Covering the enterprise end-to-end;
3. Applying a single integrated framework;
4. Enabling a holistic approach;
5. Separating governance from management.

These are important principles for cloud computing initiatives. For example, COBIT 5 may be adopted in cloud computing to enjoy the benefits of supporting business decisions and strategic goals through the innovative use of cloud initiatives. In addition, COBIT 5 provides the tools to maintain an acceptable level of IT-related risk and cost control through various process compliance guidance.

1.3.4 Service Measurement Index (SMI)

The Service Measurement Index (SMI) is a performance-orientated service standard which is being developed to support organisations ability to compare service provision based on business and IT requirements [43]. It examines and compares business objectives and business value to support decision-making tasks. The SMI provides a good platform upon which we can examine the quality of public, private or hybrid cloud services. Considering the complexity of cloud service networks, measuring the performance and value of service offerings is of critical importance to managers regardless of their organisational size (for example [44]). At Carnegie Mellon University, the Cloud Service Measurement Initiative Consortium (CSMIC) [54] is currently exploring how they might adapt a SMI hierarchical framework. The SMI model examines six main measurement categories. It provides a relative index to compare and monitor services (scoring 1-99). Therefore, SMI is dependent upon consumers' ratings which evaluate six main factors or metrics of a service:

1. Quality;
2. Agility;
3. Risk;
4. Cost;
5. Capability;
6. Security.

As the status of SMI grows their database may populate with rich data while indicating which metrics are of greater importance to various services (for example, security is of greater importance in email exchanges rather than cost). Therefore a comparison is required to benchmark performance of services with similar functionality through service taxonomy. SMI use the term "goodness" to imply the "appropriateness" or "usefulness" of consuming a service through the following characteristics (Figure 6):

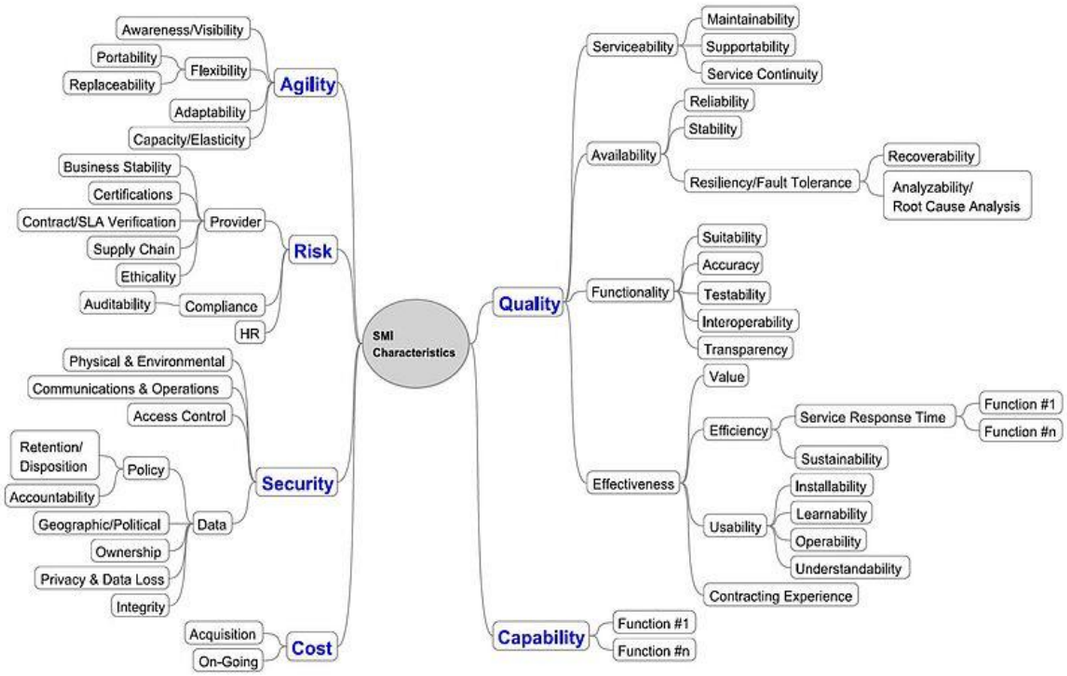

Figure 6: SMI Overview [43]

The service provider is asked to rate the service under each of the categories illustrated in Figure 6 based on their desired business objective. The key performance indicators (KPI) data is used to examine which service provider would best match their performance. In effect, this adds greater agility to a businesses' strategy, improves service quality, and 'informs' business strategy. While SMI presents significant promise to the cloud world, it remains in an early development stage. We identify the need to support SMEs in their adaptation of cloud initiatives and we approach the assessment strategy from a different perspective focusing solely on cloud readiness and service capabilities. This research wishes to establish a catalogue of cloud characteristics and their relationship to examine business value and support the assessment of cloud capability within SMEs through a registry of cloud services.

1.4 Exploring Cloud Capabilities

Understanding cloud capabilities is a critical managerial task for SMEs as they strive to provide and/or avail of cloud solutions. Thus, this CSCAF approach offers a tool which can reduce the risk of transforming cloud strategies though informed decision-making. Assessing cloud capabilities draws the author's attention towards the concept of 'capability maturity' which was first introduced back in the 1970's by the Software Engineering Institute (SEI). The initial focus of capability maturity was on three broad categories:

1. People;
2. Processes;
3. Technology.

This became known as the Capability Maturity Model (CMM). There have been many reiterations of CMM to what is now described as the Capability Maturity Model Integration (CMMI) [55]. CMMI is largely adopted as the preferred IT quality standard across the world [45]. It has been proven to work both quantitatively and qualitatively through more established and improved work paths. CMMI was originally developed as a government software assessment tool. Watts Humphery's work provided a platform for the development of systematically managing software processes [46]. The model began to evolve when he joined the Software Engineering Institute (SEI) and widely adopted as to assess the maturity of processes. There are five main maturity levels within the CMMI model:

1. **Initial**: undocumented starting point.
2. **Repeatable**: documented process to allow the process to be repeated.
3. **Defined**: confirmation of process becoming standardised.
4. **Managed**: agreed metrics to evaluate the process performance.
5. **Optimising**: managing the improvement of the process.

These levels provide a holistic view of process maturity. Within each phase there are the key process areas which examine the goals, commitment, ability, measurement, and verification as they reach greater maturity. Ultimately, these steps were designed to improve performance through quantitative process-improvement objectives. However, one of the biggest criticisms of the CMMI model is the cost associated with adopting it assessment activities (training and appraisal). Considering the focus of this work is on SMEs, the author emphasises the need to develop an inexpensive and easily adoptable framework. A capability may be simply described as the ability to perform an action. Cloud computing does not refer to a specific technology per se; rather describes an enabling paradigm which supports business capabilities. There are a number of essential capabilities which are associated with cloud computing [16]:

- **Non-functional capabilities**: describes the properties of a system;
- **Economic capabilities**: describes the resource management process through cost reduction;
- **Technological capabilities**: identifies the realisation of IT-enabled value within cloud service systems.

The author also examines these macro capabilities in further detail to gain an understanding of the capabilities of cloud service system which have also considered in the development of the CSCAF.

1.4.1 Non-Functional Capabilities

The non-functional capabilities are the properties which stabilise the cloud eco-system. These include:

- **Elasticity**: the capability of a system to adapts its underlying infrastructure to meet requirements. This is critical considering the need for greater scalability (horizontal and vertical).
- **Reliability**: the capability to constantly ensure the ability to support data and applications without loss or damage to data or services.
- **Quality of Service (QoS)**: the capability to meet specific requirements using specific metrics to analyse the level of quality (for example, response time, throughput, etc.).
- **Agility and Adaptability**: refers to an organisations elastic capability and the ability to respond to change within a particular environment. This is often measured by response time, size of resources, quality, and availability of 'different types' of resources.
- **Availability**: a central capability which supports the emergence of the cloud paradigm. The redundancy of services adds greater transparency and mechanisms of penalising service failures. This also supports scalability within the cloud environment.

1.4.2 Economic Capabilities

Economic capabilities play a central factor to the uptake of cloud computing. Cloud service systems support the following capabilities:

- **Cost reductions**: organisations avail of reduced methods of infrastructure maintenance and acquisition costs which also influence human behaviour in a number of ways, for example:
    - *Pay-as-you-use*: a consumption-based cost model which allows organisations to bill customers for the resources they utilise. Customer requirements and quality are met by the cloud offering and allowing them to avail of resources without the initial upfront cost. This also allows SMEs to accelerate their service solutions development.
- **Time to market**: this supports SMEs ability to sell more quickly without experiencing barriers with setting up the infrastructure to compete with Multinational Organisations (MNOs). This allows them to remain competitive.
- **Return on Investment (ROI)**: determining whether the cost and effort is smaller compared to the commercial value and benefits of return. Therefore, it is crucial that an organisation understands where the cut-off point is in which cloud computing is no longer a viable option.
- **Turning capital expense into operating expense**: the benefits of cloud computing may be difficult to determine. Capital expenditure is associated with infrastructural costs but outsourcing capabilities allows organisations to convert capital expense to operational expense.
- **Green IT**: this applies to an organisations capability to reduce energy costs and the carbon emissions.

1.4.3 Technological Capabilities

There are many technological capabilities associated with cloud computing some of which are considered the main ROI in cloud computing. These include:

- **Virtualisation**: hiding the complexity of cloud computing is considered to be an essential characteristic. Virtualisation also enables greater flexibility though the following attributes:
- **Ease of use**: the management and configuration of the system is often integrated in an application to easily operate and control the system.
- **Infrastructure independency**: supports increased interoperability through an independent coding platform.
- **Flexibility and adaptability**: a virtual execution environment allows organisations to meet requirements is a shorter timeframe.
- **Location independence**: cloud environments facilitate access to resources through Internet connectivity channels.
- **Multi-tenancy**: data may be sourced by multiple actors across a network although location of data may be unknown. This impacts how data is hosted and how applications are developed to port the data.
- **Security, privacy, compliance**: organisations must consider the sensitivity of data which is created, stored, and shared across a virtual network.
- **Data management**: managing data is a critical component of cloud storage which orchestrates the distribution of data in a flexible and consistent manner. This is connected with the quality of service (QoS) and both the horizontal and vertical factors associated with scalability.
- **APIs**: provides a common programming interface to create and extend service provision.
- **Metering**: organisations may offer an elastic pricing mechanics on the consumption of resources through a billing application.
- **Tools**: supporting the development and adaptation of cloud service provision and usage capabilities.

Commercial cloud tools are typically developed independently from one another which attempt to solve customers' problems. However, there is often little technical convergence between these solutions, except for the potential of what the author calls 'plug-in capabilities'. The cloud development lifecycle tends to begin in-house, provide internal solutions, and offer cloud capabilities through public cloud service offerings. Interoperability is considered one of the main issues associated with proposing a cloud interface which raises issues of an Open Cloud approach. This highlights the importance of this work in the need for cloud capabilities assessment and matching. The author presents an assessment approach to examine cloud capabilities using CSCAF as we consider the importance of the IT Infrastructure Library (ITIL). This chapter examines these and summarise their main attributes which support the establishment of the CSCAF. This chapter examines cloud capabilities from a number of perspectives including, strategies, tactical, and operational (see Figure 7).

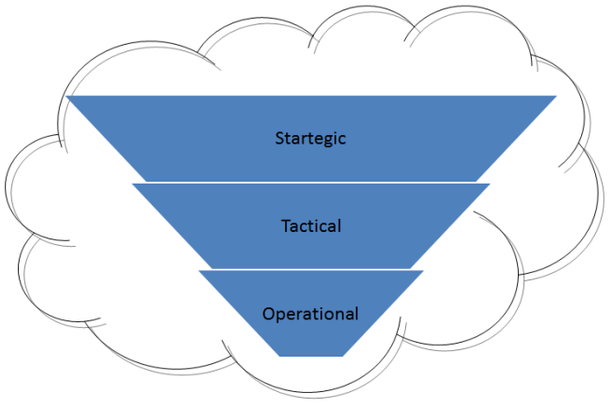

Figure 7: Overview of Cloud Capabilities Assessment

Figure 7 illustrates how the author approached the task of assessing cloud capabilities emphasising the need to "drill down" to operational capabilities and establish cloud service metrics for SMEs. Each management level typically requires different levels of analysis to support their decision-making tasks.

Strategic Cloud Service Capabilities

Strategic capability is concerned with the survival and sustainability of an organisations ability to meet business goals and identify methods to generate additional opportunity and value. The four main activities of service strategy are:

1. Defining the service market;
2. Developing service offerings;
3. Developing strategic assets;
4. Executing the service plan.

Managers must be able to identify the factors which they deem controllable and also act upon the uncontrollable to adjust internal operations accordingly. Their decisions have a direct impact on both the short-term and long-term future of an organisation. Many of their decisions are high level and driven by management vision. These may be categorised as tangible (for example increase market share) and intangible (enhance social and environmental image). Examining strategic capabilities requires a resource-based (i.e. skills, assets, and competence) lens to examine the service value-chain though internal audits, benchmarking, or a SWOT analysis. Capabilities consist of what may be described as 'soft assets' for example, management, organisation, processes, knowledge, and people [6]. This allows managers to scan the business landscape and identify how they can align and build on internal capabilities with external opportunities. For example, one should consider the following resources from a strategic capability perspective before planning to migrate to the cloud:

- **Human Resources**: how does our human capital provide value to exploit cloud opportunities?
- **Physical Resources**: how do our assets provide value and competitive advantage?

- **Technological Resources**: how do our IT capabilities provide business value and competitive advantage?
- **Financial Resources**: is cloud computing a viable option for us and how will it optimise business value?
- **Intellectual Capital**: should we invest in R&D to become leaders in innovative cloud solutions?

In addition, managers must develop an understanding of how cloud computing can support organisational functional areas (i.e. performance for specific outcomes), for example:

- **Finance department**: where can we improve on cost savings through cloud solutions?
- **HR department**: how can we attract new talent with expertise in cloud computing?
- **Marketing department**: how can we create greater awareness of our cloud capabilities?
- **Logistics department**: how can we reduce the burden of costs through cloud computing?
- **Research and Development department**: where should we invest in more research to embrace the promise of cloud computing?

Functions have certain characteristics which represent an organisation, resources, and capabilities which sustain an organisation. As suggested in the lists above, organisations must carry out an assessment and benchmark themselves against their main rivals or industry levels. This is necessary to sustain competitive advantage and motivates management to remain focused on their strategy for comparative performance (i.e. a SWOT analysis). Examining cloud capabilities from a strategic level allows managers to unveil the economic fundamentals to support cloud computing growth. It allows managers to question, for example: how do we offer a distinctive service? What can customers substitute? Which of our services offerings and channels is most profitable? What is generating profit in cloud computing and where are we positioned to benefit from this? Which service process is the most effective? What are the significant game changing trends which are emerging in the business landscape, and where are the constraints which would allow us to gain improved competitive advantage? These are the fundamental questions which managers explore to examine the configuration of underlying drivers in cloud computing at a strategic level. Therefore the following capabilities which we would associate with cloud computing at a strategic level (guided by IT Service Management (ITSM)) include:

- Business Perspective Metrics;
- Continuous Service Improvement Programme;
- Risk Management:
  - Documentation Management
  - Competence, Awareness and Training.

The major output of service strategy is the Service Level Package (SLP) which documents the business requirements and influences the service design [6]. Therefore, form a strategic perspective, it is important that managers understand the business desired outcomes and value of a service in business terms rather than IT terms. This requires managers to ask “why” they do things rather than “how” [6].

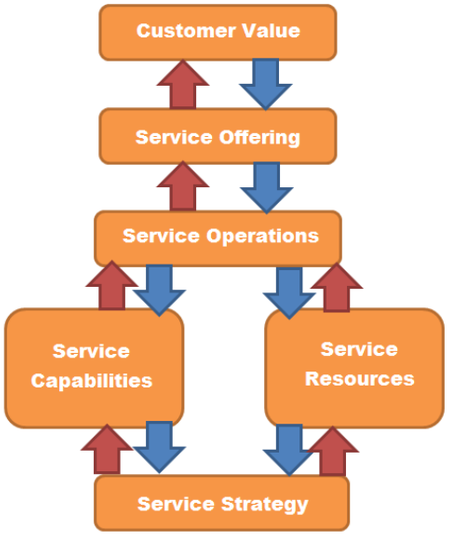

Figure 8: Dual View of Service Strategy Co-creation

Figure 8 illustrates a simplified view of service strategy of how managers must realise customers' expectations and value before they establish the strategy. This dual view highlights the need to identify the critical success factors (CSFs) which determine the underlying requirements of a service to ensure success. It also allows managers identify areas for opportunity or continual improvement. The service strategy is typically defined through a service portfolio which determines an organisations commitment to generate customer value. The author incorporates these views into the CSCAF where they can make a valid assessment contribution for SMEs in cloud computing.

Tactical Service Capabilities

Tactical capabilities are largely concerned with managing how a strategy is to be realised through various implementation processes and a set of procedures. This draws our attention towards the management of the service lifecycle since cloud computing enables service delivery. For example, some tactical capabilities would include the implementation of Capability Maturity Model Integration (CMMI) and Information Technology Infrastructure Library (ITIL) assessment practices to govern and monitor service delivery. Adopting a tactical view of cloud capabilities allows managers to examine the value-chain and how operations align with cloud strategy. This also encourages managers to examine the strategic relevance of adopting or 'the cloud'. Therefore the strategic value is reliant upon the successful execution of the tactical strategy. In general, one can view tactical capabilities in how the cloud can fulfil the organisational strategy as opposed to being just an organisational fad. From a tactical perspective, the transformation of an organisation's ability to provide or adopt cloud solutions would include the following capabilities which we can associate with cloud computing (guided by ITSM):

- Service Level Management;
- Problem Management;

- Financial Management for IT Services;
- Capability Management;
- IT Continuity Management;
- Availability Management;
- Security Management.

These capabilities are also incorporated into the CSCAF where they can make a valid assessment contribution for SMEs in cloud computing. Tactical capabilities are concerned with supporting short-to-medium term planning objectives which focuses on the current day-to-day operations ('how things are'). From a manager's perspective, they must orchestrate and govern business processes in a successful manner, for example, one year marketing strategy, a one year budget and finance plan, or project management. Tactical capabilities are more informed than strategic capabilities since tactical plans are more detailed and therefore require more rigid service metrics. However, it is worth noting that both strategic and tactical capabilities must be linked to one another considering that organisational success relies on the successful integration and completion of both strategic and tactical planning stages. Therefore, tactical capabilities are concerned with how business is conducted within the service lifecycle. Tactical capabilities must inform strategic management to become familiar with concepts which govern the success of planning and implementation. Success is critical to improve managers' confidence and competitiveness within the cloud environment. Thus, the success if tactical capabilities are also dependent upon operational capabilities.

Operations Service Capabilities

Operational management requires a more detailed approach towards designing, controlling, and managing business processes which directly impact on service operations. Operational management is entrusted with greater responsibility to ensure efficiency of service without jeopardising service quality to meet customer requirements. The author views it as a more 'hands on' approach to generate service value within the cloud. Therefore, there is a direct link on how operational capabilities support the realisation of business strategy (strategic capabilities), often controlled by tactical planning. Thus, operational capabilities require the governance of detailed service metrics. We are guided by ITSM to implement cloud service operational metrics, for example, the author considers:

- Incident Management;
- Service Desk;
- Configuration Management;
- Change Management;
- Release Management:
    - Application Support
    - Application Development
    - ICT Infrastructure Management

Service metrics are a critical part of supporting scientific management to quantify service operations and output. Cloud metrics are critical to aid decision-making and instil greater focus, vision, and cost savings within a business environment. In addition, cloud metrics assist managers to implement a 'vocabulary' which acts as a 'common language' to discuss cloud operations and cloud capabilities. The data which is derived from service metrics provide sufficient insight to report the 'truth' (or tell the story) on cloud capabilities and

performance indicators. Within a cloud environment the author considers operational capabilities and metrics to be extremely important. Defining cloud operational capabilities and metrics can be viewed as a daunting task but not a challenging one.

1.5 Establishing Cloud Capabilities and Metrics: The Process

One of the first tasks the author was faced with was to establish 'what' was to be measured regarding cloud capabilities and determine 'why' one ought to measure them. Therefore, establishing a common set of measures is paramount in order to begin a process of examining cloud capabilities. One must also consider whether we would like to establish Cloud metrics across similar service organisations or in more holistic terms, across an industry. The author opted for the latter to support the exploratory nature of this research in establishing the CSCAF. However, as this research evolves, the author will aim to derive more organisational-specific measurement approaches. For now, the author would entrust organisations to customise the CSCAF accordingly to meet their individual needs. IT resources can be pooled together to centralise core service capabilities through a ubiquitous range of hardware and software network channels. The dynamics of cloud computing impacts on the demand to meet the adjustability of service-level agreements (SLAs). This places greater importance of cloud capabilities, i.e. to optimise the value of core capabilities, for example:

- Business and Strategy Alignment;
- Financial/ Value Impact;
- Architecture and Infrastructure;
- Information/ Data Management;
- Security and Capacity Planning;
- Operations and Project Management;
- Project Portfolio and Asset Management;
- Organisation and Procurement;
- Governance and Roles.

1.5.1 Exploring Operational Cloud Processes

In the previous section the author discussed the capabilities at various management levels: strategic, tactical, and operational. This section adopt this view in terms of understanding cloud capabilities as it allows us to establish a measurement program which provides a balanced and comprehensive view of a service environment. One ay categorise service indicators into:

- Leading indicators (what we want in the future, i.e. desired results);
- Lagging indicators (how it was in the past or currently. i.e. customers' views).

It is common to incorporate and integrate both of these to determine how an organisation has progressed towards achieving their goals. Therefore, the measures which an organisation opts for must be repeatable to support the consistency of operational definitions. The operational definitions will define the specific purpose of a measure and it should address one of four broad categories:

1. Cost and effort;
2. Status and progress;
3. Non-conformance;
4. Performance and satisfaction.

Identifying which cloud capability measures belong to the categories listed above will provide organisations with the first step to establishing a cloud measurement programme (see Figure 9).

Figure 9: Assessment Overview

The steps describe above provide a holistic view of how managers should approach a measurement programme and the questions which managers might pose throughout the design phase. To support organisations achieve this one can expand on these steps and suggest that managers should:

- **Define the organisational goals** (‘*where do you plan to be in 10 years?*’);
- **Define the metrics associated with each goal** (‘*how will you know whether you have reached your goal?*’);
- **State the objective of the individual measures** (‘*what are you trying to answer through this specific metric?*’);
- **List the characteristics of interest** (‘*what factors are associated with this particular measure?*’);
- **Choose a measurement tool** (‘*how will we measure our progress?*’);
- **Determine the current status of progress i.e. benchmark** (‘*how do you compare yourself to the competition?*’);
- **Apply a method/formula to test metrics** (‘*how will we know whether we are on the right track?*’);
- **Monitor progress** (*who/what is enabling/inhibiting your ability to reach your goals?*’);
- **Communicate decision criteria** (*how have you got your team to support your vision to move in a particular direction?*’);
- **Review and repeat** (‘*what can I improve on when I repeat the process?*’).

As suggested from the list above, it is critical that each measure is linked with a business objective to achieve business goals. Once the goals have been firmly established, we can also establish the entities and attributes associated with them. This is where we begin to dissect the goals into more quantifiable metrics (both quantitative and qualitative measures). This allows us to identify what factors contribute towards the goal (i.e. entities) and how their characteristics influence measures (i.e. attributes). This is an important exercise when establishing cloud capability metrics since it identifies which indicators support decision-making tasks. It is advised that if you identify measures which do not influence decision-making, they should not be included in the measurement programme since they will not serve any real tangible purpose [36].

1.5.2 Defining Operational Cloud Processes

Defining cloud capability measures steered the author towards examining what data should be collected to construct our indicators. Firstly, one should develop clear and concise definitions of the measures we identified. The author identified the Service Management Index (SMI) assessment fields as an appropriate approach to generate cloud metrics (see Section 1.3.4). However, merely defining them is not enough. It is important that we test the measure to examine whether they derived any contributory value to the CSCAF. The measurements which reflect an organisations cloud environment must focus on the value generated by processes. Therefore, the selected measures should only be included if they can be acted upon. The simple test for this is to ask, "what can I do if this process fails" [36]. If you cannot answer this, you should not consider this to be an important metric since it will not impact on the decision-making tasks. Therefore, it is important that measures reflect the cloud environment, its objectives, and the organisational priorities. It is also important that organisations do not over emphasise one measurement over another, for example, cloud service availability over customer satisfaction. In this case, although the service is available, customers may be dissatisfied with the quality of service which can have drastic consequences for organisations. Managers must remain alert and faithful to all measures which are designed in their assessment program.

1.5.3 Establishing a Cloud Assessment Programme

Establishing a cloud assessment programme requires the commitment of the entire organisation, i.e. it must become institutionalised within the organisations culture. To begin this process, Table 4 summarises four main phases which should be considered: explore, establish, guide, and share.

Phase	Description	Component	Description
1	Explore	Processes	Overall processes used to govern and manage the project.
		Procedures	Supporting sub-processes to carry out the process.
2	Establish	Templates	Outlines and guides how to create consistency.
		Forms and checklist	Helps you plan and follow task completion and document progress.
3	Guide	Guidelines	Instructions that people can execute within the program.
4	Share	Repositories	Locations where you store your program elements for team members.
		Training material	Develop and ensure that people can adopt the program elements in a directed manner.

Table 4: Establishing the Assessment Programme

The first phase is similar to what is described in Section 1.4 which provides managers with the opportunity to analyse and reflect on the operations of their organisation. This exploratory phase may be categorised into two components:

1. Exploring the cloud processes: identify the process which support and stabilise a service environment.
2. Exploring the cloud procedures: examine the practices which govern the processes.

Once the process and procedures have been identified, the second phase requires managers to establish the process through two useful tools:

1. Templates: supports consistency in defining the processes.
2. Forms and checklists: allows managers to follow the progress of the assessment programme.

When the assessment metrics and practice has been established, it is important to document these in order to make it repeatable through the use of performance guides. This instructs people how to act within a specific guideline. The fourth phase is concerned with sharing the assessment programme and performance information through repositories and training material to ensure assessments are carried out in a structured format.

1.5.4 Reporting Cloud Service Metrics

Determining cloud service metrics is a data management and collection process. As highlighted throughout this chapter, data must support managers in their decision-making tasks upon which metrics are also tied to process ownership. The numeric objectives set out by managers must present some realistic rationale where improvements are made regularly. There are many components to the assessment processes. These components provide a solid foundation to develop service capabilities through rigorous assessment while identifying the following components (see Table 5):

Component	Description
Description	Description of the purpose and use of the process.
Entry criteria	Describe the previous activities and preconditions to successfully carryout the process.
Inputs	Items that are required to conduct the activities (e.g. documents, plans).
Actors	Roles of people to undertake the activities.
Roles	A set of responsibilities, activities, and authorities granted to a person or a team
Activities	Describe the steps to see the process through.
Outputs	Identify what outputs should appear after the activities are executed.
Exit criteria	The results that should be in place in order to conclude the process and responsibilities have been accounted for.
Measures	Define the measures you will collect for the process which will give insight on performance.

Table 5: Assessing Cloud Components

Table 5 summarises some of the main components which one ought to consider when assessing a cloud environment. This begins to structure the assessment process in measuring specific processes which best capture the data on cloud capabilities. The measures must be communicated to a team and repeatable by others. The approach we chose was to adopt was the influenced by combining ITSM and SMI since the author considered both to be the most appropriate for assessing cloud capabilities (for example, see Table 6):

Field	Description
Name of Measure	Name of measure
Description	Explain need for the measure
Specification	What objective is met
Metric attribute	Which attributes it relates to
Justification	Why measure is included
Service(s) where it applies	The specific services to which the measure is applicable
Definition(s) where it applies	Define context of application
Formula(s) and calculations	Now the measure is computed
Typical value range	What are the expected values
Examples	Links to a published use of the measure or description of its actual use.

Table 6: CSCAF Assessment Criteria

Table 6 presents the assessment criteria which are incorporated in our CSCAF assessment programme. These criteria appear to be the most suitable to quickly capture important data. It also establishes cloud metrics and supports the development of the CSCAF.

1.6 Developing the CSCAF

CSCAF is designed to offer a simplified analytical approach towards the assessment of cloud capabilities for SMEs at various levels in the cloud provision models (i.e., BPaaS, SaaS, PaaS, and IaaS). There are a number of evolutionary phases in the development of the CSCAF (Figure 10).

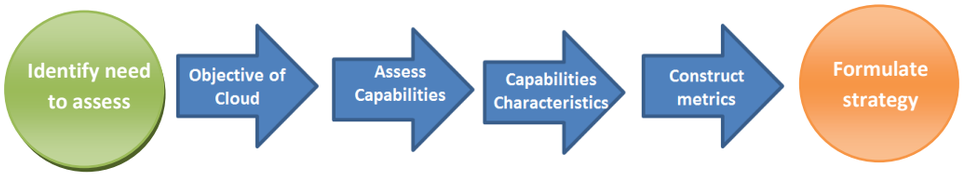

Figure 10: CSCAF Development Roadmap

While examining the promise of cloud computing, it is important to establish a framework to assess the value of cloud-enabled technologies from a business perspective. The roadmap outlined in Figure 10 is concerned with the exploration, design, and implementation of metrics for cloud readiness and adaptation while merging some of the key qualities of the frameworks that exists in ITSM and SMI. The aim of the CSCAF is to allow SMEs adopt the framework and customise it for their specific needs to realise the opportunities of value-based cloud analysis and improve capabilities. Many international standards, for example, the IT-Capability Maturity Framework (IT-CMF) examine IT functions in terms of (see Table 7):

Major IT Concern	Function
Money/Value	Financial
	Impact/value
	Portfolio management
IT Strategy	Business alignment
	Strategic planning
	Governance
IT Products	Architecture
	Engineering, Development, Delivery
	Project management
IT Services	Service, Support, Operations
	Security, Compliance
IT Assets	Asset management
	Capacity planning
Sourcing	Procurement
People	Organising, Roles

Table 7: Main IT Assessment Concerns

While the factors listed in Table 7 are undoubtedly important in the assessment of an organisational IT capability, we must be mindful that we have to cater for fast, efficient, and cost effective assessment practices within SMEs to examine cloud capabilities. This is concerned with understanding the 'business value' of cloud initiatives. Therefore, one may structure the main IT functions within the CSCAF to comprise of four macro analytical views (Figure 11):

1. **Innovate**: identifying the processes and aligning capabilities with service opportunity.
2. **Collaborate**: examining and mapping the process and information exchanges.
3. **Cost**: determine the contributory value of the process.
4. **Compare**: benchmark against existing cloud providers/users.

Each of these macro capabilities will examine the value of the cloud capability maturity and examine its status within the maturity curve (on a 1-5 scale adopted from CMMI).

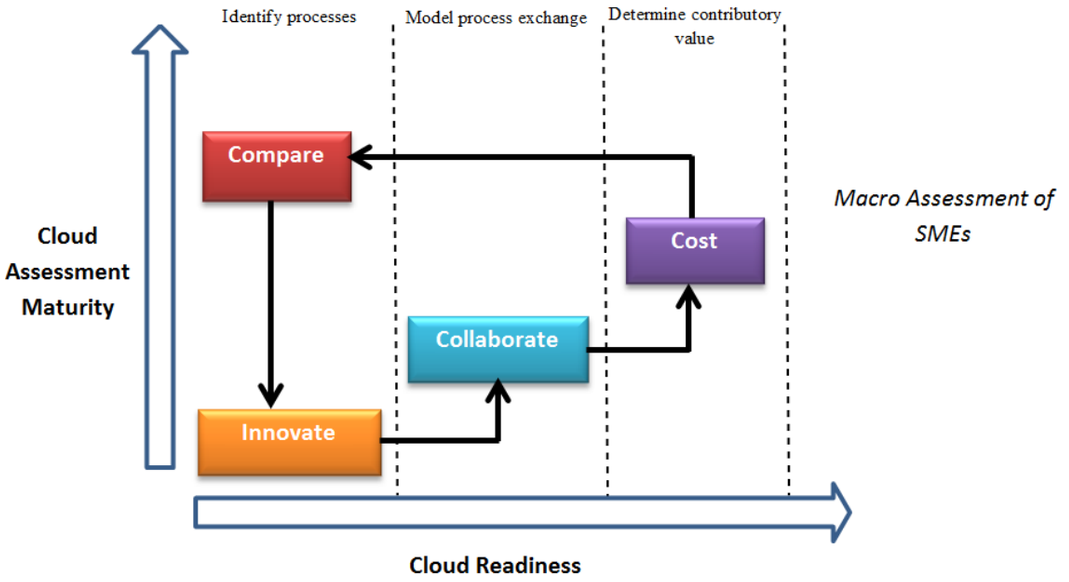

Figure 11: SME Cloud Assessment Model

From Figure 11, the author establishes the macro view of the CSCAF which assesses organisational readiness and identifies the cloud capabilities. The model offers organisations the opportunity to identify the contributory value of providing or availing of service capabilities, thus offering a capability brokerage service (illustrated in Figure 12). The 'matching service' will assess cloud provider capabilities with customer service requirements. From a service provider's perspective, one can assess how companies develop new services and analyse their service functionality as part of the assessment process. The author is interested in identifying the contributory value of service interactions and exchanges as a result of various cloud capabilities. Cloud applications can drive the value of business through various business process exchanges of cloud capabilities and resources. Therefore, monitoring the exchange of service assets becomes a critical activity within the CSCAF. This research will also explore the visualisation of service brokerage through network analysis techniques to add greater transparency on value co-creation, for example, organisational network analysis (see [37, 38]). The author refers to this as the Cloud Value Network (CVN).

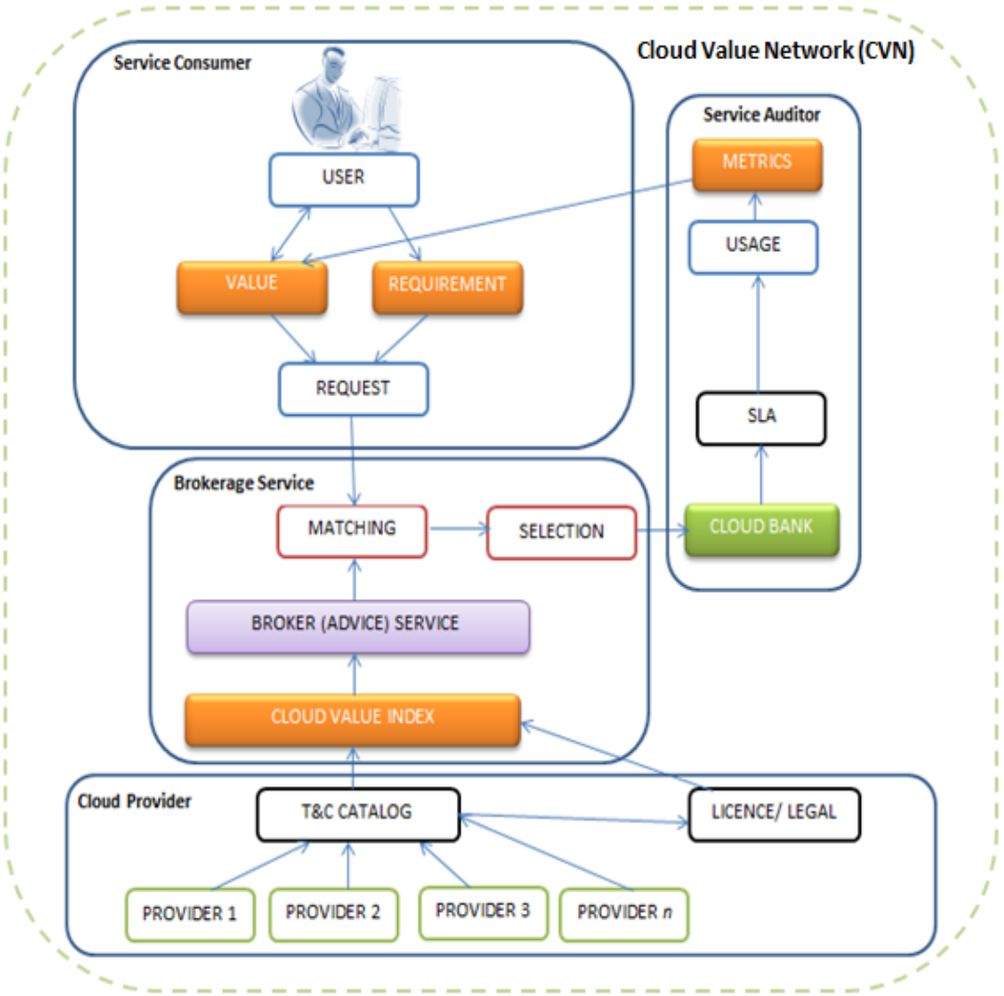

Figure 12: The Cloud Service Capability Assessment Framework

Figure 12 illustrates the overall context of the CSCAF. It examines the CVN from a number of functional perspectives including the service consumer, brokerage service, cloud provider, and the service auditor. These may be functions may be described as follows:

- **Service consumer**: identifies their service requirements and the value they wish to generate from their request of cloud capabilities and competences.
- **Brokerage service**: examines service requirements and provides a matching service based on a Cloud Value Index tool.

- **Cloud provider**: enlists their cloud capabilities and metrics to support a service catalogue of service capabilities. These metrics are referenced and matched with user requirements.
- **Service auditor**: provides a governance service to monitor quality of service and service requirements which supports the establishment of service value metrics. This also provides a reporting mechanism to support managers' decision-making tasks in their adoption/provision of cloud capabilities.

These processes support our ability to establish the CSCAF through the Cloud Value Index for service capabilities. Initially, the author examine the characteristics which are often associated with SME cloud services and provide an easily adopted framework solution which supports managers' decisions on cloud evaluations. The research will adopt a colour code system to support managers' ability to quickly visualise "goodness" and areas which warrant some concern through a 'traffic light system (i.e. a green, amber, and red colour scheme). Each characteristic is then referenced with their capabilities through the cloud life-cycle and feeds back into our Cloud Value Index for more in-depth analysis.

1.6.1 Supporting CSCAF Analysis

CSCAF offers a simplified analytical approach towards the assessment of cloud capabilities at various managerial levels in the cloud provision models (i.e., BPaaS, SaaS, PaaS, and IaaS). The contributory value of a CSCAF analysis highlights where issues exist in the Cloud operations. Although there is no "one size fits all" approach to cloud service provision, there are certain criteria which must be met in delivering cloud solutions. This chapter encapsulate this in what is described as 'cloud capabilities' which demonstrates Cloud Service Providers (CSP) strengths and weaknesses in specific services. This steers the research focus towards understanding cloud service metrics. Brooks [36] suggests that processes should be designed to monitor appropriate status from the beginning. In addition, if changes occur, communication and training should be provided to develop a thorough understanding as to the impact of this change. Brooks [36] advises that we should not implement a "catch-all statuses or categories" as metrics in service management making it is important to monitor and manage these statuses and categories, particularly in assessing cloud readiness.

1.7 Assessing Cloud Capabilities

CSCAF affords managers the opportunity to assess the organisational capabilities through a number of processes illustrated in Figure 6. This section examines these processes with particular attention on the matching and filtering process to align service capabilities with opportunities to support cloud readiness.

1.7.1 The Matching Process

As cloud capabilities become an organisational asset, our attention can move towards the collection of CSP capability libraries where services interoperate through cloud services to become plug-in capabilities. Matching service requirements with CSP capabilities becomes a useful evolutionary step. Sourcing cloud

solutions challenges our traditional understanding of acquiring on-site tangible solutions. The cloud demands a lot of trust and confidence in meeting expectations and responsibilities, thus placing immense importance on matching and managing cloud capabilities through trusted assessment practices. Therefore, one must consider a number of key factors, including establishing trust through legal guidance from improved methods associated with the following factors:

- Responsibility:
  - For CSP suppliers
  - For CSP customers
- Quality:
  - Quality of Service (QoS)
  - Quality of Experience (QoE)
- SLAs;
- Compliance;
- Security:
  - Access control
  - Data storage
  - Data in transit
  - Non-disclosure agreement
- Policy:
  - Data storage
  - Data protection provisions
- Availability:
  - Offer backup and restore services
- Accountability and Liability:
  - Service provider or reseller
  - Own data centres or rely on a third party
  - Direct management of third party management
  - Data protection
- Compatibility of technology:
  - Compatible with current specifications
  - Barriers for future CSP
- Professional recognition:
  - Cloud certification, trust standards and reliability standards

The matching process examines the various capabilities associated with CSPs and examines the competence and policies which are employed to secure a quality service (Quality of Service and Quality of Experience). When various matches are identified, a filtering process begins to align the cloud strategy with various capabilities on offer.

1.7.1.1 Universal Description Discovery and Integration

The Universal Description, Discovery, and Integration (UDDI) project, developed in 2000, is directed at establishing publishing standards for Web services. UDDI supports an extensible mark-up language (XML)-based platform-dependent framework which describes, discovers, and integrates business processes. This is particularly apt within cloud computing as services are provided through various digital channels. Discovering service transactions across a cloud ecosystem is a complex task when organisations try to assess service requirements. UDDI is one approach which manages the distributed business data through a global registry of services. This manages the business and development of publishing and locating service information. This may be categorised into three information UDDI registry pages:

1. **White pages**: basic organisational identification and contact information to discover a service.
2. **Yellow pages**: information about categorising a service.
3. **Green pages**: technical details which describes the behaviour and location of specific services.

Thus, UDDI provides several key initiatives for various service stakeholders to describe, discover, and integrate services. There is considerable value of this approach within cloud computing context to support the importation and exportation of specific service capabilities. The UDDI registry host can support our development of a Cloud Value Index within the CSCAF to establish a cloud capability matching criteria. Thus, cloud service providers can list capabilities on a UDDI Cloud registry (i.e. the CCR) and define their service applications which are integrated by Simple Object Access Protocol (SOAP).

UDDI extends other industry standards, which include HTTP, XML, XML Schema (XSD), SOAP, and Web Service Description Language (WSDL). The relationship between UDDI and other standards is illustrated in Figure 13.

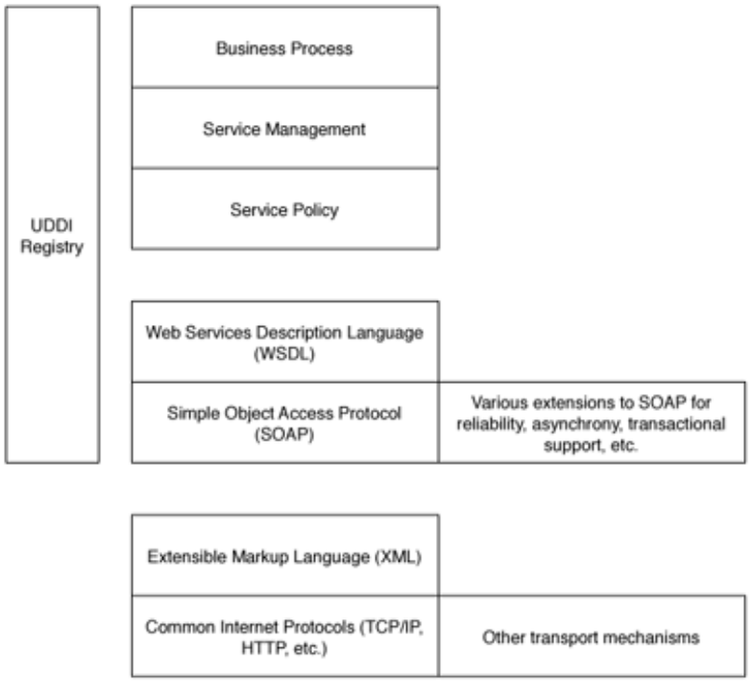

Figure 13: Conceptual relationship between UDDI and other protocols in the Web services stack ([57])

The UDDI interface may be described as the contact which the service provider commits itself to a promise to implement through a Web service. The language used to describe the interface is supported through the Technical Model or 'tModel'. A tModel is a form of meta-data and represents an interface which an organisation is going to develop and register. The tModel is a data structure which represents an XML Web services type in UDDI registry. Therefore the tModel has two key functions; to tag a service capability and to abstract the key functionalities associated with the service capability. The author proposes that each cloud service provider will register their service capabilities with UDDI through a defined list of service types, i.e. a service catalogue. This will allow cloud capabilities to become searchable and retrievable through the CSCAF. The Cloud Value Index will store and represent unique cloud concepts and constructs to (re)use cloud 'plug-in' capabilities and orchestrate service logic to filter cloud capabilities from CSP. In some cases managers will know of reputable organisations which provide certain services which address their needs. However, as in the case of SMEs or start-ups, organisations may know which service capabilities they need but have no idea who is best to provide the service and therefore service trust standards will become an important feature of cloud service delivery. Therefore, the CSCAF will be a more feasible cloud assessment service to support decision-making tasks through categorised service information. The framework of UDDI registries typically includes the following attributes:

- Service functionality description (busienssService);

- Organisation information that are publishing the information (businessEntity);
- Technical details of a service (bindingTemplate);
- Attributes of a service (for example, taxonomy);
- Registry entities relational structures (publisherAssertion);
- Tracking changes to service entities (subscription).

A registry may comprise of one or more nodes (i.e. a UDDI server) thus making the matching process more context specific to identify suitable service capabilities. In addition, one can include developments from Semantic Web literature and Linked Open Data to further develop the CSCAF.

1.7.1.2 The Matching Algorithm

The CSCAF algorithm is based on the need to match cloud service requirements with provider capabilities. The outputs from the matching process are also ranked based on user reviews to improve the efficiency of cloud capability matching (see Figure 14).

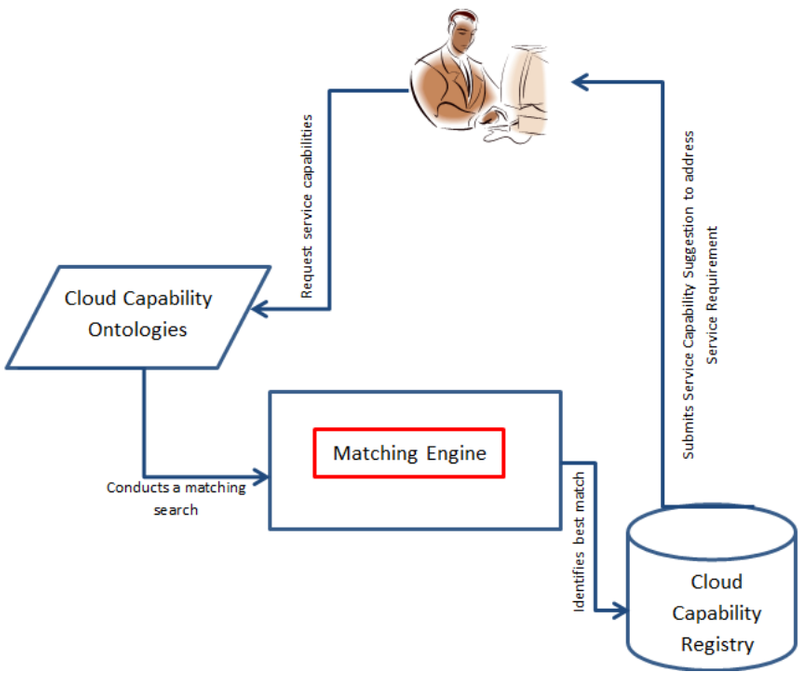

Figure 14: CSCAF Matching Process

The match must consist of the CSP reported (and committed to) output and the customer experience output. The degree of success will ultimately depend on suitability of the match detected and the relations between the service concepts using ontological information. The matching engine can draw an inference between the capability inputs and outputs of the service requests on the basis of ontology's within the CCR. For example, consider the following simple scenario. An SME is considering the possibility of outsourcing its IT security capability and allow them to concentrate on their core business process – selling books online. An example of their decision process to examine the quality of a service provider is illustrated in Figure 15. This provides an overview of their consideration to outsource their security capability for the online book store.

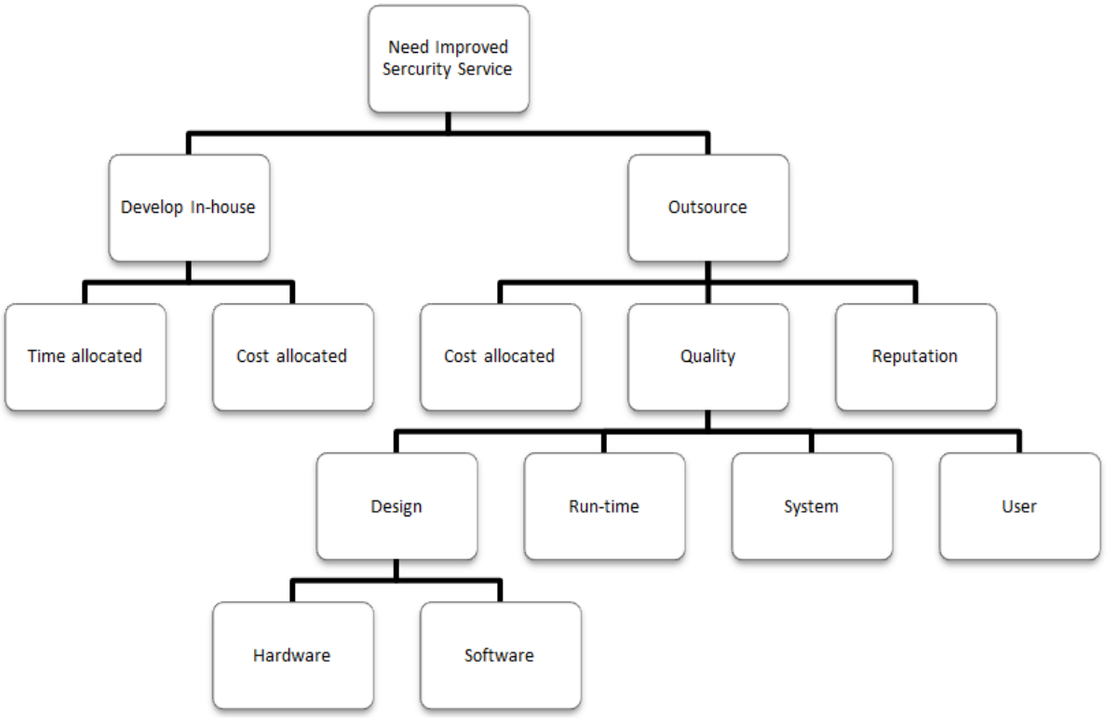

Figure 15: Overview of Decision Process

Through the use of the CSCAF, the service matching and filtering process will support the customer in seeking available cloud services and support their decision-making process.

1.7.2 The Filtering Process

The third phase of the selection process consists of filtering capabilities. The filtering process is used to determine which CSP meets the operational needs. Although an organisation may retrieve a number of cloud capability providers, managers must examine whether the service meets their needs and will have to filter the WSDL file to investigate the service inputs and outputs through referenced service tModel data structures. Thus the service profile indicates the service functionality (i.e. cloud capabilities, reputation and trust standards) which customers might avail off. Therefore, we must record the critical data associated with service capabilities such as, defining the actor, record information about the service provider, and determine the functional attributes (e.g. QoS rating) of the service capability. We anticipate that the service capabilities will support the development of a CSR which catalogues the service functionalities to offer a flexible matching engine and ranking based on similarity of service requests. Short-listing cloud service providers may be based on the following criteria:

- Pricing policy;
- Payment terms;
- Contract duration;
- Termination options;
  - Contract renewal and amendment.
- Organisational profile:
  - Geographical;
  - Reputation (for example, QoS and/or QoE);
  - Trust;
  - Technological migration;
  - Cost implications (e.g. backups and recovery).
- Accountable for software licensing (especially IaaS and PaaS):
  - Data location;
  - Data legislation adhere too (geographic);
  - Right to carry out an audit;
  - SLA complaints procedure.

From the list above, one can identify some of the key filtering decision criteria which may influence the consumption of CSP capabilities to support and align with their business strategy. This is particularly important for SMEs.

1.8 Aligning Requirements with Capabilities

Before entering into a service relationship, it is important that customers understand the operating processes and procedures to ensure proper controls and monitoring practices. The author examined SMI and ITSM to identify which capabilities and metrics are more appropriate for SMEs. This research also adds capabilities and metrics within the CSCAF (i.e. drill-down on service performance):

- **Scalable**:
  - Ability to add or remove computing resources

    - Bandwidth, storage, and compute power, SLAs
- **Virtualized**:
    - Information services
    - Servers, storage and applications.
- **On-Demand**:
    - The computer resources and applications
    - Allocated or removed within seconds at the request of the user.
- **Internet Powered**:
    - Internet capacity
- **Multi-Tenant Capable**:
    - The resources (e.g., network, storage and compute power)
    - Shared among multiple enterprise clients, thereby lowering overall expense.
    - Resource virtualization is used to enforce isolation and aid in security.
- **Service-Level Assured**:
    - The cloud service provider ensures a specific guaranteed server uptime, server reboot, network performance, security control, and time-to-response to the customer, with agreed upon service-provider penalties if those SLA guarantees are not met.
- **Usage Priced**:
    - There is no up-front cost to the user.
    - Per-use basis for bandwidth, storage, and CPU.

While the list above captures the main concerns listed throughout literature for SMEs, the author examines how this applies to develop greater analytical ability to support decision-making processes. The development of the CSCAF assessment process (Figure 16) shed some light n this. This is the first phase of the assessment agenda and there are plans to develop an online assessment tool which will allow SMEs to access the assessment process and report on their cloud readiness, capabilities and ultimately, the opportunities which exist to address business concerns.

The objective of the CSCAF (Figure 16) is to develop a much larger cloud analytics standard. The CSCAF is categorised into three main domains: economic, technological, and non-functional which adopt both a qualitative and quantitative analytical lens. These categories are applied to the five service lifecycle stages which accommodates for readiness, requirements, matching/filtering, and alignment. In short, these measures examine how one can:

- Improve customer service;
- Increase revenues;
- Cut operational costs;
- Build trust standards;
- Transfer knowledge of work activities;
- Build measurement goals and processes;
- Instil improved measurement techniques;
- Encourage process ownership in developing and implementing improvements;
- Communicating the measurement goals;
- Linking between activities, organisation goals, and the customer.

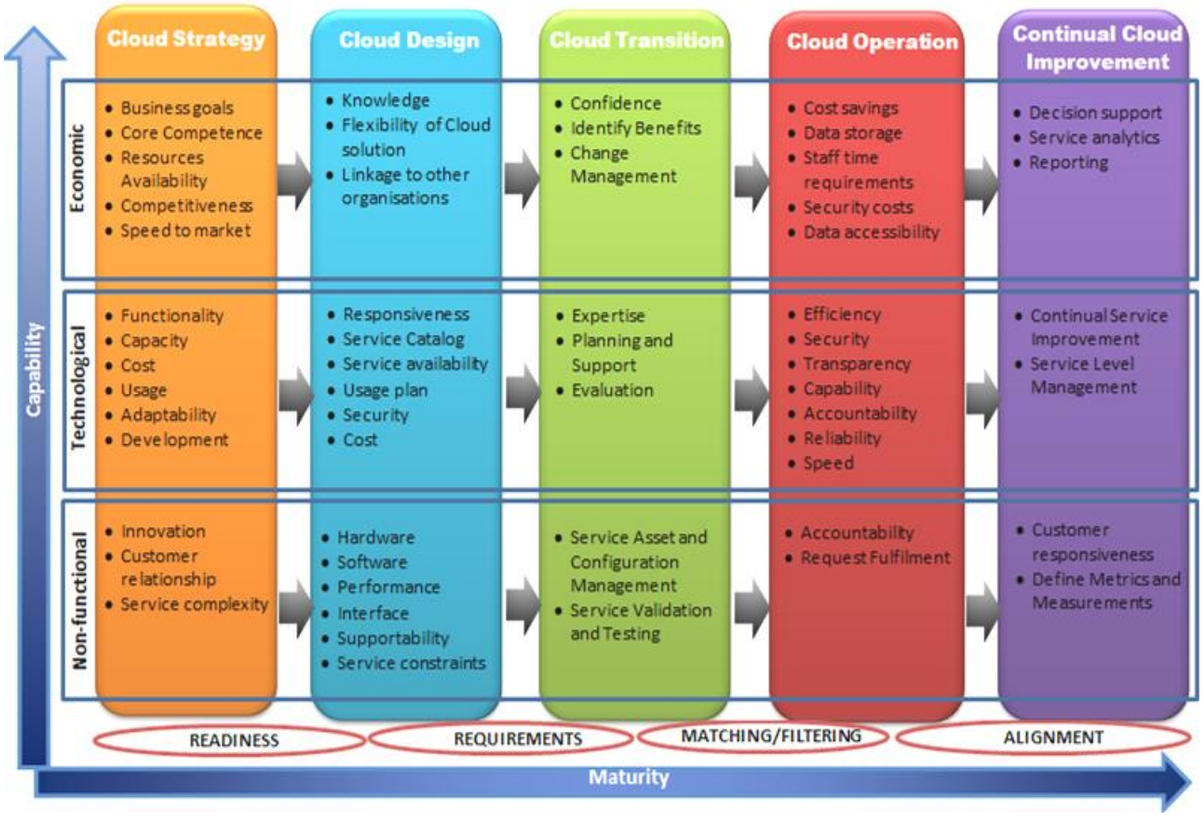

Figure 16: The CSCAF Assessment Process

Having assessed the various cloud capabilities, the assessment focuses on presenting the results with regards the cloud service lifecycle in terms of process readiness.

- *Strategy Readiness (SR)*: focuses on how the cloud will align with the organisational strategy while understanding the general demands to benefit from the promise of the cloud.
- *Design Readiness (DR)*: balancing service requirements with service capabilities.
- *Transition Readiness (TR)*: moving the service into operation through service provisions.
- *Operation Readiness (OR)*: examining effective and efficient service operations to (re)align the cloud strategy.
- *Continuous Improvement Readiness (CIR)*: monitors the governance and critical success factors (metrics and KPIs) to report on service capabilities throughout the cloud lifecycle.

We can model the organisational position through a snapshot where cloud service providers and users may view their readiness towards solutions (see Figure 17). The model represents a conceptual view of service capabilities and customer experience. Figure 17 offers an exemplary solution towards reporting cloud capabilities to SME managers. Each phase in the cloud lifecycle is scored (out of 5) to indicate it readiness to offer/avail of cloud solutions (0=not ready; 5=ready).

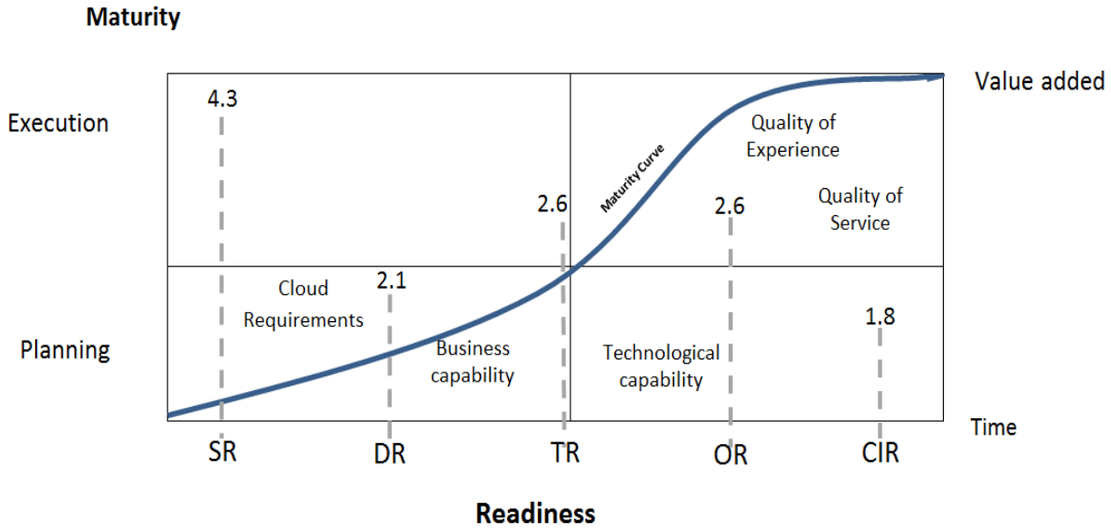

Figure 17: Example of Reporting through CSCAF

Figure 17 provides a snapshot on how we anticipate reporting CSCAF to decision-makers presenting an easily applied and acted upon assessment process. This provides a scoring overview of how CSP may assess their business environment and examine cloud readiness.

1.9 Future Work

This chapter discusses the initial step to establishing the CSCAF. There are many other challenges ahead. For example, Garg et al. [39] identifies some of the main challenges which we will also address, includes:

- Leveraging the full potential of cloud environments;
- Identify requirements and characteristics of service client against cloud providers;
- Decision-making regarding providers ability to provide QoS requirements;
- Examine various performance levels and reporting mechanisms;
- Identifying pricing strategies;
- Examining issues around cloud reliability;
- Enhancing cloud security technologies and policies.

While we will cater for these issues in the CSCAF (see Figure 16), we reverse the logic of these being issues and suggest that cloud providers ought to promote their capabilities through publically available capability assessments, allowing clients to best match organisational capabilities with their requirements. This promotes the concept of 'plug-in capabilities'. From this research perspective there was a challenge facing cloud computing on how to assess cloud capabilities within SMEs. Firstly, this research surveyed the literature to identify the key characteristics of cloud services and cloud providers. The work carried out by Iosup et al. [47, 48] examines the performance of task applications within various cloud initiatives. They also examine tools to monitor and analyse cloud performance throughout the literature. Their work supports this quest to establish the CSCAF and provide a more personalised and indeed accurate approach to cloud readiness and cloud service improvement through:

- Customer-driven approach;
- Business value centric approach;
- Market sensitive resource managements;
- Change recommendation.

These tasks all form part of our future plans for the CSCAF. In addition, the author has identified the need to incorporate other leading standards such as Business Process Management Notation (BPMN). This will add to the richness the CSCAF since BPMN does not support the visualisation of modelling organisational strategy through assessment tools or specific business rules. There are significant opportunities to address this gap and support industry on both an assessment and modelling of end-to-end process within the CSCAF. It will also promote a shared understanding and reuse of cloud capability improvement and optimisation.

1.10 Discussion and Conclusion

This chapter offers a discussion on the development of the CSCAF. It highlights the need to examine the cloud lifecycle from a number of viewpoints as illustrated in Figure 18.

The CSCAF comprises of several key components which allows us to view cloud assessments and readiness from a novel perspective. By incorporating this model, it provides a platform to assess the business and technical infrastructure in a number of key areas including strategy, process identification, valuation, and alignment. This work aims to support SMEs with improved return-on-investment and improved business models for cloud adoption (and build on work carried out in cloud assessment [56].

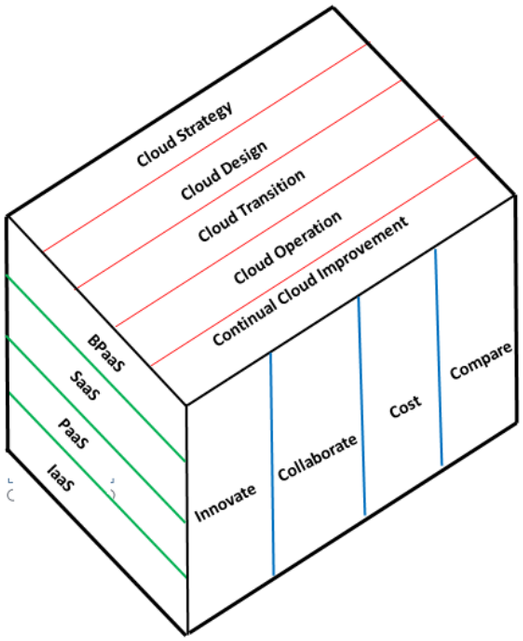

Figure 18: CSCAF Components

Cloud computing is a new and promising business and IT paradigm. However, as this chapter explains, the state-of-the-art on cloud practices has limited support for manager's assessment frameworks particularly for SMEs. This chapter discusses our initial work as we set out to provide a comprehensive and practical framework for cloud capability assessment using the CSCAF. This chapter demonstrates that cloud computing may be best described as an overarching practice with many solutions towards our conceptualisation of IT-enabled service delivery. Cloud requirements play a central role to the adaptation of cloud initiatives and the deployment of cloud models. It will come down to the simple fact of whether cloud computing offers a unique solution to business value rather than just a business fad. The work will build on existing efforts in the field of service science [49, 50, 51] t deliver a business intelligence tool to assess cloud computing capabilities. The author advocates that there is significant potential for SMEs to generate increased business value through cloud solutions (as indicated by [56]). This chapter highlights the need to introduce the CSCAF which sets out to guide managers through the assessment and selection of cloud capabilities.

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