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Measuring Capability for Cloud Infrastructure Adoption in Software Production for Finnish Non-profit Organisations

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Description

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Abstract

With the rising popularity of cloud computing and the potential of its use as a service platform, its adoption was considered necessary to be able to produce efficient services. It was understood that the adoption process would require some change in technologies, but the overall organisational compatibility with cloud computing was not clear.

To evaluate the organisation's cloud computing readiness, a research task with the goal of identifying a suitable maturity model was initiated. After review, it was concluded that the organisation's focus on products for non-profit organisations had to be considered in the evaluation, and a simplified tailored model had to be produced and an attempt would be made to include improvement methods in the model.

With model development as the assignment, qualitative approach with design research was chosen as the study method. OACA CMM was used as the basis for most of the new model, AWS CTMM was the source of the improvement methods, and a survey for the relevant personnel of the organisation and related organisations was used to supplement the items of evaluation specific to public service products.

The finished model was used in two workshops, where its usability and applicability were studied through observation of the participants. In the first workshop the maturity of the organisation at the time was evaluated. In the second workshop the desired level of maturity for each section would be set and the methods of improvement would be discussed.

In the workshops it was found that the model was considered suitable for use in the intended capacity. Implementing the improvement methods in the model proved to be impossible with the material.

Tiivistelmä

Pilvipalveluiden kasvavan suosion ja soveltuvuuden palvelualustaksi myötä sen käyttöönoton katsottiin olevan tarpeellista tehokkaaseen palveluiden tuottamiseen. Käyttöönoton ymmärrettiin vaativan joitain muutoksia teknologioissa, mutta organisaation yleinen soveltuvuus pilvipalveluiden käyttöön ei ollut selkeää.

Jotta organisaation valmius pilvipalveluiden käyttöön saataisiin arvioitua, tähän soveltuvia kypsyysmalleja alettiin tutkia. Selvityksen myötä ilmeni, että organisaation keskittyminen yleishyödyllisten järjestön tuotteisiin täytyi ottaa huomioon kypsyysarvioinnissa ja yksinkertaistetun räätälöidyn mallin tuottaminen on tarpeen, pyrkien myös kypsyyden kehittämiseen tarkoitettujen toimenpiteiden sisällyttämiseen.

Koska tehtävänä oli mallin kehittämistyö, laadullinen lähestymistapa kehittämistutkimuksen muodossa valittiin tutkimuksen muodoksi. OACA CMM toimi pohjana valtaosalle mallista, AWS CTMM lähteenä kehittämistoimenpiteille ja yleishyödyllisiin palveluihin kohdennetut arviointiperusteet hankittaisiin kyselyllä olennaisilta henkilöiltä organisaatiossa sekä vastaavissa organisaatioissa.

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Description

Valmista mallia käytettiin kahdessa työpajassa, joissa sen käytettävyyttä ja toimivuutta arvioitiin seuraamalla arvioijien toimintaa. Ensimmäisessä työpajassa organisaation senhetkinen pilvikypsyys oli arvioitavana. Toisessa työpajassa tavoitekypsyys kussakin osa-alueessa määritettiin ja keskusteltaisiin kehityksen kohteista.

Työpajoissa selvisi että malli katsottiin soveltuvaksi tarkoitukseensa. Sisällytettyjen kehitystoimenpiteiden toteutus todettiin mahdottomaksi kertyneellä materiaalilla.

Keywords/tags (subjects)

Cloud computing, non-profit corporations, maturity, design-based research

Miscellaneous (Confidential information)

Appendix OACA CMM evaluation domains, 9 pages

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1 Introduction

The purpose of the thesis is to provide a tool for measuring the maturity for cloud infrastructure adoption in an organisation. The assigning organisation is a sub-division of a medium sized software company, specialising in products for Finnish non-profit organisations. Maturity measurement would be utilised to identify areas that could disrupt efficient adoption of infrastructural cloud services.

1.1 Background

Cloud infrastructure has risen as an alternative to on-premises IT services. It provides server structure that can scale itself based on the current need and has, in appearance, unlimited resources (Kamarudin et al., 2022). In the assigning organisation, the established IT service model is based on on-premises servers with utilities selected and managed by assigned experts. Some products were identified as potential adopters of cloud computing.

Due to the difference in the business model and management, the expertise in working with on-premises environments might not translate to cloud environments. The author became aware of this while being involved in a cloud migration process for a product as a developer. The difficulties in the process were not limited to technological skills, but also to uncertainty in management and financial domains. The need for a maturity model to assess of the level of expertise was identified.

The assigning organisation provides services to non-profit organisations that deal in sensitive data and the disclosure policies regarding the products suggest that information available to the public should be limited. Therefore, specific evaluation results will not be included, but the results will be discussed in general. Product structure will not be specified either, but their requirements will be addressed by the model.

1.2 Evaluation problem

As a part of their study of companies' suitability for cloud computing, Misra & Mondal (2011) examine the benefits of adopting cloud infrastructure in organisations with existing IT infrastructure. They find that cloud adoption is reasonable if the IT services are small in scale, server workload

fluctuates, the service handles a small amount of non-sensitive data and the service does not require stringent service-level agreements. Based on the scale of the IT services and server workloads, the organisation would be suitable for cloud adoption, but the cloud suitability is decreased by targeting the products to non-profit organisations whose service model is based on sensitive data and are considered critical services. Lessening the impact of the issues by having them addressed in the evaluation is one of the goals of the study and the basis for the non-profit organisation focus.

Maturity models for evaluating cloud maturity have been developed by multiple organisations (van Dijk, 2017). The models are however not specific in their scope or otherwise inapplicable to fit the identified requirements of the assignment. The purpose of the thesis is to create a customised maturity model that is sufficiently specific for immediate use and can be used for organisations whose products handle sensitive data. The model is not intended to be used for products that handle extremely sensitive data.

The customised maturity model is intended to help the organisation evaluate its capability for cloud development and to provide improvement goals in each area. The proposed changes would be integrated in the grid of the model as different maturity levels for the issue. By design, higher levels of maturity should be considered superior in a maturity model. Occasionally the operations required for a higher level are however not applicable and therefore the organisation is expected to perform a workshop where the desired levels are set.

As the assignment is done alongside an AWS cloud migration process, the practical application of the maturity model is evaluated based on the experiences in the process. Being the first cloud migration of an established product in the organisation, some effects of low maturity can be identified in the problems caused by inexperience. Input from other organisations is utilised to ensure that the model is applicable outside the assigning organisations specific criteria.

2 Research questions and methodology

This section contains the questions extracted from the research problem discussed in the purpose of the assignment section. The research methodology is further explained with the assumed value compared to previous studies.

2.1 Research questions

The purpose of the assignment is to identify a tool for evaluating and improving the organisational cloud maturity. From that goal, the following main research question can be made:

"Is there a model that can directly be used in cloud maturity estimation for organisations that have to address data sensitivity and critical service requirements of the client and if there is none, how can maturity be evaluated?"

Modifications to the maturity model might be necessary due to the specific requirements of the clientele. This led to the secondary research question:

"What items are necessary in a model designed to help evaluate cloud maturity in an organisation with non-profit organisations as clients?"

As one of the goals is for the model to have integrated means for improvement that do not require much preparation and research from the organization, a follow up research question is:

"Is it feasible to integrate maturity improvement methods in the structure of a maturity assessment model and if so, how can they be implemented?"

2.2 Research methodology

With the assigning organisation's need for a model being the problem that the thesis is attempting to solve, it was considered necessary to have a usable model as a result, and due to the organisation's specific clientele, a perfectly suitable model was not assumed to exist. Therefore, research into maturity model development had to be included to be able to apply model frameworks and manage new sections. As research method would have to include a development goal, purely research-based methods were not considered. To produce a more universally applicable evaluation model for the circumstance, design research was finally selected as the primary method.

2.2.1 Design Research

Design research's concept is that theory and intervention should drive each other in complex and iterative ways because they are not sufficient alone in practical problem solving (Easterday et al., 2018). The separation of research and development sections allows for creation of the initial model based on previous research, supplementing its contents with expertise from the organisation and refining it through the development process. Applying the model systematically grants chances to evaluate its quality directly and improve it through iterations.

For practical application of design research Kananen (2012) suggests the approach of first mapping the present status and familiarisation with the phenomenon, analysing the problem of the study, leading the change while identifying the affected parties, generating the solution and its presentation, developing the solution, adjusting the solution iteratively with testing, and evaluating the outcome and establishing the follow-up processes.

The plan for these the stages is conducting a literature review for the mapping, familiarisation, and the problem analysis. Change leading and party identification is addressed with a discussion with the organisation. Solution is also based on the findings of existing models and studies in literature review and its development is conducted with surveys and interviews of experts. Testing of the solution is done with a workshop, where the first version is taken into use.

2.2.2 Literature review

Snyder (2019) mentions in their literature review guideline summarisation that there are three approaches to literature reviews: systematic, semi-systematic and integrative. Systematic approach works from specific research questions with the goal of gaining evidence from comparison of quantitative data. Semi-systematic approach can be used in the review of research with diverse disciplines to gain an insight into overall status of research or progress in the field. Integrative research assesses and critiques existing research to expand the foundations of research or combine different perspectives, especially in mature or new fields of research.

A literature review of cloud adoption and available cloud maturity models is done to understand the initial status of the studies in these fields and to gain understanding of the field. As the field of cloud maturity model research can be considered new and a creation of a new framework might be necessary, integrative research is the starting point of the literature review.

2.2.3 Survey and interviews

In the development phase, the model will be sent for evaluation to select people from the company, and the recipients can judge themselves if they have the required expertise to give productive feedback. The selection is done by superiors from each of the three organisations that are considered relevant for this research. The initial contact will be a request for open feedback through company email, but Kelley et al. (2003) mention that post surveys typically have low response rates and a large sample size would be required. Therefore, unstructured interviews with responders can also be used to gain more qualitative data. Recipients with specialised in a specific evaluation domain of the model will be more likely contacted in an interview.

2.2.4 Workshop

The aim in workshops as a research methodology is to gain quality data about organisational change or other processes of progress (Ørngreen & Levinsen, 2017). As the organisation is divided to multiple teams, some of which are less involved in the cloud transition, open discussion was considered an effective way to gather information from the entire organisation. When the model is refined, it will be used in workshops involving the people from all the teams in the organisation

considered best suited for evaluating the organisational maturity. The first workshop handles the evaluation of the organisation's initial maturity, with the second workshop addressing the organisational goal and the methods to reach them.

2.3 Previous research

To ensure that the thesis would not be a duplicate study, existing studies in cloud maturity model development had to be reviewed. To limit the results that had to be reviewed, the study or article had to clearly refer to cloud maturity models, their development and be accessible without expenses.

The search for terms "cloud maturity" and "maturity model" provided no results that fit the set criteria from the thesis databases of Jyväskylä University, Aalto University, Finnish Universities of Applied Sciences and Mendeley article search. The search from the database of Tampere University resulted in one study that required a closer view, as did the Google Scholar search. Mendeley and Google Scholar were searched with strict phrase, as individual terms of maturity, cloud and model produced excessive number of results. The strict search produced only a few results for Mendeley and large but manageable number of results for Google Scholar. Several studies were behind paywall and were therefore inaccessible.

Leppänen (2016) developed a method for evaluating cloud compatibility of software products as a Tampere University master's thesis. In the thesis a questionnaire chart was identified as an effective method for evaluating a product. Organisational readiness was not assessed in the scope of the thesis and expanding the method to include it could result in an excessively complex model, as the chart would not be able to begin its flow from controlled default parametres.

In the Google Scholar search result, van Dijk (2017) studies the development of a new cloud maturity model after finding seven existing cloud maturity models inadequate for the use case through review. The essay differs from the topic of the thesis by being specifically a maturity model development study that does not attempt to apply the model in practice and not being concentrated on product development organisations.

After reviewing the existing studies on cloud maturity model development, it was determined that solving the research problem presented in the thesis would require more research, as available maturity models were found inadequate for the conditions.

3 Theory basis

3.1 Cloud computing

Cloud computing is a computing model where computing resources are delivered over the internet. The model is implemented as a network of servers and as a network its size can be scaled as needed. All the resources that an application requires, such as processing power, storage, and databases, can be included. As the assets are requested over the internet, they are utilized when needed and if the resources are outsourced to a cloud provider, they can be used to replace on-premises infrastructure to eliminate the need for maintaining these servers (Saini et al., 2019).

In a study that examined measurements of suitability for cloud computing the concept of cloud computing and a presumption of its future was simplified in the following way:

> It will not be too long from now that all we will need to know is that there is one huge computer at a remote location (without even knowing where it is) which has the potential to provide all the computational power and resources that we ever really need. (Misra & Mondal, 2011)

3.1.1 Cloud services

Cloud services are services that utilise cloud computing as the way of providing resources for the task. They are provided in models, with each model providing value in a different aspect of IT services. Both Kamarudin et al. (2022) and (Misra & Mondal (2011) state that the most common service models are Software as a Service, Infrastructure as a Service and Platform as a Service and list some examples of each model.

Sofware as a Service (SaaS) applications, such as Microsoft M365 and Google Docs, allow the application to be operated with an internet browser in addition to installable software, with shared data platforms accessible remotely through internet. It is common for the application to require a licence for use and have a subscription model (Misra & Mondal, 2011).

Infrastructure as a Service (IaaS) environments, such as Amazon Web Services, Google Cloud Platform and Microsoft Azure, provide scalable computing resources, typically on pay-per-use basis. Virtualisation servers, data storage, computing and networking services are usually offered, allowing for web hosting and applications in addition to environments for testing, high-performance computing, big data analysis, storage, backup, and recovery (Misra & Mondal, 2011).

Platform as a Service (PaaS) is a model where developers can immediately access resources, utilise services and adhere to workflows and processes in a closed environment where infrastructure is managed by the service provider. It is designed to streamline the process of application development, testing and deployment. Examples of PaaS services include Salesforce Heroku, Force.com and RedHat's OpenShift (Misra & Mondal, 2011).

As the problem that the thesis is attempting to solve is related to a change in infrastructure, the model being developed will be designed to measure maturity in IaaS adoption. SaaS and PaaS adoption will not be examined systematically, but the elements of cloud computing shared by the models can be included.

3.1.2 Benefits and drawbacks

As cloud computing differs from the conventional computing model, its benefits and drawbacks had to be examined. In their study of the potential for cloud computing in small and medium enterprises Kamarudin et al. (2022) list the advantages and challenges for that scope. The benefits include lower computing costs from not having to make an upfront investment in storage hardware or networking capability while taking advantage of potentially free managed services. They also view the reliability, availability and security of data as advantages, as the data is encrypted, backed up, and stored off site in a shared storage where the latest version is always available. The remote access of cloud services is also seen to benefit work flexibility through access credentials. Finally, they find that scalability of cloud services can be utilised to provide temporary services efficiently, which can be considered less important for large enterprises, but advantageous for smaller enterprise revenue model.

Misra & Mondal (2011) approach the analysis from evaluation of IT services standpoint, but also conclude that the scalability of cloud services benefit IT services where server has fluctuating workloads. They also estimate, that if the existing IT service infrastructure is small, cloud services could be the more efficient solution. They maintain case specific benefit analysis and refrain from claiming that certain aspects of cloud services would be universally advantageous.

Müller et al. (2015) adopt business efficiency as the viewpoint of their literature review. The study agrees that absence of upfront investments and the scalability of resources offer savings along with the labour savings from the use of cloud managed services. The efficiency benefits of short-term large-scale operations over long-term small-scale operations in computing is also mentioned. In the review the reduction in the need for changes in IT infrastructure was viewed favourably for its effect in saving time in system operations. Minimising the maintenance effort of physical infrastructure and rapid service update cycle were also found to be infrastructural benefits.

Both Misra & Mondal (2011) and Kamarudin et al. (2022) find that data management is a significant challenge in cloud computing. Storing data off site exposes it to possibility of data lockout or loss if an outage occurs or the cloud service provider goes out of business and can cause issues with requirements in service-level agreements if the service is critical. The protection of sensitive data can also be a concern, even if direct security issues are not identified, due to unclear data ownership. Both studies have also concluded that cloud adoption can result in rise in IT service expenses with amount of data stored and transferred increasing the running costs.

Even though in the study conducted by Müller et al. (2015) the focus was on the benefits of cloud computing, certain risks were also identified. Cloud transitions were found to disrupt the role of IT departments when the services are managed by cloud providers and business units can adopt cloud solution in excess without IT department's involvement. They also discussed potential limitations in the benefits of cloud services, noting that when business units adopt cloud services in enterprises with low maturity, the increase in business value outside the unit is limited. Independent business units can be considered a feature of larger enterprises, but Kamarudin et al. (2022) note that small and medium enterprises might have insufficient resources for successful cloud service adoption altogether.

3.2 Maturity models

Maturity models are structured tools designed to give organisations guidance towards improvement (Gökalp & Martinez, 2021). In a well-cited research paper Becker et al. (2009) describe maturity models as a sequence of maturity levels usually measuring organisations or processes. These levels act as evolutionary stages in maturity progress with the highest stage representing total maturity. These stages can be used in an appraisal to assess the situation of the organisation for the criteria to identify the maturity level and interpret the further stages to gather methods of improvement in the areas. In a dated study of the effectiveness of the first maturity model, Capability Maturity Model (CMM), Herbsleb et al. (1997) describe it as a tool for pursuing organisational business goals and estimate that even then it was used by thousands of organisations.

The study by Herbsleb et al. (1997) is valuable for its collection of practical findings from organisations that have adopted a maturity model, despite its age and their observation that none of the organisations they studied had reached a high enough maturity level to make conclusions of the merits of extremely high maturity. They found that organisational productivity, quality, and cycle time had improved considerably, even with the small gains in maturity. Customer satisfaction was the only measurement that did not increase directly with maturity levels in their study, but Gökalp & Martinez (2021) list it among the common benefits of maturity models, along with quality, return of investment increase, error aversion, performance, and staff involvement.

The reviewed studies did not contain structured lists of the downsides of maturity models but did mention them on a case basis. Herbsleb et al. (1997) referred to general views on maturity models, such as fear of losing maturity to changes and thus avoiding risks in organisations that have reached high maturity. They mention that their findings in the survey were different, but also that many of the surveyed were surprised about the inflated cost and time required for the program and many understood the areas that should be improved but were unable to produce the required actions. The largest issues were in the areas of planning and tracking of software products. In their review of agility and maturity models, Henriques & Tanner (2017) refer to studies that imply a higher level of maturity in capability maturity model integrated (CMMI), a maturity model based on CMM, resulting in a loss of agility due to its organisational focus. They mention studies that

found that organisations with high levels of CMMI maturity showed higher project success in waterfall environments but were incompatible with agile environments in that state. Becker et al. (2009) mention the view that technological or scientific advances and changing conditions cause maturity models to inherently become obsolete.

3.3 Identified cloud maturity models

As the thesis studies cloud maturity evaluation, a literature review had to be conducted to determine applicable cloud maturity models that could be studied further.

3.3.1 Search methodology

Maturity models that measure cloud maturity were searched with conventional search engines, Google Scholar and Mendeley catalog search engine. Conventional search engines such as Google were used to gain a general view on the popularity of cloud maturity models. Google Scholar was used to gather large amount of research papers related to the topic and Mendeley search catalog's sorting algorithm was utilised as a method to identify relevant papers from the results. The results were then evaluated for relevance and usability. For conventional search engine results, they had to refer directly to cloud maturity models or applicability for cloud, had to be freely and directly available and had to be identifiable as maturity models following the theoretical basis discussed before. For research paper results from Google Scholar and Mendeley, applicability for infrastructural focus in the model on review was required, as was the criteria of referring to cloud maturity models and the free and direct availability of the study. The searches were performed in March 2022.

For conventional search engines, Google was chosen as the primary search engine for the task based on an assessment of the first page of results after brief attempts with DuckDuckGo and Bing. Search for the term "cloud maturity model" provided excessive number of results to evaluate, but alterations to the search were not found to be suitable. Additional exclusion criteria for results that appeared to market services had to be implemented to maintain scientific standards.

For Mendeley, a strict search with complete term “cloud maturity model” provided less than ten results, none of which were accessible. A non-strict search with the same words had more than 500 results that had to be evaluated based on title and description. Based on the review of the first 50 results, the Mendeley algorithm was estimated to be sufficiently effective in providing the most relevant results first and most of them were not reviewed. Emphasis for selection was on titles and descriptions that referred to the information technology’s concept of cloud. Finally, to limit the number of articles that did not refer to development of a model, words “cloud maturity model develop” were used and resulted in a manageable number of articles, but very few of them fulfilled even the first exclusion criterion.

Strict Google Scholar search with complete term “cloud maturity model” provided a manageable number of results that had to be examined for new cloud maturity models. The results were the same as in the Mendeley review but removing the complete term strictness by omitting the quotation marks did not appear to provide any new models despite the substantial increase in results.

A targeted search was also performed, as Müller et al. (2015) report that maturity models for cloud computing have already been developed by corporations such as Oracle, Microsoft, and SunGard, but did not provide working sources. An attempt was made to identify these models, even though suspicions of their validity were raised due to their apparent removal. Google Scholar or Mendeley did not provide any results, but some marginal sources were found with Google search for Oracle and Microsoft. Google search for “Sungard cloud maturity model” provided a webinar result that was initially promising but did not appear relevant after a closer review, as no references to cloud infrastructure were not discovered.

3.3.2 Microsoft cloud maturity model

The Microsoft cloud maturity model that was examined was discovered in a brief blog post, which being the primary source for the model questionable. Guerin (2019) uses Microsoft Azure as the term for cloud provider, but the contents of the model are not Azure specific, and the overall terminology and structure are simple.

3.3.3 Oracle CCMM

Oracle cloud computing maturity model (Oracle CCMM) does not appear to be available for study in its entirety, but a white paper published by Oracle (2011) has a description of it. It evaluates sixty capabilities across eight domains, such as architecture and governance, on a six defined maturity stages. The capabilities are not clearly listed in the article and the maturity stages for them are not present. Only the general structure can be assessed from the material.

3.3.4 AWS CTMM

Amazon Web Services Cloud Transformation Maturity Model (AWS CTMM) is a cloud adoption model that focuses on maturity on migration to AWS cloud services (Figure 1). The model adopts a practical approach to the stages by offering transformational activities to the problems for each stage and outcomes of these increases in maturity. The model has been archived as AWS has moved to offer a cloud adoption framework instead (Anderson et al., 2017).

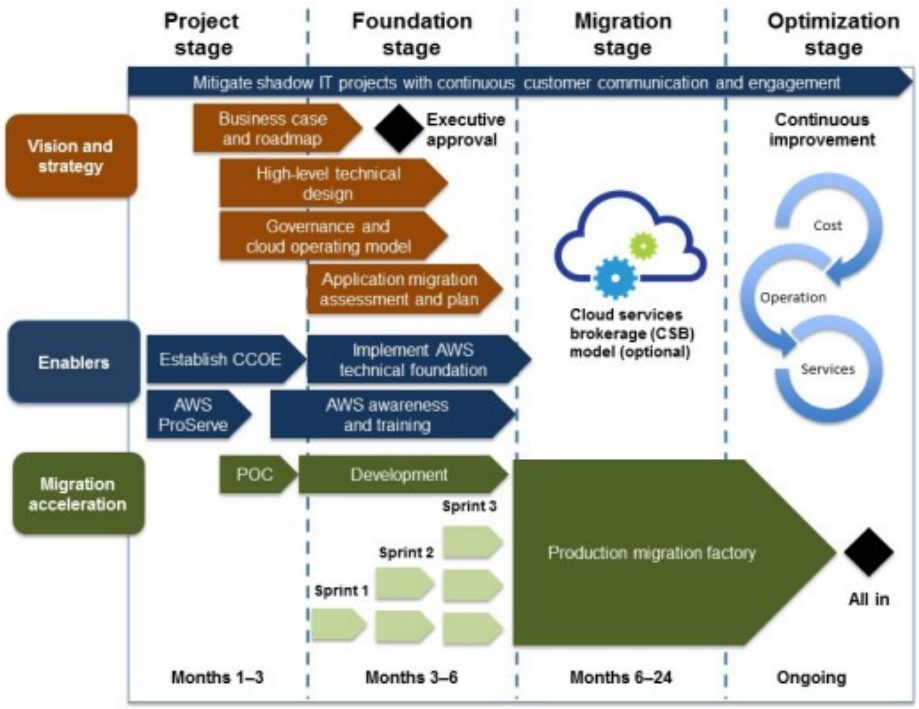

Figure 1 - AWS CTMM usage chart (Anderson et al., 2017)

3.3.5 ODCA CCMM & OACA CMM

Multiple studies referred to Open Data Center Alliance's (ODCA) cloud computing maturity model (CCMM) and both van Dijk (2017) and Antillon Lopez Salinas (2017) assess it in their maturity model development process. ODCA was a global conglomerate of IT organisations with the ambition to make cloud adoption easier for organisations. Antillon Lopez Salinas (2017) describes the model as an extensive, but general level model that could be difficult to adapt to a smaller single domain scope, whereas van Dijk (2017) describes it as a use case and business goal oriented model. It seems that ODCA has since reformed into Open Alliance for Cloud Adoption (OACA) and the publicly available model is OACA Cloud Maturity Model (CMM) (Figure 2). A review of OACA CMM, especially its analysis questionnaire, reveals that it matches the view of Antillon Lopez Salinas (2017) on ODCA CCMM on the comprehensiveness, but the model is modifiable to a more limited scope by picking subjects relevant to the domain.

Domain	CMM 0 (none, n/a)	CMM 1 (initial, ad hoc)	CMM 2 (repeatable, opportunistic)	CMM 3 (defined, systematic)	CMM 4 (managed, measurable)
Control Question	Expected Outcome at CMM Level 0 (People, Process & Technology aspects)	Expected Outcome at CMM Level 1 (People, Process & Technology aspects)	Expected Outcome at CMM Level 2 (People, Process & Technology aspects)	Expected Outcome at CMM Level 3 (People, Process & Technology aspects)	Expected Outcome at CMM Level 4 (People, Process & Technology aspects)

Figure 2 - Example of OACA CMM structure (Schwan et al., 2021)

3.3.6 CMMI

CMMI Institute's Capability Maturity Model Integration (CMMI), an appraisal tool in software development, was studied for items applicable to the practical cloud model, even if it did not fulfill the criteria of cloud focus, as the prominence of CMMI in reviewed material necessitated its inclusion. Access to version 2.0 of the model from CMMI is not free and will not be used as a source, but version 1.3 of CMMI for development (CMMI-DEV) was available. The report by CMMI Product Team (2019) is extremely extensive and complex making its rigorous review difficult. The model uses two types of levels to evaluate, capability levels with continuous representation and maturity

levels with staged representation. The process areas, goals and practices are similar between representations, but continuous focuses on individual process areas and staged on multiple process areas. Staged representation is comparable to the first CMM and Gökalp & Martinez (2021) report that it has served as the basis for CMMI.

4 Comparison of maturity models

From the discovered cloud maturity models, Oracle CCMM and Microsoft cloud maturity model had insufficient data available to be included in the definite comparison of models. The models included were AWS CTMM, OACA CMM and CMMI-DEV 1.3. AWS CTMM contains improvement methods, which is a feature that was considered favourable in a model. The analysis questionnaire of OACA CMM is easy to interpret and has an extensive set of areas of measurement. CMMI-DEV is comprehensive in structure and rigorously tested and developed.

First, the stage structure of the models will be examined, and their viability assessed based on the findings of the literature review and the initial experience on the ease of use. Then the scope of the model is evaluated to determine if it can be applied to cloud infrastructure maturity analysis. The third area of comparison is the items of evaluation to learn if they contain a set of items that can be considered usable in an ad hoc cloud maturity evaluation meeting.

4.1 Stages

In the selected maturity model, the maturity in an area is measured with levels or stages. The number of stages and their descriptions differ, and the differences are explored in this part. CMMI-DEV has differing stages for continuous representation and staged representation and must be examined from both starting points, as they are not comparable. Staged representation measures organisational maturity in a predefined set of process areas and continuous representation measures the maturity of capability in an individual process area.

The terms used for the stages of evaluation vary, and as described in the literature review, in CMMI-DEV they even differ for the stages of its two evaluation types, as continuous representation stages are called “capability levels” whereas stages in staged representation in CMMI-DEV and OACA CMM overall are called “maturity levels”. AWS CTMM, uses the term “maturity stages”, which is also selected as the common term to be used in this comparison.

4.1.1 Stage 0 – No maturity

AWS CTMM does not contain a stage with no maturity and uses stage 1 as the first stage.

Stage 0 is also absent in CMMI-DEV staged representation. In continuous representation the maturity stage uses the label ‘incomplete’ and describes the processes in this stage as partially or not at all performed. The specific goals are not satisfied for the process area and there are no generic goals for this stage as establishing incomplete processes is not reasonable.

In OACA CMM the stage is called “none” and is described as a stage where there is no automation, knowledge of cloud or virtualised environments, processes are manual, and the teams are siloed.

4.1.2 Stage 1

In the initial stage of AWS CTMM, known as the “project” stage, the organisational transformation to cloud is beginning, but typically without possessing a centralised cloud adoption strategy being sufficiently familiar with costs and benefits of cloud services.

This is also the first stage in CMMI-DEV staged representation called “initial”. In this stage processes are reactive and without control, which causes the businesses to have an unpredictable, risky, and inefficient environment. In continuous representation this stage is more advanced and is known as “performed”. The process at this maturity stage satisfies its work requirements but can be lost unless it is institutionalised by advancing in maturity.

The “initial, ad hoc” stage in OACA CMM is satisfied when existing software and services are mapped for cloud, cloud services are used, but in limited capacity and operation processes are traditional. The focus is on the private cloud.

4.1.3 Stage 2

In AWS CTMM’s “foundation” stage, the organisation has partially trained staff, executive support, some cloud experience and is intending to migrate to cloud. Characteristically to AWS CTMM the actions required in this stage are also described. These include assessment of the environment, signed contracts and migration plan that details the timeframe, approach, workloads, resources, and business case.

In CMMI-DEV, this stage is called “managed” in both representations and for both, in this stage the processes or projects follow a planning and execution policy, are monitored, evaluated, reviewed, and involve skilled people with adequate resources for controlled production. With continuous representation the threat of losing the process maturity mentioned in stage 1 is eliminated by the process discipline. In staged representation, the same preservation of maturity is present, in addition to project status being visible to management at set intervals and commitments to stakeholders are established.

OACA CMM uses the label “repeatable/opportunistic” for this stage and describes it as having defined and repeatable introduction process of cloud services, and cloud-specific updates for IT and procurement processes and controls. The focus is on full adoption of on-premises private cloud with physical-to-virtual transition and cloud awareness of apps.

4.1.4 Stage 3

AWS CTMM stage “migration” is where the organisation can migrate targeted applications efficiently by having established governance, technical and operational foundations. The actions listed in this stage are implementation of operational tools and a basis for migration along with mass migration of in-scope workloads. The risks for the stage are also described, with delays, budget overruns and application failures listed as nonspecific and decreased customer support specifically because of inappropriate migration operations.

In CMMI-DEV, both representations use the term “defined” for this stage. The final stage in continuous representation has a managed process, with maintained description, that is tailored according to guidelines from standard processes and contributes to the organisational process assets. As opposed to stage 2, the tailoring from standards provides consistency to processes, being also more rigorously described and defined. In staged representation, the process standardisation also applies. The description also addresses that generic practices not addressed in stage 2 are required to reach stage 3 in maturity.

OACA CMM has a brief description of its stage “defined/systematic” that states that automated cloud service utilisation is in place, adherence to corporate requirements and local regulation is

guaranteed with integrated risk and governance controls, and service management interfaces are implemented. Private PaaS services are created, and SaaS usage is at advanced level.

4.1.5 Stage 4

In the final stage of AWS CTMM, “optimisation”, the organisation must have successfully migrated to cloud and is managing the environment and service delivery. In this stage the processes are optimised in a constant cycle with the goal of lowering costs, improving service, and expanding value of cloud adoption in the organisation.

CMMI-DEV has only staged representation from this stage forward. The stage is called “quantitatively managed” with the focus project management being driven by statistical objectives based on the needs of the customer, users, organisation, and implementers. The goal is to have predictable performance by analysing carefully selected subprocesses.

The description for “measured/measurable” stage of OACA CMM states that the organisation must have cloud applications and PaaS in routine use with federated system landscapes, data distribution and movement, distributed application transactions and cross-boundary interaction managed with online controls. Partners are defined, data and system can be moved dynamically with integrated support tool layer, such as alerting.

4.1.6 Stage 5

CMMI-DEV staged representation “optimizing” stage has continuous improvement through accumulating experience of business and operational needs. Continually revised quality and process objectives used to respond to changes and for statistical data on deployed process improvements are measured against them. The focus is on managing and improving performance in the organisation with quantitative data collected from projects that is used to create measurable improvements.

At OACA CMM “optimized” stage, service and application deployments are automated, along with orchestration systems handling of data and applications. Cloud is optimised proactively using data collection and automatisation.

4.1.7 Advancing in stages

AWS CTMM contains transformational activities that attempt to provide solutions to the challenges stated in the maturity levels and outcomes of the activities. There is no clear progress in a maturity for individual problems and solving the challenge on a stage does not necessarily lead to a new challenge on the next level.

In CMMI-DEV continuous representation the advancement is defined with stage definitions. Level 1 indicates that the process area consists of performed processes. Reaching level 2 requires a policy and plans for the process, so that performing the process is controlled and monitored. Level 3 can be reached when an organisational standard for the process exists and can be used as the basis for defining the process being conducted. As advancing in the final stage is not possible, the process areas will be then improved with statistical analysis in high maturity areas defined in the model. The areas are Organizational Process Performance, Quantitative Project Management, Causal Analysis and Resolution, and Organizational Performance Management.

In CMMI-DEV staged representation stage definitions describe the requirements for maturity levels, but strict restrictions are not placed. Attempting to advance to a maturity level before the previous levels are properly adopted is possible but advised against, as the improvements to the process in the previous stages are foundational for the improvements in the goal stage.

In OACA CMM the advancement process is not directly described, but it can be considered similar in nature to the CMMI-DEV staged representation. Skipping maturity levels is not possible in all areas, as the analysis questionnaire contains specific items where reaching a stage would also fulfill the conditions of the previous stages.

4.2 Scope

The initial organisational experiences suggest that the maturity model should not require extensive training or other major resource investments as the target group of evaluators is large. The scope of the maturity model must be evaluated to identify how well it targets the area of focus for the study. The assessment of scope is performed based on the items of evaluation that are used in the model to evaluate maturity in a specific area.

AWS CTMM is defined as a transition maturity model to AWS cloud, which indicates a very limited scope. CMMI-DEV is a development maturity model and as a general model contains no direct approaches to cloud infrastructure. OACA CMM focuses on transition to cloud and hybrid IT for beginners and advanced operators.

4.2.1 Items of evaluation

In the AWS CTMM maturity matrix, there are 16 customer challenges, 4 in each stage, and these challenges act as the maturity indicators. Each challenge is paired with a transformational activity that is designed to solve the issue and a description of an outcome of the activity. An example of a challenge in stage 1 is limited knowledge of cloud services, which is adjusted with education and training, and leads to organisational knowledge and support.

CMMI-DEV is not a cloud maturity model and expecting it to contain cloud specific items is not reasonable. The model contains 22 process areas that are collections of practices in those areas that are considered vital for improvement. Additionally, there are generic and specific goals and practices that address the objectives and the necessary activities for reaching them. These all are divided to required, expected and informational components based on their importance in process improvement.

OACA CMM has 32 domains that indicate focus areas in its analysis questionnaire and the selection of relevant evaluation domains is advised. The domains contain a varying number of capabilities, which are divided to three target areas, people, processes, and technology. Each capability has a control question, the six CMM levels and a cell identifying the stakeholders for the capability.

4.2.2 Evaluation tool

As the model is used as an evaluation tool, the structure of the tool is also assessed. CMMI-DEV is a verbose general model and is not applicable as a simplified tool without major alterations. AWS CTMM and OACA CMM can be displayed in grids, but their structure is not comparable as estimating maturity level for a single item of evaluation is not possible in AWS CTMM but is foundational in OACA CMM. The rows in AWS CTMM contain a single challenge, transformational activity, and outcome, which does not indicate maturity progress in stages.

4.3 Summary

The identified cloud maturity models were assessed on the criteria that the model should be extensive enough to be usable in evaluation of critical systems with sensitive data, be simple enough for almost immediate use and provide improvement methods for stages.

In AWS CTMM the contents and requirements of the stages are very specific, with the four-stage model measuring the cloud transition process. Its structure is not applicable for structured measurement of progress through the stages as the continuity is not clear, but it contains transformational activities that can be used to overcome the identified challenges in maturity and is easy to adopt. It is not consistent in its representation, as certain challenges can be considered as actions.

CMMI-DEV was found difficult to compare due to the considerable size of its documentation and the generic phrasing arising from its general scope. The focus on individual processes causes the continuous representation to be inapplicable for this development process. Based on the review, the staged representation could be used to generate a maturity model with specific items, but it would require extensive research and a considerable investment in resources. The extensive contents of the model could not be represented in a simplified model while preserving the method of CMMI-DEV evaluation.

OACA CMM contains a large selection of cloud evaluation items with descriptions for all six maturity stages and is suitable for progressive maturity measurement as it has the same CMM background as CMMI-DEV staged representation but is more targeted and less demanding to adopt,

with a grid of cloud maturity indicators already present. The model is missing practical improvement methods and the evaluation items for data protection and compliance are limited.

AWS CTMM and CMMI-DEV staged representation do not contain a stage with no maturity despite their differences in structure, while OACA CMM and CMMI-DEV continuous representation do. The value of stage 0 is not well represented in OACA CMM but is reasonable in the institutionalizing of processes focus in CMMI-DEV. Iterative optimization is present in all models, but is not specifically discussed in OACA CMM.

OACA CMM was identified as the suitable model to be adapted for the specific focus of this development process. It would provide most of the evaluation items and to preserve the items, the grid structure and stages would also be adopted. The transformational activities of AWS CTMM were identified as potential source for integrated improvement methods.

To reveal findings on the usability of the selections, reviews of the selected models had to be analysed. The OACA model is not extensively studied, but Willis et al. (2021) concluded in their case study that the model is effective in animations industry. Studies on AWS CTMM are also difficult to locate, but van Dijk (2017) mentions it in their study, agreeing with the unorthodox nature of the model, but does not approach the transformational activities in depth.

5 Development of the new model

In this section the implementation of the new maturity model is examined. First, research of maturity model development had to be explored to determine the necessary measures. Then, data for the contents of the model is collected and finally the contents and structure are selected based on the data.

5.1 Method of the development assignment

Literature on maturity model development had to be explored to identify the actions required in the development process. The studies were discovered in the original literature review of the thesis. Becker et al. (2009) list the eight requirements for maturity model development in their paper. The first requirement is a comparison of existing maturity models to discover if there is a need to develop the new model. The second and third requirements are iterative development and evaluation processes to refine the model through use and quality assessment. The use of multi-methodological procedure of well-founded research methods is the fourth requirement. The fifth requirement is the identification of the relevance of the problem, where the applicability of the solution the model presents must be demonstrated. In the sixth requirement the problem also must be defined by defining the domain, conditions, and benefits of the use of the model. In the seventh and eight requirements, the presentation of the model must match its user's needs and the design process must be documented in detail.

The development of specifically maturity grids has been proposed to be conducted in four stages. In the first stage the aim, scope, purpose, and target audience of the model must be defined as well as its criteria of success. In the second stage, the process areas, maturity stages, cell contents and the administration mechanisms of the maturity grid are defined. In the third stage, the grid us evaluated against its success criteria and the need for more development iterations is assessed. In the final stage, the relevance and accuracy of the model is maintained in a continuous phase (van Dijk, 2017).

Viewing the development process of the new model against these directives, the definition of the problem and the scope of the model can be considered completed with the practical issues the

model aims to address. The comparison of the existing models has also been performed. Multi-methodological design process where the items included in the model are decided must be implemented and then the result validated with use and next iteration planned, if necessary.

5.2 Development assignment data and its collection

Due to the expansive and modular nature of OACA CMM, it will be used as the basis for the new model. To maintain a simple structure and user-friendly approach of the new model, the number of evaluation domains had to be limited. The selection of items requires a study of AWS CTMM to identify maturity indicators that would be relevant for the new model in the practical infrastructural domain. Then attempts to identify matching items from OACA CMM will be made and improvement method will be assigned from AWS CTMM.

As the selection of evaluation items is affected by personal perspective even if AWS CTMM is used as frame of reference, survey is conducted to gain qualitative data on the comprehensiveness of the evaluation domains and to see if the stages are reasonable. Special requirements placed by the focus on non-profit organisations can also be determined as a part of survey.

5.2.1 AWS CTMM restructuring

AWS CTMM does not follow the CMM structure that is used in OACA CMM. Therefore, attempt was made to restructure the AWS CTMM maturity matrix to display progress through stages to enable tracking of individual domain's maturity. In the process, all the maturity indicators in AWS CTMM model were assigned to general areas to identify if all the stages would be represented in the area.

Table 1. Assigned areas for AWS CTMM challenges

Stage	**Challenge**	**Assigned areas**
1	Limited knowledge of AWS services	Knowledge

1	Limited executive support for new IT investment	Executive, investment
1	Unable to purchase required services	Management
1	Limited confidence in cloud service capabilities	Knowledge, planning
1	No clarity of ownership	Management
2	Limited knowledge of security and compliance paradigms and requirements in the cloud	Knowledge
2	Assigning the required resources to effectively drive the transformation	Resourcing
2	Cost and budget management requirements and concerns	Management, costs
2	Lack of a detailed organizational transformation plan	Planning, organization
3	Implementing an effective and efficient migration process	Capability, action, migration
3	Managing environment efficiently and effectively	Management, capability
3	Developing an effective and efficient migration strategy	Planning, migration
3	Migrating all targeted applications (All-In) successfully	Migration, action

4	Optimizing cost management	Management, costs
4	Optimizing service management	Management, service
4	Optimizing application management services	Application, service, management
4	Optimizing enterprise services	Enterprise, services, management

The assigned areas were modified into labels and the items were assigned to labels estimated to be most accurate for the item. This was performed to identify if assessing progress in maturity levels in the label would be possible. The transformational activities related to the maturity indicators were also assessed to identify any relation between the items. The new labels were skills, executive, cost management, planning, governance, actions, service management, application management, and enterprise management. The items were then added to a rudimentary maturity grid to observe the structure (Figure 3).

Label	Stage 1 - Project	Stage 2 - Foundation	Stage 3 - Migration	Stage 4 - Optimization
1. Skills	Limited knowledge of AWS services (knowledge) Raise level of AWS awareness via education	Limited knowledge of security and compliance paradigms and requirements in the cloud (knowledge)	Implementing an effective and efficient migration process (capability, action, migration) Select and implement best	
2. Executive	Limited executive support for new IT investment (executive, investment) Seek case studies of proven return on	Assigning the required resources to effectively drive the transformation (resourcing) Conduct a People Model		
3. Cost management	Unable to purchase required services (management) Use current services or create new contract	Cost and budget management requirements and concerns (management, costs) Conduct an AWS Cost	Managing environment efficiently and effectively (management, capability) Select and implement best management environment	Optimizing cost management (management, costs) Leverage AWS tools and features to continuously
4. Planning	Limited confidence in cloud service capabilities (knowledge, planning) Execute one or more pilot/POC projects	Lack of a detailed organizational transformation plan (planning, organization) Conduct a Governance	Developing an effective and efficient migration strategy (planning, migration) Conduct an Application	
5. Governance	No clarity of ownership (management) Conduct a Kickoff and Discovery Workshop ->			
6. Actions			Migrating all targeted applications (All-In) successfully (migration, action) Migrate workloads using	
7. Service management				Optimizing service management (management, service) Utilize latest AWS tools to continuously improve
8. Application management				Optimizing application management services (application, service, management) Utilize AWS best practices and tools (e.g., DevOps, CI/CD) to continuously
9. Enterprise management				Optimizing enterprise services (enterprise, services, management) Continuously seek ways to aggregate and improve

Figure 3. Result of AWS CTMM restructuring

Completing the grid was found to be impossible with the data and the AWS CTMM maturity outcomes were also examined to complement it, but further visualisations indicated that only cost management could be evaluated on all four stages and even that construction is suspect due to the word association method being used.

5.2.2 Evaluation item selection

To populate the model with valid data, majority of the evaluation items are extracted from OACA CMM analysis questionnaire version 4.7 (Open Alliance for Cloud Adoption, 2021). The initial selection is based on OACA CMM domain descriptions and the specific capability evaluations are then selected based on areas identified in AWS CTMM and estimated practical applicability in infrastructural change.

5.2.3 Survey

The expertise of the assigning organisation and the company was applied to further enhance the model based on experiences of people working with non-profit organisations and cloud services.

The model draft version was sent for evaluation. Feedback from assigning organization, another product-based organization that has already adopted cloud services and company cloud center specially to assess the cloud technical sections of the model.

Survey setup

So, to gain insights from practical experiences in the company, the draft model was sent to select personnel in three different subdivisions for evaluation. Subdivision 1 is the assigning organisation for the thesis, specialising in providing service products for non-profit organisations. Subdivision 2 is also a product-oriented organisation but is more experienced in cloud service adoption. Subdivision 3 is the specialised cloud division of the company.

Initially the survey was intended to be open feedback and unstructured interview based on the feedback if clarification would be required. A test viewing of the model was performed with the organisational guide of the thesis to evaluate if open feedback would be a viable solution. The result of the test viewing was that the model was too complex to not have any structure in the survey and the recipients would likely find the survey too daunting to respond. Due to the time limitations caused by approaching summer holiday period and the unavailability of the recipients for an extended time if the survey would not be conducted almost immediately, decision was made to rapidly produce a spontaneous set of questions in a one-on-one discussion.

The questions were:

1. Are the general areas (skills, financial, management, design) of the model reasonable in their scope?

2. Are the general areas correctly labeled?

3. Should there be more or fewer than six (0-5) maturity stages?

4. Are the domains (rows with the control question & stage explanations) structured correctly?

5. Are the stages in the domains in correct order?

6. Are there any stages that are not applicable in practice?

7. Are there any stages that are not sufficiently defined?

8. Are the domains sufficient, or are there items that should be included in the model?

9. Is there anything else learned from cloud operations that should be included in the model?

Subdivision 1

Identifying recipients from subdivision 1 proved to be difficult even with the familiarity with the responsibility areas of personnel and structures of the organisation, as majority of the people directly contacted claimed to not have enough expertise to provide meaningful input. Only two people were initially willing to engage the matter, the solution architect acting as the organisational supervisor of the thesis was one and a product manager that had managed the cloud transition in the subdivision before leaving was another.

The solution architect was the first person contacted and presented with the draft version. In open feedback requested more emphasis on product architecture, as the business value is in it and affirmed that advanced and realistically unreachable points would be fine, even if the situation would not allow progress in them. The discussion brought up the need for the survey questionnaire to simplify the assessment of the model.

The project manager confirmed that if the client is a public service or similar to a public service, such as a non-profit organisation, they are extremely worried about data protection and if the data is kept within EU area. Claimed it as the primary concern of such parties, as they have legal responsibilities to follow GDPR and want contractual assurances of data protection. They also referred that the rules that officials must follow predate cloud services and require updating before public services find cloud services appealing.

The questionnaire was sent to both evaluators from subdivision 1, but no new responses were received.

Subdivision 2

Subdivision 2 was identified by personnel in the assigning organisation as a suitable group to gain more experienced cloud service evaluations from a product-oriented viewpoint. After contacting the supervisors, 10 people were named as suitable recipients for the model evaluation questionnaire with the aim of having an extensive set of roles. The roles were: senior manager (business), senior manager (product management), three system specialists, project manager, application architect, service manager, human resources supervisor and developer.

The first round of emails had no responses other than out of office messages due to holiday season. The second round was sent after a month had passed so that the recipients would be more likely to be present to respond, but that resulted in only one response from a system specialist and 3 out of office messages.

The system specialist argued that migration should be an area in the model if applicable to business and that service or application management maturity should also be measured, even with their own general areas. They found design to be a confusing area label, as to them the area represented application architecture. They also found that there were too few control questions per area and too many stages, arguing that 3 to 4 stages could be enough and stages 0 and 1 could be combined. In the question about their findings of practical cloud operations they responded that evaluating the specific business domain's customer's willingness for cloud transition might be beneficial. Their response could also be interpreted as them having a view that the model was AWS specific.

The third round of emails was sent after three weeks had passed and resulted in an email response from senior manager of product management and direct chat contact from human resources supervisor. The senior manager simply claimed that the model appeared to be suitable for the intended purpose. In the chat with the HR supervisor the purpose of the model had to be clarified, as it was unclear to the interviewee if the model was measuring individual clients and the usability of their licenced software in cloud. After clarifying that the model was for measuring the producing organisations capability for cloud production, they declared that the model was comprehensive.

Subdivision 3

For subdivision 3 the director was contacted, and the director allocated one other person, a senior cloud advisor, in addition to themselves for evaluation. The questionnaire was sent to both, and the responses were received almost immediately.

The director argued that in stages 4 and 5 the general organisational support for learning overrides the formal learning paths and organisational strategies can be used as a source for feedback for the learning process. They disagreed with the listed soft skills and saw them as frames of reference rather than actual soft skills such as accountability and culture of experimenting. They preferred the term FinOps for the financial area and declared that at stages 4 and 5 the role of governance should be emphasised and the proactive costs optimisation from the responsible persons is essential. For application design they expressed that definitive comparison of maturity is difficult and suggested that it could measure the level of cloud nativity in application design, with use of automatisation, high-availability, resilience and PaaS features increasing with maturity. They also noted that security and compliance should be assessed in the model and that governance would be more suitable term for management area.

The senior cloud advisor asserted that maturity models should also be targeted to the client and that the client should have input in the selection of general areas. They argued that most maturity models have 3 to 6 levels and that using fewer levels is precise enough in most cases. They state that the model had relatively few rows with focus that might not suit the client and contended that some of the maturity stages did not match the control question. They were confused about 5 questions out of 9 and mentioned that the question on cloud operations did not make sense as the model did not address them. They finished by stating that the model required more guidance, repeating the necessity for client focus and that in a maturity model the purpose is more important than structure. When contacted directly to clarify that they understood the objective of the model, they stated that they did, but further explanations were not given.

Security & compliance

After the survey of subdivision 3, a security and compliance section was added based on Capability Maturity Model for Safeguarding Privacy in Academic Research (Domingus, 2017) and OACA CMM capabilities for data access & availability and data security & privacy. Business security manager for subdivision 1 was contacted for an interview to evaluate the change. Initially the invite was to

evaluate specifically the security and compliance area of the model, but observations about other sections were also raised. The cells with multiple maturity items, such as integrated improvement methods, were found to be unsuitable for actual use, as it interfered with the progress in the stage structure. The evaluation items for security & compliance acquired from the model by Domingus (2017) and OACA CMM capabilities were also identified as inapplicable for organisational management and alterations were suggested.

5.3 Analysis of data

The data from the three methods were constantly analysed to maintain focus in the gathering processes. This section explores the final findings of each method and their effects on the development process.

5.3.1 AWS CTMM findings

The modification of the AWS CTMM model to CMM format proved to be impossible due to the lack of continuity in the stages. The main value of the attempt was the identification of general areas to focus on in the selection of domains from OACA CMM. Maturity evaluation related to skills, executive support, planning, governance and management of services, application, costs, and enterprise were identified.

From transformational activities, applicable improvement methods were extracted. Actions for stage 1 maturity were execution of proof-of-concept project to gain confidence in cloud services, improving cloud skills with training, gaining executive support with studies that prove return of interest, educating legal and procurement staff in cloud service purchasing paradigms and conducting a kickoff workshop to clarify cloud ownership. In stage 2 four workshops are suggested, security workshop to gain expertise in cloud security, people model workshop to assign specialists as cloud experts, cost model workshop to manage transformation budget and governance workshop to produce a cloud transition plan. The transformational activities for stages 3 and 4 contained were specific to AWS cloud and were considered less important.

5.3.2 Evaluation items

The 32 domains in OACA CMM were appraised with focus on areas identified in AWS CTMM, but the limited scope of the AWS model was taken into accord and the selection was also affected by the knowledge gained from the studies and professional experiences.

For the new skills general area, capabilities relating to service management skills titled as soft skills and technical skills from OACA CMM skills domain, and formal cloud training from structure domain were selected.

For the new financial general area, team cloud service purchasing capability and service cost optimization were extracted from AWS CTMM and complemented with OACA CMM items. Control of cloud spending capability from OACA CMM governance domain was also included.

The third general area was constructed from cloud service success evaluation capability from OACA CMM enterprise domain and security training from OACA CMM security domain. The area was labelled as management.

The final general area was design and it consisted of only application design capability from OACA CMM application domain.

The improvement methods from AWS CTMM were added to the cells of related capabilities and stages. The survey for assessing the first version of the new maturity model was then conducted.

5.3.3 Survey

Out of 15 people contacted for evaluation, 8 responded, of which 4 answered to the questionnaire and 4 were engaged in an unstructured interview. All 8 had different roles, which can be seen as a success for the exhaustiveness of the survey. Due to the low engagement a qualitative approach with unstructured interviews was necessary. Out of the responders, 2 viewed the model as complete, 4 suggested alterations, 1 only addressed a single part of the model and 1 was critical of the entire concept.

From the 2 responses claiming the model to be comprehensive, 1 was very brief, but the second was a result of a discussion where the objective of the model was clarified and can be considered more reliable.

From the 4 responses where alterations were suggested, the requirement for a new cultural soft skills measurement was seen as necessary, because they were referred directly and indirectly on multiple occasions. Management was renamed to governance and security capability was transferred to security & compliance section with the new cloud data security capability from OACA CMM. The suggested shift to evaluation of customers or contracts was not seen as applicable for the model, as the evaluation was to be about organisational capability for an action, which measures potential rather than process. Due to the compelling feedback on their disruptive nature, the integrated improvement methods from AWS CTMM were either removed if they did not align with the other contents of the cell or merged with the cell if they did.

The result where only a single part of the model was addressed confirmed the topic of the thesis by strongly addressing the GDPR and data protection concerns of the clients. From this a secondary security & compliance section with capabilities that are not cloud specific was added to address the items prominent in client concerns.

The critical response along with the enquiries on the client focus from a positive response and an alteration response raised the concern that the model is based on a misconception of maturity models and such a simplified approach would not be warranted. As the objective of the new model was to have a pre-set focus for product development with cloud infrastructure, major changes to the usage of the model were not seen as viable.

6 Results

6.1 Model concept

After the process of AWS CTMM restructuring, evaluation item selection and the validation of the first draft through a survey, the first version of the model was finalised to be used in workshops. In addition to complementing the content validation of the survey, the workshops also demonstrate the practical usability of the model for product teams in the organization.

Evaluation domains	Question	Stage 0 -None	Stage 1 - Initial	Stage 2 - Opportunistic	Stage 3 - Systematic	Stage 4 - Managed/Measurable	Stage 5 - Optimized
Skills (Cloud)	*Have employees gone through formal cloud training?*	No formal cloud training	Training done on individual level based on personal interest	Training done based on team's internal discussion. Some organizational support.	Training plan based on business unit and structure is in use. Success measured with key performance indicators.	Training plan based on business unit and structure is in use. Organisational culture supports additional individual training.	Training plan is proactively updated with the projected changes in structure or strategy. Organisational culture supports and guides individual training.
	Do employees have the necessary understanding of service management concepts? (ITaaS).	No	Some have limited understanding	10-25% have appropriate level of understanding	25-50% have sufficient understanding and certifications, especially in key positions	50-75% have sufficient understanding	100% have extensive understanding and business strategy training
	Do employees have the necessary technical cloud skills?	No one has any cloud expertise	Some individuals have limited knowledge of cloud services	10-25% of employees have at least intermediate cloud skills, such as security and compliance in the cloud and are proficient in the use of the UI.	25-50% of employees have advanced cloud skills and are capable of implementing an efficient migration process	50-75% of employees have advanced cloud skills.	100% of employees have extensive and certified cloud skills
Skills (General)	*Do employees have necessary "soft skills"?*	No, tasks are followed mechanically	Some level of proactive problem solving	Employees have a sense of responsibility and a drive for quality within preset task parametres	Sense of responsibility and an active drive for quality in overall culture	Tasks and problems are being handled with major responsibility and a culture of experimenting	Culture of responsibility and quality are a major part of overall organisation and it is supported with rewards
FinOps	*Are teams capable of purchasing necessary services? (New subscribtions etc.)*	No	In individual cases through a slow bureaucratic process	Through a slow bureaucratic process with identified individuals	With a purchase form. Role based KPIs in use.	With an efficient process through a purchase form. Team based KPIs.	With a management softw are that tracks the purchases and has rapid response time
	Is Finance in control of the spending on cloud services?	No, they just receive invoices	Purchases and bills are used to track cloud spending retroactively	Partners and services are listed and projects budgeted to these.	Cloud spending authorized and coordinated by the use of the list of services and partners. Value management plan implemented	Real time authorization process in use for orders	Constant process to automate and integrate the budget & authorization process further
	Service cost optimization	Costs aren't taken into consideration	Deployment of unnecessary dummy services has been discouraged	Cloud billing overview is occasionally viewed and clearly unnecessary costs eliminated	Cloud billing overview is viewed manually, but at set intervals and necessary actions taken	Automatic costs tracking is in place. Unnecessary or inefficient services are not tolerated	Cost efficiency of the used services is constantly reviewed. Finance trained in cost review
Governance	*Is the success of cloud services evaluated?*	No evaluation. Cloud service use is not managed	Service's success is defined by multiple users individually	Use of KPIs possible.	KPIs are used to evaluate. Cloud Center of Excellence involved in evaluation	The KPIs are also reviewed.	Regular review of KPIs against business outcomes
Security & compliance (Cloud)	*Does security training material include cloud security?*	There isn't much security training material at all	Security is discussed and cloud security is part of the discussion. Actual training based on personal interest	Secured offered but not required	Security training is done systematically and even cloud security alerts can be handled	Certification for cloud security required for all. Quality Gates are evaluated	Business objectives include a certain level of certification for cloud security. Certification required for every level, including partners
	Does a Data Security and/or Privacy Concept exist for Cloud?	Data security or privacy concepts do not exist at all	Non-cloud data security and privacy concept is used for cloud services.	Data access, security and transmissions handled on a project level.	Data sensitivity groups are defined. Privacy and security are differentiated for and acceptable use in cloud services. Organisational rules for data security and privacy in cloud exist and audits are defined and done regularly.	Data flows and classes for security and privacy are documented and evaluated. Audits and checks for data policy are being done to ensure data handling in transit and rest, including encryption.	Active data lossfleakage prevention for cloud services. Security and privacy audits are automatised. Data encryption, transmission and interface management automatically monitored for compliance with corporate strategy and policy.
Security & compliance (General)	*Data protection directive (GDPR)*	Not taken into consideration at all	The idea of data protection and privacy is understood. Its handling is based on individual opinions.	Data protection and privacy is being discussed as an external issue. Strategies for achieving compliance in the most obvious data protection requirements have been developed.	All employees are aw are of the data protection and privacy requirements. Compliance work is included in the workflow.	Data protection and privacy is an integral part of design rather than an external issue. All legal obligations are internally well defined.	All employees have internalised the need for data protection and privacy, as well as its standards. Regular compliance checks are in place.
	Is sensitive data handled responsibly?	No encryption is done.	Data is encrypted.	Individual services only handle the data that is necessary for their operation.	Access to saved data is limited.	Access to saved data is audit trailed	Use of sensitive data constantly monitored.
Design	*What is the organisational capability for cloud application design?*	Only client server application can be made	Stateless applications can be made. Some cloud services might be in use (storage, compute etc.) among on-premise services	Cloud storage and computing could be utilized in most applications. Monitoring and self healing in applications by design	Applications, whose services would not be affected by failures in dependent services. Transactions would roll gracefully between service instances	Applications that could be migrated without interruption of service and scale themselves based on performance needs and availability	Applications, which would be patterned and use constructor services that would function as building blocks for applications. Less manual work

Figure 4 - New maturity model grid

The main differences in first version of the model (Figure 4) compared to the model draft presented in the survey are related to inclusion of sections that were not available in OACA CMM or AWS CTMM. The contents of the evaluation items were not altered in general, aside from the removal of the AWS CTMM improvement methods that interfered with maturity evaluation in their capabilities.

To make the new model more comprehensive for software product development for non-profit organisations, evaluation items that are not strictly cloud related were considered necessary. A

capability of soft skills was added to a new general skills area to measure skills that are difficult to accurately measure, such as responsibility and the OACA CMM inspired skills were moved to cloud skills area.

In line with the data protection and compliance focus of the new model, the security & compliance area had to be established and divided into cloud specific and general capabilities. The cloud capabilities measuring cloud training and cloud infrastructure data security are modified from OACA CMM stages to be more suitable for target organisations based on the practical findings of the security expert. Measuring the legally binding requirements was a common request in the survey, so the assessment of the level of maturity in European Union data protection regulation and technical data handling had to be included.

6.1.1 Structure

As majority of the evaluation items with maturity level descriptions were adopted from OACA CMM, deviating from the OACA CMM stage structure was not considered reasonable, even though fewer stages were proposed in some survey responses. The model then follows the 0-5 stage distribution with minor alterations to their labels. Level 1 was renamed from initial/ad hoc to initial, level 2 from repeatable/opportunistic to opportunistic and level 3 from defined/systematic to systematic. The relabelling was performed to make the labels more accurate for the maturity levels in the capabilities. The maturity stages are not described, as the objective was a simplified structure, and the labels were estimated to be intuitive.

The model is presented in a single spreadsheet document as a grid to enable matrix evaluation. Due to the specific nature of the model and the assumed intuitive nature, no pre-evaluations, scope definition processes or explanations on the use of the model are provided. The evaluation areas are colour coded, but as the evaluation is intended to be based on capabilities, the areas are just for visualisation without specific purpose.

6.2 Assessment workshops

6.2.1 Workshop setup

To assemble a unit capable of evaluating the organisational maturity with the model, personnel from all the teams in the organisation were invited. The group consisted of team manager, solution architect, business security manager, technical leads of each team and the most experienced cloud developer. The evaluators were given 3 days to familiarise themselves with the model before the status workshop and additional 3 days before the goal setting workshop. The same document was evaluated in both workshops.

As one of the objectives of the workshops was to evaluate the useability of the model, status of mainly passive observers was adopted to limit the effect on the evaluators. Ability to clarify misconceptions about the model to make the full evaluation possible was retained.

6.2.2 Status workshop

The status workshop had a total of 8 attendees, not including the facilitator. Only a few attendees had inspected the model before the workshop and the function of the maturity grid had to be explained. There were initial enquiries on the method of identifying the parties capable of making and evaluation for the scope. The necessity of reaching consensus for each capability was also discussed but was later dismissed.

Due to the variation in the level of cloud adoption in teams within the organisation, initial experience was that the evaluation should be team or product based. After clarifying that a high maturity level is not necessary, and the evaluation of the entire organisation's capability is the intention. The assessment was performed in the group chat with each participant giving a value for the row almost simultaneously, which may have affected the assessment of others.

The difficulties identified in the evaluation process were minor, but numerous. Not all the concepts in the maturity levels were familiar to all the attendees, which made them incapable of coming up with an assessment for the capability. The soft skills capability was considered foundational for all areas of development and therefore important, but the differences of stages 2 and 3 were

unclear. There was major variance between teams in sections related to cloud service procurement and optimisation indicating that information sharing in organisation is limited in these areas. A maturity level for capability for measuring success of cloud services could not be presented by the evaluating group. The security & compliance capabilities that were not cloud specific were given comparatively high maturity values.

6.2.3 Goal workshop

The goal setting workshop was conducted 3 days after the status workshop and had 6 evaluators in attendance. All attendees had also attended the status workshop and were therefore familiar with the model, but general confusion on the usage of maturity grids was apparent. The difference between teams was an item of discussion in this workshop as well and adopting a mindset of strictly organisational maturity on larger scale was initially seen as difficult, as larger scale maturity improvements were estimated to require excessive resources. Especially the business and contractual perspectives were noted to impede full cloud adoption in the organisation. The attendees agreed to seek consensus for the goal maturity levels through discussion after it was explained that the organisational capability would not require similar capability from all the teams. The attendees also agreed that setting a time frame for the maturity goal would be necessary for an evaluation to be feasible. The time frame was set to 3 years.

In the goal setting discussion, it was agreed that goal setting was more difficult than the status evaluation and high maturity goals would be preferred. The label for stage 2, “opportunistic”, was seen as negative making it a less desirable maturity goal.

From the individual capabilities, soft skills inspired the most discussion with its importance and unorthodox nature. For cloud training the stage with 50% of personnel having advanced cloud skills was seen as excessive, as the skills are only utilised by certain developers. The differences of the descriptions of cloud training levels 3, 4 and 5 were also unclear. Another demanding stage was cloud security training material stage 4 due to the requirement of having all personnel being certified in it. The term self-healing in application design capability was regarded as obscure by the attendees. Assessing the application design goal was difficult overall for the evaluators. Service management concepts were regarded as necessary only for the service managers and improving the

maturity of financial control of cloud services would require changes in their role. The security areas were considered important, with GDPR capability especially so.

Overall, the conclusion of the model was that it was comprehensive, and the inclusion of technical and non-technical items was appreciated. The discussions initiated in the workshop were regarded as beneficial for the organisation.

7 Conclusions

The view of the model after the goal setting workshop was that it contained the necessary items of evaluation for overall assessment of the organisational capability for operating non-profit cloud products. Some items, mainly acquired from survey results, were viewed as important, but were not obvious. Based on the contentment in the model's scope, secondary research question "what items are necessary in a model designed to help evaluate cloud maturity in an organisation with non-profit organisations as clients?" can be seen as satisfied.

The objective of refining the model through iterations of use suffers from the long time estimation set in the goal setting workshop. With 3-year iterations the relevance of the model could be diminished through slow refinement. The discussions in the workshops also indicated that a model with this focus is more intuitive as a tool for evaluating team maturity rather than organisational maturity.

The primary research question "is there a model that can directly be used in cloud maturity estimation for organisations that have to address data sensitivity and critical service requirements of the client and if there is none, how can maturity be evaluated?" was answered in the literature review and maturity model comparison. OACA CMM was identified as a viable maturity model for most of the evaluation, but even though it contains sections on data and security, the capabilities were not suitable. An adapted OACA CMM model can be considered a suitable tool for evaluation in that scenario.

The tertiary research question "is it feasible to integrate maturity improvement methods in the structure of a maturity assessment model and if so, how can they be implemented?" can be viewed as inconclusive, as improvement methods for only a few maturity indicators could be extracted from the collected data and even they proved to be unsuccessful based on feedback. Based on the attempt, integrated improvement methods can be implemented in a maturity grid that is extremely limited in its scope and use case, but no conclusion can be made for more verbose maturity frameworks. Cloud service vendor specific models that target a single area of cloud maturity, such as AWS CTMM, could be viable for such a feature, even if AWS CTMM improvement methods were regarded as unsatisfactory.

8 Discussion

8.1 Reliability and ethicality

The author's knowledge of maturity models was very limited in the beginning of the study, and it may have influenced the assessment of value of reviewed research and material. The literature review was not sufficiently structured, especially as the selection of maturity model research gravitated towards grids that measure practical capabilities due to the approachability of their visual representation. Experiences of an ongoing cloud migration process may also have affected the perspective taken in some selections, especially with evaluation items. Therefore, the scientific rigor of the research can be met with skepticism.

The development of the model was performed with the ambition of using respected existing model as base and supplementing it with research of the special non-profit requirements and practical experiences. Even though the survey had a poor response rate and only one instance of use has been performed, there is little doubt in the validity of the model produced by the combination of methods, especially as the model is intended to be refined over time. The feedback from the workshops provided additional validation for the model as the participants were able to use the model relatively independently and very few alteration arose from the sessions.

8.2 Discussion of the main results in view of the theoretical framework

Cloud maturity model research is influenced by few studies and many studies are behind a paywall and therefore inaccessible for lighter study. Based on the literature review, maturity model development produces specialised results, with the established collaborative models such as ODCA CCMM, OACA CMM and CMMI performing as the frames of reference. Even with their influence, the limited literature review in this study indicated that cloud maturity model research is inconsistent, as some studies view maturity models more strictly as guidelines and others as tools for maturity tracking in a preset scope. The first stance appears to be more scientifically rigorous, but in the possibly naïve viewpoint of this study, the visualised model is serviceable approach for measurement.

Based on discussions and other unstructured communication during the study process, there is more organisational engagement when using simplified model as opposed to a more complete transformational model with preliminary work with target scope setting and such. Yet again, the study can be considered an application of such a framework for the use case, as major deviations were found to be unsuitable for practical use. OACA CMM was not found precise enough to be directly applicable, but as the new model is based on it, the use of the extra tools it provides, such as service capability mapping and cost benefit analysis, could have proven beneficial. Due to the lack of research on its effectiveness, especially in organisations with limited resources available for evaluations, it was not explored as an option and the model with pre-set parametres with universal applicability in the use case was the objective. In conclusion, the new model is unique with its additional sections concerning the needs of non-profit organisations and the organisations serving them, but its applicability for adaption to another scope is limited. OACA CMM serves as a valid model for adaptation.

The selection of design research as the research method for the study was reasonable, as the attempt to produce a streamlined model required a combination of literature review and survey to produce the necessary theory. Even though the measure that was arguably the most novel, integrated improvement methods, failed, the failure was a result of conducted research. As Kananen (2012) states, research which outcome is known in advance is not research.

The survey was found to be inefficient way to gather data in these circumstances, as the recipients dismissed the questionnaire entirely or were generally more eager to engage in an open discussion. An online survey with a wider selection of recipients could have proven valuable, but the time restrictions did not allow it after the initial surveys were found to be insufficient and the objective of the research was a qualitative validation of the model, so excessive number of responses would not have been beneficial.

8.3 Development proposals

As the first iteration of the constant refinement process intended for the model is complete, there are authentically identified areas of improvement for the model. The design process also prompted some findings that could not be addressed at that point.

Stages should be defined more precisely to match the structure in a model that has such a limited scope. Using OACA CMM stages directly is not applicable, even though they are well researched, as evaluation items from other sources are used as well. To preserve the approachable structure, descriptions for each stage should also have been included, as the stages are less relevant if they aren't defined well, and external document would interfere with the simplicity. Inclusion of a structured time frame setting for the goal workshop is necessary.

Involving a larger group with a comprehensive selection of roles in analysis of the OACA CMM domains and capabilities could allow identification of additional applicable capabilities, although based on the findings of the study, the process would require considerable resources.

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Appendices

Appendix 1. New maturity model grid

Evaluation domains	Question	Stage 0 –None	Stage 1 – Initial	Stage 2 – Opportunistic	Stage 3 – Systematic	Stage 4 – Managed/Measurable	Stage 5 – Optimized
Skills (Cloud)	*Have employees gone through formal cloud training?*	No formal cloud training	Training done on individual level based on personal interest	Training done based on team's internal discussion. Some organizational support.	Training plan based on business unit and structure is in use. Success measured with key performance indicators.	Training plan based on business unit and structure is in use. Organisational culture supports additional individual training.	Training plan is proactively updated with the projected changes in structure or strategy. Organisational culture supports and guides individual training.
	Do employees have the necessary understanding of service management concepts? (ITaaS,	No	Some have limited understanding	10-25% have appropriate level of understanding	25-50% have sufficient understanding and certifications, especially in key positions	50-75% have sufficient understanding	100% have extensive understanding and business strategy training
	Do employees have the necessary technical cloud skills?	No one has any cloud expertise	Some individuals have limited knowledge of cloud services	10-25% of employees have at least intermediate cloud skills, such as security and compliance in the cloud and are proficient in the use of the UI.	25-50% of employees have advanced cloud skills and are capable of implementing an efficient migration process	50-75% of employees have advanced cloud skills.	100% of employees have extensive and certified cloud skills
Skills (General)	*Do employees have necessary "soft skills"?*	No, tasks are followed mechanically	Some level of proactive problem solving	Employees have a sense of responsibility and a drive for quality within preset task parametres	Sense of responsibility and an active drive for quality in overall culture	Tasks and problems are being handled with major responsibility and a culture of experimenting	Culture of responsibility and quality are a major part of overall organisation and it is supported with rewards
FinOps	*Are teams capable of purchasing necessary services? (New subscibtions etc.)*	No	In individual cases through a slow bureaucratic process	Through a slow bureaucratic process with identified individuals	With a purchase form. Role based KPIs in use.	With an efficient process through a purchase form. Team based KPIs.	With a management software that tracks the purchases and has rapid response time
	Is Finance in control of the spending on cloud services?	No, they just receive invoices	Purchases and bills are used to track cloud spending retroactively	Partners and services are listed and projects budgeted to these.	Cloud spending authorized and coordinated by the use of the list of services and partners. Value management plan implemented	Real time authorization process in use for orders	Constant process to automate and integrate the budget & authorization process further
	Service cost optimization	Costs aren't taken into consideration	Deployment of unnecessary dummy services has been discouraged	Cloud billing overview is occasionally viewed and clearly unnecessary costs eliminated	Cloud billing overview is viewed manually, but at set intervals and necessary actions taken	Automatic costs tracking is in place. Unnecessary or inefficient services are not tolerated	Cost efficiency of the used services is constantly reviewed. Finance trained in cost review
Governance	*Is the success of cloud services evaluated?*	No evaluation. Cloud service use is not managed	Service's success is defined by multiple users individually	Use of KPIs possible.	KPIs are used to evaluate. Cloud Center of Excellence involved in evaluation	The KPIs are also reviewed.	Regular review of KPIs against business outcomes
Security & compliance (Cloud)	*Does security training material include cloud security?*	There isn't much security training material at all	Security is discussed and cloud security is part of the discussion. Actual training based on personal interest	Secured offered but not required	Security training is done systematically and even cloud security alerts can be handled	Certification for cloud security required for all. Quality Gates are evaluated	Business objectives include a certain level of certification for cloud security. Certification required for every level, including partners
	Does a Data Security and/or Privacy Concept exist for Cloud?	Data security or privacy concepts do not exist at all	Non-cloud data security and privacy concept is used for cloud services.	Data access, security and transmissions handled on a project level.	Data sensitivity groups are defined. Privacy and security are differentiated for and acceptable use in cloud services. Organisational rules for data security and privacy in cloud exist and audits are defined and done regularly.	Data flows and classes for security and privacy are documented and evaluated. Audits and checks for data policy are being done to ensure data handling in transit and rest, including encryption.	Active data loss/leakage prevention for cloud services. Security and privacy audits are automatised. Data encryption, transmission and interface management automatically monitored for compliance with corporate strategy and policy.
Security & compliance (General)	*Data protection directive (GDPR)*	Not taken into consideration at all	The idea of data protection and privacy is understood. Its handling is based on individual opinions.	Data protection and privacy is being discussed as an external issue. Strategies for achieving compliance in the most obvious data protection requirements have been developed.	All employees are aware of the data protection and privacy requirements. Compliance work is included in the workflow.	Data protection and privacy is an integral part of design rather than an external issue. All legal obligations are internally well defined.	All employees have internalised the need for data protection and privacy, as well as its standards. Regular compliance checks are in place.
	Is sensitive data handled responsibly?	No encryption is done.	Data is encrypted.	Individual services only handle the data that is necessary for their operation.	Access to saved data is limited.	Access to saved data is audit trailed	Use of sensitive data constantly monitored.
Design	*What is the organisational capability for cloud application design?*	Only client server application can be made	Stateless applications can be made. Some cloud services might be in use (storage, compute etc.) among on-premise services	Cloud storage and computing could be utilized in most applications. Monitoring and self healing in applications by design	Applications, whose services would not be affected by failures in dependent services. Transactions would roll gracefully between service instances	Applications that could be migrated without interruption of service and scale themselves based on performance needs and availability	Applications, which would be patterned and use constructor services that would function as building blocks for applications. Less manual work

Appendix 2. OACA CMM domains from analysis questionnaire v4.7

Domain	Capabilities
Finance	• Cloud awareness training • Organisational structure • Costs billing target • Key performance indicators • Incentive scheme • Project funding • CAPEX to OPEX investment • Financial reporting
Enterprise	• Executive management training • Enterprise strategy • Cloud adoption framework • Organisational change • Service success • Business strategy model
Culture	• Formal cloud training • Organisational structure • Internal IT • Business processes • Process management
Structure	• IT employee values • Innovation drive • Value of skills • Compensation scheme • Employee involvement • Feedback tools
Skills	• IT Enterprise skills • Soft skills • Technical skills • Skill improvement • Cross-training

	• Skill set defining • Skill development plan • Skills in hiring • Skills matrix • Skill development budget • Skills tracking • Training opportunities
Compliance	• Formal compliance communication • Employee compliance policy • Off-premises compliance • Formal compliance framework • Off-premises certification • Non-compliance handling • Compliance requirement defining • Privacy • Monitoring • Compliance management tool
Governance & control	• Formal communication plan • Finance & procurement control • Enterprise architecture • Risk management • Security requirements • Service brokerage • Risk, compliance, security tool
Business Process	• Business process comprehension • Business process documentation • Business process IT system documentation
Procurement	• Supporting enterprise cloud training • Sourcing & contracting • Cloud service catalogue • Procurement reporting • Shadow IT • Cloud vendor selection • Procurement tooling

Commercial	• Partner & client formal frameworks • Cloud contract templates • Commercial processes • Key performance indicators • Service costs billing target • Contract & process integration
Portfolio Management	• Portfolio management training • Business & technical service definition • Lifecycle management process definition • Online service catalogue
Projects	• Project skills • Service templates • Project initiation • Project funding bias • Project migration portfolio • Project tools
Operations (IT) processes	• Tribal knowledge • Skills management • Team organisation for cloud • Role changes • Service risk & compliance processes • Capacity management • Demand management • Hybrid IT operational reports • Disaster management • Team organisation for cloud service provider (CSP) • CSP backup & recovery • Cloud technology platform selection • Cloud vendor management • CSP quality feedback loops • Continuous release & deployment • Runbook documentation • Legacy platform virtualisation use

	• Traditional operational tool integration • Networking tool hybrid IT integration • CMDB support
Management tools	• Management tool standards • Metrics ownership • Service catalogue ownership • Management tool support • Management tool offering policy • Management tool service delivery • IT automation • CSP monitoring tools • CSP issue diagnosis
Security	• Security training • Organisational security structure • Policies & rules • Security frameworks • Privacy concept • Security monitoring • Security tooling • Security enforcement technology.
Information lifecycle management	• Information lifecycle management skills • Legacy ILM leveraging commitment • ILM processes • ILM process governance • ILM requirement comprehension • ILM process ownership • Backup & recovery services • Disaster recovery • Application & workstation backups • Record retention • Data encryption
DevOps	• Traditional IT enterprise • Developer operations collaboration • Development infrastructure separation

	• DevOps skills • DevOps cloud implementation • Development CSP tool usage • DevOps processes • DevOps continuous delivery • DevOps continuous assessment • DevOps process goals • DevOps cloud operation scale • Cloud architecture DevOps support • DevOps cloud roadmap • DevOps automation
Platform as a Service (PaaS)	• Cloud first thinking • Reusable code • Scaling concept • PaaS platform availability • Foundational PaaS • PaaS framework availability • Database as a service availability • Defined resources
Integration platform as a service (IPaaS)	• Required skills for IPaaS • Team integration responsibilities • IPaaS adoption roadmap • Application integration • Data integration
IT architecture	• Architect training • Architecture responsibilities • Architectural design standard • Architectural planning tool use • Architecture processes • Application design & development plans • Business application landscape • Standard cloud building blocks
Applications	• Developer skills • Application development roles

	• Applications organisation • Application build & deploy • Application architecture • Service communication • Technology & framework use
Software as a Service (SaaS)	• SaaS comprehension • Formal SaaS training • SaaS enterprise policy • SaaS integration concept availability • SaaS management concept • SaaS integration concept definition
Data	• Big data training • Cloud data service training • Enterprise data value perspective • Data access & availability controls • Cloud data service leveraging • Data management criteria • Data management process automatisation • Data management framework • Data management process • Information organisation • Data repository search
Infrastructure as a Service (IaaS)	• Infrastructure team virtualisation use • Network engineer virtual network use • Storage & data virtualisation use • Container-native DevOps • IaaS definition • IaaS architecture definition • Infrastructure computing virtualisation • Infrastructure identity management • Infrastructure orchestration • IaaS PaaS automatization • Development team practices • Infrastructure containerisation

	• Management & monitoring • Shared application virtualisation • Business IaaS framework • IaaS cross-cloud application design • Infrastructure container-based virtualisation
Storage as a Service (STaaS)	• Storage service • Storage platform mapping • STaaS consistency process • Storage security monitoring integration • STaaS framework • Secured data & network • Cloud storage solutions • STaaS adoption consistency • Storage site service interface • Storage security monitoring • Storage service interface • Infrastructure STaaS support • STaaS framework • Data & network securing • Storage service inclusion
Network	• Network team business alignment • Network team cloud training • Network team cloud connectivity training • Network team procurement • Network service notification plan • Network performance & availability reporting • Network hybrid IT architecture • Network instrumentation • Network mobile strategy • Network compliance • Network automatisation • IP management for hybrid

	• Network monitoring • Network security model • Network availability
AI	• AI executive support • AI training • IT/Ops data usage • Data quality assessment • Machine learning utilisation processes • AI data management scale • AI & machine learning adoption • AI & machine learning cloud utilisation • AI project deployment alignment
Internet of things (IoT)	• IoT training • Data visibility • Reference architecture • IoT business opportunity identification • IoT development environment • IoT monitoring • Provisioning process • IT business objective alignment • IoT layer standards definition • Specific IoT capabilities • IoT services availability • IoT technology element implementation • Secure interaction technologies
APIs	• API product ownership • API defining responsibility • API training • APIs as product • API access control • API lifecycle management • API standard architectural patterns • API BCP/DR plans • API secure development lifecycle

	• API business alignment • API update communications strategy • API security & compliance monitoring • Central API catalogue • API usage & billing monitoring • API deployment
Configuration management	• Configuration management alignment • Agile CM comprehension • Cloud resource tracking process • Cloud resource tracking as configuration items • Integrated CMS data repository • Automated cloud CI identification • Configuration consistency management
Code development	• Business developer training • Data ownership & responsibility • Suborganisation skills • Architecture layers as code • Code written artifact management • Code quality assurance • Governance & change management • Software development lifecycle process • Development cloud methodologies • Dependent technology selection • Code scanning • Business level of abstraction from code • Common development tool identification • Code reuse monitoring