How cloud providers elicit consumer requirements: An exploratory study of nineteen companies

Todoran, Irina ; Seyff, Norbert ; Glinz, Martin

Abstract: Requirements elicitation is widely seen as a crucial step towards delivering successful software. In the context of emerging cloud systems, the question is whether and how the elicitation process differs from that used for traditional systems, and if the current methods suffice. We interviewed 19 cloud providers to gain an in-depth understanding of the state of practice with regard to the adoption and implementation of existing elicitation methods. The results of this exploratory study show that, whereas a few cloud providers try to implement and adapt traditional methods, the large majority uses ad-hoc approaches for identifying consumer needs. There are various causes for this situation, ranging from consumer reachability issues and previous failed attempts, to a complete lack of development strategy. The study suggests that only a small number of the current techniques can be applied successfully in cloud systems, hence showing a need to research new ways of supporting cloud providers. The main contribution of this work lies in revealing what elicitation methods are used by cloud providers and clarifying the challenges related to requirements elicitation posed by the cloud paradigm. Further, we identify some key features for cloud-specific elicitation methods.

DOI: https://doi.org/10.1109/RE.2013.6636710

How Cloud Providers Elicit Consumer Requirements: An Exploratory Study of Nineteen Companies

Irina Todoran, Norbert Seyff, Martin Glinz
Department of Informatics, University of Zurich, Switzerland
{todoran, seyff, glinz}@ifi.uzh.ch

***Abstract*—Requirements elicitation is widely seen as a crucial step towards delivering successful software. In the context of emerging cloud systems, the question is whether and how the elicitation process differs from that used for traditional systems, and if the current methods suffice. We interviewed 19 cloud providers to gain an in-depth understanding of the state of practice with regard to the adoption and implementation of existing elicitation methods. The results of this exploratory study show that, whereas a few cloud providers try to implement and adapt traditional methods, the large majority uses ad-hoc approaches for identifying consumer needs. There are various causes for this situation, ranging from consumer reachability issues and previous failed attempts, to a complete lack of development strategy. The study suggests that only a small number of the current techniques can be applied successfully in cloud systems, hence showing a need to research new ways of supporting cloud providers. The main contribution of this work lies in revealing what elicitation methods are used by cloud providers and clarifying the challenges related to requirements elicitation posed by the cloud paradigm. Further, we identify some key features for cloud-specific elicitation methods.**

***Index Terms*—Requirements elicitation, cloud systems, empirical study, state of practice.**

I. Introduction

Requirements elicitation is a core activity in any requirements engineering (RE) process [22]. Using elicitation techniques that do not fit the characteristics of the project at hand increases RE costs and makes the project failure-prone [23]. Hence, numerous elicitation techniques, as well as methods for selecting the right techniques for a given project, have been developed and applied in practice [26].

In the context of emerging cloud systems, providers of cloud services need to elicit the requirements of potential and actual service consumers in order to develop commercially successful services. However, the existing body of knowledge that cloud practitioners can rely on mostly consists of the well-known requirements elicitation techniques that have been developed for use in traditional system development settings [22]. Also, findings from the fields of market-driven and distributed RE [10], [6] are not directly applicable, due to the differences between the mass-market and the cloud computing domains. Moreover, no empirical evidence on the elicitation methods utilized by cloud providers is available.

Therefore, we designed an exploratory study to better understand the state of practice in industry and the degree to which existing research results support cloud providers' needs with regard to requirements elicitation. Moreover, where applicable, this study investigates how traditional and market-driven methods are used, to what extent, where they are adapted to better suit individual needs, and where new, ad-hoc approaches are chosen. Since most of the participating companies were not cloud providers from the outset and only later adopted the cloud model, we also analyze the impact of their evolution on the elicitation process. The study consists of in-depth semi-structured interviews with 24 respondents from 19 companies located in 10 different countries.

The paper is organized as follows. We clarify the terminology and particular cloud computing features in Section II. Section III introduces the research methodology, including research questions, study design, and threats to validity. The key findings are presented in Section IV and then summarized and discussed in Section V. Section VI presents related work, and the last section concludes the paper with a summary and outlook.

II. Cloud Computing Particular Features

A. Stakeholders in the Cloud

In a traditional setting, clients typically run the systems at their own premises, either owning and maintaining the software themselves or owning licenses to run the software or parts thereof. Suppliers, on the other hand, sell or license, install the systems and potentially provide maintenance and consulting.

In the cloud context, consumers do not own solutions any more, but subscribe to services which they can use on demand subsequently. Cloud services are offered by cloud providers. A *cloud (service) provider* is an organization, rarely a person, responsible for making a service available to interested parties. According to the US National Institute of Standards and Technology (NIST), a cloud provider "acquires and manages the computing infrastructure required for providing the services, runs the cloud software that provides the services, and makes arrangement to deliver the cloud services to the cloud consumers through network access" [15]. Therefore, the provider is the actual owner of the solution [11].

A *cloud (service) consumer* is the stakeholder that uses the cloud services, and is represented by "a person or organization that maintains a business relationship with, and uses the service from, a cloud provider" [15]. Consequently, both Business-to-

978-1-4673-5764-7/13/$31.00 © 2013 IEEE

RE 2013, Rio de Janeiro, Brasil
Research Track

Business (B2B) and Business-to-Consumer (B2C) models are supported.

A *cloud system* is a system where computing resources are provided on demand, as services, through network access, and the main stakeholders are the cloud consumers and providers, with the characteristics described above. The service can most often be Software as a Service (SaaS), Platform as a Service (PaaS) or Infrastructure as a Service (IaaS) [11]. Consumers utilize services delivered by a provider based on a trust agreement (most frequently in the form of a Service Level Agreement).

B. Cloud versus Conventional, Mass Market Systems

The cloud computing setting is characterized by a large number of heterogeneous, globally distributed consumers, which can go beyond what traditional requirements elicitation methods are able to support [14], [20]. Moreover, change requests are frequent, resulting in unstable and volatile requirements [8]. Some of these characteristics are similar to those of international mass market settings, with diverse and often remotely located consumers. However, from a requirements elicitation perspective, the findings from the market-driven RE field are not generally applicable in a cloud context.

In the market-driven domain, many products have some local market, such that some of the stakeholders are within reach and available for direct interaction. In these cases, traditional requirements elicitation methods can be applied at least to some extent. Also, product managers use their own professional experience to invent requirements [18] when relevant stakeholders cannot be reached. As an alternative, some companies perform market studies to understand the trends in consumer requirements, which often leads to imitating what competitors do. Other organizations conduct in-depth studies and test their prototypes with selected stakeholders, and then generalize the results to the mass market.

Cloud systems differ from mass market systems in that cloud services usually do not have a local, individually reachable and easily exploitable consumer base to involve in the elicitation process. Furthermore, inventing requirements or imitating competitors are often seen as unreliable approaches due to the young age of the cloud model. Thus, despite being relevant for the cloud, the existing methods from the mass market domain do not suffice for cloud providers' needs. This motivates us to focus on the challenges they face in requirements acquisition, given the importance of the elicitation process.

III. Research Methodology

To understand the current state of practice of requirements elicitation for cloud systems, we conducted an exploratory study with 19 cloud provider companies. We chose a qualitative research approach [19] since such an approach focuses on information depth and allows for investigating diverse and complex data [3]. We used semi-structured interviews based on a pre-defined interview instrument[1]. All questions were elaborated to support three research questions (RQs; see the subsection below), and served as a starting point and structure for discussion. Since the interviews were semi-structured, the interviewer also had the flexibility to adapt according to individual circumstances, focus more on specific areas or discard questions which did not apply. The interview instrument included five parts. The first questions focused on the characterization of the company and interviewee. The next two parts included questions on cloud providers' methods for reaching consumers and identifying their requirements. Then, the state of practice of the company was discussed in comparison to competitors, and the interview was closed by analyzing elicitation-related challenges and possible mitigation plans.

A. Research Questions

RQ 1: What methods do cloud providers use to elicit consumer requirements?

Firstly, we are interested in finding out what requirements elicitation methods cloud providers currently use, if these are well-known RE methods, adapted traditional methods or simply ad-hoc approaches. Additionally, we analyzed the criteria used for method selection.

RQ 2: How do cloud providers' needs for elicitation methods differ from traditional software/hardware providers'?

Secondly, we investigate how cloud providers are different from traditional software or hardware providers as far as elicitation methods are concerned, what causes the potential differences, and if these have any impact on the elicitation method selection. For this, we focused on the companies which shifted from the traditional model to cloud computing.

RQ 3: To what extent can the existing elicitation methods satisfy cloud providers' needs?

Thirdly, we analyze if the existing methods suffice for cloud providers, or they require dedicated approaches, specifically tailored to their needs.

B. Study Design

1) Initial Preparation: The interview instrument was first elaborated as a list of questions linked to the RQs and the goals of the study. Then, it was validated with a group of RE researchers, and further improved. As a next step, the interview was piloted with one researcher from University of Zurich and one practitioner, who had not been previously involved in the elaboration of the study. During the pilot interviews, possible misunderstandings of questions were identified, new related areas interesting for investigation were found and thus some new questions were added. Moreover, the time needed for each part of the interview was measured. We adjusted the interview instrument based on the lessons learned while performing the pilot interviews.

2) Selection of Participants and Demographics: The sampling strategy we used for selecting the participating companies was convenience sampling [17] within our direct contacts network. We first contacted employees of cloud provider

[1] http://www.ifi.uzh.ch/rerg/people/todoran/Interview_Instrument.pdf

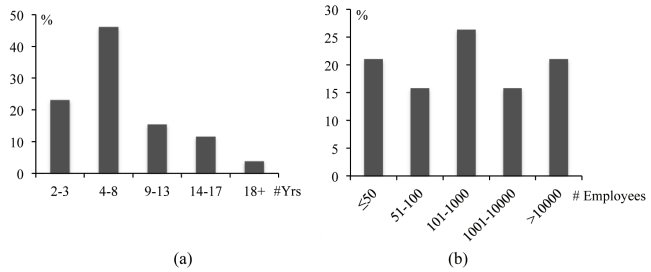
companies we personally knew. Then, during a short discussion via e-mail or Skype, we evaluated if their profile and position within the company fit with the needs of our study. If they fit, they participated themselves; if they were not a good fit, they intermediated our collaboration and recommended other employees.

As the participants needed for the study had to have a good overview of the requirements elicitation process and related company needs, only software architects, division and project managers, consultants and software engineers who had direct contact with requirements identification activities were recruited.

In total, the study is based on 26 data points from 19 different companies, located in 10 countries. From 7 companies, we had two respondents, and from each of the other organizations we interviewed one representative.

TABLE I: Companies Overview

Comp.	Type	Domain of Activity	Deployment Model
C1	hybrid	ERP systems	public (SaaS), private
C2	hybrid	Document Management systems	private
C3	hybrid	ERP, BI, SW architectures, advisory	public (IaaS, PaaS, SaaS), hybrid, private, community
C4	hybrid	Document Management systems, ERP, process planner, intranet	public (SaaS)
C5	hybrid	Dedicated servers, data centers, web hosting	public (IaaS, SaaS), private
C6	cloud	Video hosting and sharing, copyright video provider	public (SaaS)
C7	hybrid	Antivirus solutions	public (SaaS)
C8	hybrid	Dedicated servers	private
C9	hybrid	Infrastructure, hosting, consulting services, various software	public (IaaS, SaaS), private
C10	cloud	Predictive analysis, data management	public (SaaS)
C11	hybrid	Ticketing services	public (IaaS, SaaS), private
C12	hybrid	IT, business consulting, outsourcing	public (IaaS, SaaS), private
C13	hybrid	Customized software for bluetooth equipment	private
C14	hybrid	Multimedia and creativity software	public (SaaS)
C15	cloud	Managed cloud servers, collocation, private cloud setups	public (IaaS, PaaS, SaaS), private
C16	hybrid	Software for aerospace, defense, transportation and security markets	private
C17	hybrid	Procurement software	public (SaaS)
C18	hybrid	Language translation services	private, hybrid (with public: SaaS)
C19	hybrid	Energy consumption measurement systems	private



(a) (b)

Fig. 1: Distribution of interviewees by (a) years of RE experience and (b) size of participating companies

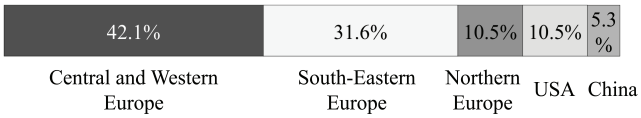


Fig. 2: Geographical distribution of participating companies

When we discussed with two employees of the same company, the interviews were individual and usually targeted complementary topics. This strategy was chosen to ensure we have the best-matching professionals responding to each part of our interview.

All participating companies have been cloud providers for at least one year and a half, and active in various domains, as outlined by Table I (built according to the guidelines in [9]). Only three of the nineteen organizations were founded as dedicated *cloud providers*, i.e. they adopted the model of delivering services on demand through network access from the outset. The others started as traditional software or hardware providers and only later extended their offer to the cloud. In Table I, we use the term *hybrid* to identify such providers that evolved from traditional software or hardware suppliers to cloud providers, and currently have all the characteristics of cloud providers, as defined in Section II. As far as the deployment model is concerned, they provide public, private or both services. For the public model, the SaaS type seems to be more frequent in our dataset than PaaS or IaaS. For confidentiality reasons, we do not disclose further data about the companies.

To ensure that interviewees' profiles fit well with the purpose of our study and thus provide relevant information, we asked each of them to evaluate their own RE experience in years, and the results are shown in Figure 1(a). Almost half of the participants (46.2%) reported between 4 and 8 years of experience in the requirements engineering field, 23.1% reported between 2 and 3 years, and 15.4% stated they had minimum 9 to 13 years. Furthermore, 11.5% self-reported 14 to 17 years and 3.8% more than 18 years of practical experience of RE. Since we did not involve anyone with less than 2 years of experience, and the mean was 6.9 years, we consider the sample relevant for the goal of this empirical study.

We did not include any age, gender or nationality assessment in our study, since we considered these would not have any impact on the participants' attitudes towards requirements elicitation activities in cloud systems. However, we noted that

the majority was represented by males, and only 34.6% of the participants were females.

As far as the geographical distribution of the participating companies is concerned, we collected information from 10 different countries, located in 5 geographical regions, as depicted in Figure 2. It can be noticed that the majority of responses (84.2%) came from Europe, and only 10.5% from the American continent (United States of America) and 5.3% from Asia (China). Within Europe, most of the respondents were employed by companies in Central or Western Europe.

With respect to size, our study covered all types of companies, from very small (under 50 employees) to very large (more than 10'000 employees). Figure 1(b) presents this distribution which, to our surprise, is a symmetrical graph. About a quarter (26.3%) of the organizations which took part in the interviews have between 101 and 1'000 employees, 21.1% have less than 50 and more than 10'000 employees, respectively, and 15.8% have between 51 and 100, and from 1'001 to 10'000 employees, respectively.

When asked whether the cloud services provided are developed internally, within the company, all respondents answered positively. Moreover, half of the companies also aggregate their services with other software from third parties, and 25% also resell or integrate complete cloud services from other providers, potentially including some customization.

3) Data Collection and Analysis: The interviews were conducted between November 2012 and January 2013, and their duration varied between 45 and 90 minutes, with an average of 70 minutes. We conducted the interviews over Skype or Google Talk and, when possible, the video feature was enabled. In two situations, when neither Skype nor Google Talk were available for participants, the landline was used.

The data analysis consisted in first aggregating and structuring all the information collected, so potential patterns can be observed and statistical calculations can be performed. Then, the interesting aspects were selected and analyzed more thoroughly. Section IV presents our key findings.

C. Threats to Validity

From the early stages of the study design, we considered the possible threats to validity for our results. As with any empirical study, it is difficult to completely resolve all the issues which can appear. In this section, we discuss the potential threats to validity identified, according to the categorization by Wohlin et al. [24].

Conclusion validity issues are caused by the inability to draw accurate conclusions based on the study. We attempted to alleviate the risk associated with measures reliability by conducting two pilot interviews prior to the study, to identify any possible misunderstandings of the questions. During all interviews, we always encouraged the interviewees to ask for clarification in case something was unclear. Moreover, we used redundant questions, to ensure the answers were consistent. However, we cannot claim that no misunderstandings occurred at all. All interviews were conducted by the first author, thus avoiding discrepancies caused by differences between interviewers. We mitigated the problems of phone interviews by scheduling all meetings in advance and holding them as private meetings such that no third parties were disturbed or involved in the discussions. We also made sure that the interviews were not disturbed by poor connection quality. In the cases where two representatives from the same company were interviewed, interviewees were asked not to talk about the content of the interview before both interviews had been conducted.

Internal validity refers to the possible causal relationship between treatment and outcome. Our selection of participants was constrained to the cloud provider employees recruited by our contacts and, where applicable, our contacts themselves. Participation was completely voluntary and this can skew our results towards practitioners who were highly motivated and interested in the research topic. However, avoiding the self-selection principle is virtually impossible in this type of study. As far as maturation is concerned, we always documented ourselves about the organizations interviewed and the cloud services provided prior to interviews. The aim of this was to avoid tiredness and boredom during discussions. Additionally, interviews were restricted to maximum 90 minutes.

Construct validity is related to generalizing the results beyond the study. In this sense, we tried to eliminate mono-operation bias by aggregating data from various sources (public company information, employees). To avoid evaluation apprehension, participants were assured that all the information they provide is anonymized and only used for research purposes, and we asked them to report if they feel uncomfortable about the discussion at any stage. Regarding the level of constructs, all participants were required to self-assess their RE experience. However, this threat cannot be completely dismissed. Hypothesis guessing is another construct validity threat which could have occurred, although the study description explained that our aim is to gain a deeper understanding of the phenomena, in an exploratory way, and did not suggest any expected results. As already mentioned, we also conducted two pilot studies and had the interview instrument checked by RE specialists to ensure the questions do not lead to any bias.

External validity threats limit the ability to generalize results to industrial practice. Since this is a qualitative study, it is rather difficult to generalize beyond the given settings and replicate the same contexts. However, we consider that the lessons learned from such a study are important and useful for industrial practice, and can be applied in other organizations as well. Therefore, we consider we can generalize our results, taking into account the sample size (19 companies) and the representativity of the participating providers: they cover all types of cloud services and all deployment models, from various domains of activity and different geographical locations. Around 80% of individual interview participants were recommended by our contact persons within cloud providers, which reduces the threat of interaction of selection and treatment (the rest of 20% were our direct contacts).

IV. Key Findings

We assigned one investigation aspect to each of the research questions. For the three aspects, we present the key findings and elaborate on the corresponding evidence data. Due to space constraints, we focus only on the study results related to the three RQs.

A. Requirements Elicitation Techniques in Use - RQ 1

The core of the discussions we conducted with practitioners focused on the requirements elicitation techniques they use for identifying cloud consumers' needs. This subsection presents the aggregated key findings related to this investigation aspect. Our discussions included two categories of requirements elicitation methods: requirements elicited from existing service consumers, and requirements coming from potential consumers, i.e. who have not signed a Service Level Agreement (SLA) document with the provider up to the moment of the elicitation process.

Finding A.1. Traditional approaches (interviews, questionnaires, analysis of existing documentation, surveys) and prototyping are the most popular and highly applied existing requirements elicitation methods among cloud providers.

Evidence for Finding A.1. To stir the conversation and have a concrete and common starting point, we used an interview appendix[2] which listed the main elicitation techniques, according to Nuseibeh and Easterbrook [16]. For clarification, we reproduced the techniques in Table II, keeping the same main categories used originally by the authors: traditional, model-driven, group techniques, cognitive, prototyping and contextual [16]. The main reason for using these approaches is that they represent a rather comprehensive list of well-known techniques, widely used as reference by the research community. We chose to treat brainstorming from two different perspectives: on the one hand, as a method used externally, to elicit requirements from consumers; on the other hand, as a method used in company internal meetings, involving only employees. This decision was made after noticing that our interviewees strongly differentiated between the two.

We designed two questions which share these same items, but have different scopes: "q_1: select the techniques you are familiar with and you previously used" versus "q_2: select the techniques your company uses in the elicitation process for cloud services".

TABLE II: Elicitation Techniques, after [16]

	Traditional		**Model-driven**
A	Questionnaires	J	Scenarios, e.g. CREWS
B	Surveys	K	KAOS
C	Interviews	L	i*
D	Analysis of existing doc.		
	Group Elicitation		**Cognitive**
E	Brainstorming - externally	M	Protocol analysis
F	Brainstorming - internally	N	Laddering
G	Focus groups	O	Card sorting
H	RAD/JAD workshops	P	Repertory grids
I	Prototyping	Q	Contextual (ethnography)

[2]http://www.ifi.uzh.ch/rerg/people/todoran/Appendix_Interview.pdf

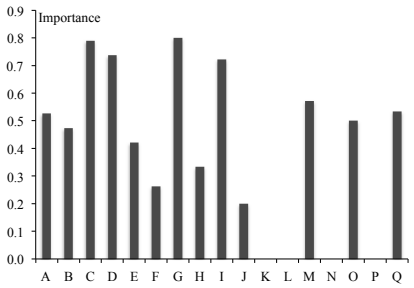


Fig. 3: Importance rating of techniques, cf. Table II

This parallelism has two main advantages: consistency check and the possibility to calculate the importance rating, as outlined by Bettenburg et al. [2]. Regarding consistency, we considered that all techniques chosen as implemented should also be known to the respondent, since all interviewees self-reported to be involved in the requirements-elicitation or related processes. If reported otherwise, we asked again to make sure the question was understood correctly. Regarding importance of elicitation methods in cloud systems rating, we can infer the individual importance given to each technique by using the following formula:

$$\text{Importance}(i) = \frac{N_{1,2}(i)}{N_1(i)}$$

Here, for technique *i*, $N_1(i)$ is the number of responses in which the technique was selected in q_1. Similarly, $N_{1,2}(i)$ is the number of responses in which technique *i* was selected in both q_1 and q_2. The assessment of the importance rating is depicted by Figure 3. When importance tends to 1, then the technique is both known and widely implemented in practice. When it tends to 0, it is not used by practitioners, even if some may be familiar with it.

It can be observed that importance is highest for interviews (C), focus groups (G), analysis of existing documentation (D) and prototyping (I).

Figure 4 depicts the general assessment of the 17 reference techniques. The horizontal axis shows the number of participating companies where at least one of the interviewees was familiar with the methods, and the vertical axis shows the number of organizations which successfully implement each method. This analysis generates some clusters, with different properties.

The top left corner of the graph is naturally empty, since the two questions were designed using the parallelism principle, thus allowing for consistency check. The bottom left corner contains techniques which are neither known, nor implemented in practice. Methods such as KAOS and i*, which receive significant attention in the RE research field, were only reported as known by one company representative, and were not implemented by any of the 19 participating organizations. Although familiar to more interviewees and implemented in up to four companies, card sorting, RAD/JAD workshops, scenarios and protocol analysis are still techniques with very low industry penetration and rather unpopular. It can be noticed that all the cognitive and model-driven methods are situated in this cluster.

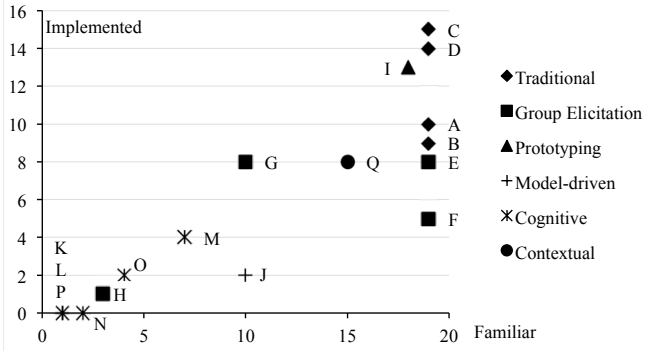


Fig. 4: Familiar and implemented elicitation techniques

The focus groups technique occupies a central position in the graph, being known to respondents from 10 companies, and applied successfully in 8 out of 19 organizations. The bottom right corner is populated only by the brainstorming method (internal and external) and ethnographic studies, showing that industry has knowledge about them, but does not implement them on a regular basis.

The top right corner cluster contains prototyping and all traditional methods. This means that these techniques are widely known to practitioners and commonly implemented as well. The top three are: interviews, analysis of existing documentation and prototyping, which are also among the top rated as far as the calculated importance is concerned. This can also be read on the graph in Figure 4: importance is high for those techniques which are closest to the diagonal.

We did not limit our discussions to the interview appendix, but went beyond it to also discuss other methods which may not have been included in our list based on [16]. Respondents mentioned additional methods such as collecting user feedback, attending field conferences and other events, but none of these had an implementation frequency higher than 21%. Therefore, if we represented them in Figure 4, they would belong in the bottom left corner cluster, along with the other methods which are only known and applied by a small number of companies.

Finding A.2. Most of the existing methods are very difficult to nearly impossible to apply in the cloud context.

Evidence for Finding A.2. 63.2% of the interviewed organizations provide cloud services to consumers that are located in regions or even countries different from any of the physical company branches. This very distributed nature and sometimes impossibility to reach consumers for face-to-face meetings were reported by our respondents as significant challenges posed by the cloud, which hinder the implementation of existing methods. In spite of some differences between companies regarding preferred elicitation methods and application scenarios, there was one point the large majority (89.5%) agreed on: the difficulty of method implementation.

For instance, one interviewee from a European cloud provider explained: "We've been recently contacted by a company representative from New Zeeland who asked for one of our DMD [Document Management Systems] solutions. In general, before we customize and sell these solutions, we use extended workshops and observation at the client's premises to understand their requirements. I had to deny that request, we couldn't have afforded such a client from a different continent. It would have been impossible to understand what he wants." This is only one example of how two of the existing methods fail in practice in the cloud context.

One interviewee from an American B2B provider shared a different experience: "We use brainstorming a lot during the first phases of the [elicitation] process, but that gets tricky when we serve a company located too far. What we tried several times was to do it somehow online, using GoogleDocs. It works to some extent, but you can never tell what other things people do at the same time, you sometimes notice they are distracted". In this second example, a workaround for the problem was found and implemented, but the quality was reported as low, due to lack of control and impossibility to ensure optimal conditions for applying the technique.

Finding A.3. Almost all cloud providers (94.7%) use ad-hoc elicitation methods at some point during their process. Moreover, the general criterion for method selection is also ad-hoc.

Evidence for Finding A.3. With no exception, all our respondents consider the cloud field still young, and the large majority agrees that there is a lack of dedicated mature elicitation methods they could apply.

For example, 21% of the participating companies reported to heavily use their marketing human resources to perform market studies on their competitors; then, they try to imitate them in service offering. Two of these companies added that this "may not be a real elicitation method, but it helps". Similarly, 21% generalize what is known from existing consumers and assume that will also hold for potential future clients. Furthermore, 26.3% of the practitioners consider that internal company knowledge is the most important method for coming up with new requirements. In this case, the main source is the personal and professional experience of the employees. We asked these respondents about the reasoning behind this ad-hoc method, and the common argument was that "our people are good enough to know". Another interviewee expressed her disappointment: "there's not much else we can do". About 10% of the companies reported to rely on simply guessing and inventing requirements, but it was not clear if this is also based on internal knowledge, market monitoring or anything else.

As far as acquiring requirements from potential consumers is concerned, the providers which develop services for public institutions explained they get numerous hints from the self-defined requirements published by these organizations. However, they added that there are numerous situations when those requirements need to be refined, since they do not always express what is needed in reality. In these cases, further elicitation methods have to be used. Moreover, other companies organize or attend conferences and various fairs (15.8%) to bring potential consumers together and get in touch with them more easily.

Strongly related to the previous finding, the widely spread usage of ad-hoc methods was reported to be linked to the impossibility of applying existing techniques. 52.6% of the

organizations even called the traditional methods "useless" or "old-fashioned". The others refrained from using such strong words, but the general attitude towards the existing approaches was that they need to be either adapted or replaced by something new to meet the cloud particularities. Nevertheless, two companies reported that they are satisfied with what is available at the moment, since they do not feel there is a special need for dedicated methods for cloud providers.

According to Nuseibeh and Easterbrook, the criteria for choosing elicitation techniques should depend on time, resources available and type of information that needs to be elicited [16]. Our study shows that things are slightly different in practice. 52.6% of the companies interviewed agreed they use ad-hoc criteria for choosing elicitation methods, and that they do not follow any standardized processes. The argument given was, once again, the young age of the cloud paradigm. About a quarter (26.3%) emphasized the consumer reachability aspect in the cloud, which often determines the methods to be used - some may not apply at all if consumers are located remotely. Other criteria mentioned were the ease of use (10.5%) and the target group (5.3%). Only 15.8% of the participating companies choose the elicitation techniques based on available financial resources and 21% based on the type of information needed.

B. Cloud versus Traditional Providers' Methods - RQ 2

With the second investigation aspect, we aimed at understanding if cloud providers perceive any particular needs with regard to requirements elicitation, compared to their previous experience as traditional providers. Therefore, this discussion is limited to those companies which underwent this shift.

Finding B.1. The cloud calls for methods which fit for more heterogeneous audiences, take less time, and can be applied remotely.

Evidence for Finding B.1. 16 of the 19 companies interviewed developed from providing traditional solutions to supplying cloud services during the recent years. We investigated if they tried to apply the same elicitation strategies they used previously also in the cloud, or they started new with something different. A large majority (87.5%) agreed they tried to apply methods used before, and reported that 65% of the attempts failed. There are several causes for this situation.

In 62.5% of the cases, practitioners found it difficult to draw the profile of their average consumers, or did it in very general, vague terms, such as "individual consumers who need to host their data in the cloud" or "small and medium businesses (SMEs) which deal with large amounts of documents". It was generally admitted that the target audience for cloud services is much more heterogeneous than the audience for traditional software or hardware products.

Secondly, several respondents observed that services are developed and launched at a much faster pace in the cloud, and this also calls for suitable requirements elicitation methods: "we cannot afford to spend half a year to collect data from potential consumers with questionnaires when we must have the service on the market in two months". When asked if they found a way to address this issue, the answer was that they use agile development to have frequent releases. However, as far as requirements elicitation is concerned, no real solution which supports a shorter time to market is available. According to the interviewees, the cloud concept is too young and most cloud providers are still too inexperienced: "we all just try different things".

Thirdly, due to the distributed nature of the cloud previously discussed, cloud providers need elicitation methods which do not necessarily require physical meetings. One of the study participants explained: "we tried to somehow adapt well-known methods and, for example, turned our old workshops into online conferences - but this is not always easy, somebody's connection fails, another is not allowed to use a specific conference platform and so on". 60% of the practitioners who tried to adapt existing methods reported that this kind of failed attempts usually discourage future trials, so different methods are chosen in upcoming projects. For our study, this applies for both methods used in early elicitation phases and more in-depth techniques.

Finding B.2. Automation is needed to a larger extent for eliciting cloud consumer requirements.

Evidence for Finding B.2. Although we did not have any specifically designed questions for the automation topic, this recurrently occurred during our interviews with practitioners, especially when discussing about the limitations of the current methods and related challenges.

For instance, when asked if they found a workaround for the stakeholder identification and reachability problem, respondents' general answer was "no", "not really", or they suggested employing more human resources who can travel to meet consumers, which is expensive. However, two of the practitioners explained that they had some attempts to solve this at much lower costs, using automation. They measure usage points on the services provided, i.e. they monitor which features are utilized by consumers frequently and how, and which are only rarely employed. This is used on both final products and α- or β-releases. The information is automatically sent to the provider every week, and then processed by a product manager. As reported by one interviewee, "this is kind of indirect feedback for us, but it also brings new requirements sometimes, or at least some hints". He further explained that this method does not require heavy financial investments, and also has the advantage of being unobtrusive.

In line with this are also the comments from other practitioners: "ideally, we'd need something which helps us get needs from people everywhere, not only in [city name], but how do you get to them?" Here, the geographical coverage was strongly emphasized. According to another respondent, "costs are very important for us, so anything which requires minimum costs and automatically brings requirements would be highly desirable".

C. Do the Existing Methods Suffice? - RQ 3

To answer the third research question, we looked into the details of the providers' development history and asked

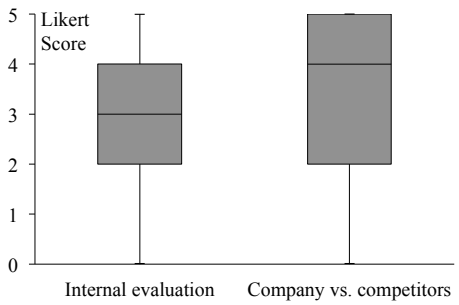


Fig. 5: Evaluation of cloud providers' satisfaction

them to evaluate themselves and their competitors with regard to existing best practices adoption. The main findings show that the current methods support providers' needs only to a limited extent, often leading to general dissatisfaction.

Finding C.1. Cloud providers' satisfaction level with regard to implementing existing elicitation approaches is low to medium.

Evidence for Finding C.1. We asked the study participants if they are happy with the implementation level of requirements elicitation best practices in their companies. For this, we told them to use a 5-point Likert scale [12], where 1=strongly disagree, i.e. the company implemented nearly nothing, and 5=strongly agree, i.e. the company uses existing practices successfully, on a regular basis.

Moreover, we asked them to evaluate their companies in comparison to their competitors, using a similar 5-point Likert scale. The results are shown in the boxplots in Figure 5. Value 0 on the vertical axis was reserved for answers which did not include a Likert score (when participants could not provide an answer).

The left boxplot represents the distribution for the internal cloud providers evaluation on the adoption and implementation of elicitation techniques. More than half of the interviewed cloud providers (68.4%) evaluated themselves as levels 2 or 3. Our respondents generally placed their employers under or around the average range, and only 10.5% of the organizations considered they were doing very well regarding methods adoption and implementation in practice. As a result, the median is 3 points, and the representation spans the quartiles Q_1=2 and Q_2=4, as depicted in the graph.

As far as the comparison to competitors is concerned, most cloud providers evaluated themselves to be better than competition at successfully applying existing techniques. The right boxplot in Figure 5 shows that, in this case, the calculated median is 4, which highlights that participants had a rather positive attitude towards their companies when comparing them to competitors. Most considered their employers leaders on the market regarding elicitation methods used, thus generating a representation between quartiles Q_1=2 and Q_2=5.

This analysis shows that cloud providers generally evaluate themselves as average or under average in elicitation methods usage, but consider they are still better or much better than their competitors. This means that cloud providers' general satisfaction level with regard to implementing existing elicitation approaches is low to medium.

Finding C.2. In more than half of the cases, public cloud providers' dissatisfaction is caused by their evolution history.

Evidence for Finding C.2. We differentiate between several categories of public cloud providers, based on the type of public cloud they supply: IaaS, PaaS, SaaS or others. All our interviews included one question about the evolution history of the company: if they started as a cloud or as a traditional provider, and how this shift happened. In this analysis, the companies which started their business as cloud providers are excluded, since they did not go through a delivery shift (traditional to cloud provider) in their history. Therefore, among the remaining participating companies in our study, 11 were SaaS providers, 5 provided infrastructure (IaaS) and 1 platform (PaaS), as shown in Table I.

In this respect, we noticed a pattern in 66.7% of the IaaS and PaaS providers. Initially, they developed infrastructure and platform services to satisfy their internal company needs, and only later on exposed these on the market as cloud services. For example, one of the practitioners clarified the phenomenon: "we were normal [traditional] software providers and were paying for a virtual server from [company name]; at some point, we decided to have our own [virtual server], then we developed in this direction even more and slowly became a IaaS provider ourselves".

Going into more details about this shift with our interviewees, we found that no real development strategy was implemented: requirements for the infrastructure service were collected ad-hoc internally and the service was provided for their own use. Later, when the service was sold outside the company, no further requirements elicitation activities were conducted, the service being sold as it was. Consequently, the organization started to provide a cloud service tailored to their own needs, but not necessarily to potential consumers' needs.

As far as SaaS providers are concerned, the situation is different. All of the 11 companies were traditional software providers at the time when they decided to become cloud providers. Therefore, they adapted their software such that it can be sold on demand, subscription-based, built the SLAs, and released the new cloud service. However, this shift happened only at the technical, implementation level, and virtually no attention was paid to the potential differences the cloud model may pose, in 63.6% of the cases. Therefore, no real requirements elicitation process took place. As new features or completely new cloud services were released, the elicitation methods of the past, the traditional software provider age, were used.

In summary, the dissatisfaction with the experienced elicitation alternatives is justified by the lack of evolution strategy, from traditional to cloud providers. On the one hand, known practices were used to acquire requirements only internally, within the company. On the other hand, providers tried to use the techniques they were accustomed to also in the cloud, not paying attention to any adjustments or changes which may be needed.

V. Summary and Discussion

This section explains how the findings presented in Section IV are inter-related and, based on these, draws the main conclusions for future research in requirements elicitation methods for cloud providers. All the key findings are summarized in Table III.

The main goal of our study was to gain a deeper understanding on how cloud providers perform requirements elicitation, what the most popular techniques are, how these are implemented, what criteria and reasoning are used for choosing them, and the associated level of satisfaction.

We found that a significant number of the elicitation methods implemented by cloud providers are well-known approaches used by traditional software suppliers. For example, our study shows that traditional approaches and prototyping are the most frequently used elicitation techniques among cloud providers (A.1). In spite of being rated as popular, practitioners admitted that traditional methods, as well as most of the other existing techniques, are very difficult to virtually impossible to apply in the cloud context (A.2), leading to general disappointment and dissatisfaction (C.1). Their popularity is usually justified by the rigid internal processes and regulations of the companies, and not by any suitability assessment or success stories. For example, if a provider used interviews in the past and it recently started to deliver cloud services along with its off-the-shelf software, it tries to apply the same methods also for the new scenario (C.2).

In most situations, these attempts fail due to new constraints posed by the cloud context, e.g., heterogeneous consumers located remotely. This often makes the synchronization impossible, thus leading to serious problems, such as failed projects or lost business opportunities. As explained in section IV B, the elicitation methods for cloud providers should apply for diverse consumers, enable a shorter time to market, be applied remotely and ideally asynchronously (B.1), and make more use of automation (B.2).

TABLE III: Key Findings

A	**Requirements elicitation methods in use - RQ 1**
A.1	Traditional approaches (interviews, questionnaires, analysis of existing documentation, surveys) and prototyping are the most popular and highly applied existing requirements elicitation methods among cloud providers.
A.2	Most of the existing methods are very difficult to nearly impossible to apply in the cloud context.
A.3	Almost all cloud providers (94.7%) use ad-hoc elicitation methods at some point during their process. Moreover, the general criterion for method selection is also ad-hoc.
B	**Cloud versus traditional providers' methods - RQ 2**
B.1	The cloud calls for methods which fit for more heterogeneous audiences, take less time, and can be applied remotely.
B.2	Automation is needed to a larger extent for eliciting cloud consumer requirements.
C	**Do the existing methods suffice? - RQ 3**
C.1	Cloud providers' satisfaction level with regard to implementing existing elicitation approaches is low to medium.
C.2	In more than half of the cases, public cloud providers' dissatisfaction is caused by their evolution history.

Noticing these new needs should be met, cloud providers tried to adapt the existing techniques or even create new, ad-hoc approaches which can support them in eliciting requirements from the new type of consumers. Therefore, an impressive majority (94.7%) of our respondents reported to use ad-hoc methods during their elicitation processes (A.3), to compensate for the lack of existing suitable techniques. However, none of these ad-hoc methods stand out as very popular, as a sign that standardization is still far from being reality. This finding also confirms other researchers' findings: since the cloud paradigm has only been around for about five years [4], there are no standardized processes to govern how requirements engineering activities should be conducted by cloud providers. In particular, there are no dedicated elicitation methods tailored to the new cloud providers' needs [25].

Based on the current state of practice described by our findings, we see a need to research new ways in which cloud providers can be supported in eliciting consumer requirements, taking into account the constraints and issues identified.

On the one hand, the development of elicitation methods should go towards adapting existing techniques, such as the traditional and market-driven, to suit the specific cloud properties (e.g. the distributed nature, on-demand delivery model), where possible. Ideally, cloud providers will restrict the use of currently available methods to only those which are well-suited and applicable in the cloud. This way, dissatisfaction will be avoided, as well as irrelevant output caused by method inadequacy. On the other hand, the current ad-hoc trials should evolve towards standardized methods, which can be used on a large scale.

Moreover, there is a need to investigate how the cloud paradigm enables cloud-specific requirements elicitation methods which go beyond what is known and used today. For example, measuring usage points on the service provided (B.2) can be considered an early step in this direction, but there is a wide range of other areas to explore.

VI. Related Work

There is a large body of work on requirements elicitation; see [26] for a comprehensive overview. Several studies point out the strengths and limitations of requirements elicitation approaches in different settings [14], [23], [10]. Other research addresses requirements elicitation in market-driven [10], [20], distributed [6] and asynchronous settings [7].

Our work goes beyond the state-of-the-art knowledge by revealing what kind of requirements elicitation techniques are used in the cloud context. Furthermore, we identify ad-hoc requirements elicitation approaches which are introduced by cloud providers in order to complement shortcomings of existing approaches. Moreover, our study confirms results of previous research in the field of market-driven RE [5], [1], [10]. For example, cloud service providers also use invented requirements, as mentioned by Potts [18].

Our results are also in line with research on distributed RE. For example, Tuunanen [23] points out that reaching and involving stakeholders is a key problem in distributed

contexts. He observes that involving so-called wide audience end-users, who are not within organizational reach, is not addressed by traditional requirements elicitation techniques. Other research explains that the identification of heterogeneous users is critical and needed [16], and that adequately identifying stakeholders in environments where the nature of stakeholders varies is challenging. Lim et al. [13] present first ideas regarding this problem by highlighting an asynchronous and distributed stakeholder identification approach. In their work, they assume that key stakeholders are known and that they can identify other relevant stakeholders based on their domain knowledge. Our research demonstrates that this challenge is also true for requirements elicitation in the cloud, and that sophisticated methods regarding the identification of heterogeneous stakeholders and their needs are needed.

Another key problem is that most well-known requirements elicitation methods support the elicitation from a predefined, limited number of stakeholders [8]. Particularly in the cloud context the number of stakeholders might be beyond of what traditional methods can support. Researchers highlight the need for user-driven approaches, which encourage users to actively push their needs to software developers, and therefore allow the involvement of large numbers of stakeholders in requirements elicitation [21]. However, current approaches focus on identifying ideas for new applications rather than communicating more detailed requirements [21].

VII. Conclusion and Future Work

This paper reports on the results of an industrial exploratory study on requirements elicitation techniques used by cloud providers. The study involves 19 companies from 10 countries, represented by a total of 24 respondents. Our main contribution is to reveal which elicitation approaches are used in cloud systems, their limitations, and new challenges posed by the cloud paradigm with regard to requirements elicitation. Moreover, we identify key features of future dedicated methods that can address the issues observed.

Since the study was directly conducted with practitioners, we consider the results relevant for both industry and academia. For industry, they are an assessment of the state of practice from which cloud providers can understand the general adoption level of best practices and learn from the experiences of other organizations. For research, our work draws some possible directions for the future and shows new areas which need to be further explored and supported with new methods and tools.

In our future work, we will exploit these results to further investigate what elicitation methods would best support cloud providers in consumers' requirements acquisition.

Acknowledgment

We would like to thank the companies and their representatives for making this research possible.

References

[1] C. Alves, S. Pereira, and J. Castro, A Study in Market-Driven Requirements Engineering, *9th Workshop on Requirements Engineering (WER'06)*, 2006.

[2] N. Bettenburg, S. Just, A. Schröter, C. Weiss, R. Premraj, and T. Zimmermann, What Makes a Good Bug Report?, *Proc. ACM SIGSOFT Symp. on the Foundations of Software Engineering (FSE'08)*, ACM, pp. 308-318, 2008.

[3] L. Blaxter, C. Hughes, and M. Tight, *How to Research*, Open University Press, 2001.

[4] R. Buyya, C. S. Yeo, S. Venugopal, J. Broberg, and I. Brandic, Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility, *Future Generation Computer Systems*, vol. 25, no. 6, pp. 599-616, 2009.

[5] A. G. Dahlstedt, L. Karlsson, A. Persson, J. N. Dag, and B. Regnell, Market-Driven Requirements Engineering Processes for Software Products - a Report on Current Practices, *1st Intl. Workshop on COTS and Product Software: Why Requirements are so Important (RECOTS'03)*, 2003.

[6] D. E. Damian and D. Zowghi, RE Challenges in Multi-Site Software Development Organisations, *Requirements Engineering*, vol. 8, no. 3, pp. 149-160, 2003.

[7] P. Grünbacher and N. Seyff, Requirements Negotiation, in *Engineering and Managing Software Requirements*, A. Aurum and C. Wohlin, Eds., Springer, pp. 143-162, 2005.

[8] J. D. Herbsleb, Global Software Engineering: The Future of Socio-Technical Coordination, *Future of Software Engineering*, IEEE-CS Press, 2007.

[9] M. Ivarsson and T. Gorschek, A Method for Evaluating Rigor and Industrial Relevance of Technology Evaluations, *Empirical Software Engineering*, vol. 16, no. 3, pp. 365-395, 2011.

[10] L. Karlsson, A. Dahlstedt, J. N. Dag, B. Regnell, and A. Persson, Challenges in Market-Driven Requirements Engineering - an Industrial Interview Study, *8th Intl. Workshop on Requirements Engineering: Foundation for Software Quality (REFSQ'02)*, 2002.

[11] S. Leimeister, C. Riedl, M. Böhm, and H. Krcmar, The Business Perspective of Cloud Computing: Actors, Roles, and Value Networks, *Proc. 18th European Conf. on Information Systems (ECIS 2010)*, 2010.

[12] R. Likert, *A Technique for the Measurement of Attitudes*, Archives of Psychology, 1932.

[13] S. L. Lim, D. Quercia, and A. Finkelstein, StakeNet: Using Social Networks to Analyse the Stakeholders of Large-Scale Software Projects, *Proc. Intl. Conf. on Software Engineering (ICSE 2010)*, pp. 295-304, 2010.

[14] W. J. Lloyd, M. B. Rosson, and J. D. Arthur, Effectiveness of Elicitation Techniques in Distributed Requirements Engineering, *Proc. 10th IEEE Intl. Requirements Engineering Conf. (RE'02)*, pp. 311- 318, 2002.

[15] National Institute of Standards and Technology. Available at: www.nist.gov Accessed: March 2013.

[16] B. Nuseibeh and S. Easterbrook, Requirements Engineering: A Roadmap, *Proc. The Future of Software Engineering at ICSE 2000*, ACM, pp. 35-46, 2000.

[17] M. Patton, *Qualitative Evaluation and Research Methods*, Beverly Hills, CA: Sage., pp. 169-186, 1990.

[18] C. Potts, Invented Requirements and Imagined Customers: Requirements Engineering for Off-the-Shelf Software, *2nd Intl. Symp. on Requirements Engineering*, 1995.

[19] C. Robson, *Real World Research*, third edition, Wiley, 2011.

[20] P. Sawyer, Packaged Software: Challenges for RE, *Proc. of the 6th Intl. Workshop on Requirements Engineering: Foundation for Software Quality, (REFSQ'00)*, 2000.

[21] N. Seyff, F. Graf, and. N. Maiden, Using Mobile RE Tools to Give End-Users Their Own Voice, *Proc. IEEE Intl. Requirements Engineering Conf. (RE'10)*, pp. 37-46, 2010.

[22] I. Sommerville and P. Sawyer, *Requirements Engineering: a Good Practice Guide*, Wiley, pp. 63-109, 2006.

[23] T. Tuunanen, A New Perspective on Requirements Elicitation Methods, *Journal of Information Technology Theory and Application*, vol. 5, no. 3, pp. 45-72, 2002.

[24] C. Wohlin, P. Runeson, M. Höst, C. Ohlson, B. Regnell, and A. Wesslén, *Experimentation in Software Engineering: An Introduction*, Norwell, MA, USA, Kluwer Academic Publishers, 2000.

[25] S. Zardari and R Bahsoon, Cloud Adoption: A Goal-Oriented Requirements Engineering Approach, *Proc. 2nd Intl. Workshop on Software Eng. for Cloud Computing (SECLOUD'11)*, pp. 29-35. 2011.

[26] D. Zowghi and C. Coulin, Requirements Elicitation: A Survey of Techniques, Approaches, and Tools, in *Engineering and Managing Software Requirements*, A. Aurum and C. Wohlin, Eds., Springer, pp. 19-46, 2005.