Demand for Cloud Services as an Infrastructure in Higher Education

Abstract

Cloud computing is one of the major current trends in IS. It is said to be able to increase work productivity and simultaneously lower costs in organizations. However, institutions of higher education, like universities, remain hesitant to adopt it. The 'NSA scandal' and similar revelations lead to a sharp decline in trust (especially in Europe) in commercial cloud computing providers like Dropbox and Google. At the same time, cloud computing solutions often are not customized to students’ and employees’ needs. In this context, we examine the concept of ‘university cloud computing services’ by discussing it from the theoretical viewpoint as an ‘infrastructure.’ We conducted a large-scale survey with over 10,000 student respondents and employees from three universities. Our findings indicate a high demand for cloud computing at those universities and offer valuable implications for designing and managing cloud computing in a higher educational context.

Keywords: cloud service, education, university, infrastructure

Introduction

In recent years, the importance of cloud computing has increased greatly for private and business purposes. Further, a growing number of higher education institutions is busy adopting cloud computing. These services allow users to store files remotely and synchronize and share them over multiple devices. It is said that cloud storage services have the ability to increase the efficiency and the effectiveness of collaboration, personal information management, and knowledge transfer. Bhattacherjee and Park (2013) summarize the main benefits of cloud computing for organizations and individual end-users from a hardware point of view as: universal access (anytime, anywhere) to cloud-hosted resources and processing power, significant cost efficiencies for users due to the economies of scale and cost advantages of Internet-
based computing, the low risks and responsibilities of owning and operating an IT infrastructure or software, and, finally, protection from demand elasticity or fluctuations in computing needs. Conversely, the literature also identifies risks related to the use of cloud computing, such as data security (Loske et al. 2013), data privacy concerns (Yuan and Chang 2012, Miller 2008), vendor lock-in (Sultan 2011) or significant downtime (McGeogh and Donnellan 2013), which can have significant impact on the organization’s performance. In sum, despite cloud computing’s potential contribution to an effective and efficient learning and research environment, there are two main problems: data privacy and the lack of cloud solutions customized to academic needs.

The first issue affects researchers more than students. Profit-oriented companies, like Dropbox, Google, Microsoft and Amazon, all which have their jurisdiction in the US, provide public cloud computing services. In 2013 a former employee of the US National Security Agency (NSA), Edward Snowden, uncovered the extent of the NSA’s secret surveillance program PRISM. Following him, the NSA intercepts phone and Internet communications of over a billion people worldwide and tracks the movement of hundreds of millions of people using cellphones. It is also said that the NSA created or maintained security vulnerabilities in most software and encryption (by collaborating with, coercing, or infiltrating numerous technology companies such as Microsoft, Apple, Google, Dropbox).1 Owing to the “NSA affair,” politicians’ and society’s formerly high trust in commercial IT’s integrity has shown a massive decrease, especially in Europe. Not only US companies’ commercial IT services, but also local providers, seem unable, or unwilling, to prevent national or international intelligence agencies or espionage from accessing their systems. To date, there is no international legislation ensuring the protection of data. Moreover, national laws are rarely comparable and may even contradict each other on a global level. Universities and other research institutions in higher education have a tremendous amount of confidential data, such as research results, seminar and final papers, and personal data. Simultaneously, in such institutions, employees often self-organize cloud usage due to the lack of an appropriate IT strategy. For those researchers who want to participate in the advantages of cloud computing but do not trust commercial providers, or who are not allowed to use such providers, there are currently hardly any adequate alternatives. Further, Internet access is all that is needed to drop and share files with colleagues, and it would be impossible to keep people from storing their data in the cloud if they wished to do so, even if this was prohibited.

The second issue affects both researchers and students. Current commercial services do not provide features, which become increasingly important with the advanced work that researchers and students are doing in ever more mobile, interdisciplinary, and distributed structures. These features, such as collaborative and simultaneous work on documents are commonly not provided, with very few exceptions, for example, Google Drive.

To date, very little is known about how strongly data privacy concerns influence usage behavior regarding cloud computing in a university context. Further, there are no studies on what potential users expect from such a University Cloud Computing Service (UCCS), even though this is an important question to address in order to make design decisions (for example, regarding the offered features, data storage volume, etc.). This study is one of the first to provide comprehensive empirical data on the demand and expected usage behavior of cloud storage services in a university context. Our analysis is based on responses from 7,623 students and 2,744 employees at three different universities. We collected this data in 2013 as part of a large-scale project called Sync&Share NRW. The project aims to provide a cloud storage service for up to 500,000 users (students and employees) from different universities in Germany.

In this research, we not only regard UCCS as an additional service in researchers’ and students’ working environment, but we consider it as an ‘infrastructure.’ The overall goal of this paper is to discuss the actual need for UCCS, based on the aforementioned theoretical perspective, a literature review and on comprehensive empirical data. Furthermore we seek to identify the required features as well as data storage volume (design implications), and derive implications for the management of these services. The remainder of the paper proceeds as follows: In the next section, we provide an overview of related work on cloud computing and take the perspective that it is an infrastructure. Furthermore, we discuss extant studies in the university context. Subsequently, we explain the research design and present our survey

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results. Thereafter, we discuss our findings. The paper ends with a conclusion and an overview of possible future work.

### Related Work and Theoretical Background

Cloud computing has been subject to manifold research activities in the past years. Yang and Tate (2012), for example, provide an overview of the literature in this field. They found a notable number of articles and classified them into four categories. However, since their study was published, quite a number of new papers have appeared in all of their suggested categories: technological issues (e.g. Long et al. 2014; Sommerville 2013; Rasheed 2013; Simi et al. 2012), business issues (e.g. Wang 2014; Morgan 2013; Loske et al. 2013; Walterbusch 2013; Djemame 2013; Stankov 2012), conceptualizing cloud computing (e.g. Ovadia 2013), as well as domains and applications (e.g. Quick 2014; Bhattacherjee and Park 2013; Khan et al. 2013; Clohessy and Acton 2013). This paper does not aim to repeat the general basics of cloud computing but concentrates on the perspective that cloud computing can be understood as an infrastructure and on its relevance in university contexts.

#### Cloud Computing as an Infrastructure

The US National Institute of Standards and Technology (NIST) defines cloud computing as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction” (Mell and Grance 2011). For Vouk (2008), cloud computing “embraces cyber-infrastructure, and builds on virtualization, distributed computing, grid computing, utility computing, networking, and web and software services.” Both definitions focus on the technical perspective and on providing users with access to services. However, in the context of cloud computing at universities, it can be understood as a (new) work-oriented infrastructure for the students and employees. Hanseth and Lundberg (2001) state that “work-oriented infrastructures are shared resources for a community; the different components of an infrastructure are integrated through standardized interfaces; they are open in the sense that there is no strict limit between what is included in the infrastructure and what is not, and who can use it and for which purpose or function; and they are heterogeneous, consisting of different kinds of components - human as well as technological.” Following this definition, infrastructures differ from standardized task-orientated software. Therefore, the design and the management of an infrastructure adoption process, such as that of cloud computing, need to consider infrastructures' basic characteristics.

According to Pipek and Wulf (2009) and similar to Star and Bowker (2002), infrastructures have five characteristics:

- **Interconnectedness and complexity:** Cloud computing, like other types of infrastructure relies on hardware (for example storage, processors, and servers), as well as software. Additionally, the hardware and software have to be connected to other services to support an efficient work environment.

- **A layer approach and standardization:** Cloud computing is based on a variety of different protocols and environments (for example, Internet, and intranet). Even though users do not recognize most of these layers (which potentially are completely replaced over time), they are crucial to make the infrastructure work and influence the variety of functionalities. Three types of cloud computing service models can be generally distinguished: (1) Software as a Service (SaaS) offers software applications that run in the cloud; (2) Platform as a Service (PaaS) provides operating systems and, thus, cloud-based development and deployment of applications; and (3) Infrastructure as a Service (IaaS), which offers units of computation and storage to customers accessing these services via Wide Area Networks (Bernius 2012, Hay et al. 2011, Marston et al. 2011).

- **(In)Visibility in use:** Users do not recognize infrastructures as long as everything works correctly. Cloud computing at universities therefore needs to be integrated into the workspace environment in order to make the system “invisible” to the users.

- **Versatility:** Infrastructures such as cloud computing can be used for many purposes. These are open systems that allow users to individually decide (to a certain degree) about usage scenarios. Furthermore, cloud computing can be extended by adding new functionalities (for example, integrating
features for collaboration). Both aspects may help organizations like universities react faster to environmental changes (for example, new technologies, new work concepts, and new content).

- Reflexivity: Not only does infrastructure allow users to store data (including data related to the infrastructure itself) and to identify use cases, but it is often redesigned on the basis of usage experiences. In this sense, the user becomes an essential part of the infrastructure design, thus ending the strict separation between users and designers.

It is crucial that universities be aware of the nature of cloud computing as an infrastructure. This knowledge should be considered in the configuration stage (for example, relevant user groups should be involved, use cases should be identified, and the service should be well integrated into the work spaces), as well as in the adoption phase (for example, students and employees should be able to develop their own usage concepts, and the service should provide enough storage and technical stability to become invisible to the users). During the implementation of new infrastructure, legacy systems, such as isolated solutions and databases, often need to be identified and potentially transferred to the new infrastructure. While this is already technically challenging, users need to be persuaded to change their working routines and to adopt a new solution. In this sense, not only do the technical aspects have to be considered, but also the actual individual demand for a new solution, as well as the willingness and ability to use it. Researchers have already developed various models to address these considerations, for example, models for technology acceptance like TAM, UTAUT (Davis 1989, Venkatesh 2003) and for adoption processes such as Diffusion of Innovation Theory (Rogers 1962, 2003), which we will not discuss in detail.

In conclusion, cloud computing should not be seen as an artifact that has to be designed from the top down; it rather needs to be continuously tailored and adapted to fit the surrounding environment. Moreover, these are socio-technical systems that include hardware, devices, software, conventions, and usage routines. Pipek and Wulf (2009, p. 452) argue that “where traditional IT design approaches focus on the artifact, the skills of designers, the information interfaces and practices to be supported, and the effective organization of design work, the infrastructural aspects [...] demand opportunities to renegotiate the border between what remains the same and what is changed when designing information systems; to renegotiate who changes aspects of information systems; and to renegotiate when these aspects are changed (before use vs. during use).”

It is thus obvious that understanding cloud computing at universities as an infrastructure has strong implications for the management, who will face challenges such as the technical design process and the users’ adoption process. A true understanding will underline that knowing the users’ demands and expectations is crucial for such a service to be successful (e.g. to offer appropriate features and to provide sufficient data storage volume).

Cloud Computing in Higher Education

Several publications focus on the use of cloud computing in higher education. The early works of, for example, Bristow et al. (2010), Ercan (2010), Katzan (2010), Brown (2009), Wheeler and Waggener (2009), and Currie (2008) call for the use of cloud computing in higher education due to its inherent advantages, which Armbrust et al. (2009) see in the following three aspects: (1) the illusion it provides of infinite, on-demand computing resources, (2) the elimination of the need for potential higher education customers to make an upfront commitment, and (3) the possibility the users have to pay for the use of computing resources when they need them for a very short period. The aforementioned authors’ papers discuss how cloud computing contributes to the higher education field, especially to universities, and what can be done to increase students’, lecturers’, and researchers’ benefits regarding common applications. When discussing the motivation for using cloud computing, these works often focus on cost savings, which have to be seen in the context of the financial crisis at the time of writing. Other authors concentrate on elements required in respect of the potential use of cloud computing, such as identity management and trust services (Suess and Morooney 2009).

Another group of authors provide the first frameworks, apply theories, or suggest use cases, although they do not present a concrete case study. Ivanova and Ivanov (2010) discuss a model for using cloud computing to author process automation. Calvo et al. (2011) describe the architecture of a collaborative writing environment used to embed related collaborative learning activities in engineering courses. Here, the writing tools, as well as the storage of student content, are outsourced to third-party cloud computing

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providers. Bungo (2011) proposes a new approach to embedded systems programming in academia by using cloud computing features. Masud (2012) presents a framework that specifies the number of steps that academic organizations need to take to adopt cloud computing for e-learning purposes, and also offers guidelines for building trust.

Parallel to their discussions of cloud computing’s general value and suggestions for frameworks, several authors have provided the first case studies, which are mostly descriptive and do not offer theories or frameworks as a background. Hicks (2009) and Sultan (2010) explore the increasing use of cloud-based mail (Gmail) and office programs (Google Apps) by higher education institutions in the UK, such as the Leeds Metropolitan University, the former University of Glamorgan (now the University of South Wales), the University of Aberdeen, the University of Westminster, London University's School of Oriental and African Studies, and the Royal College of Art. A number of other publications focus on universities in different parts of the world that also applied cloud computing, for example, in East Africa (Wanjiku 2009), China (Kshetri 2010) and India (MacMillan 2009). Most of the institutions in these areas also use Google's cloud computing services. Doelitzscher et al. (2010) are some of the first scholars to discuss a “private” cloud for collaboration and e-learning services at a small university for applied science in Germany. This university’s internal computer center offers these services by pooling its computers and small servers. In their work, Taylor and Hunsinger (2011) use the Theory of Planned Behaviour (TPB) for a first study of students’ usage and acceptance of cloud computing (Google Docs) in a university setting. These authors found that the three TPB constructs - attitude, subjective norm, and perceived behavioral control - have a significant and positive correlation with the intention to use Google Docs. In their study, Bhattacherjee and Park (2013) investigate why end-users move to the cloud by establishing and testing a hypothesized model of a migration-theoretic analysis. Subsequently, the authors compare the results of a longitudinal survey of Google Apps adoption among students at two Korean universities. Besides discussing how migration research differs from IT adoption research, they identify relevant factors that enable or hinder cloud migration, examine the interdependencies between these predictors, and introduce migration theory as a new theory to the information systems literature.

Truong and Dustdar (2011) provide one of the first researcher-oriented publications to focus on cloud computing by discussing the state of cloud computing for small research groups in computational science and engineering. The authors conclude that there is added value for researchers in improving the sharing of research results and data, improving collaboration with other researchers and scientific groups, helping to create reproducible research findings, and, above all, reducing the operation, management, and resource costs. Bernius and Krönung (2012) also contribute to this topic by offering a cloud user's perspective of academic research. These authors discuss the research results of a cloud project at the Goethe University of Frankfurt in Germany. The project addressed researchers and small research groups’ adoption of on-demand cloud computing and storage resources that a third-party cloud computing vendor provided. The findings show that the surveyed users benefit especially from fast and easy access to computing power for their research.

**Cloud Computing Services for Application in Higher Education**

As described, a university cloud computing service can be understood as a new (working) infrastructure for students and employees. Therefore, the aim of our research is to learn more about the demands required from this infrastructure. Hence, we refer to cloud computing services in a university context as Masud and Huang (2012) suggest. According to these authors, designing a cloud system for higher education is not only a matter of technical sophistication. They recommend incorporating a strategic framework into the system design process. Furthermore, they highlight five important attributes of a UCCS:

- **Online Storage**: Cloud computing needs to provide adequate online storage for students and employees. This will allow the users to maintain and manage individual data, such as presentations, homework, and collected empirical data.
- **Collaboration**: Cloud computing should allow users to collaborate and generate content. This may include synchronous and asynchronous collaboration on text-based files, or the sharing of such files.
• **Access:** Not only does data traffic require a high bandwidth, but the registered users (and only they) should be able to access the service from anywhere. Additionally, the devices through which the users will be able to access the services need to be clarified.

• **Interoperability:** Universities usually provide a series of different computing resources and applications, such as e-learning systems. Cloud computing in higher education therefore needs a certain degree of interoperability as well as user profile integration and authentication to prevent cloud computing services from becoming a standalone and isolated IT solution within the university context.

• **Security/Privacy:** Cloud computing management should apply a data security framework and data privacy standards, which should be communicated to the users to create trust.

The mentioned services are intuitively necessary for cloud computing at universities. However, each of these services raises several questions regarding its specific design. For example, what would be an adequate storage volume? How and on what do the participants wish to collaborate? Which features will these collaborations require? What is necessary to fulfill the data security and privacy requirements, and how important are these for the participants? This information is very valuable for understanding the demands required from cloud computing in higher education and for shaping such a (working) infrastructure. We therefore set up a large-scale service to shed light on the current demands and expectations of the students and employees at various German universities.

**Empirical Study**

**Background - The Sync&Share Project**

Dropbox and other cloud-based services allow users to store files remotely and to synchronize them over multiple devices. The ubiquitous accessibility of personal files, especially through mobile devices, like smartphones and tablets, as well as the improved possibilities to collaborate with other students or colleagues, has led to an increased focus on cloud computing. However, to date, there has been no international legislation covering data protection. National laws are rarely comparable and may even contradict each other on a global level. Further, all major public cloud storage providers, like Dropbox, Google, Amazon, Microsoft, and Apple, are located in the US, which many users outside the US regard as a drawback. The recent revelations of mass data analysis in the course of the mass surveillance that the NSA and other intelligence services undertook, caused a further loss of trust in commercial cloud computing. As shown in our literature review, the utilization of cloud computing, even for storing sensitive research and teaching data, is not uncommon. This creates substantial data privacy and confidentiality issues, which specifically conflict with German law and European data privacy legislation.

Against this background, universities in the most populous German federal state of North Rhine-Westphalia (NRW) have launched a project called Sync&Share NRW. The aim of the Sync&Share project is to set up a cooperatively operated ‘private cloud’ for researchers and students in order to host and run the necessary servers on-premise. This cloud computing service will contribute to different study and work domains in higher education, thus supporting learning, collaboration, coordination, and administration. In 2013, three of the 10 universities, headed by the University of Münster, founded a consortium to design, implement, and manage services of cloud computing that will possibly be available to up to 500,000 users, which is approximately 60 percent of the academic community in NRW. Currently, a joint task force of IT staff members of the universities’ consortium is designing the system. It is considering distributing the storage system between the three major universities to keep the resource consumption of the data center’s real estate and network bandwidth at an acceptable level for each university within the consortium. This action underlines the project’s cooperative character. The plan is to allow other German universities to also use the cloud computing services in the future.

**Research Design and Data Collection**

Based on the proposed understanding of the UCCS as an infrastructure (Pipek and Wulf 2009), as well as on Masud and Huang’s (2012) service-centered approach, we used the software UniPark to design an online questionnaire that would collect empirical data on a large scale. In our questionnaire, we focused
on asking students and employees about their requirements and expectations of a UCCS. In order to generate meaningful results, we conducted the survey at three large German universities:

- **RWTH Aachen (UA):** The Rhenish-Westphalian Technical University (RTWH) Aachen was founded in 1870. With its 40,000 students and 7,900 employees in December 2013, it is the largest technical university in Germany. It hosts 10 faculties, including the faculties of Civil Engineering, Mechanical Engineering, Georesources and Materials Engineering, and Electrical Engineering and Information Technology.

- **University of Münster (UM):** Founded in 1780 and with about 41,000 students, as well as 6,700 employees, the University of Münster is one of the biggest and oldest universities in Germany. It has 15 faculties, including Economics, Law, Mathematics and Computer Science, History and Philosophy, Educational Science, Medicine and Theology.

- **University of Bonn (UB):** The University of Bonn was established in 1818. A total of 31,000 students and 6,200 employees study and work at this institution. The university has seven faculties: Law and Economics, Humanities, Medicine, Mathematics and Science, Agricultural Science, Catholic Theology, and Protestant Theology.

At the UM and UB, an electronic message invited all the students and employees to participate in the survey. At the UM, the survey was conducted between June 16, 2013 and June 30, 2013. At the UB, the survey period lasted from November 18, 2013 to December 1, 2013. The UA published the link on its internal news websites and digital blackboards. The students and employees could participate in the survey between October 17, 2013 and November 18, 2013.

We designed our questionnaire by referring to the services that Masud and Huang (2012) propose. Moreover, we conducted 10 semi-structured interviews (each lasting about an hour) with individuals in different potential user groups (for example, students of different disciplines, administration staff, academics) in order to come to insights regarding potential answers to multi-choice questions.

In the questionnaire, the participants had to answer a maximum of 27 questions, depending on their replies to certain filter questions. The survey consisted of four major parts: In the first section, the respondent was assigned to a participant group (student or employee) and to a specific faculty or department (for example, administration). The second section was aimed at determining the status quo. For example, the actual memory storage requirements and gained experience with other cloud storage services (such as Dropbox) were queried. In the third section, the Sync&Share project was described in detail. This section then focused on the relevance of certain properties, features, and functionalities, as well as on the participant’s willingness to use the service. The last section included the collecting of demographic and additional personal data (including age, gender, used devices, and operating systems) that the respondents could provide voluntarily. Most of the survey consisted of multiple-choice questions that allowed them to select single and multiple predefined answers. At certain points, the respondents were also allowed to make comments, provide additional information, and specify their responses with regard to certain aspects in the fields provided.

At the University of Münster and Bonn, a mail with the survey link was sent out to all students and employees. At the Aachen University we were not able to do that due to university internal mail policies. There, the survey link was published on news sites and ‘black boards’. That is why compared to Münster and Bonn, the response rate of students as well as employees is significantly lower. In total, we received some 10,367 completed questionnaires for analysis: 7,623 students and 2,744 employees (7.6% overall response rate).

**Survey Results**

Following, we will present the most relevant survey results of the two different user groups. In this analysis, we emphasize the demographics, requirements, and expectations of cloud computing as a working environment in a university context.
Student Responses

We received more than 1,000 completed questionnaires from each of the universities for our analysis. The responses from Münster and Bonn universities were rather balanced with regard to gender. However, male students at Aachen University responded more frequently due to the institution's much higher ratio of male students (Table 1).

<table>
<thead>
<tr>
<th></th>
<th>Aachen</th>
<th>Münster</th>
<th>Bonn</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>Number of students in total</td>
<td>40,500</td>
<td>40,800</td>
<td>31,500</td>
<td>112,800</td>
</tr>
<tr>
<td>Number of participants (response rate)</td>
<td>1,013 (2,5%)</td>
<td>2,704 (6,6%)</td>
<td>3,906 (12,4%)</td>
<td>7,623 (6,8%)</td>
</tr>
<tr>
<td>Gender: male/female</td>
<td>851/162  (84%/16%)</td>
<td>1,541/1,163 (57%/43%)</td>
<td>1,875/2,031 (48%/52%)</td>
<td>4,267/3,356 (56%/44%)</td>
</tr>
<tr>
<td>Average age (standard deviation)</td>
<td>22.6 (2.8)</td>
<td>25.4 (6.4)</td>
<td>23.4 (4.5)</td>
<td>24.0 (5.3)</td>
</tr>
<tr>
<td>Affiliation to discipline (three most frequently mentioned)</td>
<td>Mechanical Engineering: 324 (32%), Informatics: 243 (24%), Electrical Engineering: 142 (14%)</td>
<td>Humanities: 649 (24%), Economics: 352 (13%), Informatics: 297 (11%)</td>
<td>Natural Sciences: 1,367 (35%), Philosophy: 1,250 (32%), Law: 469 (12%)</td>
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Given that UA has a strong technical focus, a clear majority (95%) of the students there indicated that they already use services that are based on cloud computing (90% of them use Dropbox). We also found high numbers of cloud computing users at UM (85%) and UB (75%). Besides Dropbox, Google Drive and Apple iCloud were most frequently used at all the universities. Interestingly, an even higher number of students (97% or more at all the universities) indicated that they would use a UCCS if it were offered. The participants also mentioned that they would exclusively use the UCCS instead of the commercial service (38% UA, 27% UM, and 25% UB) if such a service were offered. We also asked those students who currently do not use cloud computing why they did not do so. The most frequent answers were: (1) a lack of trust (77% UA, 64% UM, 49% UB), (2) no need to do so (40% UA, 41% UM, 33% UB), (3) a lack of knowledge (17% UA, 35% UM, 33% UB), (4) the risk of data loss (27% UA, 32% UM, 22% UB), (5) too complicated to use (4% UA, 16% UM, 16% UB), and (6) insufficient data storage volume (37% UA, 14% UM, 10% UB). These responses clearly affirm our assumption that data protection concerns are a major driver of the potential usage of a UCCS. A total of 83% at UA and 64% at UM and UB also mentioned that they wish to access the UCCS via their smart phones (Table 2).
Table 2. Usage of Cloud Computing at Universities (Students)

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<tr>
<th></th>
<th>Aachen (n=1,013)</th>
<th>Münster (n=2,704)</th>
<th>Bonn (n=3,906)</th>
<th>TOTAL (n=7,623)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud computing users</td>
<td>961 (95%)</td>
<td>2,285 (85%)</td>
<td>2,939 (75%)</td>
<td>6,185 (81%)</td>
</tr>
<tr>
<td>Non-cloud computing users</td>
<td>52 (5%)</td>
<td>419 (15%)</td>
<td>967 (25%)</td>
<td>1,438 (19%)</td>
</tr>
<tr>
<td>Intended use of UCCS</td>
<td>1,002 (99%)</td>
<td>2,629 (97%)</td>
<td>3,816 (98%)</td>
<td>7,447 (98%)</td>
</tr>
<tr>
<td>Intended use of UCCS via smartphone if offered</td>
<td>840 (83%)</td>
<td>1,720 (64%)</td>
<td>2,503 (64%)</td>
<td>5,063 (66%)</td>
</tr>
</tbody>
</table>

When setting up a new infrastructure, such as services based on cloud computing, decisions need to be made to determine how much data storage should be offered, and what features and functionalities should be considered for the roll-out stage. These issues are major challenges, since they have a direct impact on the financial investments (for example for buying storage capacities) and maintenance, as well as for the users’ acceptance of the system and its usefulness for them.

Table 3 shows that students at all the universities indicated they expected to need more data storage when using the UCCS than they currently do. This might be due to: (1) the students planning to store more data in the UCCS because of their higher trust in the provider, or (2) the students anticipating that they would need more data storage in the future. Again, students from the UA, who are more focused on technical subjects, specifically mentioned requiring more data storage volume. We discovered that students from technical disciplines at UM and UB also mentioned needing more storage volume.

Besides the data storage volume required, the potential users’ requirements of a UCCS had to be determined. Therefore, referring to Masud and Huang’s (2012) suggested services, as well as our interview results, we asked the students about their preferences (we suggested eight features and provided an open text field to allow the participants to suggest additional features). Table 4 shows the demand for the seven most frequently mentioned features.

Table 3. Data Storage (Students)

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<th>Bonn (n=3,906)</th>
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<tbody>
<tr>
<td>Estimated current use of data storage</td>
<td>&lt; 1GB (11%)</td>
<td>1-20GB (69%)</td>
<td>&gt;20GB (19%)</td>
</tr>
<tr>
<td></td>
<td>&lt; 1GB (28%)</td>
<td>1-20GB (58%)</td>
<td>&gt;20GB (8%)</td>
</tr>
<tr>
<td>Expected use of data storage on UCCS</td>
<td>&lt; 1GB (3%)</td>
<td>1-20GB (73%)</td>
<td>&gt;20GB (24%)</td>
</tr>
<tr>
<td></td>
<td>&lt; 1GB (8%)</td>
<td>1-20GB (74%)</td>
<td>&gt;20GB (13%)</td>
</tr>
<tr>
<td></td>
<td>&lt; 1GB (11%)</td>
<td>1-20GB (71%)</td>
<td>&gt;20GB (11%)</td>
</tr>
</tbody>
</table>
Table 4. Demand for Features (Students)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Aachen (n=1,013)</th>
<th>Münster (n=2,704)</th>
<th>Bonn (n=3,906)</th>
<th>TOTAL (n=7,623)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared access to data with other persons</td>
<td>962 (95%)</td>
<td>2,515 (93%)</td>
<td>3,515 (90%)</td>
<td>6,992 (92%)</td>
</tr>
<tr>
<td>Real-time collaboration on documents</td>
<td>841 (83%)</td>
<td>2,217 (82%)</td>
<td>3,164 (81%)</td>
<td>6,222 (82%)</td>
</tr>
<tr>
<td>Version management of documents</td>
<td>831 (82%)</td>
<td>2,136 (79%)</td>
<td>3,047 (78%)</td>
<td>6,014 (79%)</td>
</tr>
<tr>
<td>Full-text search</td>
<td>810 (80%)</td>
<td>2,325 (86%)</td>
<td>3,320 (85%)</td>
<td>6,455 (85%)</td>
</tr>
<tr>
<td>Commenting on documents</td>
<td>608 (60%)</td>
<td>1,839 (68%)</td>
<td>2,578 (66%)</td>
<td>5,025 (66%)</td>
</tr>
<tr>
<td>Text chat</td>
<td>213 (21%)</td>
<td>838 (31%)</td>
<td>1,367 (35%)</td>
<td>3,394 (45%)</td>
</tr>
<tr>
<td>Synchronizing calendar and contacts</td>
<td>517 (51%)</td>
<td>1,189 (44%)</td>
<td>1,562 (40%)</td>
<td>3,268 (43%)</td>
</tr>
</tbody>
</table>

One of the main purposes of cloud computing services is to share data with other students, which our respondents also mentioned as one of the major features that they required. All of the major commercial providers currently offer this feature as well as version management. However, the students mentioned that they would want more co-working features to be integrated into a UCCS (for example, real-time collaboration, text chat, and commenting on documents) than those that Google Docs currently offers.

**Employee Responses**

The introduction of a cloud computing does not only potentially provide benefits for students, but also for university employees. However, their typical working behavior differs greatly from those of students. We addressed employees in a separate, but generally comparable, survey. Overall, 2,744 employees participated in our study. A large majority of them are academics working for different faculties and disciplines at the three universities. The universities’ administrative staff was also included in the survey (Table 5).
The majority of the employees at each of the universities uses cloud computing (see Table 6). This information is highly relevant, because it indicates that these employees have potentially already stored research data and personal data about students in commercial cloud computing. The answers of most of the employees confirmed this assumption: They stated that parts of their stored data in cloud computing services are directly related to their work (UA: 73%, UM: 78%, UB: 77%). Nearly one-third of the university employees do not, however, use cloud computing. As with the students, Dropbox is the most frequently used cloud computing, followed by Google Drive and Apple iCloud.

Interestingly, most of the employees who do not use commercial cloud computing stated that they would use a UCCS (83% UA, 76% UM, 71% UB). In this context, privacy concerns regarding the stored data seem to play an important role. The employees’ reasons for not using commercial cloud computing are: (1) a lack in trust (75% UA, 62% UM, 60% UB), (2) no need to do so (27% UA, 25% UM, 27% UB), (3) a lack of knowledge (20% UA, 36% UM, 29% UB), (4) the risk of data loss (23% UA, 28% UM, 23% UB), (5) too complicated to use (8% UA, 12% UM, 8% UB), and (6) insufficient data storage volume (11% UA, 12% UM, 8% UB).
As with the students, the employees’ demand for data storage volume is higher than their current use (probably for the same reasons) (see Table 7). Compared with the student analysis results, we found notable differences between employees in different disciplines and work areas (for example, technical disciplines and natural sciences require more data storage volume than social sciences research does).

Table 7. Data Storage (Employees)

<table>
<thead>
<tr>
<th></th>
<th>Aachen (n=513)</th>
<th>Münster (n=1,070)</th>
<th>Bonn (n=1,162)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated current use of data storage</td>
<td>&lt; 1GB (16%) 1-20GB (47%) &gt;20GB (37%)</td>
<td>&lt; 1GB (19%) 1-20GB (47%) &gt;20GB (27%)</td>
<td>&lt; 1GB (23%) 1-20GB (40%) &gt;20GB (30%)</td>
</tr>
<tr>
<td>Expected use of data storage on UCCS</td>
<td>&lt; 1GB (3%) 1-20GB (65%) &gt;20GB (29%)</td>
<td>&lt; 1GB (6%) 1-20GB (61%) &gt;20GB (27%)</td>
<td>&lt; 1GB (6%) 1-20GB (58%) &gt;20GB (28%)</td>
</tr>
</tbody>
</table>

We found that the employees of the different universities had remarkably similar expectations regarding the features they required from a UCCS. It seems that even though the employees are affiliated to various disciplines and departments, their general working behavior and required technology support are comparable. The employees stated that besides data sharing, other services and features to support collaboration had to be integrated into a UCCS (see Table 8).

Table 8. Demand for Features (Employees)

<table>
<thead>
<tr>
<th></th>
<th>Aachen (n=513)</th>
<th>Münster (n=1,070)</th>
<th>Bonn (n=1,162)</th>
<th>TOTAL (n=2,744)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared access to data with other persons</td>
<td>487 (95%)</td>
<td>952 (89%)</td>
<td>1,046 (90%)</td>
<td>2,485 (91%)</td>
</tr>
<tr>
<td>Real-time collaboration on documents</td>
<td>400 (78%)</td>
<td>813 (76%)</td>
<td>883 (76%)</td>
<td>2,096 (76%)</td>
</tr>
<tr>
<td>Version management of documents</td>
<td>431 (84%)</td>
<td>856 (80%)</td>
<td>941 (81%)</td>
<td>2,228 (81%)</td>
</tr>
<tr>
<td>Full-text search</td>
<td>405 (79%)</td>
<td>856 (80%)</td>
<td>953 (82%)</td>
<td>2,214 (81%)</td>
</tr>
<tr>
<td>Commenting on documents</td>
<td>303 (59%)</td>
<td>653 (61%)</td>
<td>651 (56%)</td>
<td>1,607 (59%)</td>
</tr>
<tr>
<td>Text chat</td>
<td>93 (18%)</td>
<td>161 (15%)</td>
<td>151 (13%)</td>
<td>405 (15%)</td>
</tr>
<tr>
<td>Synchronizing calendar and contacts</td>
<td>313 (61%)</td>
<td>717 (67%)</td>
<td>732 (63%)</td>
<td>1,762 (64%)</td>
</tr>
</tbody>
</table>

We found that the employees of the different universities had remarkably similar expectations regarding the features they required from a UCCS. It seems that even though the employees are affiliated to various disciplines and departments, their general working behavior and required technology support are comparable. The employees stated that besides data sharing, other services and features to support collaboration had to be integrated into a UCCS (see Table 8).

**Discussion and Implications**

**Demand for a University Cloud Computing Services**

While companies increasingly use private cloud computing, universities seem to lag behind in this development. Our survey data makes it clear that this delay causes serious problems: First, even though most students and employees use commercial cloud computing to increase their work productivity, a considerable number of them avoid using commercial services, primarily because of their privacy concerns or legal constraints. One can therefore assume that this behavior also prevents them from generating productivity advantages, thus potentially harming the universities on a large scale. The second
problem, as our survey data shows, is that most of the employees already use commercial cloud computing for their work (to increase their productivity). However, this means that the actual owner (the university) does not completely control the data, which leads to various legal issues. In this case, the university staff and the students depend on enterprises such as Dropbox, Google, and Apple and could be negatively affected by any of these enterprises’ decisions, for example, to change their usage conditions (for example, a reduction in the provided data storage volume, or even the termination of the service). From the universities’ point of view, preventing the usage of commercial cloud computing does not seem to be realistic. Not only would banning the usage potentially lead to a reduction in the university employees’ productivity, but it would also be extremely difficult to control their usage of commercial cloud computing.

Both aspects are strong arguments for establishing a ‘private’ UCCS that national laws would protect. However, the design and the management of such an infrastructure is a challenging and complex task. A crucial first step is to gather data on the potential users’ requirements. In the following section, we discuss our findings in this regard.

**Design Implications**

To date, very little has been known about the design of a UCCS. Following the normal approach to infrastructures, such a system generally includes components that work in the background and that users usually do not recognize (for example, the backbone network, backup procedures, and memory virtualization). However, the design of these components could affect users’ satisfaction with the system (for example, fast/slow data transfer rates and data access, system errors). A bad design would make the background systems ‘visible’ to the user and increase dissatisfaction, although according to Herzberg’s model of hygiene factors, properly working systems do not necessarily ensure satisfaction.

In our study, we concentrated on the system components (features/functionality, data storage volume) and attributes (such as interoperability, and privacy policy) that are recognized and of immediate interest to the (potential) users. The design of these components and attributes has a direct impact on employees’ and students’ decision to use the system, keep using it, or avoid using it. This aspect is especially meaningful because potential users can easily compare the characteristics of each component or attribute to those of profit-oriented services. However, simultaneously, it should be kept in mind that the potential target users of a UCCS include various heterogeneous groups, such as students and employees. Their disciplines, working areas, and the specific working behavior and organizational culture at their universities can influence the individuals in both groups. Our study therefore collected and analyzed information on the demand for the following components and attributes that Masud and Huang (2012) suggest:

- **Online storage**: Our survey data shows that the university students and employees expect to need more data storage volume than they currently use on commercial cloud computing. The reasons for this could be: (1) users’ higher trust in the UCCS and their plan to store additional data, (2) users anticipating they would require a higher data storage volume in the future, (3) users already facing profit-oriented providers that limit the data storage. Our data shows that about three-fourths of the students and approximately two-thirds of the employees at all the universities stated that they would require data storage volume of between 1 and 20 GB. Based on a maximum user base of 500,000, this would mean a total of between 0.5 and 10 petabytes. Given the users’ heterogeneity, data storage should be virtualized to offer each employee and each student as much volume as possible. This could also positively affect the service’s perceived attractiveness. However, investment decisions are very complex in this area, since it is difficult to estimate the actual demand. Additionally, the design of such an infrastructure needs to be seen as an ongoing dynamic process (for example, the required data storage volume might significantly increase over time, and other commercial services could extend their offering).

- **Collaboration**: Our survey shows that there is a high demand to integrate collaboration features into a UCCS. For example, employees want to share documents (91%), collaborate with each other in real time (76%), and comment on other employees’ documents (59%). As Table 4 shows, we found an even higher share of students who require these features than among the employees. Taking this finding regarding the design process into account could result in higher user satisfaction and workforce and student
productivity, and could increase the attractiveness of the services compared with that of the profit-oriented competitors.

- **Access:** All user groups mentioned PCs as the most important device from which to access a UCCS. However, our survey results confirm the success of smartphone usage at universities. Overall, two-thirds of the students stated that they planned to access the UCCS via a smartphone if possible. More than half of the employees shared this opinion.

- **Interoperability:** The integration of the UCCS with other services has also been mentioned as an important design issue. For example, 64% of the employees and 43% of the students wish to integrate their calendars and task lists into a UCCS. More than half of the students and half of the employees want the UCCS to be integrated into the existing learning system or work environment.

- **Security/Privacy:** The survey results clearly show that security and privacy concerns play an important role and will most probably be one of the major drivers. For example, 60-70% of the students at all the universities and approximately 80% of the employees mentioned that the physical data storage should be located in Germany. We also found that a lack of trust is the major reason for not using cloud computing. A university may benefit from being perceived as a trustful organization. More than 80% of the students and more than 75% of the employees confirmed that they would trust the cloud computing that a university provides more than one provided by enterprise-operated services.

Through our study, we gained insights into what students and employees expect from a UCCS. Even though we draw on a solid database, it is important to state that the design of such an infrastructure is a continuous process. Further, different changes in the environment (such as technical, political, and legal changes) affect all of the five elements of a UCCS that have been discussed. Therefore, all of the relevant stakeholders, such as representatives of different user groups, should be involved in the continuous process of development and adaption.

**Management Implications**

In order to establish cloud computing as a new infrastructure at universities, managers need to create an open system that could be used for various working tasks. However, the implementation and adoption of private cloud computing face several problems. A major challenge is that university services have to compete with commercial services in several respects. Universities are expected to offer the same or even more data storage volume, different types of devices should be able to access their services, and these services should be easily integrated into the daily workspace. One of the major benefits of commercial services is their large user base, which results from their high economies of scale. Moreover, the current services have a first-mover advantage, and users are very familiar with them. In this sense, the introduction of university cloud computing services is a typical “entering the market” problem.

In such a situation, it is crucial to benchmark the planned features of the UCCS against other solutions that the target groups already use. More generally, the universities should at least offer comparable benefits but should also compensate for their users’ switching costs. Given the specific situation at universities and based on our survey results, we can verify that the potential participants do not only consider the offered features and the storage volume to be beneficial, but also the provider’s branding and their trust in the provider (university).

It is thus crucial to create awareness of these issues and to develop an appropriate strategy to spread this information to the target groups. Furthermore, the management could initiate procedures to increase their students’ and employees’ benefits if they were to use a UCCS and their motivation to do so. For example, well-known approaches from other contexts are: (1) providing the initial content and useful information, (2) providing students with direct access to the system on their first day at university, (3) increasing the offered features over time, and (4) communicating beneficial use cases (Meske et al. 2013). When introducing new software, potential users often have to be trained, which, depending on the number of people involved, is a large investment. However, when introducing a UCCS, a large-scale investment does not seem necessary for the following two reasons: First, as an infrastructure, a UCCS should be self-explanatory and motivate its users to establish their own usage scenarios; second, as our survey shows, most of the target groups are already familiar with this type of technology.
As mentioned before, it is essential to continuously adapt the system to the changing environment (for example, storage requirements, new working routines, new tasks, improved technologies). In order to do so, managers need to continuously gather information on the system's statistics and user behavior. Of course, managers should carefully consider all the privacy issues before doing so; if they fail to do this, universities risk losing their most important asset: trust.

Conclusion

Motivated by the public's massive decline in trust in commercial cloud computing providers that are located in the US, European universities started to seek for alternatives to commercial and commercial cloud computing. To date, it remains unclear whether the potential user groups, such as university students and employees, actually require such a service. Furthermore, there is a lack of information on how to design such a service. In our study, we referred to the theoretical concept of infrastructures to better understand the specific challenges of designing a university cloud computing service. Besides their characteristics as an infrastructure, we considered the components and attributes of cloud computing in a university context in our analysis. Based on both approaches, we developed and conducted a survey that more than 10,000 individuals completed. Our findings confirmed the assumption that privacy concerns and a lack of trust in commercial services are the most important reasons why students and employees would potentially use a UCCS as opposed to a commercial cloud computing service. Furthermore, our survey provided interesting insights into the features and data storage volume that would be required. We also identified that one challenge would be to deal with a very heterogeneous user group.

This study has several theoretical and practical implications that contribute to the IS field: First, to our knowledge, we are the first researchers to examine cloud computing at universities from an infrastructure perspective. Moreover, other examinations of cloud computing at universities lack empirical data. In this regard, our survey results are a step forward, will help other researchers compare their findings, and will open new research questions. The paper also contributes to practical issues by providing university decision makers with substantial information on the actual demand for a UCCS and with several design implications, as well as empirical data.

Our study does not come without limitations. We based our discussion on a solid and comprehensive empirical basis (more than 10,000 participants, students and employees, of three different universities). However, only 7% of the students and 12% of the employees responded. Furthermore, we only included German universities, and that the results should therefore not be generalized without caution. For example, public discussions about privacy issues in cloud computing may result in different reactions than it is the case in Germany. In addition, the UCCS management should keep in mind, that there might be a gap between the 'required' features or storage volume and the 'actual' need for it. For example, participants might have based their answers on comparisons to the offered storage volume of existing services such as Dropbox, and not on their actual volume requirements. Furthermore, our database is based on an online survey. There might be a bias in our data, because technophile students and employees tend to participate more than average in online questionnaires. However, given that a large number of students and employees from non-technical disciplines participated in the survey, we believe that this specific limitation is negligible.

Our research opened several new research questions: The adoption process of such a university cloud computing service needs to be investigated in order to evaluate whether the anticipated demands are actually helpful in predicting subsequent user behavior under real-world conditions. Further, there is no analysis of whether cloud computing in a university context does indeed improve learners’ and employees’ productivity. Our study also indicates that more research should concentrate on users’ switching behavior, considering the related transaction costs potentially caused by users’ trust or distrust of a provider or by differences in the system’s features and design.

References


