A Virtual Environment and Infrastructure to ensure future readiness of Data Centers

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1. ABSTRACT

The ongoing digitalization leads to a need of continuous change of ICT (Information and Communication Technology) in all university domains and therefore affects all stakeholders in this arena. More and more ICT components, systems and tools occur and have to be integrated into the existing processes and infrastructure of the institutions. These tasks include the transfer of resources and information across multiple ICT systems. By using so-called virtual environments for domains of research, education, learning and work, the performance of daily tasks can be aided. Based on a user requirement analysis different short- and long-term objectives were identified and are tackled now in the context of a federal research project. In order to be prepared for the ongoing digitalization, new systems have to be provided. Both, a service-oriented infrastructure and a related web-based virtual learning environment constitute the platform Campus.UP and creates the necessary basis to be ready for future challenges. The current focus lies on e-portfolio work, hence we will present a related focus group evaluation. The results indicate a tremendous need to extend the possibilities of sharing resources across system boundaries, in order to enable a comfortable participation of external cooperating parties and to clarify the focus of each connected system. The introduction of such an infrastructure implies far-reaching changes for traditional data centers. Therefore, the challenges and risks of faculty conducting innovation projects for the ICT organization are taken as a starting point to stimulate a discussion, how data centers can utilize projects to be ready for the future needs. We are confident that Campus.UP will provide the basis for ensuring the persistent transfer of innovation to the ICT organization and thus will contribute to tackle the future challenges of digitalization.

2. Virtual Environments for different user needs

Nowadays, the ICT infrastructure of universities is scattered with respect to organizational and technical aspects. While ICT changes rapidly and new technologies, design paradigms and systems evolve continuously, especially for university data centers it is hard to keep pace. On the one hand, they have to ensure the maintenance of legacy systems and thus constantly have to revise and conceptually redesign the historically grown infrastructure and systems. On the other hand, they have to recognize valuable trends and developments, which glimpse on the horizon (Johnson et al., 2016), and connect them with the aims of simplifying the daily business.

Aggravatingly, the digitalization proceeds in various university domains (e.g. education, research and administration) and affects all stakeholders involved (e.g. students, academic staff, scientists, researchers and non-academic staff). This poses a tremendous challenge for data centers to deal with the different needs and requirements and to best to cover all conceivable use cases. As a result, more and more infrastructure and systems appear and need to be integrated seamlessly into the existing business processes and have to be combined with the existing ICT landscape (Becker 2011). This in turn requires the conception and implementation of new service interfaces and sometimes the adaption or even the profound revision of the existing underlying infrastructure and systems.

While technology plays a crucial part in our daily life, ICT becomes also an enabler of previously inconceivable academic and research scenarios. Out of research projects completely new requirements arise, which do not have much in common with the traditional tasks of data centers (e.g. operation, maintenance and ensure availability). However, in this context data centers mission is to respond as quickly as possible to the changing conditions and to provide an appropriate infrastructure and solutions (e.g. research data management, digital humanities). A basic requirement is a working infrastructure, but neither researcher, academic staff student nor employees do get much value out of infrastructure in itself. This aggravates the situation of historically grown data centers, especially when developments in this direction did not take place in the past. As a result, the dilemma between having to innovate but also having to operate even more is an obvious one.

While more platforms, services and tools appear, especially for the various stakeholders it becomes challenging to keep track of the different systems. Although each group of stakeholders has individual needs, they all share the common fate of having to deal with ICT services and platforms that differ from one another in terms of of user guidance. Due to a limited interoperability, there are only few opportunities to share resources, artifacts and information between system boundaries. The daily usage of ICT systems for all stakeholders therefore turns into complex endeavor. In order to tackle these problems and to ensure the best possible support for everyday activities of university stakeholders, diverse virtual environments (VEs) arose over the last few years.

However, the field of VEs is very heterogeneous and stretches from dedicated platforms for learning and teaching to research or workplace learning. Especially in the field of technology-enhanced-learning, the term “Personal” is stressed in order to accentuate the focus on the individual person’s actions and the customized environment. Therefore, the terms Personal Learning Environment (PLE) or the Personal Research Environments (PRE) are used. If further web 2.0 applications, tools, content repositories and data sources get integrated within these environments, and the users are additionally able to manage these applications themselves, the environment is also referred to as a Learning Stack or an educational cloud (Johnson et al., 2016). To establish those VEs for personal and institutional contexts different approaches are used (Kiy & Lucke, 2016). They reach from a variety of web-based approaches (e.g. link lists, adapted social software and mashups) to desktop and mobile approaches (e.g. desktop widgets, browser extensions and mobile applications).

The majority of these VEs were developed as a part of large European research projects (Kiy & Lucke, 2016). As a result, these VEs lack in real connections to the basic ICT infrastructure of their universities (systems and operation, or rather: maintenance). Consequently, these environments do not constitute an ecosystem around students or lecturers by integrating central ICT services from the university. Due to the missing connection to data centers during research, these VEs were never fully operational, because neither the maintenance and operation nor the further development of such systems had been considered during the projects’ run-times. The data centers on the other hand often did not try to draw any kind of benefit from these innovative developments for their daily work or just did not take any notice of the projects.

This article presents an ICT ecosystem that combines research and operations aspects at core of the matter. A service-oriented infrastructure is presented, addressing the various demands of university stakeholders on different levels. Even though the work is theoretically based in the field of PLEs, it nevertheless extends the aspects to a broader audience and focuses on personalized learning, teaching, research and working. First, the needs of the stakeholders are summarized. Afterwards, the challenges are presented that have to be tackled in order to establish a new ICT infrastructure within a historical grown data center. Because the current focus lies on e-portfolio work, the according use cases and an evaluation of the e-portfolio focus group are described in the following. The article closes with a discussion, how both innovative research and classic operation were combined in this project, and how classic data centers have to change in order to compete with the progressing digitalization in all university domains.

3. Rethinking academic practice and needs

Caused by the ongoing digitalization several aspects of our daily work and life are changing and affects university domains in various ways, ranges and speeds. Especially, university data centers and ICT organizations have to realign continuously to be able to meet current and future needs.

In order to get a good impression of user’s insights and to generate a meaningful overview of user’s current requirements and wishes, a user requirement analysis based on user stories was conducted

across all status groups of the university until the end of 2016. Out of the over 200 different user stories, both short-term and long-term needs for the ICT infrastructure were identified, from which subsequently single steps of actions were derived:

- provide systems and technologies to enable new learning, teaching and research scenarios
- simplify the access and the discoverability of university tools, information and services
- reuse and combine services and functions across different software systems
- ease the transferability of information, resources and artefacts between system boundaries
- increase the autonomy of the users, thus they can achieve tasks with little support

From a technical point of view, the following short- and long-term objectives were identified:

- provide a spectrum of self-services to users (e.g. students, teachers, staff, researchers) to create an ecosystem according to their specific needs (e. g. software as a service by creating user-driven instances of wikis and blogs)
- aggregate isolated tasks from single systems in overarching processes, to improve the user experience, perceptual use and the productivity of students, staff and researchers
- provide an infrastructure with documented APIs which simplifies further developments, works as an service abstraction layer and allows the integration and reuse of external or federated services and tools
- offer a starting point for all services and tools within the university in a single environment
- support the individual creation of virtual learning and research scenarios and environments
- initiate a transformative process and a paradigm shift to everything as a service

While some of the objectives can be achieved with small efforts, others entail a lengthy process, affecting existing infrastructure along with changes of the established practices and attitudes. In the following, the status quo and the primary objectives are illustrated. Subsequently, the service-oriented architecture, its components and the web-based environment are presented, which serve as an enabler of the previously illustrated long-term objectives. All aspects taken together constitute Campus.UP – the approach, architecture and platform proposed in this article.

3.1. University-wide IT services

The ICT organization at the University of Potsdam missed-out on some developments and shifts between the years 2000 to 2012. From the point of view of the data center the most notable miss was a doubling in almost all indicators for the size of the university while the number of staff at the data center remained constant. This led to a highly dedicated guerrilla-like culture within the data center to keep system and infrastructure afloat and to provide reliably run-of-the-mill IT-services for the users at the university. The exception being the network and connectivity (including WiFi) that were always kept up-to-date. The usual shift from systems to services and serious approaches to service-orientation had not been attempted, nor was any IT-strategy in place or followed. The poor housing of the central IT systems being another point in missing developments.

Of the historically five faculties in Potsdam, only one had a distinct affinity for ICT. This might explain why on the one hand IT resources did not follow suite the expansion of the university, and on the other hand how the university was able to successfully operate without an adequate central IT organization. Those groups that had higher ICT demands created their own ICT systems in an unregulated manner; hence, there exists a culture of shadow IT in Potsdam.

In the past four years, several new systems were brought into operation, in parts with the help of large-scale projects in the wider E-Learning area. Amongst them are a data storage application, a media-server, a bunch of feature-rich Moodle systems serving particular needs (e.g. education in general, assessment platform and for international courses), several small e-learning apps (e.g. etherpad, clicker, information panels), a revamped communication platform (email, chat) as well as the known Shibboleth-based single-sign-on infrastructure. Furthermore, several systems supporting administrative tasks were introduced (e.g. business intelligence, online travel permits, online procurement). All systems and interfaces are geared towards mobile usage and are predominately open-source. These systems extend the existing ecosystem by some badly needed functionalities.

About one year ago, a reorganization of the internal structure of the data center was set in motion. This process is still ongoing. The aim is to move “Hey Joe” administration and “whole-stack” system administrators to a more manageable structure with specialized teams, IT service management being the ultimate goal. In the year 2011 the position of a CIO was established, in 2014 a first IT strategy was passed and there is a silver-grey lining on the number of staff as well.

3.2. The architecture of Campus.UP connecting single services

The architecture underlying the web-based virtual environment has already been proposed in 2014 (Kiy, Lucke & Zoerner). In the meantime, the architecture was extended by further components to satisfy the continuously evolving requirements, current trends and newly identified future needs. The architecture is service-oriented and is composed of two layers, each containing a special realization of an enterprise service bus (ESB), called the university service bus (see fig. 1).

The Private Service Layer provides the basis of the service-oriented architecture with a set of web services to central organizational units (e.g. library, student services, learning & campus management system), a process engine handling cross-system processes as well as some specialized databases and services (see fig. 1).

While the Private Service Layer encapsulates all university-internal services and connects them to the ESB, the Public Gateway Layer in contrast provides possibilities to connect different user interfaces, third-party services and tools to the underlying infrastructure. This opens up possibilities to reuse the provided APIs to implement solutions for various new use cases, like public information panels, mobile applications or more sophisticated workflows or systems. Once a web service and workflow is implemented, it can be reused in any kind of application, be it on a web page like Typo3 or in a mobile application. The proposed architecture may also be used as a basis for cooperation across higher education institutions, since it abstracts from dedicated implementation details and specific services. The StApps project, which tries to provide a cross-institutional mobile application, uses a similar approach (Lehmann & Huber, 2015). This implies a consequent interface, protocol and format abstraction on the infrastructure, platform and software level (cf. IaaS, PaaS, SaaS) for all thinkable services (e.g. storage, authentication, e-mail, calendar). As an example, storage can be connected on an infrastructure level via S3 (Simple Storage Service) and via WebDAV (Web-based Distributed Authoring and Versioning) on a software level.

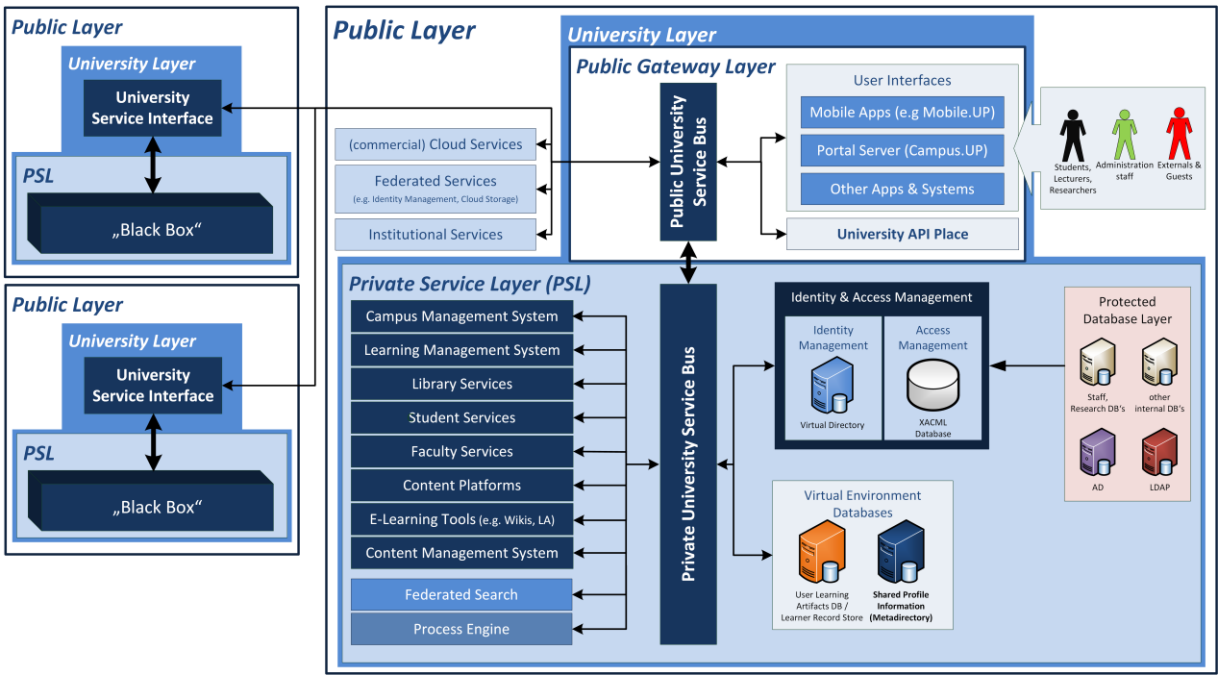

Figure 1 - Campus.UP's architecture with the two different layers and a subset of its components, databases and interfaces

A crucial requirement for combining single services in order to provide high value services is the initial determination of the essential ICT systems and services of the institution. After they are

identified, the next step is to define reusable and abstract service interfaces, or if already existent, to make them accessible by other applications. From then on, the services can be used in any kind of application and can be mashed up in one portal to address the complexity issues of the stakeholders and to simplify the tasks of the service staff at the same time. Furthermore, the different systems themselves have to be connected with each other by the use of plugins or connectors to support the resource transfer. On top of this, ways of integrating third-party applications have to be considered as well. As a result, central systems should be ready to be extendable by connectors enabling access to both central services and external services e.g. Dropbox, Google, Microsoft, Youtube or Social Networks. This will ensure at least a minimum opening-up of the institutional systems to the real-world experiences of the respective stakeholders.

3.3. Campus.UP – the platform for academic collaboration

Due to the use of a service-oriented architecture, services can be combined to create new high value services or applications. Therefore, on top of the previously presented infrastructure, several web-based and mobile user interfaces were implemented. Each interface, or rather application, uses a different set of services to fulfill the specific needs of the stakeholders (e.g. apps for study organization, apps to support student's introductory phase, research apps, information panels or classroom response systems). As a central access point, the web-based portal application Campus.UP was developed. Campus.UP tries to simplify and unify the access to the central ICT services and systems and provides a user interface for cross-system processes.

As presented previously, different approaches are used to implement virtual environments (Kiy & Lucke, 2016). At the University of Potsdam, a hybrid approach was chosen. On the one hand, the portal Campus.UP is the centerpiece of the infrastructure and reunites the various available services in one consistent, web-based user interface. On the other hand, the application Mobile.UP forms the mobile counterpart, providing the user with information and services, which are useful in a mobile context (Kiy, Geßner, Grünewald, & Lucke, 2015).

In addition to the previously conducted requirements analyses, a focus group analysis was added in order to better understand media-didactical needs and to derive use cases for learning, which have to be supported by a unified platform. By the combination of an interdisciplinary design-based research process (DBR) and by methods of the agile software development, the web-based platform Campus.UP has been designed and continuously further diversified. The DBR approach involves central e-learning stakeholders, lecturers and students. Therefore, the current state of the infrastructure is a result of an ongoing negotiation process and still leads to relevant developments.

Even if the mobile and the web-based implementations of the virtual environment are undoubtedly interesting, this article explicitly focuses on Campus.UP and the underlying infrastructure. Campus.UP is the access point to all services, systems and acts as the cockpit of the personalized virtual environment for students, teachers and staff. Therefore, the software, which had to be chosen, had to ensure the integration of different information resources, systems and services in one consistent interface. When it comes to the integration of information and implementation of virtual environments, the following web-based approaches are preliminary used (Kiy & Lucke, 2016): the extension of social software (e.g. MediaWiki, WordPress), the extension of institutional applications (e.g. Learning Management Systems like Moodle) or the use of widget- or portlet-based applications. However, the categories are not distinct and several systems already use widgets or portlets to encapsulate functions and information.

One central goal of the research project is to create a solution, which is transferable from one institution to another. Due to this decision, the possibility to extent a dedicated learning management system fell out of the equation, because such systems have to be replaceable like any other infrastructure component or service. From a developers point of view it was reasonable to choose a system, which uses well-known frameworks, libraries and technologies to ensure extensibility. Due to monetary aspects, a complete development from scratch was discarded as well. Instead, an open source project enabling further development was the preferred option. Any useful system has to deal at least with the crucial aspects of user authentication, role management, the management of resources and content; at best, it offers a broad range of plugins and extensions over a community-driven marketplace. Finally, as usual, it came down to the near-religious question, whether to use Java, Python or PHP as a programming language. Since nearly all web services are being developed

using Java and more experiences and competencies were at hand for Java and its frameworks, Java was consequently chosen as the language for implementation.

After a short market analysis, several big players like JBoss Portal (http://jbossportal.jboss.org/), Liferay (https://www.liferay.com/), eXo (https://www.exoplatform.com/) or Jasig/Apereo uPortal (https://www.apereo.org/projects/uportal) were evaluated. Due to various reasons, like license restrictions, which limit further developments, ongoing costs and feature limitations, which would have had to be expensively implemented, an existing university community and test installations, finally the choice fell upon the open source enterprise portal Liferay. The software belongs to the branch of enterprise information portals, which provides a framework for integrating information from various sources. Another benefit of Liferay is the use of established background technologies like Solr or Lucene for search, Java-Caching technics, Business Process Integration, the support for a high availability or cluster setup, the utilization of a layered architecture, which is extensible e.g. by the use of web services and Liferay is highly customizable by various hooks and extensions. Caused due to the fact, Liferay is a content management system itself; it covers out of the box social software and functionality, like for example blogs, wikis, social profiles, a message system and chats. Thus, several media didactical demands for a virtual learning environment are covered already without any extra efforts.

Over several iterations, Campus.UP has been further developed. This entails the continuous update and change of the already existing and additionally built up infrastructure and its components. Step by step, central ICT components and systems are connected and thus integrated within Campus.UP. However, due to the fact that current stakeholders are primarily interested in independent and collaborative e-portfolio work, the current focus lies on the e-portfolio components. In Campus.UP every user owns private and public pages. In order to avoid unnecessary duplications with an external e-portfolio management system such as Mahara, it was decided to implement a generalized e-portfolio workflow, derived from various e-portfolio systems, within Campus.UP. Currently, users can create pages and in sense of the e-portfolio workflow can share pages and request feedback for sites, which can be given as an message, chat message, e-mail or during a live session (Kiy, Grünewald, Weise & Lucke, 2016). Some pages are preconfigured and not editable to ensure at least a basic functionality for all. From this starting point it is always possible to create own pages and populate them with so-called portlets. These portlets act as an integration bridge to the central ICT components. To embed functionality within Campus.UP different integration levels are used, either by framing different user interfaces (e.g. Mobile.UP) or by the use of web services or standardized protocols.

Up to now, different concepts of spaces so called workspaces have been conceptualized and implemented, each accentuating different needs. One workspace focuses the teaching aspects, one enables the group work as equals and yet another allows hierarchical communication scenarios as may happen in central administrative units. Each workspace is preconfigured with different pages, tools and services. So far, the group workspace, which all users share common privileges in, is available. Each user, despite whether student, teacher or staff, is able to create workspaces, configure them according to their needs and invite other users to collaborate, share resources, publish or present information. For this reason, Campus.UP is not only referred to as a learning environment but rather a learning, teaching or work environment.

4. Evaluation – User Scenarios

The work with e-portfolios in Campus.UP is focused on the possibilities to autonomously form groups and contribute in form of so called workspaces. In the meantime, most central services of the University of Potsdam are prepared for integration within Campus.UP. This includes the extension by web services based on standard and semi-standardized formats and protocols, the connection to the single-sign-on infrastructure and the definition of cross-system processes. However, since the current implementation focuses on learning a corresponding evaluation based on focus groups is presented. The focus group consists of educators from various disciplines like didactics, philology and cognitive science. As mentioned before, the design-based research approach is used as a development and research methodology, which directly ensures the continuous inclusion of feedback from focus groups to the agile development process.

With the help of Campus.UP several learning scenarios were realized. This includes the classic summative e-portfolio work, in which each student has to write an e-portfolio for a given period (i.e.

to accompany an internship), which then has be submitted for review or grading. Additionally, students can continuously request feedback on their e-portfolios at any time, which is rather used for ongoing semester courses. Furthermore, the platform's workspace concept is used to either provide independent spaces for group work associated with a teaching-course, enabling collaborate e-portfolio work, or to organize and support common course work.

In the course of regular meetings with the focus group, the requirements and the feedbacks after each semester are collected, redacted and then find their way into the development process. All learning scenarios could be implemented with the help of Campus.UP. However, it turned out that an increasing number of educators use videos as a starting point for reflections on experiences and situations during internships or work placements of students. Since the integration of the cloud-storage with Campus.UP is not fully implemented yet, it was cumbersome to upload videos and embed them into the portfolio pages. In particular, due to privacy regulations of recorded people, especially pupils in teacher training scenarios, the existing possibilities to share and embed videos, which are publicly available, cannot be used. Since e-portfolios are a form of formative and summative assessment, the results have to be archived in order to comply with legal regulations. Therefore, the lecturers need an option to export as PDF or print out the corresponding e-portfolio pages. The last crucial feedback concerning collaborative work with Campus.UP is associated with the management of guest accounts in the data center. Many persons collaborating with students and lecturers from courses are not affiliated in any kind with the institution like for example the mentors or teachers in schools or other persons who play part in the internships. So far, most communication is handled by e-mail and telephone. To improve this situation the possibilities to invite and collaborate with persons external to the institution has to be redefined in the ICT organization.

With respect to the interface and the usability of the platform, we did not receive any negative feedback. We attribute this to the fact that students and lecturers were always involved in the conception, in prototyping and in testing. Due to the continuous user evaluation and feedback, the demands regarding the e-portfolio workflow were rapidly integrated. For example, the students and lecturers asked to improve the notification system in Campus.UP. Therefore, the functionality to receive e-mail notifications in addition to the existing activity stream was implemented. Now, for example, students and lecturers get e-mails when sharing a portfolio-page, when asking for feedback or when an assessment of a page was done.

While more and more services like the learning management system, the cloud-storage and the video-platform get integrated in Campus.UP, the activity stream is overloaded by messages and notifications from the platform itself and from the connected systems like the learning management system moodle. As a result, filter functions with respect to connected systems and workspaces is being implemented. Furthermore, a redesign of the activity stream took place to stop information overload and distinguish whether the information is created by Campus.UP itself or an "external" system. All obtained results are generalized to cover at best all future scenarios of information publishing. All insights regarding user guidance, usability, notification management and the integration of services and processes will be agile refined, thus to be reused for the stakeholders like researchers or non-academic staff. The design-based approach with direct stakeholder participation is extended to other domains now.

5. Bridging between research-driven innovations and continuous operation

The project Campus.UP is the first project at the University Potsdam that seriously tries to integrate features and functions from different systems seamlessly into a service for a group of users at the university. It also introduces a service-oriented middleware that potentially allows combining existing systems and their features into new high quality services for further use cases. The ICT architecture and the according changes in the infrastructure as well as in the ways of conducting business at the data center and the ICT organization as a whole creates significant efforts. This poses the question on whether "we are doing the right thing" and leads to the million-Euro question what the aims of ICT services at a higher education institution should be, now an in the foreseeable future.

There are lot of opinions on this topic out there. Tracy Schroeder (2014) talks about a "post-enterprise concept" and states that "increasingly, the main challenge for higher education faculty, staff, and students might not be getting support from the enterprise IT organization but, rather, getting around the enterprise IT organization so that they can use the consumer apps they want." She identifies three other significant future areas but states that "without ensuring a base level of

quality and efficiency in utility services, the IT organization will be precluded from contributing in any of the other areas identified […]. But this level of maturity is not easily achieved."

So ultimately, the ICT organization has to ensure the availability of safe-to-use utility services and at the same time innovate in order to meet future demands. Users may say that "I don't want you [the IT organization] to be a service provider in this situation; I don't even know what I want, or what is possible. I need you to create something with me" (Schroeder, 2014). Schneider (2016) concludes an article on the mission of a higher education ICT organizations with the statement that the "currency" of the ICT organization "is trust", in the sense it being able to fully apprehend the challenges the users face. So useful ICT services must be capable of creating individually tailored solutions for now unforeseen scenarios in the context of Academia, or at least be able to support solutions. This possibly leads to a paradigm that Dreyer et al. (2015) describe as "Anything as a Service" (XaaS).

The project Campus.UP constitutes a building block to tackle challenges and demands described above. Yet other innovations and changes will have to follow to create a future-proof ICT ecosystem. The question then becomes "are we doing things right?" The components used are open-source, which certainly helps in keeping developments under one's own control. To make innovations in higher education ICT a research area of Academia itself also seems a feasible option. However, both aspects pose risks and challenges.

We do not claim to fully deal with all risks and challenges when faculty gets involved in innovation processes at the (central) ICT organization comprehensively, but rather describe local experiences with this approach in the context of Campus.UP. We think about things around three topics: *Governance, Marketing and Finance* and *Sociological Aspects* without ever making them explicit anywhere. Our underlying answer to all questions will be "trust" and "communication".

One of the unsolved critical issues at the University of Potsdam is an immature ICT governance. This poses a problem in just about any situation, but with respect to faculty innovating at the institution-wide ICT one has to deal with conflicts as people already serving multiple roles possibly getting pulled into conflicting situation even further. The statement of Drucker (2008) "management is doing things right; leadership is doing the right things" can become mingled up beyond all recognition. A clear decision-making process, respective commitments and transparent prioritizing can be hard to come by in this situation. This is not a quite unusual situation at a university. Cohen et al. (1972) described this situation as a "Garbage Can Model of Organizational Choice". However, the situation becomes aggravated when faculty start innovating from their expert point of view, but other flanking measures that should accompany major changes (like an appropriate change management process) lag behind. This situation can easily happen when faculty on the one hand is eager to push their ideas and do have the funding to conduct their expertise part of the innovation, but governing bodies distrust those ambitions and do not release any further funding.

The difficulties then lie in a distrust between the focuses of the groups involved in the process. The data center staff may feel that the faculty staff are striving for a once-off success story on the completion of their project, whilst the faculty staff sometimes do not fully comprehend the data center staffs' dedication to the reliability of their systems. Yet further trust has to be instilled in the data center-side of things from management or leadership (choose appropriately). The data center have to trust that they are (not again) being left alone with growing demands and complexity issues that could potentially undermine the reliability of the then underlying IT systems. To ensure the reliability of systems and services a lot of routine has to go into the daily "production". Major changes in organizing this production alongside with the introduction of new technologies pose a threat to those routines. To make the project Campus.UP a sustainable success at the university, a lot of distributed knowledge from within the ICT organization (and possibly beyond) has to be pooled and responsibilities have to be shared. This constitutes yet another cultural change away from the guerrilla-like dedication mentioned earlier. Hence, accompanying measures to manage the changes have to be taken. Dreyer et al. (2015) describe a similar challenge when introducing an open-stack environment: "Where managing techniques are changing, also new knowledge and new skills have to be built up and incorporated into the daily process", i.e. the new tasks and ways of working ("from operating to managing"?) and even change in itself have to become routines.

Trust-instilling measures should of course happen (and be promoted) on the personal level between people of all groups of stakeholders. This however does not sufficiently address the different planning horizons and focuses inherently to the different groups in question as well as their necessarily different way of working. In order to be able to gauge new projects (approved in- or outside the ICT

organization) with respect to their values and risks for the targeted infrastructure, a roadmap or a program for necessary, desired and innoxious innovations is needed. Ideally, such a roadmap derives from the IT strategy or via some business IT alignment and obtains commitment from governing bodies. This will then form the basis for suitable measures in the ICT organization like the establishments of an architectural framework, a technology portfolio as well as a suitable project structure.

Often enough projects are started under the flag of being "lighthouse projects", with the hope of them being followed. This then may or may not happen for various reasons. However, if these things happen at the infrastructure level it becomes dangerous. One way to alleviate the situation would be to equip the data center with enough own developmental power to enable them to innovate along the critical paths themselves. The extra resources and projects from faculty could then be used to speed up or improve things. The alternative approach of externalizing innovation has its charms therein that external consultants might have more luck in convincing leadership or management to go with a more holistic approach. This may happen because they can sell matters better (instill more trust), but sadly it may also be down to the general culture of distrust and greed within universities. The "Prophet in His Own Country" syndrome may also play part here. We can also not exclude the possibility that the amount of money involved when going external focuses management's attention better than research-funded in-house developments.

From the point of view of sheer results, one would expect that faculty-aided on-campus developments, hopefully with partners in other institutions, deliver better and more sustainable results – if done under the right conditions. The chance of them failing badly or not being sustained due to issues grouped around distrust and missing commitments is high.

One could discuss whether an "in-house" or an "external" variant is better suited when innovation is either incremental, radical, evolutionary or disruptive (Clayton 1997). However, we believe that in order to add value to higher education institutions through innovations in ICT the issues presented above have to be tackled in any case. Maybe in today's world, where "good work" counts for little and success is everything, a common "success story" for all involved has to be created. A good narrative could form the basis for many good things stemming from good work.

6. Conclusion & Outlook

This article started with a requirements analysis and the derived objectives, which have to be tackled by ICT for successfully acting now and in the future. Considering the past and present developments at the University of Potsdam, the future developments were outlined and a service-oriented infrastructure, its corresponding services and the platform Campus.UP were presented. In addition, corresponding evaluation results of the current focus group, which concentrates on e-portfolio work, have been presented and the results were arranged in the order of the next steps necessary.

The current findings indicate a tremendous demand of new solutions (software, tools and services) to tackle new, and not yet conceivable scenarios in research, education and daily student life. Since the platform Campus.UP already supports several social aspects (e.g. networking, profiles, workspaces), it can be easily extended to be used as an intranet or service platform of the university. While the past steps explicitly focused on learning and e-portfolio scenarios, the future development steps will deal with extension of Campus.UP to more institutional scenarios. Therefore, the work of central units, student representatives and committees will be supported.

Further developments will deal with cross-system and cross-device support. This includes the seamless shift from one device to another and therefore aims to dissolve the distinction between formal and informal respectively non-formal experiences. Systems and services have to be available everywhere and at all times, no matter in which personal context the user interacts. In this regard, the mobile application Mobile.UP will be extended to act as a mobile sensor node, enabling the access of the most used services on the one hand, but also to collect valuable context information of the user on the other hand. The context information will be used in Campus.UP to provide a more personalized feeling, e.g. to provide tool recommendations, synchronize the working state of the mobile and the web portal and to adapt the user interface to the specific needs of the user.

Campus.UP and its corresponding infrastructure is only seen as an interim step of providing a service-oriented scalable infrastructure enriched with software, services and tools, which supports the individual needs of the different stakeholders of universities at its best. However, a platform can only be as good as the basis on which it stands. Every promising approach and innovation only has a

chance to stand the test of time, if it manages to leap from the state of a research project to establish itself persistently as a service. For this to happen it must be transferred and adopted as a sustainable routine in the data center. While requirements increase and more complex systems and infrastructures evolves, data centers have to adopt their perspectives and find new ways of providing infrastructure, tools and services (e.g. hybrid cloud infrastructures) (Moeller 2016). In a decade where everything as a service lurking around every corner, data centers (and ICT organizations of academic institutions as a whole) have to be systematically put into the positions out of which they can move to provide crucial services for knowledge-based enterprises like higher education institutions in the era of digitalization. In this context, a paradigm shift from operation to management and new ways of providing and maintaining ICT infrastructure are be needed. In order to ensure competitiveness business and operating models (in house, hybrid or external) have to be taken under consideration. Both the use of (hybrid) cloud services and cross-institutional cooperation (regional, national and international) on all aspects of ICT can on the one hand free valuable resources, but is probably more fundamental to sustaining efforts. After all, good ICT-solutions, tailored for Academia, if not exclusively but in large, structurally independent of commercial offers, will form the basis of successful Academic work in the future.

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