SATW

Schweizerische Akademie der Technischen Wissenschaften
Académie suisse des sciences techniques
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Swiss Academy of Engineering Sciences

White Paper

Cloud Computing

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SATW in brief

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Outstanding experts

SATW has around 240 individual members and 60 member organizations. Individual members are eminent figures from the fields of education, research, commerce and industry and politics. They are appointed for life. Specialist Swiss organizations serving the engineering sciences can apply to become member organizations of SATW. Member organizations pay an annual subscription and can apply to the Academy for grants for specific engineering projects and events.

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The SATW is contracted by the Federal Government to identify opportunities and challenges posed by new technologies at an early stage and to bring these to the public's attention. A key mandate includes raising interest in and promoting understanding of technology among the population. The SATW and its three sister academies SAGW, SAMW and SCNAT are recognized as scientific institutions under Federal research law. Around 80% of the SATW's funding (approximately CHF 1.8 million a year) comes from the Federal Government.

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Foreword

Every 10-15 years, the Information and Communication Technology (ICT) industry is transformed by innovations that fundamentally change the way we use computers, how we access information, how businesses derive value from ICT and even how consumers live their daily lives. The main-stream introduction of the Internet via the World Wide Web in 1995 was one such revolutionary change. It enabled ready access to information regardless of where it geographically derived from. It removed barriers to publish information, and to conduct business online. The web has indisputably and fundamentally changed entire industries, including publishing, music and telecoms, to name but a few.

In 2000, at the height of the dot-com bubble, **Application Service Providers** (ASP) entered the market, offering a simple browser interface for interacting with applications. Rather than hosting applications inhouse, they could be hosted elsewhere, and were simultaneously offered to multiple clients, accessible via a browser. Salesforce.com, an enterprise software company with a customer relationship management (CRM) product is a successful example of an ASP.

Simultaneously, academic research institutions began to experiment with **Grid Computing**, so-called because it is analogous to the power grid, in which many power plants supply energy and consumers can draw power at will. Grid computing is a distributed system with non-interactive workloads that involve a large number of files, loosely coupled, heterogeneous and geographically dispersed.

Around this time a third trend soon became mainstream: **Virtualization**. Although the technology itself had been around for more than 30 years, Intel began to enable physical processors to host multiple operating systems concurrently. In this way, a physical server that previously may have only been used at 10-15% of its capacity could now be fully utilized.

In 2004, **Cloud Computing** rose to public awareness. Essentially, it is the model used by companies (such as Salesforce.com, Amazon, Google, and Facebook) that run their own infrastructures to be always on, with changes and upgrades occurring on the running system and the system scaling in accordance with demand.

Cloud Computing has since become the predominant way of delivering and consuming IT infrastructure (computation and storage), middleware and applications. In our opinion, Cloud Compo-ting is one of the fundamental transformations that – as with the advent of the web – will change how we communicate, do business and offer services.

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Topical Platform ICT, SATW
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President SATW

Management Summary

This White Paper is the result of an SATW-sponsored workshop conducted in April 2012 by the ICT topical platform to better understand the opportunities of Cloud Computing for Switzerland, specifically in the education and public sector arenas. We aim to inform the appropriate decision and policy makers to ensure a timely implementation of the recommendations proposed herein.

After defining what cloud computing is and describing its many advantages, this white paper presents various examples of successful cloud computing implementations from such diverse fields as education, public administration, business, and industry. All these projects have in common that the cloud solutions resulted in appreciable cost savings and provided better scalability than traditional IT implementations.

An interesting finding is that, in terms of the use of cloud computing in its industry and administration, Switzerland does not rank among the top industrial countries despite the fact that it is one of the countries with the highest ICT expenditures per capita worldwide as a recent study of the Swiss cloud computing landscape revealed. Despite the fact that numerous strategy papers exist, their implementation unfortunately is a long time coming. The reasons are manifold, but the main culprits seem to be a lack of security, a lack of trust in the new technology, and a lack of experts.

The gap analysis performed in the framework of the SATW Cloud Computing Workshops clearly revealed the specific technical and regulatory challenges that must be addressed to foster a more timely adoption of could computing. These challenges are the

(1) implementation of a Trusted Data Cloud so that business can entrust their data to third parties in a manner that is fully compliant with their respective regulatory environments.

(2) implementation of a Cloud of Clouds to allows users to combine and obtain cloud services from various providers, which will also ease the switching from one provider to another.

(3) implementation of specific standards and guidelines that regulate various criteria of cloud services ranging from data protection to quality of service and liability, for both users and provider.

In this, the public administration plays a special role. It should act as forerunner and set an example for the private sector. Moreover, because of its clearly defined requirements, it is ideally positioned to drive the challenges described above closer to their solution. Government agencies should not only use cloud services and but also offer them to the public. Finally, they should also thoroughly investigate and consider the implementation of a government cloud to answer the need for increased security.

A widespread implementation of cloud computing holds significant opportunities for the Swiss economy, but the focus must be on what Switzerland is famous for – its outstanding quality. To aim for high-value in terms of the non-functional criteria such as availability, security, legal framework, and interoperability— to name just a few—is inevitable.

The white paper concludes with the recommendation to create a Swiss community cloud for education and research. Such a cloud will not only help advance cloud computing research, but also can be a first step towards addressing the above challenges. Its main use, however, will be that it will provide the stakeholders and players in Switzerland's education and research with a unique environment throughout their educational and professional life.

1 Introduction to Cloud Computing

1.1 Definition

Various practical definitions exist for cloud computing (CC). Almost every web service is already being dubbed a “cloud service,” often purely for marketing reasons. However, a “real” cloud has characteristics that exceed the mere offering of a web service. A comprehensive definition is provided by the National Institute of Standards and Technology NIST[1], which we will largely follow throughout this White Paper

Cloud computing is 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.

Several major benefits arise from adopting and utilizing CC, the most important of which are:

• CC enables **economies of scale**. On the provider side, this leads to a higher productivity in provisioning infrastructure services and, concomitantly, to flexibility and a higher survivability when difficulties occur. On the user side, these economies of scale decrease investment and running costs. The return on investment also grows, leading to increases in the level and pace of innovation overall.

• CC allows organizations to **focus on their core competencies** in a sustainable manner. Non-IT-service providers can sustainably outsource the IT services they need for their business activities. In contrast to conventional outsourcing, it makes sense for CC service providers to continually reinvest in the modernization of the services they provide.

• CC follows IT’s evolutionary logic, or the achievement of ever-greater complexity and to continually improve **information hiding** or “transparency engineering.” Moore’s Law lies at the core of IT developments, a growing maturity of hiding unnecessary information, in parallel with CC development, enables the possibility of controlling systems with increasingly abstract policies. For service users, this not only means that any unnecessary details will be hidden, but also that the parameters needed for the core business become easier to control.

1.2 General characteristics

Cloud Computing has specific characteristics and realizations that, compared with other forms of outsourcing, have both advantages and disadvantages. Because of its growing topical significance and use, the term “cloud” is often misused. According to the above NIST definition, the term “comprehensive cloud offering” should only be used for cases where a cloud offering that has all the characteristics listed in **Table 1**.

Table 1 – Cloud computing characteristics

Characteristic	Description
On-demand self-service	IT is used as service and is readily available on demand without requiring manual intervention.
Broad network access	The service is made available via a network independently of the user end device. The network connection must be of sufficiently high performance and available for that particular service.
Resource pooling	The provider makes the necessary resources available to multiple consumers using technologies such as virtualization and multi-tenancy.
Rapid elasticity	The resources necessary can be provisioned rapidly and released without manual intervention when no longer needed.
Measured Service	A service consumed must be measurable in terms of the resources used. In this way, consumption-based billing becomes possible. Also known as “pay as you go” or “pay-per-use.”

Source: Based on “The NIST Definition of Cloud Computing” by P. Mell and T. Grance, Special Publication 800-145 (National Institute of Standards and Technology, Gaithersburg, MD, Sept. 2011)

1.3 Special characteristics and benefits

An organization’s specific CC business expectations are necessarily dependent on its particular circumstances. Generally speaking, however, they can be summarized as follows:

Cost containment: By employing CC and its scalability possibility, organizations no longer have to invest money in building up and maintaining their own IT infrastructure, as services and desired capabilities are available on demand and paid on a per-use basis. In this way, organizations no longer have to pay for internal resources that are not used, and can invest the money saved to drive innovation into their core business, rather than having money tied up in unused infrastructure. Prior to adopting a cloud-based solution, however, current IT costs and the potential cloud solution costs should be weighted to ascertain the total costs (TCO) involved.

Innovation speed: In contrast to traditional IT projects, cloud services can be provisioned with just a few hours’ notice, rather than weeks or months. In this way, a business can respond rapidly to changes and keep the time-to-market as short as possible.

Availability: Larger cloud providers can offer high availability due to their ability to scale. Redundant interconnection and load balancing make it possible to satisfy high availability business requirements. However, the availability promised should be measured by an entity that is independent of the provider. If the service level agreements (SLA) agreed upon cannot be fulfilled, there is the possibility of escalating the problem with the service provider or of terminating the contract (exit clause).

Scalability: The flexibility and scalability of cloud services enable the rapid adaptation of IT to changing business needs. IT is thereby able to better meet, and support, the business’ needs and to react rapidly – or even automatically – to peaks in demand because the services are available to scale to meet them. Resources can be allocated as necessary.

Efficiency: With efficient IT in place, an organization can focus on its core business and invest innovatively into research and development. This cloud solution advantage can not only mean a substantial contribution to the growth and competitiveness of an organization, but also exceed the financial benefits it realizes.

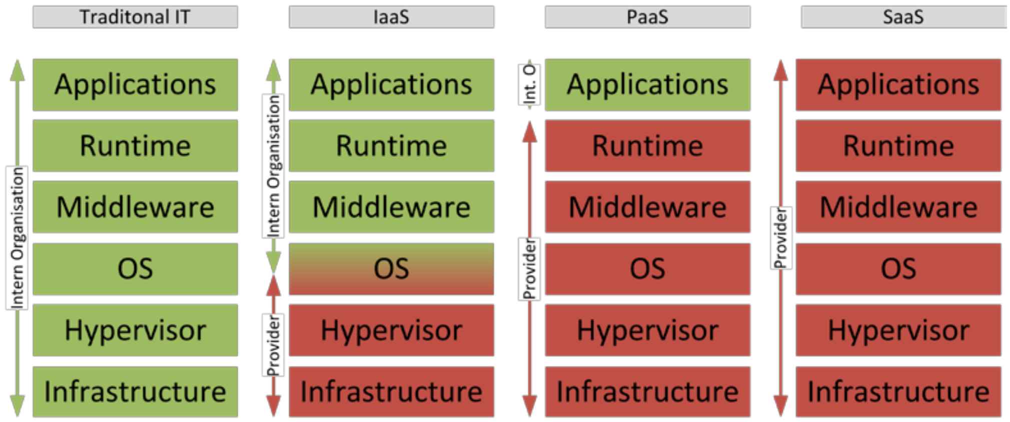
Elasticity: The cloud provider has mirrored systems that can be used both for disaster recovery, and for load balancing. By implementing a geographical separation of server rooms, it is possible to protect the cloud solution against even natural disasters.

By adopting cloud solutions, an organization can focus on their respective core business, as cloud providers are able to run operative IT better, faster and more cost-efficiently.

1.4 Service models

Service models describe what kind of services can be obtained from the cloud (see Fig. 1). Three main service classes are distinguished: IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software as a Service). Depending on the model selected, the provider delivers different services. These services are generally classified according to the level of the IT architecture they reside on.

Fig. 1 – Service models. Green indicates as level owned and operated by the organization, red that is run and operated by the service provider.



Source: Based on the model developed by NIST (2011)

The services themselves are offered as “black boxes.” The service provider determines how the service is offered within the agreed upon SLA, and how the services on underlying layers may be accessed. The following layers are differentiated:

Applications: The special applications used by a business.

Runtime: The environment in which the chosen application is executed, including the runtime library of the application’s requisite functions.

Middleware: Middleware and/or switching software is needed for communication with other applications, databases and the operating system.

OS: The operating system provides and manages the system resources of the hardware or hypervisor to the user.

Hypervisor: A virtualization layer that provides the virtualized infrastructure resources to the operating system.

Infrastructure: The infrastructure consists of the physical units, such as servers, CPU, storage, and the network.

As we have seen, there are three service models: IaaS, PaaS, and SaaS. **Table 2** summarizes the advantages and disadvantages of **Infrastructure as a Service** over owning the infrastructure.

In the **Platform as a Service** model, the service contains a complete platform and its development tools. These solutions are typically used for in-house (proprietary) development or for special software or applications on that platform. The underlying infrastructure is supplied and managed by the provider. **Table 3** summarizes the advantages and disadvantages of PaaS over owner operation.

Under the **Software as a Service** model, entire applications are made available, usually via a web interface. The customer has no influence on the platform and its underlying infrastructure. **Table 4** summarizes the advantages and disadvantages of SaaS over owning the software.

Table 2 – Advantages and disadvantages of IaaS over owning the infrastructure

Advantages	Disadvantages
• High scalability of the systems required based on actual needs • Redundant data storage • Physical separation of data use and data storage • No maintenance for setting up and running the infrastructure • OPEX instead of CAPEX OPEX - OPerational EXpenditures: expenses incurred in the operation of the business infrastructure. CAPEX - CAPital EXpenditure: investment expenses for long-term fixed assets. • Pay as you go	• Data location not always identifiable (transparent) in public and private clouds • Strong dependence on the availability of infrastructure and networks • No or insufficient distinction between or isolation of data processing (for the various users) • Unauthorized access to data possible in case of misconfiguration • Guarantee of confidentiality, security or integrity of the data; liability in case of a breach thereof.

Source: Adapted from (EuroCloud Swiss, 2012)

Table 3 – Advantages and disadvantages of PaaS over owner operation

Advantages	Disadvantages

• Less administrative effort as there is no need to implement/run the infrastructure in-house
• Development by (geographically distributed) teams possible
• Single platform with minimal costs (standardization)
• No maintenance in setting up and running platform and its tools
• OPEX instead of CAPEX
• Pay as you go
	• Vendor lock-in
	  o Lack of portability
	  o Lack of interoperability
	  o No standardized technologies
	• Insufficient flexibility
	• Special requirements in case of proprietary applications or development environments

Source: Based on (EuroCloud Swiss, 2012)

Table 4 – Advantages and disadvantages of SaaS over software ownership

Advantages	Disadvantages
• Separability/multitenancy of the application • Rapid deployment; faster project introduction (time to market) • No maintenance needed to run the business functionalities • OPEX instead of CAPEX • Pay as you go • Lower TCO • Mobility, location independence	• Choice of right provider • Lack of portability • Lower integrability into existing application environment • Lower adaptation possibilities as standardization is given • Potentially longer response times • Security vulnerabilities when using shared SaaS solutions • Cannot be used without access to internet

Source: Based on (EuroCloud Swiss, 2012)

1.5 Deployment model

Cloud Computing can be run in various deployment models (see **Table 5**). Which deployment model is used depends on the user requirements and on market availability.

Table 5 – Deployment models

Deployment model	Description
Private Cloud	Here the user of a solution is an explicit organization or an organization unit. A private cloud can be run internally or by a (third-party) provider. The advantages of the cloud cannot be fully exploited, and the degree of customization possible may be limited.
Community Cloud	The service is used by several members of a defined group. The services may be offered by several providers who are either internal or external to the community.
Public Cloud	The service is available to the public, and in general provided by a single provider. In this model, scalability and resource pooling can be fully exploited.
Hybrid Cloud	Hybrid clouds offer a combination of various organization forms, combining their respective advantages and disadvantages. For example, data that need to be protected can reside in a private cloud, whereas public data and/or applications can run in the public cloud.

Source: Based on (NIST, 2011)

2 Case studies and best practice

2.1 Introduction

Cloud Computing can be obtained and used in various ways and configurations for a vast range of application scenarios. The four case studies described below have been carefully selected to represent best practice examples in different industries and scenarios that use a wide range of differing Cloud Computing services.

The first case study, swisstopo, illustrates the use of infrastructure services from a public cloud. The second study, the University of Bari, describes the joint provisioning and use of such services by various public and private partner institutions in a community cloud. The third case study, Fleurop-Interflora, shows the use of Infrastructure as a Service from a private cloud that is set up and run by a provider. The final case study, Cisco's use of Salesforce.com illustrates how international businesses can apply cloud services to efficiently realize country-specific requirements.

Additional user reports (in German) will be published on the "Cloud-Finder Schweiz"[2] platform (see Section 4.7).

2.2 swisstopo: cloud computing in the public administration

In the framework of e-Government Switzerland, swisstopo, the Federal Geo-Information center, runs the Federal Spatial Data Infrastructure (FSDI), which is based on a cloud computing architecture. This enables FSDI to be easily and rapidly scaled in response to large load fluctuations due to, for example, press releases. Consequently, the costs incurred reflect the effective use, as swisstopo will be charged only for the IT resources actually used.

Moreover, as FSDI uses only open standards and open-source software, there are no licensing fees. In addition to benefiting from the low costs of this solution, swisstopo can focus its personnel resources on developing and extending its core business, as it no longer has to allocate resources to managing the hardware for the web infrastructure.

The cloud computing solution used for accessing geographical data first and foremost is a new form of flexible, demand-oriented IT services provisioning. It is not a new technology, but rather the direct result of the further development and extension of existing technologies (in this case server virtualization and web services).

For IT users, this solution is attractive because they can obtain the IT capacities, computing power and applications needed to satisfy their business requirements in real time as a "service from the web" rather than having to go through the (often tedious) equipment procurement process. In business terms, the typical "pay-as-you-go" payment model of cloud services shifts these costs from the investment to the operating side. This has a beneficial effect on the innovation capacity of an enterprise, as it eliminates the (often considerable) investments in the IT infrastructure, which in classical IT projects are typically incurred prior to the start of a project.

swisstopo relies on Infrastructure as a Service (IaaS)

In its function as the provider of the Geographic Information Systems (GIS), swisstopo has been using cloud computing successfully for the past two years to establish the so-called Federal Spatial Data Infrastructure (FSDI, or in German: Bundes-Geodaten-Infrastruktur or BGDI) and to implement the Federal Act on Geoinformation (Geoinformation Act, GeoIA), which came into force in July 2008.

For this, swisstopo chose the Infrastructure as a Service (IaaS) model (see Fig. 2). The IaaS model, as used by swisstopo, does not require the organization to purchase its computing infrastructure ("our servers are in our basement"), but rather rents the necessary server infrastructure on demand. This choice has many advantages, some of which are listed below:

• Peak loads can easily be accommodated

• Rapid growth can be handled without problems (scalability)

• Unused capacities can be released immediately

• Single-use or rarely used applications become affordable

• Existing virtualization technology allows straightforward testing of software on a wide variety of platforms

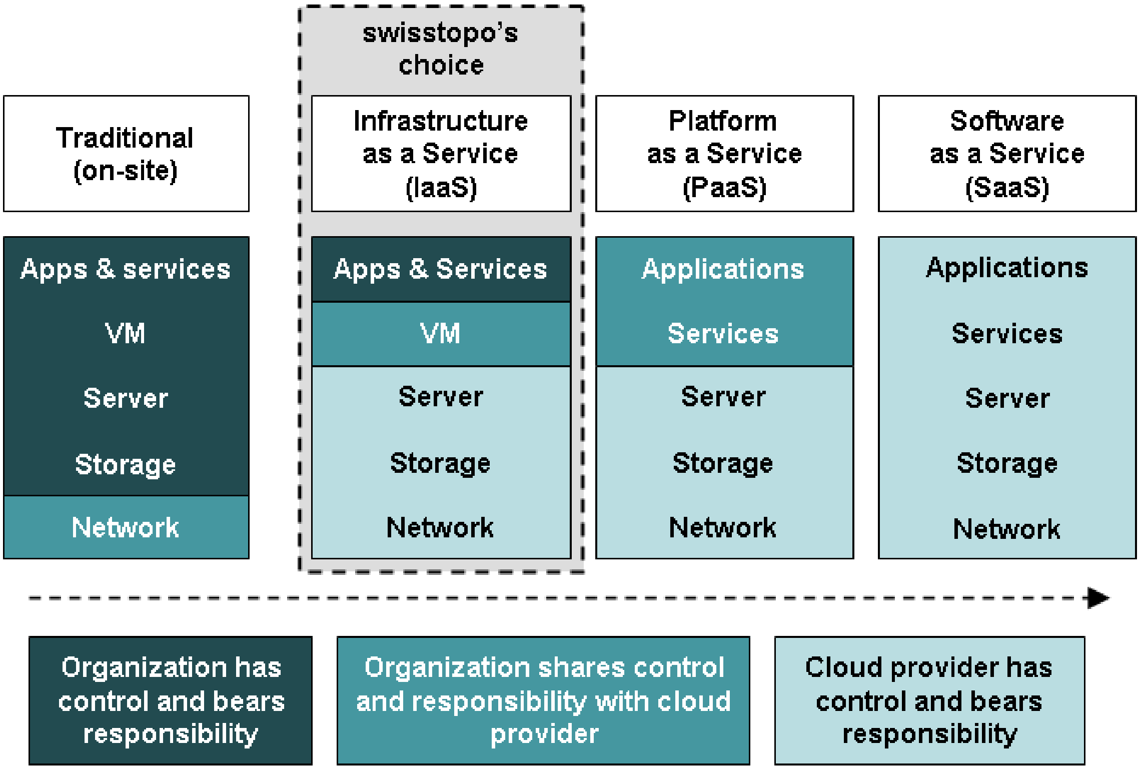


Fig. 2: How the various deployment models affect the governance of IT organizations (VM = virtual machines)

swisstopo's decision was based on the following reasons:

• Unlike in the PaaS und SaaS model, swisstopo as a cloud service customer in the IaaS model retains full control and responsibility of its dedicated applications and services running on the virtualized servers. As provider of the GIS service, it is crucial that swisstopo does not share with a cloud provider the control over and flexibility of its core business, GIS.

• The complex tasks of provisioning, operation and capacity planning of a server and storage infrastructure are handled by a cloud provider specialized in infrastructure management. In this way, swisstopo can focus on its core business.

• swisstopo benefits from economies of scale and the service excellence of the cloud provider. This has a positive effect not only on its costs but also on its service quality.

• swisstopo consumes an infrastructure service. The availability of highly abstracted infrastructure resources, such as computational power and storage, via a web service API (application programming interface) facilitates the establishment of an on-demand scalable infrastructure, almost as if the infrastructure itself becomes "programmable."

• The multitenancy of infrastructure services is an innovation driver. IaaS customers of all sizes – but especially small- and medium-sized enterprises – benefit instantly from improvements and/or extensions to the infrastructure service. ISO 27001- and PCI-certified cloud infrastructures (such as Amazon Web Services) have disproven the initial concerns that were raised over the safety of multitenancy.

Operation and architecture of swisstopo's cloud infrastructure

It is crucial that the migration of GIS business applications and services from a traditional "in-house" datacenter into an IaaS cloud are adapted considerably, so as to be fully cloud-enabled, in order that the cloud providers' SLA commitments (such as rapid and unlimited scalability) are able to be fully exploited.

The cost of the flexibility promised by the cloud provider must not be taken for granted. From an operational point of view, high infrastructure flexibility translates into a high frequency of changes to that infrastructure. The infrastructure team must be able to cope with this rate of change (e.g., daily changes in the number of active servers). Without appropriate and enforceable procedures and a high grade of automation, this is impossible to handle successfully in daily operation. Therefore, swisstopo relies on the open-source datacenter automation tool "Puppet" on the infrastructure level. This tool facilitates the automatic roll-out of new virtual servers and their subsequent monitoring during operation.

"Puppet" can also be used in traditional datacenters, thus "bridging the gap" between the cloud and the internal datacenter. Such an approach alleviates the often-evoked dependence on the cloud provider substantially. Dubbed "vendor lock-in," this aspect must be taken into consideration when assessing the risks of a migration to the cloud, because in this highly dynamic new market with little standardization, a strong dependence on the vendor should be avoided as much as possible.

Accordingly, when designing its cloud architecture, swisstopo focused on ensuring that it would use the absolute minimum of the (unfortunately still largely proprietary) interfaces of the cloud provider. Wherever possible, swisstopo avoided interweaving its business logic with these interfaces. Instead, "Puppet" manages them, independently from the vendor, in the virtual server.

Figure 3 shows a simplified overview of the cloud infrastructure of Swiss Confederation's "geoportal" www.geo.admin.ch, the most prominent application that swisstopo runs on the Federal Spatial Data Infrastructure.

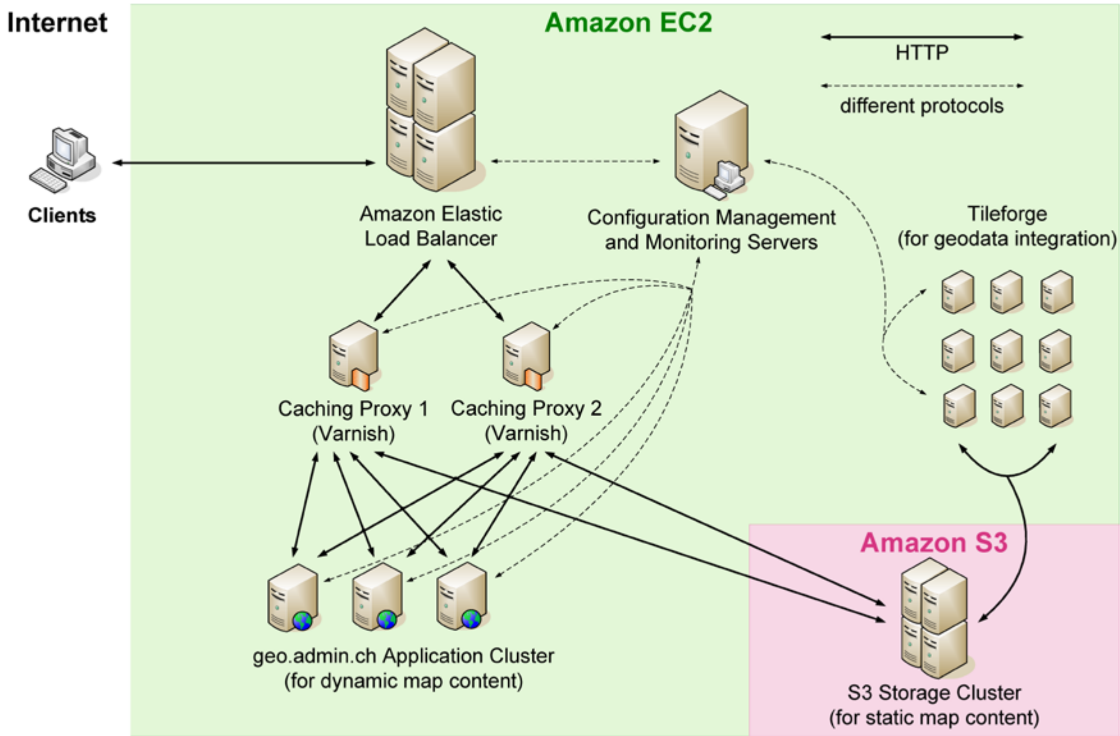


Figure 3: Cloud infrastructure of the Swiss geoportal www.geo.admin.ch

Practical example geo.admin.ch

The Swiss Confederation's geoportal, geo.admin.ch, is a publicly accessible platform for geographical information, data and services. On the one hand, it is the concrete realization of the FSDI architecture of the Federal Administration, while on the other, it serves as portal to the FSDI. It enables the geographical data of the Federal Administration to be made available on an infrastructure platform for the first time, so that requirements as set forth in the Geoinformation Act (GeoIG) and the Geoinformation Ordinance (GeoIV) can be fulfilled. Under GeolG, public institutions must make the basic geographical data (geodata) related to their jurisdiction available, provided these data are listed in the catalog of basic geodata (GeolV, Art. 1, paragraph 2).

As GeolG came into force on July 1, 2008, the GIS coordination group (GKG) wanted to show the usefulness of this law to Swiss citizens by realizing an appropriate implementation (i.e., a technical infrastructure and an innovative interface) as quickly as possible. According to Art. 1, the purpose of GeolG is *"…to ensure that geodata relating to the territory of the Swiss Confederation is made available to the Federal, Cantonal and municipal authorities, to industry and commerce, to academic and scientific institutions and to society at large, **for the broadest possible use, in a sustainable, up-to-date, rapid and easy way**, with the required quality and at reasonable cost."*

Why a cloud-computing solution?

The specifications imposed a very ambitious schedule by allowing a time frame of only one year for realizing a portal with a map viewer. Moreover, from the beginning of the project, the key focus was on a solution that would easily adapt to actual usage and demand levels.

This was important because the actual sizing requirements, such as the number of expected users after deployment or the peak volume at "go live," were unknown. In addition, a portal breakdown resulting from overload at deployment had to be prevented to ensure that no damage occurred to swisstopo's reputation. A broad spectrum of GIS-user expectations – ranging from experts to the lay public – had to be accommodated by the limited financial resources available.

The requirements for the geo.admin.ch web infrastructure can be summarized as follows:

• Strict adherence to provisioning schedule

• High performance of the entire solution

• On-demand scalability

• Highly transparent but low operating costs

For the technical infrastructure, the IaaS model (see Section 1.4 and Fig. 1) was chosen. On the service and application level, open-source software was rigorously adopted to avoid licensing issues when scaling the number of servers. A key factor influencing this decision was undoubtedly also the knowledge and experience swisstopo had been able to gain from its successful operation of the "SchweizMobil" cloud application. "SchweizMobil" went online in 2008 and is similar to geo.admin.ch, from an infrastructure point of view. Moreover, swisstopo had more than eight years experience successfully using open-source software for web applications.

"The Federal Geoportal set new standards"

A novel combination of open-source frameworks and an innovative cloud computing architecture ensures short access times to portals and services, even during peak demand times. The solution chosen was a first in terms of cost/benefit ratio for the Swiss administration. Thanks to an innovative implementation and the massive use of caches, it is possible to display more than 140 datasets Switzerland-wide in the form of more than a billion pre-computed (and thus rapidly transferable) map tiles.

In this way, the geo application and its underlying infrastructure were able to cope with the surge in user access triggered by a media campaign, which met with huge public interest - within a day, the number of user-access events increased by a factor of 20 and reached 33,000 unique visitors, with almost 1 Terabyte of data delivered per day. At peak times, 1,300 map tiles were delivered per second! At the same time, the data management and server operation costs remain low, and the various services can be scaled to meet demand as required.

The Swiss Geographical portal is thus a best-practice solution for open-source map applications on the basis of the MapFish development framework combined with cloud computing. It was nominated for "CH Open Source Award 2010," and its implementation was recognized with the 2010 Swiss "Excellence in the Public Administration" award in the e-government category. In June 2012, it was the runner-up for "United Nations Public Service Award" in the category "Advancing Knowledge Management in Government."

[This report is largely based on the contribution from Christ, Oesch, Schilcher [editor]; which appeared in *Geoinformations-systeme – Beiträge zum 16. Münchner Fortbildungsseminar*, (2011)]

2.3 University of Bari: cloud computing in education and research

The University of Bari is not only one of southern Italy's premier educational institutions, but also a member of DAISY-net, a consortium of public universities and ICT companies in the Puglia region. DAISY-net carries out research and development and provides technology transfer and training to foster economic and industrial growth in the region. As part of this remit, DAISY-net wanted to create a highly secure, scalable and flexible architecture for application development and deployment in order to bring cloud-based IT support into the local community.

The University of Bari decided to offer a community cloud (see Section 1.5 and Table 5) that hosts the IT infrastructure for running several applications for users in the region. The fishermen use the auction service, which they access via touch screens installed on their fishing boats. When they pull in their catch, they can enter information about the particulars of what they have caught. If they think that they will not be able to get a fair price for their catch, they can throw it back into the sea. If they find a buyer, they can sort and prepare the fish on the return trip so that it is ready for collection when the boat reaches the dock, thus saving valuable time. A similar application exists for local winemakers, and there is also a logistics application that interacts with sensors on trucks to collect information about temperature, humidity and traffic congestion. This information can then be analyzed to determine the best route.

This provides an excellent example of how smart communities can benefit from private cloud services offered via a community cloud (run, in this case, by the University of Bari). Cloud services can support dozens of community-focused applications that are specific to the community or geography they serve. Because these cloud services are offered only to a specific group of constituents, certain cloud-related issues (such as the security concerns linked with public services) can be avoided. The cloud users (i.e., the local businesses) pay the university a small fee for using the cloud, which helps to defray the research and development costs.

Creating the cloud platform

The University of Bari provides the community cloud and hosts the infrastructure deploying an agile and dynamic solution. In this way, simple and rapid provisioning and management of new development, test and production environments is provided, enabling each environment to scale up or down to meet with its actual level of demand. This flexibility inspires concentration on application innovation rather than on infrastructure-related issues. As the basis for the new community cloud infrastructure, the university selected the IBM® System z® Solution Edition for Cloud Computing.

Working with teams from IBM Italy and MAUDEN, an IBM Business Partner, the university install-led the System z platform and began providing members of DAISY-net with access to core resources. By leveraging a Linux® for the System z cloud on top of these core platforms, the developers were able to quickly create a wide range of innovative solutions, using service-oriented architecture (SOA) principles to enable the rapid development of composite applications by orchestrating existing services and components. The Linux for System z architecture is controlled by the IBM Tivoli® Service Automation Manager, which automates the key processes involved in the request, deployment, monitoring and management of standardized virtual server images.

Business benefits

The vast majority of this project's development focuses on exploring new ways to help communities and small businesses in the Puglia region, especially in areas and industries not traditionally penetrated by ICT, such as fishing, wine production and local transportation.

The solution that one of the DAISY-net development teams created for the fishing industry is particularly interesting. It provides a touch-screen solution that fishermen can install in their boats and use to report the size and species of the fish they catch. This information is then automatically shared with potential customers, including local markets, shops and restaurants, all of whom can compete in a live auction for the catch whilst the fishing boat is still out at sea. When the fish has been purchased, the solution shows what customers have bought which fish, so that on the way back to the harbor the fisherman can package it ready for delivery upon dock arrival. As a result, the fishermen obtain the best price for their catch, their customers get the freshest fish possible, and there is no wastage of a highly perishable product.

Making small-scale solutions viable

The key advantage of developing such applications on cloud platforms is that it is easy to start small with trial implementations for just a few users, and then very quickly scale up with increased adoption.

“In a traditional ICT model, the idea of creating a solution for a small group of fishermen or a local transport company would probably never get off the ground, because the initial infrastructure costs would be too high,” explains Professor Visaggio, professor of Software Engineering at the University of Bari. “Cloud computing eliminates the trouble and expense of buying and managing new infrastructure, making the development of small-scale solutions much more viable. Moreover, as demand for a solution increases, the cloud can simply allocate more resources, so there is no problem with scalability. This new cloud infrastructure has already made a huge difference to businesses and communities in southern Italy, and will continue to provide an agile, flexible platform that helps our brightest students and ICT professionals collaborate and express their most innovative ideas.” In particular, it allows small- and medium-sized companies to create new business models. The approach therefore has the additional benefit of facilitating local ICT start-ups to differentiate and stimulate an innovation cycle.

Motivation for private cloud (see Section 1.5 and Table 5)

An increasing number of universities in Europe, Asia and USA are building up their own private clouds, just as the University of Bari has done. This is especially true for universities with software development faculties. Their motivation is:

• To get access to hidden technologies behind the cloud for their own research purposes

• To provide a secure sandbox for students to test and run their own applications.

• To avoid vendor lock-in

• To use open-source applications customized for own requirements

2.4 Fleurop-Interflora: cloud computing in the private sector

Fleurop-Interflora EBC AG is a global commercial enterprise with 17 national units operating in 40 associated member countries. Fleurop-Interflora distributes more than 1,000,000 orders for flowers worldwide every year via its webshops www.fleurop.com and www.floristgate.com.

Background and environment

Consistent and flexible availability of IT services is crucial for Fleurop's business performance and success. As the group's external turnover is generated exclusively via a web platform, the availability of the corresponding IT infrastructure is highly business-critical: the web platform must be available around the clock (24/7/365). However, availability is not the only criterion for the success of such a platform: performance, flexibility, scalability and support also play important roles, in order that the platform can respond to peaks in demand. For example, on special days (such as Valentine's Day), the turnover increases by a magnitude of 10x. Therefore, the resources needed to accommodate both anticipated and unpredicted peaks must be available reliably, at short notice and in full.

For these reasons, Fleurop opted for the private-cloud solution (see Section 1.5 and Table 5) of nexellent ag in Glattbrugg, Switzerland, in 2011. Prior to the private-cloud solution, the Fleurop datacenter had been outsourced to and run by a provider in Belgium. However, an unexpectedly high number of outages, in addition to services that were wrongly or partially incorrectly implemented, resulted in follow-on investments and high support costs. Negotiations repeatedly proved to be difficult and time-consuming due to the distances involved — a situation that was aggravated by misunderstandings due to language barriers. An increasing deterioration of the Fleurop services resulted, resulting in their decision to engage a new service provider from the private cloud area.

Make-or-buy decision

This "make-or-buy" decision was taken after a comprehensive analysis and evaluation. Key areas of concern included the growing complexity ensuing from the integration of services and networks, and the investment and operating costs of an in-house solution. As Fleurop did not have its own datacenter, considerable costs would have been involved in establishing one to meet its requirements, taking into account availability, security, operational and cooling issues. Moreover, the physical and geographical redundancy of the infrastructure for powerful internet connections were taken into consideration.

Subsequent to an in-depth analysis, Fleurop opted for the "buy" alternative, and thus for Infrastructure as a Service (IaaS) and the private cloud model. A key motivating factor was that this solution would enable Fleurop to focus its efforts on its core competencies: the extension of its platform and applications to market its own services.

Private-cloud solution

The chosen solution comprises the dynamic allocation and management of network, storage and computing resources for Fleurop's web platform. Its entire infrastructure is run by two geographically separated datacenters within a private cloud. Redundancy was an important criterion for the executive board of Fleurop, as services had to be continually available. End-to-end monitoring was also implemented to verify availability and to be able to recognize and better respond to emerging potential bottlenecks. Not only was the availability checked on both servers and network, but also the procedures and the process flow-down to application details are monitored on an ongoing basis. This monitor-and-alert generation is an intrinsic component of the proactive management of the Fleurop platform.

Firewall cluster installations serve to protect the Fleurop servers from web-threats and performance bottlenecks of individual servers. Hereby, not only applications such as intrusion detection (IDS) and intrusion prevention systems (IPS) must be considered, but also a suitable distribution of web traffic by means of redundant load balancing. Thanks to the implementation of the private-cloud solution, Fleurop was able to lower its IT costs considerably and also to substantially improve the quality of its services by deploying state-of-the-art technologies. Fleurop now consumes IT services as a pure service, and in so doing, benefits from no longer having to invest in new hardware as well from achieving clarity and transparency in the expenditures for its IT service.

Challenges

In the creation of this private cloud, it was clear very early on that it would not involve the deployment of a new platform, but rather a classical migration of an established web platform and brand. Therefore, it was crucial that the migration from the old to the new provider took place without service interruption. This was the primary reason for the decision to build up the private cloud in parallel to the existing infrastructure.

The structures of the previous Belgium-based IT provider were connected to the new environment at nexellent via VPN to enable database mirroring using the master-slave process. The actual change-over happened via DNS adjustment and the switch of the database at nexellent from slave-to-master.

During the first production week, several start-up problems could not be avoided. For example, the load balancer initially was not able to manage the load correctly, and there were some difficulties in configuring the backup. This unfortunately led to some timeouts on the database. However, with the support of the new provider, these problems could be solved within a week, and normal operation could be ensured.

Business advantages

Using the private cloud of nexellent, Fleurop is able to benefit from the following:

• Predictable OPEX.

• Ongoing reduction of operating costs.

• Higher web platform availability.

• As a result of the "pay-as-you-grow" approach, Fleurop pays only for the resources actually needed (main memory, computing power and storage space).

• Scalability at peak times, such as Valentine's Day or Mother's Day ("performance as you need, when you need it").

• Fleurop can focus on its core competencies and frees itself up from concerns about investments into IT infrastructure and the development of IT skills.

• Access to a professional datacenter infrastructure that meets the security requirements.

• Responsibility for the growing complexity of cloud computing remains with nexellent, while Fleurop can focus on refining and developing its web application further.

2.5 Cisco: international use of cloud computing

Cisco's objective was to make networks with built-in intelligent, fast and reliable services, and to deliver them globally. In this way, their networks would deliver the required performance at ever-increasing transmission speeds and form the basis of a constantly evolving infrastructure.

Background and environment

Cisco, a globally-operating network specialist, faced increasing integration challenges with third-party systems due to its outdated CRM systems. But one casualty was an important and long-needed account-planning functionality - postponed due to the high effort that would be involved with adapting or replacing it. Cisco's growth as an enterprise translated into ever-more employees needing access to its system. This was not however possible, due to its (in part) outdated architecture, the scalability of which was strictly limited, and thus could not keep pace with the business' growing needs.

It was necessary that a new solution be found, because the existing CRM system increasingly hampered Cisco's operational and growth possibilities. The proposed new solution had to be a first-class CRM system, to ensure that the data could be centralized, and the business' worldwide distribution and financial planning improved. In addition, it had to be a multi-lingual and multi-currency solution, to service Cisco global locations.

Partners play a crucial role in Cisco's distribution structure. Therefore, it was essential that the proposed solution supported networked cooperation, and encompassed "partner relationship functions."

It was clear to Cisco from the beginning that approximately 15,000 employees would be using the new application at launch, and that at least 10,000 more users would need to be accommodated in the near future. This meant that the solution had to offer a high degree of flexibility and scalability, in order that functions and services could be rapidly adapted in accordance to demand.

Solution

In selecting "Salesforce," Cisco teamed up with one of the leading CRM specialists offering its products as cloud services (Software as a Service, see Section 1.4 and Fig. 1). The CRM solution chosen from the wide range of available products was "Salesforce Unlimited Edition." This application was initially deployed to 15,000 users worldwide, from Indiana to India and from Dubai to Dublin.

In addition to its ability to flexibly integrate and scale, the Salesforce solution also includes the following functions:

• Dashboards that present data (such as opportunities, lead-conversion rates, number of account plans and top accounts) even enable (authorized) users to generate reports themselves, in order to document their progress in diagrammatic form.

• The use of the Salesforce partner portal for cooperation in the areas of leads and opportunity.

• The screening, installation and testing of additional functionalities via the Salesforce AppExchange.

To accommodate important integrations and complex hierarchies, Cisco developed additional key components together with Successforce Consulting. For example, two tabs (forecast and "my business manager") were adapted and deployed in accordance with customer needs.

Benefits

Cisco's users operate across the globe, but can all simultaneously access the various functionalities of the corresponding enterprise categories in the cloud. As also temporary employees use the system, a centralized information management was implemented to support the enterprise by ensuring data security and to safeguard access to data.

Salesforce also supports “account planning,” a function that would have been extremely costly to realize with the previous CRM solution. Moreover, additional comprehensive integration efforts allowed various applications, which had now become obsolete, to be shut down, which resulted in further cost reductions.

The ongoing close cooperation of Cisco with its partners has been ensured by the Partner Relationship Management (PRM) feature of the Salesforce platform. It both helps Cisco extend leads to partners, and allows the conversion of those leads into opportunities to be tracked. Salesforce also enables a simplified integration with the Siebel solution. The bi¬-directional integration with a Siebel outlook generator enables higher transparency, and consequently the integration of the Siebel Regional Hierarchy of Cisco and with Microsoft® Outlook® could be achieved.

2.6 Overview and key elements

Below is an overview of the key elements of the case studies presented herein:

Example	swisstopo	DAISY-net	Fleurop	Cisco
Service	Infrastructure as a Service	Infrastructure as a Service	Infrastructure as a Service	Software as a Service
Deployment	Public Cloud	Community Cloud	Private Cloud	Public Cloud
Requirements	• Accommodation of peak loads • Procurement on time • High performance of the entire solution • Simplified software testing • Avoidance of overcapacity	• Vendor independence • High security • Scalable systems • Flexible architecture for development and use of applications	• Availability of services • Support • Cost predictability • Data and information security • Professional monitoring	• Scalability of services • Support of multiple languages and currencies • Integration with various systems and services
Benefits	• High performance • On-demand Scalability • Low and transparent operating costs • Multitenancy • No infrastructure management needed	• Deployment of ICT for third-party and small businesses • Flexibility and focus on innovation • New sales channels • Higher market attractiveness	• Cost reduction • Focus on core competencies • Transparent, usage-based costs • Scalability • High availability • High security standard	• High scalability • Ease of integration with other IT systems • Support for partner relationship tasks

3 Current situation in Switzerland

3.1 Introduction

For four years running, Switzerland has been leading the Global Competitiveness Index of the WEF[3]. 1n 2012, the “Global Innovation Index”[4] named Switzerland the innovation world champion for the second year in row. Switzerland ranks among the top countries in terms of its per-capita industrial production [5], contrary to the assumption that Switzerland is facing a downturn as an industrial location. Switzerland and its population benefit from an above-average economic power, an attractive business location, high quality of living, stability and security, low unemployment, an excellent international reputation and level of trust, and first-class education and research.

But all these achievement have their price – and often at a much higher price than in other countries. The Swiss healthcare system is one of the most expensive in the world. Moreover, the difficulties of implementing the eHealth Switzerland strategy mean that, in this respect, it lags behind other leading nations. Also, in terms of E-Government, Switzerland had ranked fairly low for many years, and only recently managed to catch up. Switzerland spends the most money per capita on ICT. This did not, however, prevent it from losing ground in the Digital Economy Ranking, so that in 2010, Switzerland ranked 19th, despite the fact that for a number of previous years it had been in the Top Ten

3.2 Use of ICT

Switzerland’s relatively poor performance in the Digital Economy Ranking is not due to an insufficient availability of broadband networks, hardware and applications, because these are widely available throughout Switzerland [6]. At the end of 2011, Switzerland had 6,430,363 internet users (84.2% penetration) and 2,727,600 Facebook users (35.7%). According to the “Networked Readiness Index 2012,” [7] Switzerland is among the top worldwide, actually ranking 5th, and in the latest “Web Index,” [8] Switzerland ranks 6th.

Nonetheless, Switzerland lags some way behind in realizing the opportunities and exploiting the full potential that ICT use offers. For example, e-Commerce only accounts for 8.2% of the business turnover. There seems to be little interest, motivation and pressure to exploit and realize the full potential of ICT across all regions, sectors and application areas. The private sector presented its “Digital Agenda Switzerland 2020” only in 2011.

In 1998, the Federal Council issued a clear statement of its principles and recommendations in its “Strategy for an Information Society in Switzerland”[9] – much earlier than many other economies or international organizations. In the educational sector, initiatives such as “Public Private Partnership – Schule im Netz” (PPP-SiN, 2000-2007; Public–Private Partnership, Schools online) and “Swiss Virtual Campus” (SVC, 2000-2008) provide important incentives (see Chapter 6). In the administrative sector, the “E-Government-Strategy Switzerland” was defined in 2002, followed by the “eHealth Strategy Switzerland” in the public health sector in 2007. However, there are considerable difficulties in implementing these strategies, and in the international comparison, the country fails to achieve a high ranking.

There is no shortage of related strategies and position papers (abridged list)
Strategie des Bundesrats für eine Informationsgesellschaft in der Schweiz (1998)
E-Government-Strategie Schweiz (2002)
Strategie zur Aussenwirtschaftspolitik (2004)
Strategie Informationsgesellschaft Schweiz (update, 2006)
E-Government-Strategie Schweiz (update, 2007)
Strategie «eHealth» Schweiz (2007)
Qualitätsstrategie des Bundes im Schweizerischen Gesundheitswesen (2009)
Infrastrukturstrategie des Bundesrates (2010)
Nationale Gesundheitsstrategie (Projekt, 2010)
Vorprojekt «eEconomy» (SECO), Lancierung «eEconomy Board» (2010)
Digitale Agenda Schweiz 2020 (economiesuisse, ICTswitzerland) (2011)
Masterplan CleanTech (2011)
Strategische Planung Vote électronique (2011)
Strategie Informationsgesellschaft Schweiz (new version, 2012)
eEconomy in der Schweiz: Monitoring und Report (2012)
Energiestrategie 2050 (2012)
Wachstumspolitik 2012-2015 (2012)
Nationale Strategie zum Schutz der Schweiz vor Cyber-Risiken (2012)
Departementsstrategie UVEK 2012
Cloud Computing-Strategie der Schweizer Behörden (2012)
Technologiestrategie (SATW, Mehrjahresplan 2012–2016)

Switzerland is primed to pursue a systematic and timely exploitation of the potential of ICT, and the opportunities, innovation, sustainability etc. that results from its adoption. In the Cloud Computing arena, the administration fortunately not only issues appropriate strategy papers, but also sets an excellent example in terms of its implementation and use of ICT (see Section 2.2).

3.3 Prerequisites

As shown in Section 3.1, Switzerland is ideally positioned to fully embrace ICT, it has political and financial stability, economic prosperity, a high level of education, high innovation, quality of life and business location rankings – in short, Switzerland is an ideal environment in which to attract the best and foster top performance. Despite all this, however, the e-economy in Switzerland is progressing very slowly. Why?

Switzerland is an SME-driven country[10]. 99.6% of all Swiss enterprises employ fewer than 250 people, with 87.1% of these employing fewer than 10. However, even current world-leading enterprises such as Apple and Google began as small start-up businesses. Switzerland's industrial and service history is rich in pioneers, innovators and innovative business – but also in the early termination of experiments. At the turn of the millennium, platform projects such as "bluewin," "Conextrade," "plenaxx," "Yellowworld" and others generated an atmosphere of change. The collapse of the e-hype in 2001 resulted in investors withdrawing, and the opportunity to gain an advantage with strategic projects was gone, practically overnight. Switzerland's enterprises are capable to develop using today's leading platforms and networks, and to harness the resultant growth. But achieving this vision still somehow seems out of reach.

Switzerland needs to increase the interest of children, young people and future teachers in the so-called MINT subjects (mathematics, informatics, natural sciences and technology) in order to promote their corresponding career paths. There is a significant shortage of specialists in ICT and medicine, and Switzerland currently depends on importing highly qualified professionals and managers from abroad. The consequent availability of ten thousands of highly skilled engineers from BRIC countries seems to render local graduates superfluous.

Despite its financial power, leading qualities and high level of innovation, Switzerland fails to realize and exploit the potential of ICT and the e-Economy under a comprehensive and strategic vision (see also "Smarter Planet"[11]). Here, Cloud Computing - thanks to its considerable advantages and host of usage possibilities - can serve as ideal entry point.

The advantages of virtualized infrastructures, platforms, application and business processes that can be used via networks are clear. However, they also require suitable measures to ensure, for example, security, protection, peak performance and stability - all qualities that Switzerland has traditionally embraced and is used to delivering. Consequently, it is not surprising that some 4,000 data centers are already located in Switzerland, and that another 10 are planned for 2012 [12]. Switzerland seems well on its way to become a safe location for virtualized instances, data and information. Moreover, in this way, Switzerland can also prove that its stated commitment to Green IT [13] and sustainable development are not merely rhetoric.

To realize this potential, however, greater efforts are needed. In addition to increased levels of educational and training, these proposed efforts would include attracting the necessary professionals and leaders, attracting more subsidiaries of world-leading enterprises and research institutions, intensifying competition, optimizing conditions, reducing regulatory and trade barriers, and implementing targeted incentives and stimuli. To achieve this, all players are called upon to hold corresponding workshops and projects, and to document the benefits these efforts have with concrete examples (see Section 2 and [2]).

The health sector, for example, can illustrate how the population (especially the ageing digital immigrants) can be motivated and empowered to keep personal health records (such as Evita[14], VitaClic[15] etc.) and to make this data available to health providers (and from 2015 on, in the electronic individual health record ePD[16]) in a differentiated, secure and reproducible manner to improve the quality and efficiency of healthcare and lower its costs. But without a concerted effort, "TeleMedCare" will remain wishful thinking for years to come.

By providing their customers with intelligent and secure devices in addition to "data purses" (i.e., a digital "vault" for safeguarding personal data and documents that allows data to be exchanged via a single electronic account), transport, traffic and logistics enterprises and public utility companies contribute to optimizing customer behavior. Concepts such as "Smart Work" can be realized and used immediately if the work is organized in order to contain a high share of home-office-capable services. This will also simultaneously help to ease the pressure on ever-growing requirements and the demands for greater mobility.

Important prerequisites for the acceptance of online services and network-based interaction are competence, motivation, security, trust, easy-to-use devices and intuitive applications. These topics must be added to the educational curricula [17] in order that they can be treated in a systematic manner during formal education and training. Moreover, the various target groups must receive information in a manner that suits their needs, and communication over multiple channels should be intensified. Providers, intermediaries and users must all be encouraged by attractive business models, stimuli and incentives to change their behavior and to exploit as much potential as possible.

4 Key workshop results

4.1 Introduction

At its Cloud Computing Workshop 2012 held at IBM Research – Zurich on April 12 and 13, 2012, The Topical Platform ICT [18] of the SATW brought together experts from a variety of areas to identify and discuss important aspects of the Swiss cloud-computing ecosystem. The participants heard presentations from the user, research and provider perspectives. Each perspective was then discussed in detail. Finally, the workshop findings were consolidated in the form of a gap analysis and a discussion of recommendations.

A large number of topics were identified and discussed. From them, key points were identified and prioritized based on the various sectors of Switzerland's economy as well as on their importance. The results are presented below. The Topical Platform ICT of SATW plans further activities in 2013 to intensify the discussion in follow-up workshops, to extend it to other sectors, and to present the insights gained to the general public.

4.2 Trusted Data Cloud

Introduction

Trusted Data Cloud is a term whose meaning, views and characteristics differ depending on whether it targets the user or the provider of a cloud service. The group of users can be further divided into natural persons and legal entities. In the case of private users, often a considerable amount of personal data is uploaded to the internet via social-media cloud services (Facebook, LinkedIn, Xing etc.). In so doing, many users are hardly concerned with data protection or with how their data can be viewed and used by others.

In the case of legal entities and their use of cloud services, the situation differs:

• An enterprise is legally obliged to ensure observance of law, data protection and compliance.

• An enterprise is subject to regulatory influences that depend on its industry or sector.

• For an enterprise, all person-related, product-related, financial etc. data are a fundamental part of its business, and may result in substantial business risk if handled incorrectly, lost or stolen.

Trusted Data Cloud for legal entities means that strategic and operative factors play a role when using cloud services, as well as adhering to the applicable legal and regulatory framework. Most of these framework conditions must also be observed in traditional outsourcing projects.

For providers of trusted cloud services, this is part of or their core business. In order to succeed in their core business, they must do the following:

• Act as custodians in the management of customer data,

• Offer services that meet the legal and regulatory needs of the customers,

• Implement a security management system that safeguards the logical, organizational and physical security of the services offered,

• Have a standardized, flexible and automated service portfolio that can be customized to customer needs at the appropriate security level.

Characteristics of a Trusted Data Cloud

The basis of a trusted data cloud is formed by the following:

• Standardization of the IC technology, processes, interoperability, and connectivity as well as of the service portfolio.

• Comprehensive IT security management concept (encompassing everything, from the terminal unit to the internet connection, service provider, operation and datacenter security).

• An integrated and coordinated operation and security concept if the business model comprises more than one party.

• A trusted and reliable service provider.

• The creation of and compliance with a legal framework.

On the provider side, the existence or creation of guidelines for the following will enable cloud service providers to offer trusted data cloud services, and thus to also generate trust:

• Contractual aspects, laws, data protection and compliance.

• Standardization of technologies and processes, interoperability.

• Security concepts and implementation of security management systems.

• Governance, operating models and service management.

• Trusted and sustainable reliable service providers.

However, for a trusted data cloud, also reliable institutions and organization are needed that:

• Have the necessary competence to set up guidelines.

• Have the necessary professional competence to qualify such guidelines and perform audits.

• Are qualified to certify offers.

The trust in such institutions and organization would be created or enhanced by an accreditation issued by the national government.

4.3 Cloud of Clouds

The exponential growth in the number of cloud service providers and the diversity in their service portfolio enables current and future cloud service users to choose the solution best suited to their needs. However, alongside these opportunities are various threats inherent to the adoption of cloud-computing services, which include: data privacy, increased complexity and vendor lock-in. Existing cloud services may not have been set up with interoperability and portability in mind. They consequently tend to lock customers into a single cloud infrastructure, platform or service, preventing portability of data or software created by the customers.

Moreover, the intense competition for predominance between big vendors such as Amazon, Google, Salesforce etc. makes them reluctant to agree on common standards rather than promoting their own, incompatible formats. This situation increases the lock-in effect and may even deter small and medium-sized enterprises (SMEs) from entering the cloud market. The European Network and Information Security Agency (ENISA) and the European Commission have categorized vendor lock-in as a high risk to cloud infrastructures. On the other hand, considering the heterogeneity of the resulting solutions, it is extremely difficult and complicated to ensure that the cloud services will work individually and in concert with other services as desired.

Cloud brokers and integrators play an important role in resolving this challenge, as they can act as the interface between cloud service consumers and cloud service providers. Often, cloud brokers not only integrate the services of the cloud providers, but also enhance them by providing additional layers for security, server management etc. They advise the end users and make recommendations about which components to choose and how to facilitate the migration of data and software applications to a new platform. Cloud brokers abstract out the deployment model of cloud services, creating what could be called a “cloud of clouds.”

According to Gartner, a “broker” can be “software, appliance, platform or suite of technologies that enhances the base services available through the cloud.” Enhancement here can mean an improvement in access, integration or even completely new services. Cloud brokers working as intermediaries can enhance the underlying service functionality by adding value. For example, a broker can provide add-on services (such as a secure gateway, access management, service monitoring, encryption of outgoing sensitive data, and implementation of standard API) to manage the underlying cloud ecosystem. With aggregation functionality, various cloud-computing services could be combined into one virtual service, thus providing a uniform view across the distributed landscape.

The possibility to obtain the same cloud service from several different geographical locations, for example, could minimize the risk inherent in the dependency on a single geographic location. Similarly, the aggregation of cloud services in different network silos distributed across various wide-area networks (WANs) could lower the risks of unpredictable performance fluctuations and data-transfer bottlenecks, whilst it simultaneously increases the availability and reliability of the system. Moreover, the risk associated with provider reliability can be minimized to a certain extent by offering redundant and seamless failover solutions.

Apart from the concept of cloud brokers, another topic currently being discussed is how so-called community clouds can help solve interoperability problems. Community clouds (see for example the G-Cloud project [19]) could also define a common data model and a common architectural model with clearly defined standardized interfaces to resolve the issue of different cloud service APIs. As the requirements of the various sectors, industrial branches and organizations are likely to differ, community clouds (i.e. for government, education, healthcare etc.) that integrate with private and public cloud solutions in hybrid cloud models could offer a way to overcome this difficulty. Section 6.1 will investigate different community cloud approaches in the context of the academic sector.

Apart from aggregation in hybrid cloud models, another enabling feature is the arbitrage functionality, i.e., the flexibility to choose and seamlessly migrate to any cloud service provider meeting the applicable specifications. Brokers could thereby not only prevent cloud service users from having to pay exorbitant vendor fees, but also play an important role in spurring competition between various cloud service providers in terms of the value/benefit of the services offered, which would in turn benefit consumers. Such a service would help to mitigate the risks associated with vendor, software or data lock-in.

4.4 Standards and guidelines

Why are standards and guidelines needed for Cloud Computing?

Cloud Computing – the new web-based ICT sourcing model for enterprises that also has novel and innovative cloud services for private users – is based on new technical concepts and new business and distribution models. Cloud computing’s main differences to classical outsourcing are:

• Users are primarily interested in the web-based ICT services and not in the technology.

• New solution designs render ICT more flexible, modular, mobile and also less expensive to use.

• Cloud services are shared services, for which a volume-based business model applies

• Modularization and standardization of cloud services will turn ICT into a commodity business.

This fundamental transformation of ICT also raises many questions, including:

• How do cloud services affect my business?

• What are my opportunities and risks in using cloud services?

• What are the applicable laws? What are my rights and duties as an enterprise or as a service provider? As a cloud service provider, what do I have to pay special attention to?

• How can I measure and evaluate service quality? What are suitable parameters for this?

• What must I pay attention to when I, as a private person, use cloud services?

• How do cloud services affect me as an ICT provider?

• How do we handle the blending of private and business ICT practices?

To generate a broad foundation and acceptance of cloud computing and to answer these and additional related questions, standards and guidelines for private and business users are needed.

Standards and guidelines for private users

From the perspective of private users, cloud-computing-based services (such as Facebook, Google Docs, IQ, mail servers, Xing etc.) typically serve to store and manage large amounts of data and information on the internet. Most users hardly know what they should observe in terms of data protection, malware, spam, access protection, the unintentional distribution/proliferation of data and content, and what the consequences are if their data is abused. Therefore, this target audience needs standards and guidelines that cover the following aspects:

• Access protection, protection against spam and malware;

• Protection of data and content;

• Prevention of misuse of data and content.

Standards and guidelines for businesses

For the perspective of enterprises and their use of cloud services, guidelines should be established that cover the following:

• Legal responsibilities in respect of applicable law, data protection and compliance.

• Dependence on regulatory and trade-specific influences.

• If customers' personal, product and financial data are mishandled, lost or stolen, this violation of a fundamental part of the business can result in considerable business risks.

Most of these aspects must also be taken into account in traditional outsourcing. In order that enterprises can assess their risk and the entrepreneurial factors correctly, general as well as trade-specific standards and guidelines are necessary.

General standards and guidelines help in the assessment of the following:

• Quality of cloud services and of their providers.

• Content and extent of cloud service contracts (service level agreements, SLAs).

• Integration and use of cloud services.

• Legal and financial aspects.

• Risks, compliance and governance.

Trade-specific standards and guidelines for the evaluation and use of cloud-computing-based services are especially appropriate for the following sectors:

• Public authorities (e-government), public procurement procedures.

• Banks, financial institutions, insurance companies.

• Gesundheitswesen (E- Healthcare (e-health, personal health records, ePD, TeleHealthCare, …).

• Educational institutions.

• Transportation and logistics, utility companies, etc.

Standards and guidelines for service providers

For providers, cloud services represent their core business, with which they aim to succeed in the market. A successful cloud-service portfolio is marked by modularization and standardization in addition to a high degree of automation. Standards and guidelines regarding the form, use, operation and sustainability help customers assess the cloud services and quality of a provider better and more transparently.

Regarding the operation of cloud services, a number of standards already exist, for example:

• ISO 2001, ISO 2002, ISO 27001, ISO 27002

• ITIL, COBIT, Coso, PS, SOX

• SAS 70, IASE 4301, ISA 402 etc.

However, these standards are not very meaningful for assessing service quality, as it is also influenced by the operation model, the solution architecture, trade-specific regulations and the integratability. Therefore, guidelines for the operation model, solution architectures, cloud software development and interoperability are needed. A comprehensive assessment of the service quality, standards and guidelines in order to govern the qualification and certification of cloud services, in addition to rules governing the accreditation of auditors, is needed.

The following standards and guidelines govern use and sustainability:

• Standards for contracts (applicable law, contractual aspects, data protection, compliance).

• Guidelines for governance and service management.

• Guidelines to ensure sustainability of cloud services and providers.

• Standards for the certification of the service quality.

EuroCloud Swiss, the Swiss trade association for cloud computing, compiled and issued a code of best practices entitled “Cloud Computing Risk & Compliance” (in German). Additional guidelines are being compiled in collaboration with other associations.

4.5 Government cloud would set example

In terms of their adaptation to IT, government authorities see themselves more in the role of follower rather than as first mover. The broadly supported Swiss authorities study for its 2012 cloud computing strategy [20] was carried out as a joint effort between the industry and government agencies from all levels. The government authorities involved regard the use of cloud computing as a potential way of promoting the e-government strategy [21], in addition to being a way to increase efficiency and flexibility. Especially in Switzerland with its federal structure of approx. 2,500 communities and an additional 1,500 government offices, cloud computing could improve the efficiency of the individual authorities, as it would allow them to offer services easily and seamlessly, without having to make substantial investments.

Just as with outsourcing, all the relevant risks have to be taken into consideration, as the provisioning of a service will be outsourced to a service provider on whom the government office depends. Although in the long term, the complexity of the entire system will likely decrease, as existing services will be reused, the initial complexity will increase from the point of view of each individual government office.

By using cloud computing, the Swiss Federal Office of Topography, swisstopo, was able to make the highly regarded www.geo.admin.ch freely available to anybody without problems – at least as perceived from outside (see Section 2.2). The on-demand elasticity enabled by the cloud solution whenever higher performance is needed would have led to substantially higher costs if a traditional ICT implementation had been chosen. Another important aspect to take into consideration is that the highest possible care in handling personal data is expected from the authorities, so that if private infrastructures fail in case of crises or conflicts, government infrastructures are able to take them over.

Therefore, the Swiss authorities must always assess the use of cloud computing carefully. But if "even" government authorities with their special requirements use cloud-based services, there should be nothing to prevent the private sector and other sectors (education, healthcare) to also employ them. The aim of the cloud strategy [22] is to enable the authorities to assess the opportunities of using cloud services and to address how the challenges should be met.

The cloud strategy vision specifies three points:

The government authorities use cloud services. To the extent permitted by law, the Swiss authorities and their ICT providers use cloud services as the ICT support of their business, if such a solution is economically advantageous and appropriately secure.

The government authorities offer administrative services as cloud services. The services of the Swiss authorities are made available in the form of cloud services (SaaS) to the administration and public if this solution is economically viable and results in added value for the customers.

A government cloud is created to meet higher security requirements. For data and applications that require a higher level of security and protection, the authorities will use dedicated government-cloud services, which will be made available as community clouds.

Let us examine several specific points of the strategy. For example, as is the case in the USA, the guiding principle in Switzerland should also be "cloud first," meaning that suitable cloud offers should be examined for new product developments and investments. Another important point is the principle of national sovereignty: any critical core administration processes must be made available within Switzerland and within a time frame that is appropriate to the security needs. In addition, any critical datasets must be saved within Switzerland. In all other respects, the sourcing strategy of the government is identical to any good enterprise sourcing strategy.

The use of cloud services in government authorities will be supported and promoted in five focal areas by suitable measures:

• Promotion of a responsible cloud use.

• Adherence to the legal framework.

• Creation of dedicated cloud offerings for government authorities.

• Creation of cloud offerings for private people and the industry.

• Collaboration with the industry and international efforts.

The implementation of the cloud strategy of the Swiss authorities is driven by the prioritized e-government project "Cloud Computing." eCH has been set up as a standardization organization, to prepare standards and supporting documentation. Cloud solutions are typically offered by other government agencies [23]. In the framework of their task of providing information (such as, for example, swisstopo), the authorities may even explicitly offer cloud services to the public. In addition, the authorities should also use cloud services for their management and support tasks.

4.6 Cloud computing in education and research

A look at the education and research sector in Switzerland reveals a broad and varied vista. The K-12 segment mainly consists of many small- to medium-sized institutions in a highly fragmented regulatory and funding context. At the other end of the spectrum, the cantonal universities and the two Federal Institutes of Technology are large organizations with commensurate budgets, strong traditions of ICT use, and the ambition to be competitive at the global level.

Cross-cutting requirement

These differences must be taken into account when assessing the suitability of cloud-computing technologies for this sector. Despite the pronounced differences, many areas lend themselves to a common approach. For example, the entire sector could benefit from a common *identity and access management (IAM)* infrastructure, or from a portfolio management system to manage certifications of learning qualifications. Such services could ease the transitions of individuals between learning stages and support the vision *of life-long learning*.

A national cloud infrastructure tuned to the needs of research and education would help leverage a larger investment and reduce capital and operation costs:

• Although academic institutions will build and operate private clouds on their campuses, such clouds will likely be influenced more strongly by enterprise-IT vendors and traditions than by industrial-scale cloud infrastructures. They will have streamlined Virtual Machine (VM) provisioning solutions, but will lack many of the cost advantages of a large-scale cloud infrastructure. Specifically, vendors could charge a premium for fully integrated systems based on “enterprise-grade” equipment with full support. This point will be treated in more detail in Section 6.1. It may seem attractive for universities to turn to one of the many vendors selling “turnkey” solutions of private, virtually private or managed private clouds, but in doing so, they stand to lose many of the cost and flexibility benefits.

• Research is becoming increasingly data-driven, and the preponderance of big data takes center stage in areas ranging from digital humanities to scientific discovery and analytics. These data-driven systems differ fundamentally from HPC (high-performance computing), where the focus is on computation. Data clouds could be built on emerging commodity platforms tuned for data-driven science and research, so that they will therefore consume significantly less electricity than conventional HPC platforms.

• MOOCs (Massive Open Online Courses) are proliferating both in Switzerland (e.g., EPFL and gomath.ch) and worldwide (e.g., Coursera, a consortium of 16 world-class universities, edX, Minerva, Khan Academy, Straightline, University of the People, and Udacity). The increasing delivery of secondary and tertiary online courses, freely accessible on the internet and geared towards very large student numbers, will challenge many notions about higher education. Although this topic clearly exceeds the scope of this White Paper, the impact of MOOCs must still be considered here, because many – if not most – of these courses will be run off data clouds.

Requirements specific to academic research and education

The Swiss academic community was well represented at the workshop, by both researchers and ICT organizations. In the course of the workshop, not only the potential for cloud computing, but also some issues currently perceived as obstacles to adoption and/or implementation, were discussed in depth:

• Academic institutions regard Cloud Computing technologies as being an efficient way to run ICT systems, and are investing in *private cloud infrastructure (see Section 1.4 and Fig. 1 as well as Section 1.5 and Table 5)* on their campuses. These private clouds are seen as a potentially attractive model for future

HPC and/or throughput offerings. There are also efforts to *"federate"* private clouds across institutional boundaries.

• The *management of scientific information* in digital form is seen as a significant and long-term challenge in academic research. The scientific community needs to develop not only policies for data life-cycle management, but also mechanisms for sustainable long-term archival of information. These need to be financially viable as well as sustainable in the sense that they must survive the transition (and obsolescence) of data formats and researchers who need to be able to make sense of the data. Cloud Computing technologies can facilitate the cost-effective storage and processing of large amounts of data. However, it is considered highly problematic that most existing large-scale cloud providers operate outside Swiss control and public governance. As a result, the notion of a *Trusted Data Cloud* for Switzerland was popular at the workshop.

• Researchers want to help advance the *state of the art* in Cloud Computing on the various levels, be it by improving the underlying hardware architecture, by developing new kinds of scalable data/knowledge management tools, or by contributing to progress in data-center networking etc. *Access to a cloud infrastructure at the "provider" level* (i.e., not as simple users of standardized offerings) would help them gain knowledge through experimentation and credibility as they could validate their ideas at scale, and would open up new ways to exploit their results for wider (and possibly commercial) application.

• Academic institutions are under a certain degree of *"commoditization"* pressure by cloud-based services provided to them by industrial players that are able to offer good quality and – sometimes – unbeatable prices (e.g., e-mail and calendaring services, personal data-storage and file-sharing services, etc.). Given that many researchers and lecturers already rely on such services privately, the temptation to also use them to improve their professional productivity is quite real and very pervasive. This raises a number of regulatory/legal, responsibility and security/control issues, not least because almost all such services are operated by entities outside of Swiss legislation and jurisdiction.

• Researchers increasingly resort to commercial cloud-computing services for computationally intensive or advanced forms of usage that are difficult to achieve otherwise. However, in addition to the legal/control issues mentioned above, the pay-per-use model does not fit well with the established models available to researchers for access to computing resources. Cost and performance issues related to the transfer of large datasets to and from remote clouds are also a concern.

• A classification system for the needs of academic institutions should be established that also considers the difference to HPC and throughput requirements.

In general, we note that universities, research organizations and institutions of higher education all are well positioned to take advantage of cloud computing. They also often have sufficient connectivity to use cloud infrastructures located off-site or abroad.

Requirements specific to K-12 education

Institutions in the earlier phases of education are often relatively small, and ICT – in terms of infrastructure, teaching, use, and complexity – accordingly plays only a minor role, although much progress has been made in the past decade. Computers and the Internet have found their way into classrooms and into various administrative processes, but - especially for smaller schools - their acquisition and upkeep are a burden.

Schools could benefit from SaaS offerings to replace costly and complex on-premises IT by more user-friendly and less maintenance-intensive devices that provide access to cloud applications via the web.

It is essential that such services be offered in a way that ensures user privacy and data security. Although the adoption of cloud computing carries some risks in this respect, it also provides numerous opportunities for better security than offered by current solutions – as long as the cloud-based services providers can be entrusted to treat the data of their users in a responsible manner and to apply state-of-the-art security practices.

4.7 Market development

Cloud Computing as a modern ICT sourcing model and as technology has been a familiar notion with “techies” (ICT managers, providers and professionals) for a long time. Given its many advantages and possibilities, they have embraced it because it is part of their job. Many have successfully implemented solutions and use(d) cloud services in business as well as other contexts (see Section 2). Still, there are many that shy away from the cloud, due to concerns regarding the security, integratability, dependency etc., or because they fear losing control, power or status, or even their job and their employability.

In the executive suites of enterprises across all sectors, the situation is quite different. Here, mainly so-called “digital immigrants” [24] (i.e., those born before approx. 1980) are in power. And only those who have a special affinity for ICT are likely to investigate cloud computing in detail, although many of them already use devices and services that are based on cloud computing.

As shown in Section 3, currently there is insufficient interest, motivation or pressure to exploit the full potential of ICT systematically. One of the reasons may be that the ICT budgets in many enterprises (still) are economically feasible and bearable – but it is not really transparent what these often sizable amounts are actually spent on.

A number of studies have shown that between two thirds and over 80% of ICT expenditures are used for operation and maintenance, meaning that only approx. 20% to a third of the remaining expenditures must cover new investments, development and innovation. This is a dire situation, as ideally the exact opposite should be the case! Cloud Computing provides a sourcing model for any sized organization that comes much closer to the ideal scenario and that can be rapidly deployed. If used optimally, then not only will large ICT investments become obsolete, but massive savings in terms of operation, support and personnel costs can be realized, and/or the corresponding funds allocated elsewhere – for example, for research, development, innovation and business expansion.

For such a market development to occur and to prove successful on a large scale, several conditions, actions and instruments are necessary:

Overcoming the competence issue. The application and use of cloud computing (and ICT in general) require the key players to have appropriate core competences and the public at large to have a minimum of competences. These must be demanded, generated systematically, and fostered in a lifelong manner.

Solving the transparency problem. Often, investment and operation costs that are (still) bearable are not allocated optimally. Every expense item must be challenged – by critically assessing innovative models not only for service provisioning, but also for the allocation of investment, operation, support and personnel resources.

Building security and trust. New IC technologies and sourcing models must not be accepted at face value, because the potential risks and damage potential are too high. All players and their services must pass a critical assessment by providing proof that they adhere to standards, guidelines, certifications, labels etc. and have to agree to be audited periodically. Transparency, also in terms of interoperability, portability of data and applications, governance and compliance, is a prerequisite.

Publicizing case studies and best practices. In each sector and in each application area, projects are underway, innovative approaches are being developed, and excellent solutions exist for optimizing and reorganizing existing business models and processes, even to the extent that novel business models are created. These must be rapidly and widely publicized.

Tackling the complexity of cloud computing. Although a technology-based view undoubtedly is useful, it cannot convey the necessary comprehensive insights (in terms of market, business, law, technology, etc.) into specific aspects (advantage, cost effectiveness, manageability, transparency, security). A holistic view and discussion, including an active exchange between solution providers, users, experts and other stakeholders, will help break down and master the complexity.

For these reasons, cloud-computing initiatives have repeatedly proposed the creation of a Competence Center for Cloud Computing. However, given the numerous and interdisciplinary aspects of cloud computing, a single center would quickly be out of its depth. Instead, open expert and market platforms and networks are proposed and, to some extent, have already been successfully implemented [25]. Their aims are to show possible competitive advantages of cloud computing by means of customized and effective communication, to present cloud computing from various angles, and to show decision makers an easy and secure way into the cloud by means of suitable tools and thus promote cloud-computing projects.

5 Implications for Switzerland

ICT is increasingly permeating all sectors and application areas, as a result of the digitalization of data, information and the media. New concepts, including service-oriented architectures (SOA) and application service providing (ASP), new sourcing models and virtualization, high requirements regarding performance, security, standardization, automation, and cost effectiveness (in combination with limited budgets) have led to new organization forms and provisioning models, such as grid and cloud computing.

5.1 Cloud computing prevails

It is difficult to imagine flexible, cost-efficient, powerful and scalable ICT solutions without cloud computing. Infrastructures, platforms, services and business processes are obtained on-demand from the cloud and generally paid as used (see Section 1.4 and Fig. 1 as well as Section 1.5 and Table 5).

The high penetration of ICT devices of all kinds means that today almost everybody owns and carries with them at least one personal device (including tablets and smartphones), resulting in what has become known as “bring your own device” or BYOD[26]).

This is not only a challenge for classical IT and its providers, but also opens up new possibilities for business line and process optimization, reorganization and innovation. It may even lead to novel business models (disruption). In this context, experts are already talking about the fourth industrial revolution [27] (Industry 4.0), and appropriate high-tech projects are systematically supported through government programs and by support agencies. From this viewpoint, it is highly desirable that exemplary cloud projects in Switzerland benefit from such support to stimulate the proliferation of cloud-computing-based solutions and to allow use effects to be realized across the board and in a timely manner.

In addition to the ubiquitous public clouds, dedicated private clouds, community clouds for specific communities or groups, and hybrid clouds are all gaining in popularity [28]. In 2011, preparation for a cloud computing strategy for Swiss authorities, including a catalog of measures, began [22] and was approved by the steering committee on October 24th, 2012. This will have a signal effect on other sectors because many of the targets, criteria, tasks and services are generic and can be transferred to other areas without endangering the independence, structures, culture, traditions – or even federation - of these areas. Precisely because they are generic, they can be integrated into, and used in, specific environments.

5.2 Focus on quality

Given its special situation (see Section 3), Switzerland is ideally positioned for – and depends upon – providing high-quality services, innovative solutions and top-rate performance in selected niches. Therefore, the focus in cloud computing should be on services and offers with high added value in connection with location-specific aspects. Basic offers only make sense if they will open up additional opportunities in connection with services with high added value – and if they do not compete with the established solutions of global players. High-quality secure services with maximum availability and reliability create opportunities that meet the highest expectations and requirements.

The Swiss market is characterized by a high degree of technical differentiation, and the standards for protecting the data of private persons and organizations are among the strictest in the world. However, considerable scope remains for optimization, especially with respect to the flexibility of the e-economy in general and cloud computing in particular, by means of improving the general conditions (e.g., existing structures, competition creation) and/or removing obstacles (e.g., laws that differ from canton to canton, barriers).

Sustained infrastructure optimization (high-performance computing centers and networks), increased efforts in the educational sector, greater levels of international and research collaboration, and attracting the talent and institutions of global top players are all prerequisites for increasing the levels of quality. Whilst the chief objective in all sectors and all organizations is to improve overall efficiency, this can in general only be achieved through a systematic use of modern and innovative ICT solutions – which in turn requires full awareness of the importance of ICT and its use.

“Swiss Quality” is a label that is known and respected worldwide. Therefore the delivery of high-quality solutions and services as well as their commercialization must be on Switzerland’s cloud-computing agenda. Establishing a “Swiss Premium” label that is based on and guaranteed by high standards, optimized processes, certification, audits and accreditation could complement Switzerland’s traditional strengths of transparency, security and trust.

One of these strengths is also that Switzerland, in contrast to many other countries, does not pursue a dirigiste economic policy, but instead leaves it to the various players to pursue research, development and innovation, as well as to exploit the opportunities and potentials. The combination of a liberal attitude, careful economic and fiscal politics, ideal conditions, reduction of barriers and specific incentives contributes substantially to Switzerland’s attractiveness for business and motivation for top performance.

5.3 SME country Switzerland

Micro-enterprises and Small- and medium-sized enterprises stand to benefit the most from the flexibility and scalability of cloud computing. They can improve their efficiency whilst redirecting their financial and other resources towards their core business, rather than having to invest in their own IT infrastructure. To enable and promote this development, however, any imponderables (for example, in terms of security, transparency, trust, interoperability and portability) and obstacles (such as differences in applicable law and regulations) must be removed by improving the information available to enterprises and by promoting tools, standards and certification efforts.

The level of migration to cloud environments and the use of cloud computing could be significantly accelerated by widely publicizing and promoting generic services as well as sector-specific model projects. Here, the various associations in their function as stakeholders of SMEs are called upon to assume their responsibility and fulfill their role.

The consolidation and migration of IT away from inefficient small units towards optimized datacenters and services on demand will also foster a more ecological use of ICT across the board (Green IT[13]). However, this requires not only state-of-the-art energy- and resource-efficient datacenters and networks, but also leadership and rethinking in the various sectors, organizations and IT departments. The latter often seem reserved when it comes to cloud computing, either because they wish to retain the status quo, or because they are afraid of losing control, security and/or independence.

This highlights the importance of educating entrepreneurs, business leaders and finance managers about the true advantages and consequences of cloud computing, so that they are able to identify and assess the opportunities and risk for their enterprise and take informed decision.

5.4 Legal aspects

There are various legal requirements relating to cloud computing services that must be observed under Swiss law. These include – but are by no means limited to – contract law (in particular contracts with suppliers of cloud services, data protection and security, confidentiality and regulatory requirements). These legal issues have to be approached in a systematic, differentiated manner according to the type of cloud services, the organizational form of cloud computing (public, community or private cloud) and the type of data concerned, etc.

Contract Law

Cloud services are offered under non-negotiable bulk business standard conditions. However, negotiations are customary for cloud computing contracts above a certain contract volume, or if the customer appears to be of significance to the supplier as a reference.

The content, scope and quality of cloud services need to be clearly defined. The service descriptions and service level guarantees, especially with regard to scalability, availability, performance, data security etc., such as are frequently offered in standardized SLAs, are to be reviewed, and if necessary, negotiated and amended to ensure they meet customer requirements. Care must be taken to ensure that the prices and the price adjustment mechanism are regulated comprehensibly and transparently.

The regulations on duration of contract, termination and exit management are important for avoiding a vendor lock-in. Standard supplier contracts often provide for short periods of notice and the customer must check whether these are sufficient for it to obtain a new solution for cancelled cloud services, or whether a longer period of notice needs to be negotiated. If the support of the supplier is necessary for the retransfer of data and applications, the corresponding support services and their cost have to be specified as precisely as possible in the contract.

Suppliers' contracts often contain extensive disclaimers. This practice is widespread in ICT contracts. If the disclaimer proves to be non-negotiable, the customer must decide, having given due consideration to the benefits associated with the cloud offer, the probability of an incident and the associated potential for damage, whether the contract is ultimately acceptable.

Foreign suppliers regularly provide for the application of foreign law and foreign jurisdictions in their terms and conditions. In case of a dispute, this represents a significant difficulty for the customer. But here too, negotiations are possible: several US suppliers offer the agreement of jurisdictions in Europe as a compromise.

Data protection, Data Security and Confidentiality

Swiss data protection law permits the transfer of personal data for processing by third parties. The customer retains the responsibility for data protection and must contractually ensure that the contractor processes the data in a way that is permissible and with appropriate security measures in place.

Which data protection measures are agreed upon ultimately depends on the circumstances and the sensitivity of the data. Throughout, the customer retains the right to issue directives concerning the supplier's data processing. Other considerations include binding agreements on data protection and security policies, access control for the supplier's employees, the obligation to provide data protection and security certification, obligations to provide notification in the event of data protection breaches, and obligations to provide evidence of data protection and security measures (e.g. submission of reports on data protection and security audits by independent third parties). Some cantonal authorities impose strict IT outsourcing regulations guidelines, which may impede public cloud usage, e.g. if customer access rights or audits are mandatory. However, as suppliers do not automatically or typically accept such audits, the customer (in a case with suppliers who operate globally distributed systems) would not be able to effectively exercise these rights.

The secure transfer of personal data across territories is a critical requirement. The high level of Swiss statutory data protection applies domestically and across EU and EEA countries. If the data recipient is certified in accordance with the Safe Harbor regime [29], an equivalent level of data protection is then guaranteed with respect to the transfer of data to the US. Against this background, international suppliers offer the possibility for regionalization, and should ensure that the data remains in Europe.

If equivalent statutory data protection is lacking in the recipient country, contractual agreements can compensate. As data protection, compliant data processing and data security are regulated with the supplier, it should also be specifically taken into account in the SLA that the customer's data will be transferred to countries that do not have appropriate statutory data protection regulations in place.

There is currently considerable uncertainty regarding access to cloud data by US authorities, as authorized by the US Patriot Act[30]. Whilst not all types of personal data have the same probability of access by public authorities, it is generally recognized that public authorities can access data under certain conditions for certain purposes, e.g. to obtain evidence in criminal, civil and administrative proceedings. Countries with a high level of data protection, equivalent to Swiss levels, still have very wide-ranging official facilities for access in order to safeguard national security and to combat terrorism. Public authorities' access to data must generally be expected in any country, including Switzerland. However, an assessment of the legal situation is complicated, as it is often not merely a question of whether public authorities have access to data, but of which authorities (law enforcement authorities, tax authorities, intelligence services, etc.) and under what conditions data access is permissible. In the case of data that is more likely to be of interest to the public authorities, such as (for example) log files or accounting data from online suppliers, more detailed legal clarification is recommended prior to the use of foreign suppliers' cloud services.

Specific requirements must also be met if data is subject to an obligation of confidentiality (e.g. official, professional, banking or telecommunications secrecy). In each case, the conditions under which the data may be transferred to an external supplier must be precisely clarified, particularly in the case of a transfer abroad, as the criminal laws which serve to protect confidentiality are not enforceable abroad. In some cases, the use of cloud services abroad is only possible with the prior consent of the persons concerned.

The legal issues relating to data protection and confidentiality can be circumvented, in part, by technical means using sufficiently robust data encryption methods or, if assignment to specific persons, can be definitively ruled out by making the data anonymous. Whether pseudonymization is also sufficient depends on whether the possibility of conclusions being drawn about identifiable people is excluded by the removal of certain individualization features.

Regulatory Framework

Checks should be made on a case-by-case basis to ascertain whether special precautionary measures are necessitated in accordance with regulatory requirements. It may be a matter of following generally applicable guidelines, such as: the regulations for commercial accounting (system documentation, securing of data integrity) or sector-specific regulations; such as the FINMA circular concerning outsourcing within the banking sector, or the regulations relating to the storage of data and obligations to provide information for the purpose of monitoring telecommunications.

5.5 Need for action

For any information- and knowledge-based society, cloud services and their efficient and secure use represent a competitive advantage. As has been outlined, in this respect, Switzerland is lagging behind other leading countries. Possible explanations for this are:

• A lack of competence.

• A lack of transparence.

• A lack of trust.

• Retention of the status quo.

• A fear of potential bottlenecks or breakdowns.

• Uncertainty regarding the legal situation.

SMEs stand to harness the greatest benefit, but this is dependent upon whether they gain more trust in the services and their consequent use through use cases (see Section 2, [2]) and certified cloud offers (see Sections 4.2 and 4.4).

International standards and sector-specific guidelines, possibly adapted to Switzerland's situation, as well as to certified providers and services, will foster the security of and trust in cloud-computing-based services. But getting there is complex and costly. Therefore, cross-sector collaboration with standardization and certification experts is strongly recommended, in consultation with existing guidelines [31].

6 Recommendations: cloud in education and research

Taking into account the above-mentioned drivers, Cloud Computing and its related generic services are expected to be widely adopted in education and research to the extent that they will largely supplant traditional IT, along with its roles and institutions. The following are ready to be employed for the benefit of all actors in learning, teaching, and research in Switzerland: “Bring your own device” (BYOD[26]), Community Clouds for education and research, Personal Education Data Purse, and services supporting applications such as SWITCHaai[32], SuisseID[33] and STORK[34].

6.1 Cloud computing in research and science

Academic researchers in Switzerland and their institutions are well positioned to play an active role in this transformation. An institutionally-based non-profit private cloud could address the privacy and security-related concerns, in addition to lowering the barriers for introduction. However, for Switzerland to remain competitive in adopting cloud computing, a number of obstacles will need to be overcome.

Academic IT organization’s perspective: Consumerization and scaling challenges, outsourcing and collaboration opportunities

Even though academic institutions in Switzerland cover the entire spectrum, from smaller universities with a focus on arts and humanities to large, well-funded science and engineering institutions, such as EPFL and ETHZ, their respective IT services typically serve their local users with a *high level of quality and maturity*. However, even at the most well-equipped institutions, the IT service providers often find that they cannot cover the full range of their users’ IT needs without outsourcing. Academic institutions require a wide range of processes that can fall into three broad categories with disparate constraints and requirements: research and development/industry transfer, which requires external collaborations across organizational, national, and academic/industry boundaries; teaching; and administration.

Cloud services needs can typically be specified by category (e.g., storage for research data, academic management systems, etc.). Otherwise, they are generic and applicable to categories (e.g. mail system, generic storage, collaboration tools, etc).

Academia has historically been an early adopter of new forms of IT - not only due to the high levels of curiosity, creativity, and IT knowledge that go with the profession, but also because (compared with the corporate world) faculty enjoy a high degree of liberty and are less bound to directives from IT departments. Accordingly, there is a high take-up of commercial cloud services in academia that transcends individual or recreational use: tools such as Dropbox are used by researchers to store and share research data, and by students to collaboratively work on team assignments and projects.

Legal uncertainty as an obstacle to adoption of public cloud

Academic departments have limited resources and, as a result, cannot compete with the user-friendliness, scalability, and continuous improvement of generic cloud-based services. Some institutions choose to embrace the new possibilities by integrating commercial offerings with organization-wide IT infrastructures, such as *identity and group management systems*. However, they can be held back by concerns about issues such as liability, dependency and cost. In particular, they require *authorita-*

tive guidance on what kinds of data they are allowed to move to public clouds, where there is – at best – limited control over the locus of storage and processing.

It would be valuable to analyze the strengths and weaknesses of a Swiss cloud for foreign users from a legal standpoint, based on different geographical locations: such information would available for those interested in localizing and developing cloud services in Switzerland aimed at serving users in (but not limited to) Switzerland.

Private clouds and the need to join forces

At the same time, IT organizations seek to adopt cloud-based techniques in order to render their own infrastructures more efficient. However, they recognize that the scale and professionalism required for true cloud efficiency exceed the individual capabilities of most institutions. As their counterparts in the commercial world are doing, they could turn to the many vendors selling "turnkey" solutions of private, virtual private, or managed private clouds – however, in the process, they stand to lose many of the cost and flexibility benefits. Unlike most commercial firms, however, academic institutions can join forces as a community and collaborate on solutions that are mutually beneficial.

ID management: The cornerstone of collaboration

All actors involved in the service and provision of IT for academia (IT departments, Switch, etc.) have heavily invested in ID management, with technical solutions such as Shibboleth, LDAP, Active Directory, etc. and internal policies regarding accreditation, complexity of passwords, etc. As public cloud solutions are increasingly becoming de facto standards, academic end users increasingly bypass these technical solutions and internal policies by using the userIDs and passwords provided by the cloud vendors.

The vast majority of research activities and projects involve scientists from different disciplines from different institutions. Paradoxically, it is easier for researchers to share and exchange information on cloud platforms, where everyone seems to already have individual accounts (such as Google, Dropbox, Skype, etc.), than to use internal tools, which require the creation of guest accounts with defined passwords for external users – which most users tend to forget almost immediately.

To protect ID management investments, and possibly leverage them in the cloud environment, strong measures should be implemented to extend their collaborative usability between and across different universities and platforms. Without such efforts, there is a substantial risk that institutional userIDs and the related policies will gradually be replaced by de facto standards imposed by cloud vendors, without any academic influence.

Collaboration towards community clouds

Community clouds can be considered a subset of public clouds offering a range of services (including infrastructure-, software- or platform-as-a-service) that are tailored to a specific vertical industry (such as government, healthcare or finance). The National Institute for Standards and Technology defines them as "an infrastructure shared by several organizations that supports a specific community that has shared concerns."

A *shared community cloud* would provide multiple benefits to Swiss education and research: a **Cost reduction** resulting from economies of scale and a decrease in the number of isolated applications; improved **agility and scalability** via frictionless access to a large pool of resources; **easy evaluation of new services** through a shared environment; and higher **efficiency and effectiveness** through improved cooperation between institutions.

We look here at possible ways to construct such a community cloud. Academic communities in many countries have already begun to investigate these options. However, a consensus has not thus far been reached on the relative merits of these models, not least because – with respect to community clouds – "one size does not fit all".

Community cloud option: Commercially provided, possibly "brokered"

A community could seek commercial market suppliers that offer either a service or preconfigured solution(s). Community value could be added during the procurement process by gathering specific requirements and leveraging the combined market power and scale to drive down prices. In addition, technically, the community could work with the vendors to integrate their existing solutions with these commercial systems, for example in identity mechanisms. Examples of this approach include: SURFnet's (NL) cooperation with GreenQloud, Internet2's (US) "Net+" services and the Helix Nebula project's cloud for large-scale scientific data processing, all based on multiple commercial suppliers.

This option minimizes the risks for the community in that it requires very little capital investment. However, it impedes the community's influence over the long-term evolution of the infrastructure and offers limited opportunities for experimentation with novel approaches. Whilst this may be less of an issue for the education part of the community, it reduces the attractiveness for the research side.

Community cloud option: Federated private clouds

Some institutions in Switzerland have recently begun to ascertain the possibility of federating their virtualized clusters (private clouds), with a view towards scaling HPC workloads seamlessly, from local infrastructures to the inclusion of resources from partner institutions, and possibly also from commercial public clouds. The move towards a pan-European federation of private clouds is part of a strategy proposal [35] being discussed by the European Grid Infrastructure (EGI).

For over a decade, federated models have been explored in depth through various large-scale efforts in grid computing. Important lessons have thereby been learned about the potential – and limitations – of this approach. In federated models, individual institutions generally retain control over their respective infrastructures. Whilst this is attractive to the institutions and facilitates bottom-up innovation at individual sites, the resulting overall service often lacks cohesion and operational efficiency. Federations are based on the idea of *resource sharing*: in particular, the opportunistic sharing of "excess" resources. Federation partners are primarily accountable to their local constituencies, and do not consider themselves to be service providers for the federated community – this weakens the service and makes it difficult to achieve sustainable operation and funding.

Community cloud option: Centrally provided by community mandate

The institutions in a community can also create a common entity (or mandate an existing one) to build and run the community infrastructure. This provides scaling advantages and operational efficiencies, and the community still retains control over the long-term evolution. Ideally, researchers can use the common platform to validate their ideas experimentally and contribute actively to its development.

In the networking domain, this was the model used in many countries when the first research networks were built in the 1980s. These organizations (National Research and Education Networks or NRENs, such as SWITCH) persist today and have been able to adapt through many technology changes and orders of magnitude increases in demand. Most notably, they have found sustainable mechanisms of governance and funding.

Although this approach holds very high potential for long-term benefits, it also requires a strong initial commitment in the form of investments in infrastructure and skills: developing cloud services in Switzerland based on this model would require a large-scale datacenter with at least two distributed sites, and the required investment would likely run to eight-digit figures in Swiss francs. Moreover, the skills and expertise needed for running a complete datacenter would require the creation of a sizeable team. However, a national academic community can build on the structures and experience gained over decades in a national research and education network (NREN). Examples for this approach are GRNET's ~okeanos cloud (GR), the UMF/Eduserv Cloud Service (UK), or SARA's Big Grid services (NL).

Education and research clouds as platforms for sharing vertical applications

There are many academia-specific applications that have been successfully implemented on an individual campus level. Occasionally, they are even shared with other institutions on an ad-hoc basis. A shared (community) cloud platform would significantly facilitate this exchange as such applications could be offered to other institutions as Software as a Service (SaaS).

A research and education app store?

An app store can be defined as a marketplace for the sharing and reuse of online business applications, services and components between academic institutions or institutions in primary or secondary education. It can be thought of as a portal where commissioners or purchasers of services can browse a catalogue of available services. The app store will also provide detailed information relating to the costs, capacity, service levels and lead times for getting a particular service live. As a key part of the community cloud, the app store must be fully resilient and fault tolerant.

Long-term vision for the organization of academic IT infrastructure

Academic IT systems could soon be composed of a wide spectrum of infrastructures at different levels: At the end, large parts of the computing and storage requirements in research, teaching, and administration could be carried out cost-effectively on public clouds. At the other end, on-site private clouds could be used for highly specialized or security-sensitive applications. In between, community clouds could provide trusted platforms supporting cooperation and community-driven innovation.

National academic communities are clear candidates for pioneering community clouds, but other concepts are equally viable: nationwide public-sector clouds, such as the French Andromede project, or pan-European sector-specific clouds.

6.2 Cloud computing in primary and secondary education (K-12)

It should only be a matter of time until cloud computing and generic, interoperable and portable services will become the standard in schools. The technology for largely replacing classical IT and its traditional setup, operation and support structures exists and is ready.

Bring your own device (BYOD[26]), community clouds for education and research, Personal Education Data Purse, SuisseID[33] - and STORK[34] -enabled services for all stakeholders in learning, teaching and research institutions already exist and, together with active participation in the Digital Single Market[36], wait to be used in order to contribute to the location advantage of Switzerland.

The technologies used by teachers – and especially students – in their private lives are slowly finding their way into the schools. Particularly in the area of scholarly education and continuing education, modern ICT is progressing slowly, although the level-appropriate teaching of computing fundamentals and key competencies are one of the basic duties of formal education, and prerequisites for a sustainable information and knowledge society. Thus far, however, few Swiss cantons have committed to this target in their curricula in a binding manner, and even then, often only in the form of already outdated statements in the current curricula.

In the past decade, the national "Public Private Partnership – Schule im Netz" (PPP-SiN[37]) project and the activities of the SFIB in the education network "educanet2[38]" project provided momentum to consolidate ICT in schools. Visible signs thereof are the increasing connection of schools to the internet provided by Swisscom and the purchase of hardware by cantons and communities. In tandem with these efforts, several initiatives promoted the development and improvement of the ICT skills of teachers. However, despite these efforts, the level of ICT equipment, its use in teaching, and how the basics of computer science and ICT usage competencies are taught differ from canton to canton and even from school to school within a canton.

Within the "PPP-SiN" project and other efforts, research groups, mainly from universities of teacher education but also from institutes of the ETH and EPFL and from universities, successfully conducted important research efforts, investigations and pilots with modern ICT and supportive measures to promote ICT and MINT competencies. Numerous foundations, interest groups, associations, experts and student and teacher councils strongly supported these efforts.

Despite all this, the potential of ICT in the education sector is still not being exploited in a comprehensive and consistent manner. There is considerable catching-up to be done, and much room for improvement. In terms of equipment, many schools have reached a high level and continue to expand their hardware, but its usage may still lag behind. Media studies on the one hand, and computer knowledge on the other, are very slowly finding their way into curricula. Even in the development of new curricula for primary schools, media studies and informatics still do not get the status they deserve. They often remain the exception, except in specific fields.

In this way, it is not possible to acquire the information literacy needed to master either life or computer knowledge systematically. This is a key challenge to Switzerland's success, as it will impede the transfer of skills, knowledge and competencies that are part of the school curricula – and that can be exploited for gaining competitive advantage – to other sectors and application areas. Only a few educational institutions and some cantons have recognized and acted upon this. They are now consequently able to keep pace with the rapid penetration of our society with network connections, mobile devices and social networks. However, they are the minority.

A massive and concerted effort to remedy this unsatisfactory situation is called for. An integral part of this effort will be the replacement of (sometimes) outdated systems and proprietary applications by modern infrastructures, services and hardware. Here, the concept of a hybrid community cloud with standardized solutions and services and Bring Your Own Device offers a tremendous opportunity – by implementing and using this concept consistently, it would be possible to achieve and exploit the full potential of ICT at every level of education. Moreover, it could even defuse unsatisfactory personnel, technical and financial situations. It does, however, also imply that appropriate efforts be made to win over, educate and compensate teachers.

The characteristics and properties of mobile devices, such as iPads, offer a great potential for cooperative learning, mobile work and communication, especially in teaching. Scholastic publishers have begun to capitalize on the possibilities of these devices, but of course are also under considerably economic pressure themselves. In terms of lifelong learning and of the interlinking of pre-school, informal, formal and non-formal education, not only the specific requirements and solutions of schools but also – and especially – the generic aspects across all levels of education need to be considered. What is needed are visions that take into account the economic and social reality. Maintaining the status quo does not make sense. The change that has already begun seems irreversible.

In the context of education, also the issues of identity and trust must be considered; they are an integral part of the media education, and serve to protect all education stakeholders. It is not only desirable, but strongly recommended, that basic services and applications, such as identity & access management (IAM), provisioning and use of electronic contents, collaborative work environments and personal documents (Education Data Purse) etc., be developed in such a way that they can be used on all levels of education, and that they only need to be adapted to the respective context (scholarly level, institution, learning environment).

7 Proposal for an action plan

7.1 Cloud computing in research and science

The action plan has been structured into three sections – from general to specific targets:

• General shift in computing architectures.

• Research & education community.

• Scientific finance and governance bodies.

General shift in computing architectures

• Data storage is becoming at least as important an issue as computing resources. Cloud Computing has been instrumental in this paradigm shift.

• Data storage is required to develop new governance models that can cope with distributed resources controlled by different actors. This means that the IT department – hence the institution – is no longer in full technical control of its IT resources. Consequently, a suitable governance model that can be practically implemented needs to be developed.

• New distributed technical architectures have to be developed that optimize information storage (depending on its source – bound to a specific location or location independent, its size, its level of confidentiality, etc.) and information processing (generic, shared or spread across different providers). Additional technical tools will be required for supporting the architecture, with special focus on ease of use for end-users.

Research & education community

As research and academia have special needs, we should focus on the sector-specific, pertinent challenges, and not just "duplicate" commercial clouds.

• Establish and maintain an up-to-date legal framework for cloud services that delineates which cloud services (private, community and public) can be used under what conditions and establishes the conditions and limitations for cloud services provision out of Switzerland to foreign users.

• Preserve and leverage the important investments made in ID management (SWITCHaai, Shibboleth) to provide a transparent single sign-on to cloud services for the Research & Education community.

• Increase the reusability of data across projects and time. Upcoming national initiatives for the management of scientific information will create new opportunities or obligations on researchers concerning data management, long-term archiving, and other access by third parties.

• Implement related processes and systems for supporting the new approach.

Scientific finance and governance bodies

Bring together the main actors in the Swiss R&E/policy arena to discuss cloud computing opportunities for addressing old and new challenges for the academic sector, in particular:

• Funding for using ICT needs to become part of the overall funding (for devices as well as for computing and storage services).

• Cloud Computing is an important topic for funding bodies. Therefore, encourage research and technology transfer for new services in the cloud invented and developed in Switzerland. Systematically consider cloud services as an alternative to buying (and operating) in-house systems where appropriate in sourcing options. In addition, if applicable, funding decisions should systematically include a data management plan.

• SWITCH plays an active role in shaping an Academic Community Cloud and Data Life Cycle Management (DLCM) in the context of the CRUS project «Information scientifique: accès, traitement et sauvegarde». The findings of this joint project will be distributed among the participating universities. SWITCH currently focuses on developing an information infrastructure for DLCM, especially for primary and secondary research and education data.

7.2 Community clouds for schools (K-12)

As shown in Sections 6.2 and 7.1, there is a need for action in a number of generic as well as specific aspects not only in the educational sector at large, but also and especially in schools. From the findings of the workshop, the following concrete action plans can be deduced:

Idea "EduCloud" (construction of an Education Community Cloud)

We propose to set up a "Cloud Computing in Schools" (K-12) project that aims:

• To conduct an in-depth investigation of the generic and specific requirements, infrastructures, platforms, applications and processes on the basis of cloud computing (i.e., one or several hybrid community clouds for schools in Switzerland).

• To compare the results gained with insights from other projects in education (and on other education levels, see Section 7.1).

• To include the authors and publishers of teaching materials in this discussion.

• To solicit and collaborate with the ICT departments in each canton.

• Conduct and evaluate regional pilot projects.

• Recommend suitable actions for the next multi-annual planning period.

The EDK, educa and (from 2013 onwards) the State Secretariat for Education, Research and Innovation SBFI [39] should act as the primary stakeholders. It is also highly desirable that schools from all geographical and linguistic regions of Switzerland participate, in order to achieve a holistic view and to be able to have meaningful regional pilot projects. Promotion agencies, foundations and solution providers need to be engaged to support the project as a whole as well as the regional pilots. Academic institutions can offer support in the areas of communication, workshops and knowledge transfer.

A new Public Private Partnership

To focus the proposed project in terms of its content as well as in terms of organizational, temporal and financial aspects, it is recommended that a new public private partnership be set up (modeled on PPP-SiN) with efficient coordination and administrative support in which the authorities, educational institutions, educa, SWITCH, ICT service providers, educational research, academies etc. all actively participate.

With 2012 as the starting date, the duration of three years for a project of this type seems reasonable (cf. the "cloud computing for Swiss authorities" project):

• Approx. 6 months for analysis and concept.

• Approx. 6 months to realize one or several pilot community clouds.

• Approx. 1 year for the pilot phase.

• Approx. 6 months for its evaluation.

References

[1] NIST: The Nist Definition of Cloud Computing
[2] CloudFinder: Anwenderberichte (in German)
[3] World Economic Forum: The Global Competitiveness Report 2012-2013
[4] INSEAD: The Global Innovation Index 2012
[5] Avenir Suisse: Das am stärksten industrialisierte Land der Welt (in German)
[6] SECO: eEconomy in der Schweiz: Monitoring und Report 2012 (in German)
[7] World Economic Forum: The Global Information Technology Report 2012
[8] Web Index: Web Index 2012
[9] BAKOM: Federal Council's Strategy
[10] BfS: Businesses - Indicators
[11] IBM: Smarter Planet
[12] Source: IBM Symposium 2012, Luzern, 05.06.2012
[13] Wikipedia: Green IT
[14] Evita (in German)
[15] VITACLIC (in German)
[16] BAG: Elektronisches Patientendossier (in German)
[17] Akademien der Wissenschaften Schweiz: Zukunft Bildung Schweiz (in German)
[18] SATW: Topical platform ICT
[19] CabinetOffice: Data Centre Migration, G-Cloud and Application Store Programme
[20] W. Müller, J. Dischl, U. Widmer. Cloud-Computing-Strategie der Schweizer Behörden 2012 – 2020. Version 12, 25.4.2011 (in German, released by the Project Committee).
[21] E-government strategy Switzerland. passed by the Federal Council on January 24, 2007.
[22] ISB: Cloud Strategie (in German)
[23] W. Müller, J. Dischl, U. Widmer. Kommentar zur Cloud-Computing-Strategie der Schweizer Behörden. Version 10, 25.4.2011 (in German, approved by the Project Committee)
[24] Wikipedia: Digital Native
[25] Example: Cloud-Finder (in German)
[26] Wikipedia: Bring Your Own Device
[27] Deutsche Bundesregierung: Hightech-Strategie (in German)
[28] pwc: IT-Sourcing-Studie 2012 (in German)
[29] Wikipedia: Safe Harbor
[30] Wikipedia: USA PATRIOT Act
[31] Euro Cloud Swiss: Leitfaden Cloud Computing (in German)
[32] SWITCHaai – the key that connects students and the university
[33] Suisse ID (in German)
[34] European Commission: STORK: Secure Identity Across Borders Linked
[35] Seeking New Horizons: EGI: EGI's Role in 2020, S. Newhouse et al., April 2012
[36] European Commission: Digital Agenda for Europe
[37] EDK: PPP-SiN: Ein wichtiger Impuls - zur richtigen Zeit (in German)
[38] educanet2.ch (in German)
[39] BBT: Mauro Dell'Ambrogio leitet ab 1. Januar 2013 das neue Staatssekretariat für Bildung, Forschung und Innovation (in German)

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