A VERY REAL CLOUD

Best Practices for Cloud Adoption

in Higher Education

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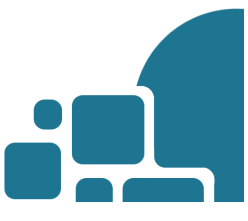
RÉPUBLIQUE FRANÇAISE

MINISTÈRE
DE L'ÉDUCATION NATIONALE,
DE L'ENSEIGNEMENT SUPÉRIEUR
ET DE LA RECHERCHE

Université numérique
Paris Ile-de-France

Contents



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Why publish a guide to cloud computing?

The Office of Educational Technology (*Mission numérique pour l'enseignement supérieur* or MINES) identified the need for a white paper on cloud computing. UNPIdF, with its advanced subject expertise and understanding of the French context, was tasked with drafting the paper.[1]

The guide's main objective is to provide a common knowledge base on cloud computing and its applications in higher education. It ties in with the EdTech agenda, which stipulates under Action no. 12 the need to *"encourage higher education institutions to rationalize their IT infrastructure by pooling their data in secure, eco-friendly data centers."*[2]

This paper draws on the expertise of the Paris Ile-de-France Digital University (*Université Numérique Paris Ile-de-France*, or UNPIdF), which has accumulated a significant amount of knowledge over the past five years through participation in international conferences, writing white papers and managing projects focused on cloud computing. For instance, its work in collaboration with industry partners on the UnivCloud R&D project has paved the way for development of a community cloud for universities.[3] The guide also aims to highlight the key issues that the cloud raises for universities.

This guide is intended for all those involved in higher education IT. Far from being limited to experiences in the Paris region, it presents initiatives being conducted in various parts of France as well as offering an international perspective. The use cases presented throughout the paper were chosen for their relevance to cloud computing; they also reflect the willingness of respondents to be interviewed.

Chief information officers (CIOs) and vice presidents for information technology are the first concerned by this guide. It is intended as a practical, easy to understand and illustrated resource from which they can draw information for any presentations or brochures they need to prepare. It will be updated from year to year.

The guide's success will be measured by the extent of its distribution within the EdTech ecosystem. It is designed for all actors of higher education IT, in the aim of optimizing knowledge transfer. Each chapter stands alone, so readers should feel free to take only what they need with no fear of impeding their understanding.

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[1] UNPIdF is the force behind the Univcloud project, outlined in the box on the following page.
[2] The Ministry of Higher Education EdTech agenda (in French, *Agenda numérique*) is available on the France Université Numérique platform http://www.france-universite-numerique.fr/18-actions.html accessed May 18, 2015)
[3] For more information on the Univcloud project, visit the dedicated website: http://univcloud.fr/

Introduction

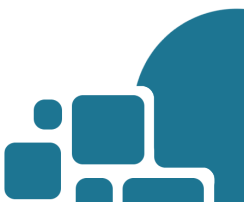
For the vast majority of the public, cloud computing remains a mystery. It is enough to recall a few recent – and funny – movie lines, where storing a video in the cloud is assumed to mean it will be lost forever in some far-off galaxy and that its destiny is therefore entirely out of our control. This concern over data control is a central issue of cloud computing.

A whole legend has been built up around the cloud by an unending stream of speeches and press articles, some of which are poorly researched. So much so that no one seems to agree on the origin of the word. Some explanations have it that network architects surrounded the icons for servers with a circle, and a cluster of servers in a network diagram had several overlapping circles, which resembled a cloud. Later, a cloud-like symbol was used to represent the Internet, giving rise to the term "cloud." The general public first became acquainted with the cloud in the early 2000s, when Amazon offered to rent some of its data storage capacity to its customers.

But what is the difference between the cloud and a data center? A data center is a *physical* technical facility housing the servers of one or more businesses or organizations, with its own means of ensuring reliable and secure operations (electricity, air conditioning, and broadband access). The cloud, meanwhile, offers users access to virtualized computing resources over the Internet through standard mechanisms (as specified in the National Institute of Standards and Technology definition), which a data center does not. These digital services can vary, ranging from equipment or infrastructure services (storage space, computing power, etc.) to platform services (development environments, databases and application servers) to software services (software applications for businesses and individuals). A cloud system may draw on multiple data centers. These services are deployed either over shared, pooled environments for the general public (public cloud), over environments specific to a limited consumer group (private cloud), or over a well-defined community (community cloud).

Since it was introduced to the consumer market, the cloud has been the hottest topic in technology. Governments, under the pretext of sovereignty issues, are keen to follow the United States or the United Kingdom in starting their own cloud; companies look to optimize their IT expenses by outsourcing part of their data storage management; communities want to pool their resources, etc. In higher education and research, data center projects abound but the financial context is increasingly restrictive. With mounting pressure from the government to pool resources – IT resources included – the time seems ripe to provide an update on the cloud situation that will clarify not only the financial issues, but also the security and organizational issues involved in implementing a cloud in the higher education sector.

How can we define the cloud today? How can we best address security-related issues? In what way is mainstream use of the cloud transforming universities? How can universities adapt to the changes that new technologies bring? In what ways has the cloud generated a new financial model? How does it alter the map of technology use in different regions?



This paper aims to answer these questions in order to build, if not a new, then at least an up-to-date vision of the possibilities the cloud offers for higher education and research.

In the first chapter, the guide examines the main principles and characteristics of the cloud, as well as market factors and advantages for universities.

The second chapter provides factual information about the different forms of deployment. It also gives examples from French experiences of deployment.

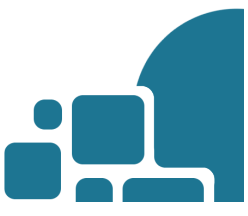
The third chapter addresses the key issue of security. It provides not only the keys to understanding the security debate, but also points of reference regarding personal data and solutions for protecting against the security risks posed by the cloud, especially in terms of data hosting and reversibility.

The fourth chapter focuses on organizational aspects, such as the changes the cloud entails in university IT departments, including in their relations with other departments.

The fifth chapter concentrates on the economic and financial implications of introducing a cloud, and how it transforms management arrangements within the IT department.

The sixth and final chapter recalls that the cloud is not just an abstraction. Not only are the infrastructures that support the cloud dependent on geography, but the presence or absence of facilities has real implications for any region's future.

In parallel, use cases are presented throughout the guide, some of which are entirely original. Most of them concern initiatives currently underway in higher education and research, but they are not limited to this field. Indeed, the cloud opens up new areas of collaboration, pooling, and practices, which represent a huge potential for universities.



Chapter 1 – One cloud, many realities

Definitions of the cloud abound. What differentiates the cloud from a data center, for example, has been summarized by the NIST:[4] on-demand self-service, rapid elasticity, broad network access, resource pooling, and measured service. It can be complicated to interpret the various cloud service models, and this partly explains the ongoing price war in the cloud market, in France and worldwide.

Universities are already using cloud services, and today they too can take full advantage of the storage potential and economies of scale generated by the cloud.

A. The cloud's main attributes

Cloud computing gives users access to a number of resources, including online services, development platforms and virtual machines.

One thing is certain, there are plenty of definitions of the cloud in the literature.

Definitions of the cloud

Of the definitions we analyzed, these four are the most pertinent.

(1) "A solution to enable the purchase and use of IT services from around the world through a network. It is based on four key criteria: resource pooling; metered services, modularity, and standardization of functions " (CIGREF).

(2) "Mode of consumer data processing delivered over the Internet by providers in the form of services" (CSTIC – *Commission Spécialisée de Terminologie et de Néologie de l'Informatique et des Composants Électroniques*, or special commission for IT and electronics terminology and neology)

(3) "Model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources" (NIST – National Institute of Standards and Technology).

(4) "A style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service using Internet technologies" (Gartner).

Box 1: Definitions of the cloud

Most definitions retain five main characteristics from the NIST guidelines: the notion of services, elasticity, pooling, measured capacity, and broad network access.

Tech companies, ever the marketeers, are quick to append the word "cloud" to any form of IT service outsourcing. Appearances are sometimes deceiving, and there are services in the cloud that do not correspond to the five attributes described below. Whether or not this is as it should be is another question, which we will not attempt to resolve here.

[4]List of characteristics established by the National Institute of Standards and Technology (United States) in the publication *The NIST Definition of Cloud computing* available at: http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf (accessed April 23, 2015)

1. On-demand self-service

The cloud is above all an environment that provides access to computing resources, in the same way as utilities deliver water, gas, electricity, Internet access, etc. to users.

As long as you sign up or subscribe to an offering, cloud resources are self-service and delivered on-demand. The external digital resources can be ordered online from a catalog, without human interaction.

In addition, the infrastructure's usage and capacity are magnified by the virtualization of resources. The services share the same physical server infrastructure regardless of the type of user. The data is stored on the same physical infrastructure, but separated in terms of data ownership and who is authorized to access it.

2. Rapid elasticity

Elasticity is the ability to increase or decrease the resources available (virtual machines, applications, etc.). Users subscribe to and/or terminate capabilities according to their needs. Changes are implemented swiftly or indeed automatically.

As such, the cloud provides scalable resources, and this is directly reflected in the bill; users pay more if their needs increase and vice versa.

3. Resource pooling

The cloud is based on the philosophy of pooling.

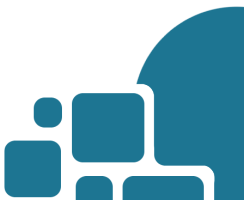
The cloud is based in large part on the philosophy of pooling – sharing a set of resources to generate economies of scale and maximize utilization. What started with vegetable gardens and fields was soon applied to council services and, today, cars and apartments.

The sharing of physical resources (servers, infrastructure) is central to the principle of the cloud. However, resource pooling does not mean that the resources' location can be clearly identified. If they are moved, users are not normally affected.

4. Measured service

The cloud offers CIOs and/or administrators real time visibility into resource usage and availability. This principle also enables usage to be controlled in advance for maximum cost-effectiveness.

To stick with the utilities comparison, the measurable aspect and its impact on billing lies in the "smart meters" that give an idea of usage in real time, like for water, heating or electricity.



5. Broad network access

Access to the cloud is provided continuously through the use of Internet protocols (see Figure 4) on various devices (PC, tablet, smartphone). Users can access their resources regardless of time, place, or the device they are using (fixed phone, laptop, smartphone, tablet, etc).

B. The cloud market in France and worldwide

1. A booming global market

In 2013, the cloud computing market was worth over 50 billion dollars worldwide.

By some estimates, this growing market (expanding by 20 to 30 percent per year) is expected to represent over 50 percent of global IT spending in 2020 (source: Markess).

From now until 2017, the private cloud (where the company owns its own infrastructure) and public cloud (where pooled resources are delivered by a third party – the cloud service provider or CSP) markets should increase more or less in the same proportions:[5]

- The income of private CSPs is expected to increase by 21 percent (source: ICD)
- Business spending on public cloud services is expected to increase by 17 percent (source: Gartner)

Together, Amazon, Google and Microsoft currently hold the majority of market share.

Characteristics of a data center

A data center is a facility with four main characteristics:

* Availability of electricity: electric power supply and transformation, uninterruptible power supply (UPS), generators, inverters and batteries

* Cooling systems: electrical equipment gives off heat, so an air conditioning system must be used to keep the apparatus working

* Computer equipment: bays (application servers, storage servers, etc.), network equipment. In a shared data center, the IT equipment may belong to several companies, with each company pooling only the hosting resources (square meters, air conditioning, electricity, etc.)

* Security: access is secure and a warning system is in place in case of any adverse event.

Box 2: Characteristics of a data center

[5] The public cloud and private cloud are discussed in chapter 2.

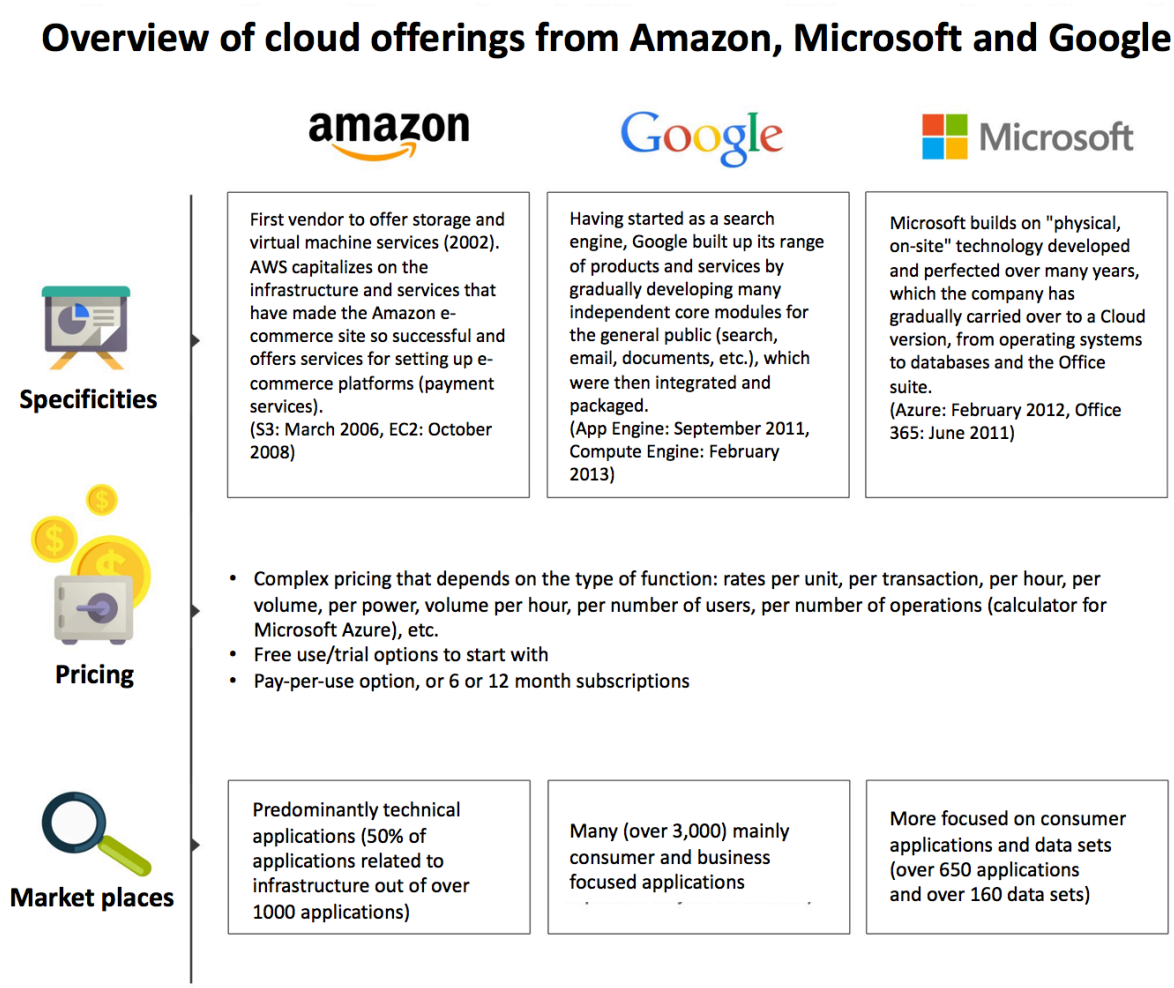


Figure 1: An overview of offerings from Amazon, Google, and Microsoft (source: Infhotep)

2. The price war is also going on in France

The major players in the French cloud market include Orange Business Service (Flexible Computing Premium), SFR Business Team (IS Infrastructure), Gandi, OVH, Colt (Colt Enterprise Cloud), Osiatis, and Steria (Infrastructure on Command). Other, smaller companies also offer cloud services, such as So Privé and Waycom (cVirtuel).

The diversity of companies claiming to offer cloud services reflects the vast range of possibilities

This throng of companies from different backgrounds sometimes uses an aggressive and even brazen approach, to the extent that the word "cloud" can hide many more or less cloud-based solutions. The diversity of companies claiming to offer cloud services reflects the vast range of possibilities, from provision of hosted infrastructure to software available on the Internet via access to databases, storage solutions, and more.

Several government cloud projects have emerged in the French market, in the aim of offering greater transparency to government and public sector organizations. They are addressed in chapter 2.

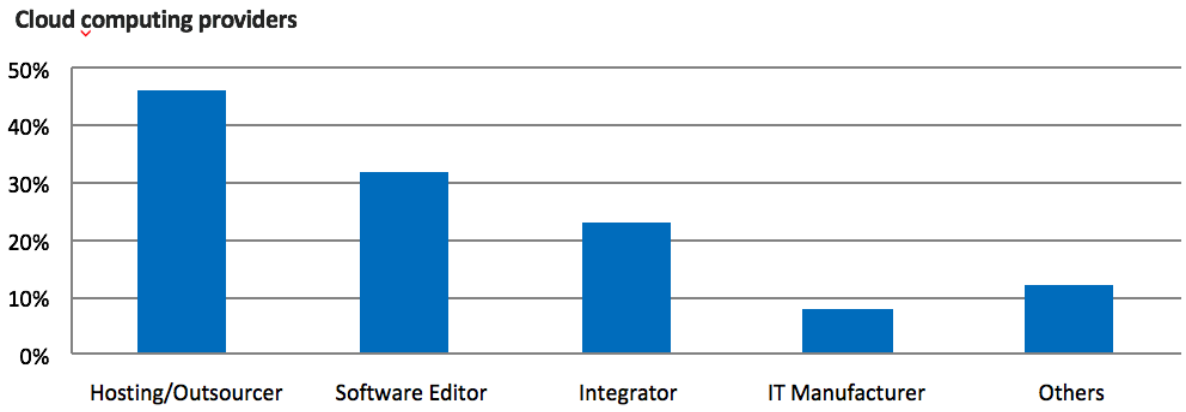


Figure 2: Cloud service providers (source: Infhotep, data from CRIP)

This business model confers a first mover advantage, since the first entrant has already made the investments necessary for launching its service. All those that follow must not only align with the prices offered but also cover fixed costs.

Data center and cloud at the Lyon COMUE (university grouping)

Two questions for Laurent Flory, CIO of the Lyon COMUE

How are cloud projects organized at the Lyon COMUE?

One of the universities in the COMUE hosts the grouping's management information system. The Lyon COMUE has been granted a pre-planning loan under the CPER (state-regional authority investment plan) for setting up a data center.

What are the services offered?

The data center will provide a useful SaaS business application that acts as an interface between the contracting owner and the project management team for the campus development plan.

Box 3: Data center and cloud at the Lyon COMUE

C. What can the cloud bring to universities?

Three types of resources are offered in the cloud: business applications, software, and hardware.

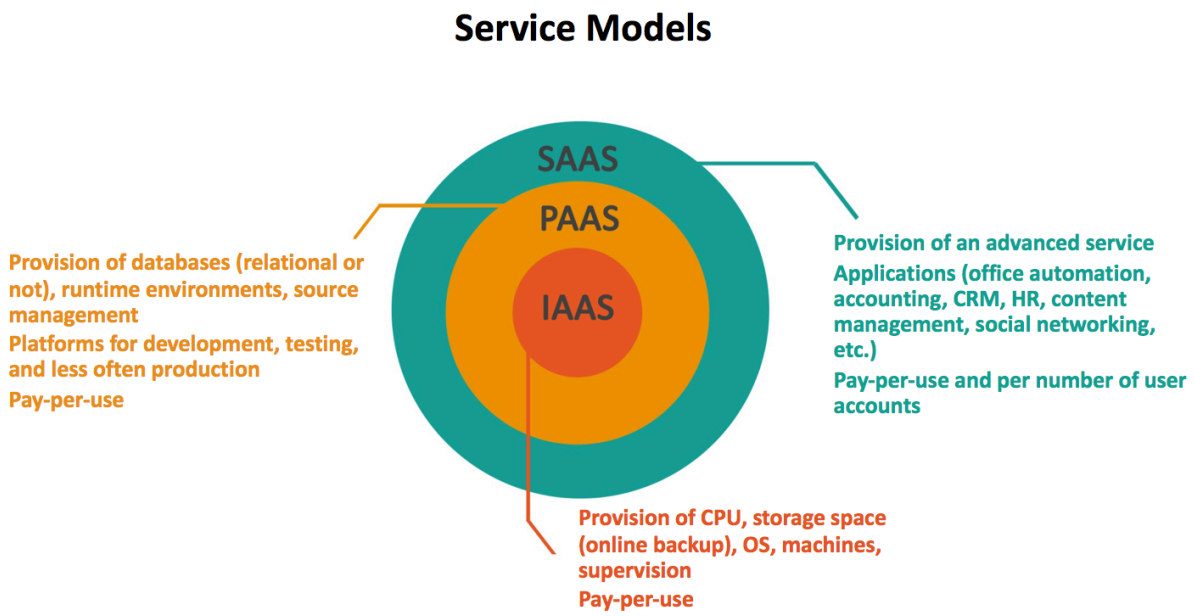


Figure 3: Cloud service models

1. Software as a Service (SaaS)

A provider licenses web applications to customers for use as a service on demand. Many organizations or institutions can use the application at once, and all share the same version of the software.

- SaaS gives to access advanced, relatively standardized services, including desktop applications, business software, a DMS, collaborative tools, etc.
- The cost of the service depends on the number of users and level of use.

In the French university landscape today, there are few companies delivering SaaS applications. AMUE and Cocktail offer a number of business applications and tools for universities, for the moment in IaaS mode.

Collaborative service offerings from Google and Microsoft compete with the services that universities provide to their users because they make it possible to escape from the silo of the institution. These suites take full advantage of the cloud by being cross-organizational. Universities could offer much broader collaborative solutions if they were to pool their services and infrastructure.

University of Tours data center

Four questions for Franck Estay, Vice President for Information and Communications Technology

What are the main characteristics of the University of Tours data center?

In 2012, the University of Tours embarked on construction of a 70m2 data center that hosts the management applications and servers of the various departments and laboratories. Its main characteristics are:
- Power: 100 kW
- N+1 redundancy
- Batteries: 1hr runtime
- Monitoring, humidity sensor
- Power delivery path from above.
- Real estate cost: one million euros, renovation of the second floor of a building requiring a slab to be laid

This is also a green data center with a hot/cold aisle configuration. The cube is air-conditioned. The data center uses the fiber optic broadband available throughout Tours and its suburbs.

Does the data center host other organizations besides the university?

We have a partnership with the City of Tours. The data center currently hosts a bay for the Tours council (disaster recovery plan). The university is seeking other partnerships with other universities (Poitiers, Limoges, Angers) to optimize the use of storage capacity.

The university has made a proposal to the COMUE to create a network of three data centers, but this project is still in the early stages.

In the future, the plan is to double the data center so as to set up a DRP (disaster recovery plan)/BCP (business continuity plan), bearing in mind that the higher education and research network can support up to 10GB/s.

What are the plans for pooled cloud services?

Currently, there is a project to extend the Moodle platform (which is already shared with Orleans) to the INSA (National Institute of Applied Sciences) Center in Val de Loire. Expertise is being pooled for the project, which is currently in the testing phase; two full-time staff work on the project throughout the year. Orleans draws on Tours's expertise, uses the platform and funds the staff assigned to the project. In return, it has a certain number of days per year to carry out its own projects. INSA also intends to use Tours' expertise.

What are the existing cloud services?

The university uses collaborative tools in the cloud. It uses different open source components for the access portal (Liferay), workflow (Bonita) and file management (Nuxeo), archiving (Asalae), streaming (Sollan), and document recognition (EMC Captiva). This project will be rolled out gradually to cover all 2,500 university staff and faculty members, starting in June 2015.

With these collaborative tools, the university intends to set up a project for the dematerialized management of research agreements with a connector to the accounting information system (AIS) (that AMUE could integrate into the AIS) and document management. The goal is to have a document management system available that can be linked to the multiannual financial operations.

Finally, for four years now, a cloud printing service (pull print) has been available at the University of Tours. Wherever they are, staff and faculty can print from a single driver, copy or scan and distribute their work with their multiservice card. This has allowed the University to make significant savings thanks to a considerable drop in the number of copies and printers, and to multifunction deployment on all sites.

Box 4: University of Tours data center

2. Platform as a Service (PaaS)

PaaS provides access to the middleware that supports business applications over the web: databases, application servers and operating systems. Organizations often have a weaker grasp of this segment. Currently in France, PaaS remains confined to large accounts for “disposable” uses, such as prototypes or temporary websites for events.

It gives access to a platform for executing code, which may include databases (relational and non-relational: DBMS, RDBMS), execution environments or source management (CDN, desktop). It also provides access to development and testing platforms, but rarely production platforms.

The cost of the service depends on the level of use.

3. Infrastructure as a service (IaaS)

IaaS is a means to outsource machines, disk space or computing time.

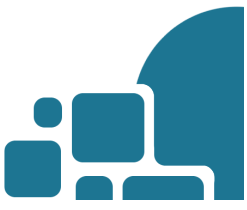
IaaS provides on-demand access to machines, disk space or computing time. Today, large organizations often provide private IaaS, with a view to capitalizing on their internal skills and their investment in infrastructure.

For example, the French company Gandi.net has become specialized in the IaaS segment.

The cost of the service depends on the level of use.

Services intended for customers or users represent the “front office” of the cloud:

- SaaS: this group of services delivers the functionality of a software or application (via an interface, a web service or website);
- PaaS: this group of services provides a hardware and software platform and associated services for the development and/or running of applications;
- IaaS: this group of services make IT infrastructure available, along with the associated material resources, through virtual machines.



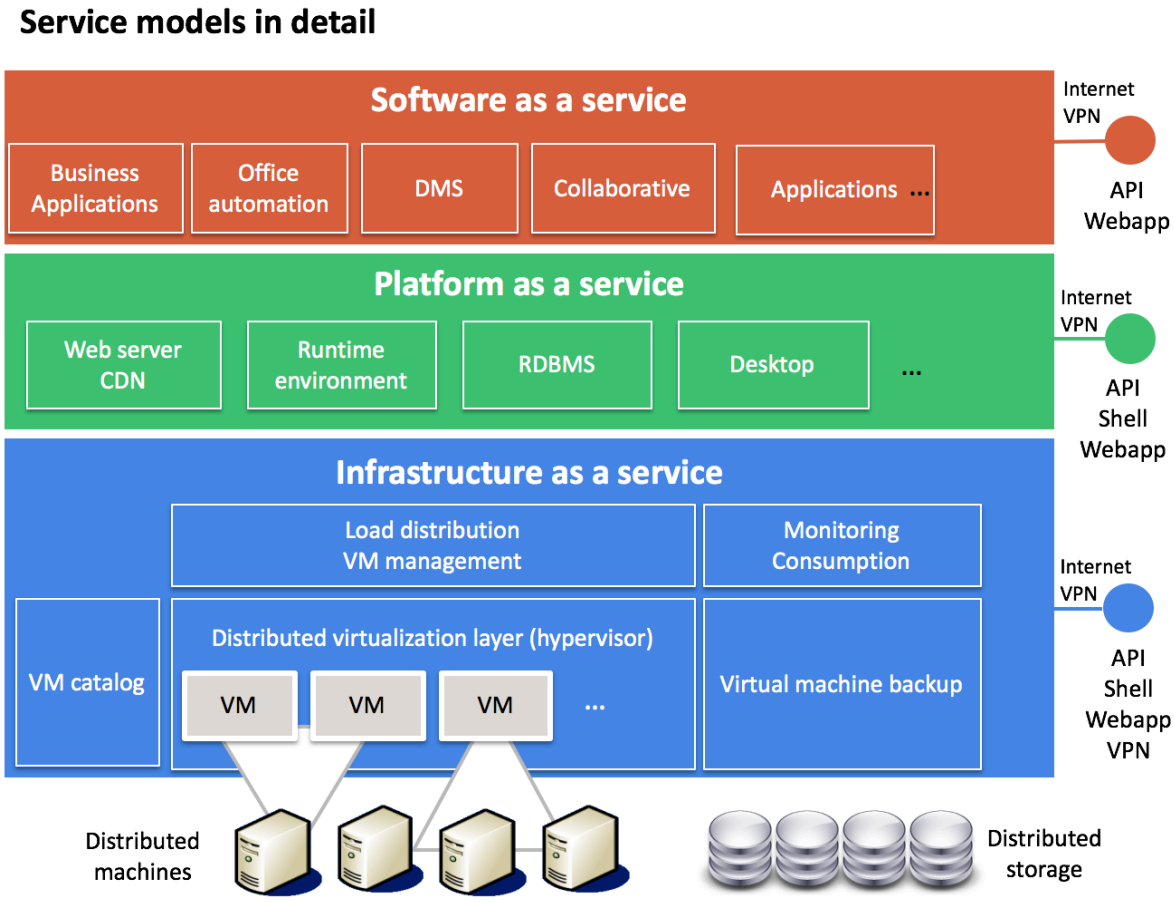


Figure 4: Content of the various cloud services

D. Cloud use in universities

When it was preparing its financial model, UNPIdF took a comprehensive inventory of the costs of its member institutions' information systems.[6]

A questionnaire was sent to 31 institutions.

The response rate (77 percent, or 23 responses out of 31 questionnaires) was sufficient to draw representative conclusions, including in terms of cloud use. The figures provided below derive from the responses to the questionnaire sent to CIOs (excluding local IT and ICT in Education departments). The figures collected are from 2013 data. The survey also shows that, due to a lack of pooling, universities are over-equipped with regard to the needs of each institution. The level of virtualization is low, and storage capacity is excessive compared to actual use, as each institution provides for a margin of expansion that could perfectly well be pooled.

50 percent of the institutions surveyed were using cloud-based services in 2013 and 10 percent planned to initiate projects in 2014.

[6] See Report on the UNPIdF financial model

The main services implemented in the cloud by the universities surveyed were email, the use of collaborative spaces, hosting (data, virtual machines, websites) and storage.

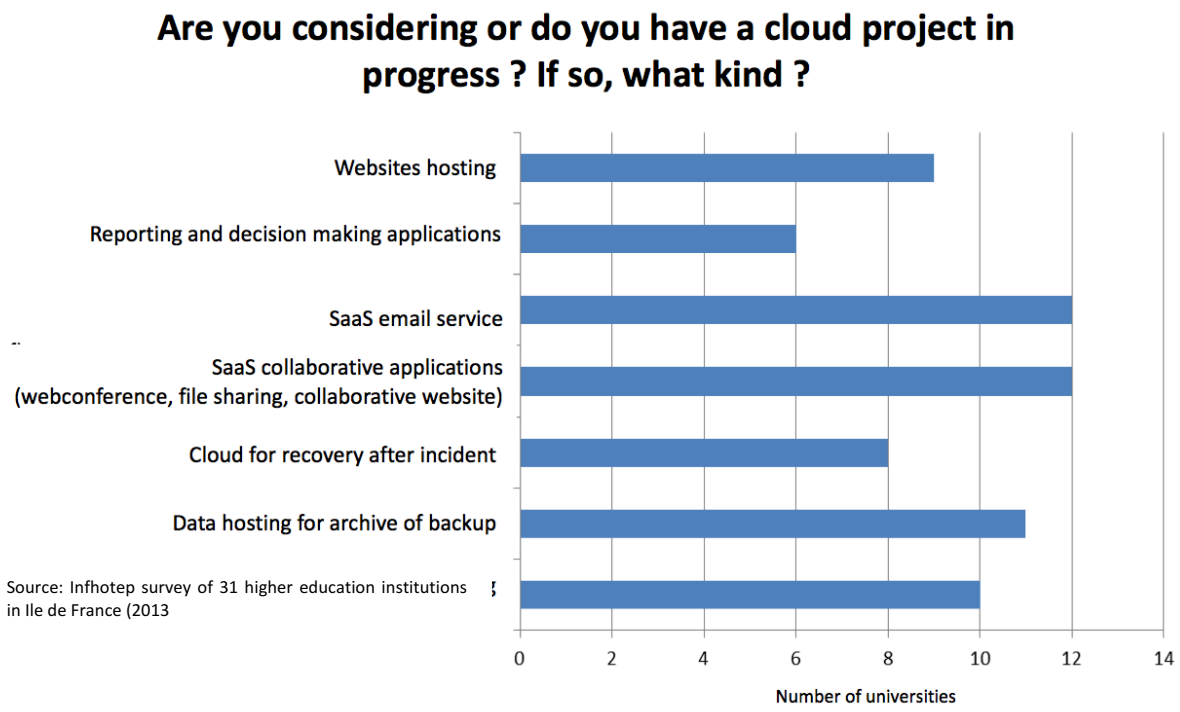


Figure 5: Nature of cloud projects under consideration or implemented.

University of Nantes data center

Five questions for Michael German (CIO of the University of Nantes) and Vincent Barré (Digital Project Manager at UNAM - Nantes Angers Le Mans university grouping)

Could you present the data center in a few words?

Our 160m² data center is very new; it was delivered at the end of November 2014 and it has just been officially opened (April 2, 2015).

How are the buildings designed?

The building was designed in a modular fashion with four main zones. (1) University of Nantes: corresponds to the current needs of the Information Systems Division as a whole as well as the current and future needs of other university staff and departments; (2) HPC (High Performance Computing): specialized for scientific computing (for research centers: CCIPL, IRS, etc.) with the ability to host very high density equipment; (3) Network / Renater: hosts the central network of the University of Nantes, the Gigalis regional network, and the Renater national network; (4) Third parties: possibility of hosting the machines of other public bodies (other universities in the region or even beyond).

What are the safety and security guarantees?

All exterior and interior elements of the building are of course secure. Nevertheless, to ensure easy access to the data center's various users, centralized access controls have been deployed which are compatible with the access cards of university staff (and extended to UNAM staff).

In addition, the building can hold 52 bays of equipment and use up to 400 kVA of electric power while maintaining its tolerance to breakdown and energy efficiency.

How was it funded?

The project was supported by three main actors: the region, the university and the state. The Pays de la Loire region provided 800,000 euros in funding, the state 200,000 euros and the University of Nantes 200 000 euros.

What prospects are there for pooling?

The question of pooling was integrated from the outset. The data center already hosts machines, and an Infrastructure as a Service (IaaS) system will be available from late 2015. This will allow any user to start a complete, secure virtual infrastructure in the data center (computing resources, storage, networking, and preinstalled operating systems), all very simply (with a few mouse clicks) and in a matter of seconds.

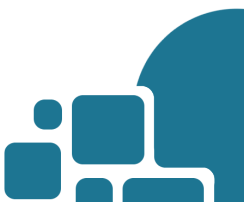
Box 5: The University of Nantes datacenter

Chapter 2 – Cloud Deployment

The principle of the cloud is to share infrastructure and service resources to optimize their use and achieve economies of scale. Four deployment models exist with differing levels of accessibility.

- Public cloud: the cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a private or public organization. It exists on the premises of the cloud provider.
- Private cloud: the cloud infrastructure is provisioned for exclusive use by a single organization. It may be owned, managed, and operated by the organization or a provider. It may exist on or off premises. Large companies may decide to set up private cloud infrastructure to streamline their operations (for example, the Ineo Group applied the findings of UnivCloud's research to its organization).
- Community cloud: the cloud infrastructure is provisioned for exclusive use by a specific community with shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community or a third party. It may exist on or off premises.
- Finally, the hybrid cloud offers a combination of private and public infrastructures.

To get round the confidentiality problem raised by the public cloud, the French government is trying to establish a government cloud project (see below).



A. Deployment models

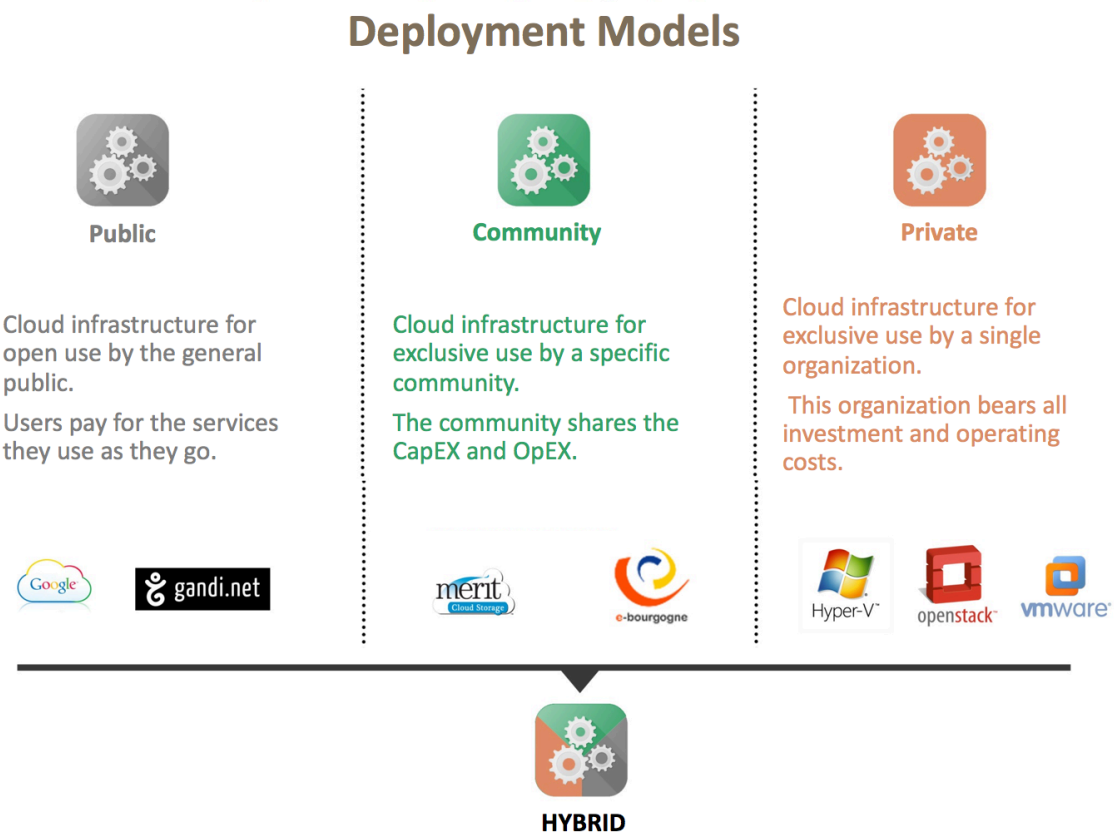


Figure 6: The four cloud deployment models

1. Public cloud

The public cloud can be deployed nationally or globally. The infrastructure is made available to several categories of users (and not to a specific organization). These users pay for the services they use as they go. The distinction between "public" and "private" therefore has nothing to do with the economic sectors concerned.

The advantages of this type of cloud derive from large-scale use, which multiplies the benefits of pooling. This ensures greater capacity, economies of scale and a pay-per-use pricing model. Users only pay for operating expenditure or OpEX; they do not have to bear the initial investment costs. However, the public cloud elicits strong reservations with regard to sovereignty issues, and to the fact that infrastructure is not hosted locally (or at least on national soil).

Because of this, and to counter public cloud offerings from the giants Google and Amazon, states are trying – with varying degrees of success – to deploy domestic solutions (see below).

2. Private cloud

When large organizations (companies, local authorities, etc.) decide to launch their own cloud and therefore become their own cloud service provider, this is a private cloud. They do not use a CSP's services, but deliver the service themselves. This means that the infrastructure is made available to a single organization.

The private cloud requires a large investment because the organization that hosts the infrastructure bears all investment and operating costs.

This model has many advantages, such as the ability to adapt services as closely as possible to the organization's needs (customization), greater security, a degree of control, and more simplicity in legal terms. However, it generates capital expenditure (CapEX). This model usually applies to large corporations, which pool the infrastructure of several of their subsidiaries or affiliates.

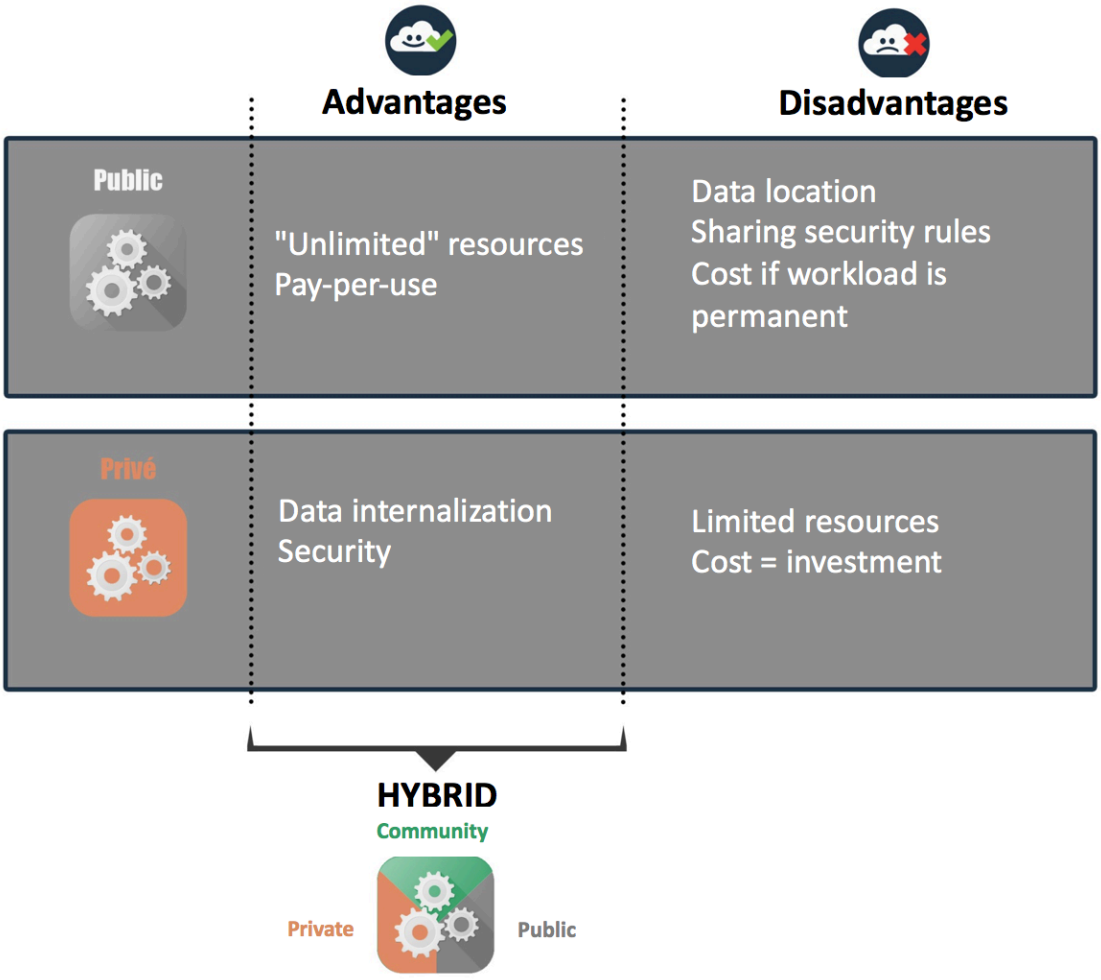


Figure 7: Public cloud / private cloud summary table

3. Community cloud

Halfway between the private cloud and public cloud, the community cloud implements an infrastructure for a community, which shares the CapEX and OpEX (UnivCloud project at university, Amadeus for airlines, CMed for

pharmaceutical companies, e-Bourgogne for local authorities, etc.). This type of cloud is popular, and rightly so, particularly because it solves the problem of trust by addressing a defined circle, which complies with regulatory and legal requirements, and thus limits the reversibility conditions of public procurement.

The entity operating the cloud can take many legal forms: public, public service delegation, public interest group, public-private partnerships, etc. The appropriate legal form depends on the specific context.

Furthermore, besides the fact that it is reassuring, data proximity solves the bandwidth issue. Over a large area, network quality often falls short. However, to ensure adequate connectivity with central offices, access to the network must be effective. Geographical proximity is still the easiest way to ensure this in the short or medium term.

These two reasons explain why many projects for new data centers (or cloud services) are emerging in France, despite promises of a national public cloud.

The UnivCloud project

Five questions for Amandine Alehyane, UNPIdF project manager (Paris-Ile-de-France Digital University)

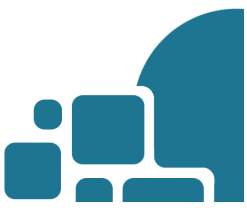
How was the project initiated?

The UnivCloud project is France's first inter-university cloud. It was selected in 2011 by the French government as one of five cloud computing projects to support the emergence of next-generation IT infrastructure. This research and development project is part of the French state investment scheme, "Investissements d'avenir". Initiated by Paris-Ouest Nanterre La Défense and Paris I Panthéon-Sorbonne universities and run by UNPIdF, UnivCloud aims to pool information system and digital infrastructure for higher education and research. The objective is to offer a flexible, responsive and agile shared platform to all universities and local authorities, so they can deploy and use digital services on demand (university services, student life services, local services, etc.)

What makes the project innovative?
The project in itself is atypical. It managed to bring together the university and industrial spheres, as well as start-ups, to work together over the course of many months. It is also one of the most ambitious university projects in the last ten years in the tech field, with 26 institutions involved. Furthermore, this large-scale collaboration introduced a new operational model to the university arena. Various workshops were set up with permanent exchanges between all participants. If bringing several universities together several times a month and getting them to collaborate was a challenge in itself, doing it in the Paris region was even more so. But everything worked: we were able to successfully complete the pilot phase in a very short time – under two years.

What exactly does the UnivCloud project involve?
It is true that there are many cloud offerings on the market. But for faculty and students, data protection is crucial. The project involves setting up a specific cloud for this community, with data centers located in France. That way, the data remains on home ground, under the responsibility and control of the community. The UnivCloud project proposes to deliver IT resources on demand to member universities, and enable IT departments to order and then manage all the resources they require. It also allows inter-institutional digital services to be put in place.
Universities will have access to:
- an "operator" portal for advanced control of operations and continuous performance improvement.
- a "user" portal to access the catalog of services that universities will provide to users, faculty, etc.

Box 6: The UnivCloud project



4. Hybrid cloud

This IT environment makes use of several clouds, which may be public, community or private.

Many companies offer their users a combination of private and public clouds. In some cases, this mixture is fully integrated in a portal that offers users the best of both clouds (seamless use of various cloud solutions, service orchestration, automation and aggregation, etc.)

B. Government cloud projects

Communication on government cloud projects is not always transparent, whether from government or industrial stakeholders, so it is hard to provide an exhaustive overview.

Government cloud projects aim to provide a specific offering in response to the issue of confidential data protection and to the Patriot Act.[7] The mistaken belief that data must be stored on servers physically present in the US is still widespread. Of the multitude of projects proposed initially, two still exist: CloudWatt (Thales, Orange, CDC) and Numergy (SFR, Bull, CDC).

The French Ministry of Education cloud

Interview with Mathieu Jeandron, CIO for Education

Why move towards the cloud?

Several issues led the Office of Education Technology to take a close interest in cloud computing. The first is the need to streamline infrastructure through pooling and greater virtualization of machines, and to be able to offer services. This issue directly concerns IT departments. The second challenge is to make developers' lives easier by helping remove infrastructure contingencies from the equation – by providing them with a catalog of services, for example. The third issue is to accelerate the adoption of digital tools, especially collaborative services, while bearing in mind that schools can't invest anywhere near as much as Google, Microsoft, or Apple to develop such tools.

The political question is: should we focus on developing solutions internally or look to external providers? Outsourcing does not pose a major problem in terms of security, as long as there is an adequate a legal framework. This means that contracts need to be put in place, and if we take this on at state level, we can arrive at more advantageous agreements. We're left with the big question of the Patriot Act and the NSA [National Security Agency].[8] The issue of economic patriotism is misplaced; France's interest lies in the development of new and innovative services.

How is the Ministry of Education placed at present in terms of data centers and digital services?

Each regional education authority has a computer room of six to ten bays. Very few of them have their machines elsewhere. There is a strong culture of sourcing internally. Schools have access to the education authority's applications, and to more learning-focused applications that are not provided by the education authority (these are provided by the regions for high schools, and the departments for junior high schools). Many software publishers are considering providing their services in SaaS mode. Some tools provided by the

[7] American anti-terrorist law that requires all cloud service providers operating in Europe or anywhere in the world to comply with requests for data if they also have operations in the United States.

[8] Patriot Act: see definition p. 19

CNED [National Center for Distance Education], Canopée for example, are hosted in their own data centers.

In terms of the operations being planned, it is not economically viable to maintain small IT rooms, so when major upgrades are undertaken, pooling is the way to go. This includes:

- densifying the network as much as possible: the regional education authority has already had work done and has square meters available;

- pooling with universities, etc. We can mention several interesting initiatives here (Montpellier: H2M; Grenoble: @ GR3; Clermont: the two universities wanted to consolidate with a room a third full open to the entire education authority, and they are working with the region to host start-ups; Rouen: the CRIAN initiative which the education authority is encouraged to join).

At national level, there are applications shared by all the regional education authorities that need hosting. The previous team at the ministry of education outsourced this to IBM four or five years ago. Today there is a strong will to host these applications internally again using the square meters we have available. Moreover, it would be an additional cost to switch aging applications to the cloud. The cloud is made to host new applications.

What needs have been identified for cloud computing?

The cloud is necessary for new developments at the national level: on-demand learning environments, qualification environments, virtualization tools for highly standardized workstations, and various tools such as developer-oriented tests.

The cloud is also necessary for a service offering from the education authority: 3D visualization environment, websites, production and hosting of videos, an online store for purchasing online resources, social networks (today there is the Viaeduc social network for teaching professionals, and the idea is to set up a network for the teacher-learner relationship), and storage.

The choice will be based on the level of integration with the IS.

Are there any link-ups or collaborations planned with Higher Education and Research?

Of course, we have the same network and identity federation. The Ministry of Education is very interested in the FUN/MOOC system. It may be possible to reflect jointly on a service offering, which would mean deciding on the right level of pooling for infrastructure and applications.

Box 7: The French Ministry of Education cloud

1. The French Numergy and CloudWatt projects

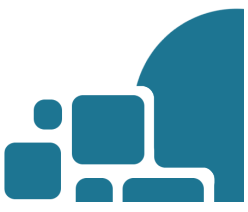
The government cloud project, dubbed Andromède, was launched in 2009 to counter American public clouds (IBM, HP, Microsoft, Amazon Web Services, etc.) and protect state data with regard to the Patriot Act.

Andromède was designed as an IaaS platform to which partners could add services (storage, safety, software, etc).

After several options had been considered, Andromède spawned two competing projects, both funded by the state to the tune of 150 million euros (75 million euros each):

- Numergy (SFR (47%), Bull (20%) and Caisse des dépôts (French public funding body) (33%))
- CloudWatt (Orange (44,4%), Thales (22,2%) and Caisse des dépôts (33,3%)).

The technical and commercial approaches of CloudWatt and Numergy are very similar. There are differences though, such as Cloudwatt's OpenStack (opensource) specialization and Numergy's advanced cyber security approach.



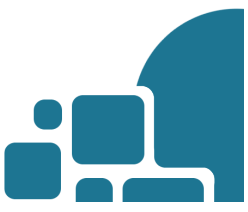
CloudWatt	*Numergy*
Founded in September 2012, CloudWatt presents itself as "a producer of digital power offering on-demand IaaS cloud services: servers, storage, and network".[9] CloudWatt is based on an open source platform (OpenStack) and a computing power solution (Compute - Infrastructure as a Service). The company says it can provide its customers with: • preconfigured virtual servers on demand • storage (block and object); • network components for building private networks in the cloud that can be connected to corporate networks via the Internet. CloudWatt guarantees data location on French soil (Tier 4 data center located in Val-de-Reuil, operated by Orange). In January, negotiations began over acquisition of CloudWatt by Orange. Orange has since completed the takeover, acquiring the 33.3% stake held by the Caisse des dépôts and the 22.2% stake held by Thales for undisclosed amounts.	"Founded in September 2012, Numergy is a company specialized in the construction and operation of cloud computing infrastructure for the French and European markets."[10] The company offers various levels of services to businesses (small, medium, and large accounts) and public organizations including: • virtual machines • storage • bandwidth The data centers are all located in France, in Courbevoie, Vénissieux and Trappes. Numergy runs a dedicated network of partners (software publishers, IT engineering firms, integrators and IT resellers), and promises high availability infrastructure and data location in France.

Currently, the future of these two projects is compromised. Some analysts argue that the strategic positioning of the French government cloud has been misguided from the outset. It was devised to counter offerings from Amazon, Microsoft and Google, which achieve significant economies of scale with their huge number of servers (Google is said to have about two million servers, Microsoft more than a million, Amazon about 500,000).

To succeed, the government cloud might have been better to focus on a less ambitious, more achievable objective:

- Building a cloud for public administration (state, public services, ministries, etc.)
- Building a European cloud?
- Building a cloud for French software publishers?
- Building a cloud to host health data?[11]

[9] Source: https://www.cloudwatt.com/fr/a-propos/index.html (accessed March 20, 2015)
[10] Source: https://www.numergy.com/ (accessed March 20, 2015)
[11] Source: http://www.silicon.fr/faux-depart-cloud-souverain-109780.html#xHk41jwVrUVGbits.99 (accessed March 20, 2015)



2. The American experience

In the United States, federal agencies committed in 2010 to consolidating their data centers (Federal Data Center Consolidation Initiative – FDCCI) in favor of more efficient computing platforms with a smaller ecological footprint, in order to reduce IT investment and optimize information systems.

The cloud.cio.gov website lists the best practices of cloud systems within each US government agency. It details lessons learned from various experiences – business applications, agile infrastructure, social networking services, email services, website hosting – in government agencies with different missions – treasury, agriculture, environment, defense, general administration, aeronautics, etc.

The site mentions several success stories in various areas of the cloud:

- Applications
- Website hosting
- Infrastructures
- Email solutions
- Collaborative spaces
- Security

In each of these areas, one or more federal agencies are cited as examples, with fact sheets that outline the problem encountered, the chosen solution, and results (quantitative and qualitative).

Figure 8: Objectives of the cloud.cio.gov site

The failure of the American experiment is a useful case study to consider in order to avoid making the same mistakes when launching a cloud across a region or a state.

This website exists in large part because of the failure of the apps.gov site, which was suspended in 2012. The site had been designed like a store, where federal agencies could choose the cloud applications and services they needed. It was a good idea, and many people were disappointed when the project was abandoned.

Several lessons have been learned from this failure:

- Overall aesthetic is important. According to some observers, the site looked like a "service catalog from 1998;"
- Overall usability is also a success factor: apparently is was impossible to find the application you wanted;

- The applications and services offered had not all received the accreditation and certification necessary for their adoption by a federal agency.

The cloud and state modernization

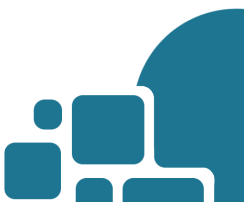
The establishment of the French interministerial office of information systems and communications (*direction interministérielle des systèmes d'information et communication*, or DISIC) in February 2011 was a strong signal from the French government of its intention to streamline and coordinate ministerial IS policies. Public sector CIOs face two major constraints: the reduction of public spending, and information protection and cyber crime prevention.

Like the U.S. government, the French government wants to offer a cloud service, which would be run by DISIC. In principle, this initiative would allow for better control of the applications deployed and a streamlined choice of services.

The cloud would offer both IaaS and SaaS services (collaborative, business, and mobile applications).

NB: This cloud does not cover the Ministry of Education or the Ministry of Higher Education and Research.

Box 8: The cloud and state modernization



Chapter 3: Cloud Security in Perspective

A number of studies mention the barriers to cloud adoption, and security always figures at the top of the list. Cloud security actually concerns three distinct issues:

- availability of data
- confidentiality
- regulations, particularly regarding the protection of personal data

This chapter aims to shed light on the security debate, alleviate concerns and clear up some misconceptions surrounding the cloud, particularly on the issue of data hosting and reversibility (the reversibility of the contract with the CSP needs to be thought out carefully to prepare for a potential change of partner).

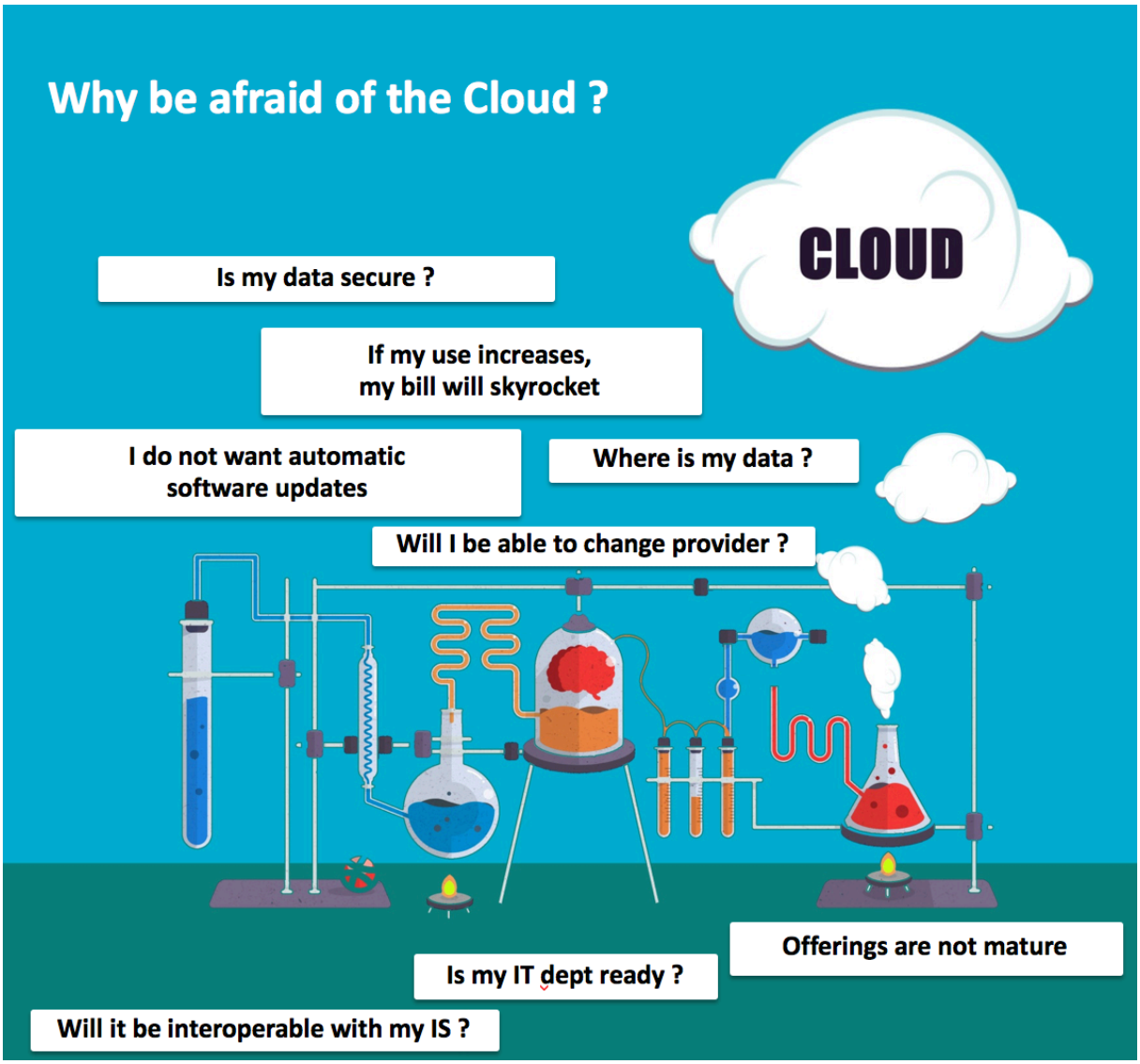


Figure 9: CIOs' main worries about the cloud

A. Understanding the security debate

The security aspects of the cloud generally focus on topics such as data hosting, confidentiality and reversibility (i.e., the possibility of changing CSP). One common misconception is to think that because the data is hosted externally, the security risk increases. However, figures show that 80% of cyber crimes are committed within organizations themselves. In addition to data location, the issue of access control is paramount.

There is no such thing as absolute security

The tech industry prefers to talk about "risk management" rather than security. This means understanding and assessing the real risks that an organization may face. To use a famous metaphor, it is no good installing a reinforced door if the walls are paper-thin and the people with the keys hide them under the mat.

Real data security is far from a purely technical problem. It depends on the strength of the weakest link – men and women who are not always aware of the risks in the event of data loss or leaks. The General Security Framework (*Référentiel général de sécurité* or RGS), written in 2010 by the French agency for information systems security (ANSSI) and updated in June 2014, recommends in the first instance to carry out an assessment of the risks that threaten information systems:

"The risk analysis process involves identifying the events that may affect the security of the system, estimating their consequences and potential impact, and then deciding which measures to implement to reduce the risk to an acceptable level. The risks to consider are those that actually threaten the system and the information it processes, transmits and stores, in the environment in which it is located."[12]

The General Security Framework (RGS)

The RGS defines the security rules applicable to the public authorities for securing their information systems, especially regarding any online services they put in place. It entered into force in May 2013.

Source: http://references.modernisation.gouv.fr/rgs-securite (accessed April 10, 2015)

Box 9: The General Security Framework

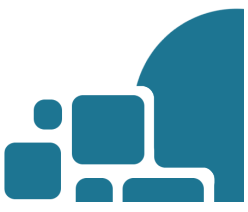
1. Data access

Access to data is the first dimension of the security question.

To guard against any risks when access to data is being considered, the following questions must be answered: who has access to the data? How is the data used? Does the data need to be encrypted?

This means managing user identities and their related access permissions. If the data is accessible to third parties such as CSPs, a confidentiality clause must be included in the contract (see below).

[12] *Référentiel général de sécurité*, Agence nationale de la sécurité des systèmes d'information (ANSSI), 2010 (http://references.modernisation.gouv.fr/sites/default/files/RGS_v-2-0_Corps_du_texte.pdf accessed April 10, 2015)



2. Data location

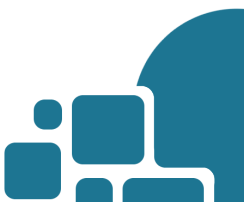
First, it is always possible to find out where data is stored, even in the cloud. Only a company like Google maintains any real uncertainty about data location. Other CSPs offer a map of their data centers, and sometimes it is possible to choose the geographic area(s) where your data will be stored.

At first glance, outsourcing data storage seems more risky than keeping it in the organization, but experience shows that storing data internally does not guarantee confidentiality.

Furthermore, a lot of information is still kept on paper and that data, even when sensitive, is not subject to any particular security measures.

Finally, some supposedly sensitive data is communicated by email – therefore over the Internet – without being encrypted. For example, in some cases, payroll files are sent to the Bank of France by email every month. Ultimately, whether data is hosted internally or externally makes little difference if, meanwhile, confidential information (in our example, payroll data) is transmitted over an insecure channel.

In conclusion, the issue of data location is less a matter of whether it is outsourced or not than of knowing about the actual storage facilities and means of communication. It also requires knowledge of the CSP's obligations. In terms of location, the legislation of the physical location most often prevails (with the exception of the American extraterritorial jurisdiction). That is why it is essential to know the rules that apply to the CSP. There are potentially three main regulatory categories.



Impacts of legislation on the cloud	Examples	Explanation
Rules on sector-specific data	Sarbanes-Oxley (Sarbox or SOX)	CEOs and CFOs of companies listed on North American financial markets with the Securities and Exchange Commission (SEC) take individual responsibility for the accuracy and completeness of corporate financial reports, including if the data comes from the information system.
Rules on personal data	Commission Nationale Informatique et liberté (CNIL)[13]	In the contract, responsibilities are shared between the client and the CSP. In any case, a CSP can only use the personal data provided by its clients if it obtains their explicit agreement.
Rules on access to data by government authorities	Safe Harbor	Set of data protection requirements published by the US Department of Commerce, to which companies based in the United States voluntarily adhere. They ensure an adequate level of protection for the transfer of personal data from the European Union. The EU Court of Justice decided on Tuesday, October 6, 2015 to suspend the "Safe Harbor" agreement. It considers that the personal data protection authorities must retain their powers of oversight and enforcement over how the personal data of Europeans are treated.

Figure 10: National legislations and impact on the cloud

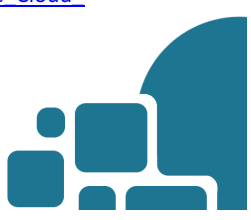
In terms of data protection, various problems may arise, such as security vulnerabilities, attacks and malicious acts, as well as the loss of data.

Most of the solution to this type of risk lies in the certifications held by the CSP (ISO-27001, SSAE 16 type II, ISAE Type II, FISMA…). Security audits should still be conducted, however, at least once every two years.

Currently, the trend is to implement an excessive number of standards. Aware of the laxity of some cloud offerings in terms of security, some cloud vendors want to reassure their customers by surrounding themselves with certifications. Fortunately, a set of tools is starting to emerge to help companies evaluate the risks and the level of security offered by cloud vendors:

- ANSSI provides a guide to control outsourcing risks
- ENISA provides a risk assessment tool specific to cloud services
- The Cloud Security Alliance offers a Cloud Controls Matrix based on Security Guidance for Critical Areas of Cloud Computing v3.0

[13]Summary of responses to the public consultation on cloud computing launched by the French Data Protection Commission (CNIL) from October to December 2011, and analysis by the CNIL. Available at http://www.cnil.fr/fileadmin/images/la_cnil/actualite/Synthese_des_reponses_a_la_consultation_publique_sur_le_Cloud_et_analyse_de_la_CNIL.pdf (accessed April 23, 2015)



ISO 27001	ISAE 3402	Health data hosts	PCI DSS
• Establishment of a security management system with annual risk review and audits of security measures • Annual on-site audit by a certification body • Universally adopted, has become mandatory	• Inspection and certification via a risk analysis once a system of internal control has been established • With regular specific and comprehensive audits • US obligations (SOX compliant)	• Set up of specific measures including authentication management, ethical behavior, etc. • Specific CNIL audit • Required for health data in France	• Implementation of specific measures and techniques in terms of hosting and access to premises for organizations that handle branded credit cards • Annual on-site audit • Adopted by the main international companies

Figure 11: Examples of security standards

B. Personal data

1. Personal data in universities

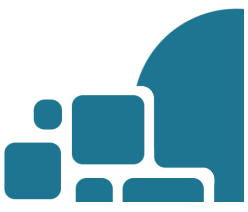
The French Data Protection Commission (*Commission Nationale Informatique et liberté* or CNIL) considers personal data to be any information relating to an individual who is identified or identifiable, directly or indirectly, by reference to an identification number or to one or more elements specific to the person.

For a university, personal data can include anything from staff addresses and phone numbers, to marital and parental status, to sensitive social information (disabilities, etc.), as well as the information in human resources information systems, such as annual evaluations and personal reviews.

Over and above the question of personal data, awareness of security issues in universities seems to focus more on research faculty than on other groups (teaching faculty or students). CIOs either opt for a clearly defined security policy (with specific tools), or adopt more generic approaches (using the tools available: Skype and Microsoft Office suite, Google, etc), in which case the twin issues of responsibility for and control over data are raised.

Recall that any organization that collects personal data in France has a legal obligation to:

- inform people of their rights and enable these to be exercised;
- keep the data for a limited period;
- process the data for a specific purpose;
- ensure that personal data are kept securely;
- declare the processing of personal data to the CNIL using the appropriate forms;



2. Regulatory requirements

Organizations, whether public or private, are not free to choose to host IS user data wherever they want.

This principle is set out in Article 68 of the French Data Protection Act (Act 78-17 of January 6, amended), which prohibits the transfer of data outside the European Union. Exceptions are provided for in article 69 of the Act; transfers outside the EU are authorized, however, if the recipient country or company ensures an adequate level of protection for the data being transferred.

Pending the final adoption of the EU regulation, the legal rules that apply are those of the country in which the data is hosted. The new regulation will apply to the processing of data belonging to persons residing in the European Union, regardless of hosting location. There are also sector-specific regulatory constraints regarding personal data for the health and banking sectors and data transfer (CNIL).

Management and Protection of Personal Data

In France, the relevant legislation is the Data Protection Act of January 6, 1978 amended by the Act of August 6, 2004. It defines the principles to be respected for the collection, processing and storage of personal data. It strengthens peoples' rights over their data, simplifies the paperwork required for notification, and specifies the CNIL's powers of oversight and enforcement.

In Europe, Directive 95/46/EC is the reference text for the protection of personal data. It sets up a regulatory framework which seeks to strike a balance between a high level of protection for the privacy of individuals and the free movement of personal data within the European Union (EU). To do so, the Directive sets strict limits on the collection and use of personal data and demands that each Member State set up an independent national body responsible for the supervision of any activity linked to the processing of personal data.

Towards a new European regulation for the protection of personal data

On January 25, 2012, Viviane Reding, Vice-President of the European Commission responsible for Justice, released a new draft regulation on the protection of personal data. After three years in the pipeline, this reform should be implemented in late 2015.

The European regulation imposes new obligations on CSPs, and customers will have to strengthen the contractual framework for their relations with providers.

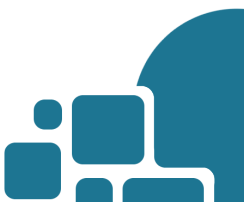
Once the new regulation comes into force, CSPs will also be responsible for the security of data provided by their customers. They will have to document any processing and make this information available to the supervisory authorities, and ensure the legality of any data transfers to their own subcontractors or providers located outside the European Union.

Customers, in turn, may require the presence of a data protection officer, a risk analysis, or certifications.

Box 10: Personal data

3. CNIL recommendations

Cloud computing services have flourished in recent years. However, their use by organizations raises new issues from both a legal and risk management perspective. To clarify the applicable legal framework, the CNIL launched a public consultation on cloud computing in late 2011. Armed with the many contributions received,



it updated its analysis of the applicable legal framework, and published practical recommendations[14] on June 25, 2012 for organizations planning to use cloud computing services. These recommendations are currently the only reference text in France that helps regulate the use of cloud computing services.

The CNIL's recommendations of June 25, 2012 are based on seven priorities. They identify the key points to be verified by data controllers and CSPs in order to protect personal data in the cloud computing environment.

1) Clearly identify the data and processing operations which will be passed to Cloud
2) Define your own requirements for technical and legal security
3) Carry out a risk analysis to identify the security measures essential for the company[15]
4) Identify the relevant type of Cloud for the planned processing
5) Choose a service provider offering sufficient guarantees[16]
6) Review the internal security policy
7) Monitor changes over time

C. Guarding against cloud-related security risks

Security risks do not necessarily increase when data is hosted externally. So, if the choice is made to outsource, certain elements must be closely examined when the contract is being established with the CSP:

- Availability of data
- Integrity and confidentiality
- The service-level agreement (SLA)
- The audit clause
- The reversibility plan

These aspects are explained in the chart below:

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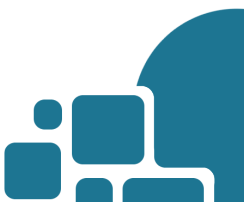
[14] Recommendations for companies planning to use cloud computing services http://www.cnil.fr/fileadmin/documents/en/Recommendations_for_companies_planning_to_use_Cloud_computing_services.pdf (accessed December 2, 2015)

[15] CNIL suggests limiting the analysis to the 35 most significant risks to data protection provided by ENISA (European Union Agency for Network and Information Security): http://www.enisa.europa.eu/activities/risk-management/files/deliverables/cloud-computing-risk-assessment (accessed April 23, 2015)

[16] CNIL proposes model contractual clauses that can be inserted into cloud service contracts. In the event of an audit, these models are an indicator of the level of prudence shown by the customer or of the risks assumed.



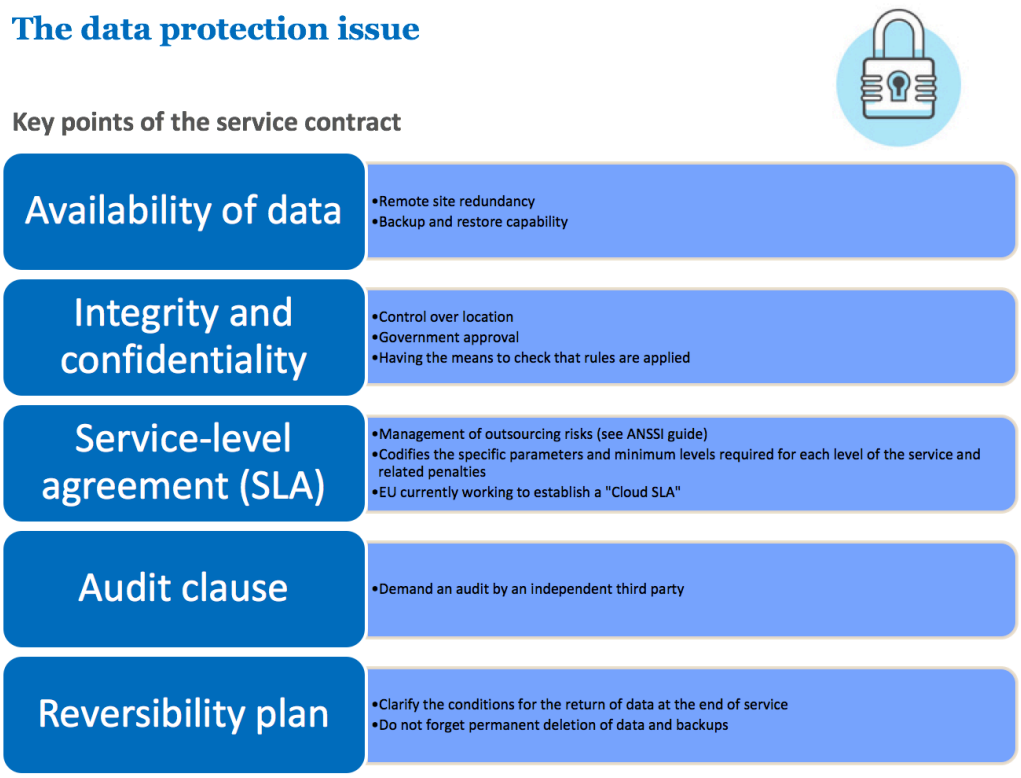


Figure 12: Key points of the service contract

The European GEANT project

GEANT is very high-speed network for research and education that connects almost all the academic networks in Europe. This European Commission program also comprises service activities and research activities.

GEANT brings together over 10,000 institutions, or more than 50 million users from 40 European countries. It offers high bandwidth services, a hybrid network technology and services to users. Its vast coverage connects several continents.

The project is led by a consortium of 32 NRENs (national research and education networks), such as the RENATER network for France and the TERENA Association (Trans-European Research and Education Networking Association). The project is coordinated by DANTE (Delivery of Advanced Network Technology to Europe), an organization dedicated to the development of research networks around the world.

All CSPs are encouraged to include their services and capabilities in the catalog, so as to make them accessible for the whole community. In return, they must comply with certain requirements. The catalog proposes a structured directory of CSPs that meet cloud security requirements, thereby helping the research and education community to make informed decisions when purchasing cloud services.

The GEANT project (codenamed GN 4) is funded by the European Commission. Since May 1st, 2015, GEANT, TERENA and DANTE have merged into a single organization.

Source: http://www.geant.org/Pages/Home.aspx (accessed May 28, 2015)

Box 11: The European GEANT project

Chapter 4: The Cloud Changes Core Competencies for IT Departments

Cloud computing entails a profound change for IT departments. IT's role in organizations is constantly changing and should be reasserted. In some companies, business departments equip themselves cheaply with SaaS solutions, without going through IT staff. The cloud means big changes in the work methods and scope of IT departments, which remain responsible for the overall consistency and security of the information system.

A. The new technology context transforms IT departments

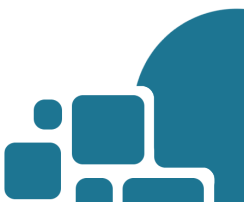
1. The trend is to outsource and pool skills

This section describes the changes observed within companies at macroscopic level. The position of IT departments is often different in universities, because the issues are not the same. The overall coherence of the IS prevails over cost issues.

Initially, IT departments were focused on IT operations with little automation, such as server hosting and maintaining physical networks. Progressively, virtualization and the introduction of cloud computing have brought about greater automation of operations and more outsourcing. In large organizations especially, the complexity of technology has led to the outsourcing of non-core business operations (e.g. HR and payroll functions). In this respect, the cloud offers the advantage of hosting the business applications of different departments. Today, IT departments are trying to position themselves midway between functions related to innovation, strategy, and the anticipation of new uses, and a project management role. They are aiming to become equal and trusted partners of business departments, so as to inform the technology choices which now fall to line of business managers by contributing contractual, technical (integration with the existing IS, security) or legal expertise.

Although this new configuration allows IT staff to focus on their core business, it has the disadvantage of greater dependence on CSPs.

Things are a little different in universities, particularly because the positioning of IT depends heavily on the policy choices of the university's leadership, and on the dynamic created by the quality of the information system. CIOs and IT staff are closer to the other departments. They will need to move from an infrastructure management role to managing and leveraging data analytics.



Shared IT services at Umeå University (Sweden)

Interview with the Umeå University ICT Services and System Development (ITS)

What is the role of ITS at Umeå University?

Umeå University plays a leading role in Sweden as a provider of IT services to all Swedish universities.

ICT Services and System Development (ITS) has 200 staff, 150 of whom work on software development and IS operations. Some are external consultants. ITS also works for other universities and some local government bodies.

We develop and manage applications installed in several Swedish universities. In addition, ITS is involved in various cross-cutting working groups and provides IT services to some county administrative boards [branches of central government that are headed by a state-appointed governor, and are responsible for economic planning and regional development]. For example, ITS collaborates on the analysis of health care records, which are managed by the county administrative boards.

How many data centers are there and what services do they provide?

Most universities have their own data centers, but they use services offered by CSPs.

These services vary according to the data centers' capacity and maturity. The three data centers that are certified for the *Ladok* are the most high-performance [*Ladok* is the Swedish higher education management information system, which handles student results, enrollment etc.].

Does your university use cloud-based applications? Which ones?

Yes, the main one being Office 365, which is shared by all students and soon most employees.

Do you share data centers with other universities? Do you provide cloud services to other universities or other organizations?

ITS delivers cloud services. We also have a state-of-the-art VMware platform, and we will be participating in VM World 2015 [global cloud conference held in San Francisco in September 2015 and in Barcelona in October 2015]. We are going to present a publication there on the services we have set up.

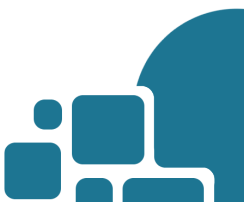
In addition to our platform, we have integrated our cloud with Microsoft Azure and Atea (a large Lithuanian CSP, which is very active throughout Scandinavia and the Baltic region). So we are well placed and sufficiently flexible in terms of capacity and ability to offer the services best suited to our users' needs.

There are other universities that provide services at the national level, such as shared data centers.

Other, less technologically advanced universities only use the IT infrastructure available locally. Many existing services are not exploited to their fullest extent.

In general, universities in Sweden talk to each other a lot about infrastructure security issues and other services.

Box 12: Pooled IT services at Umeå University (Sweden)



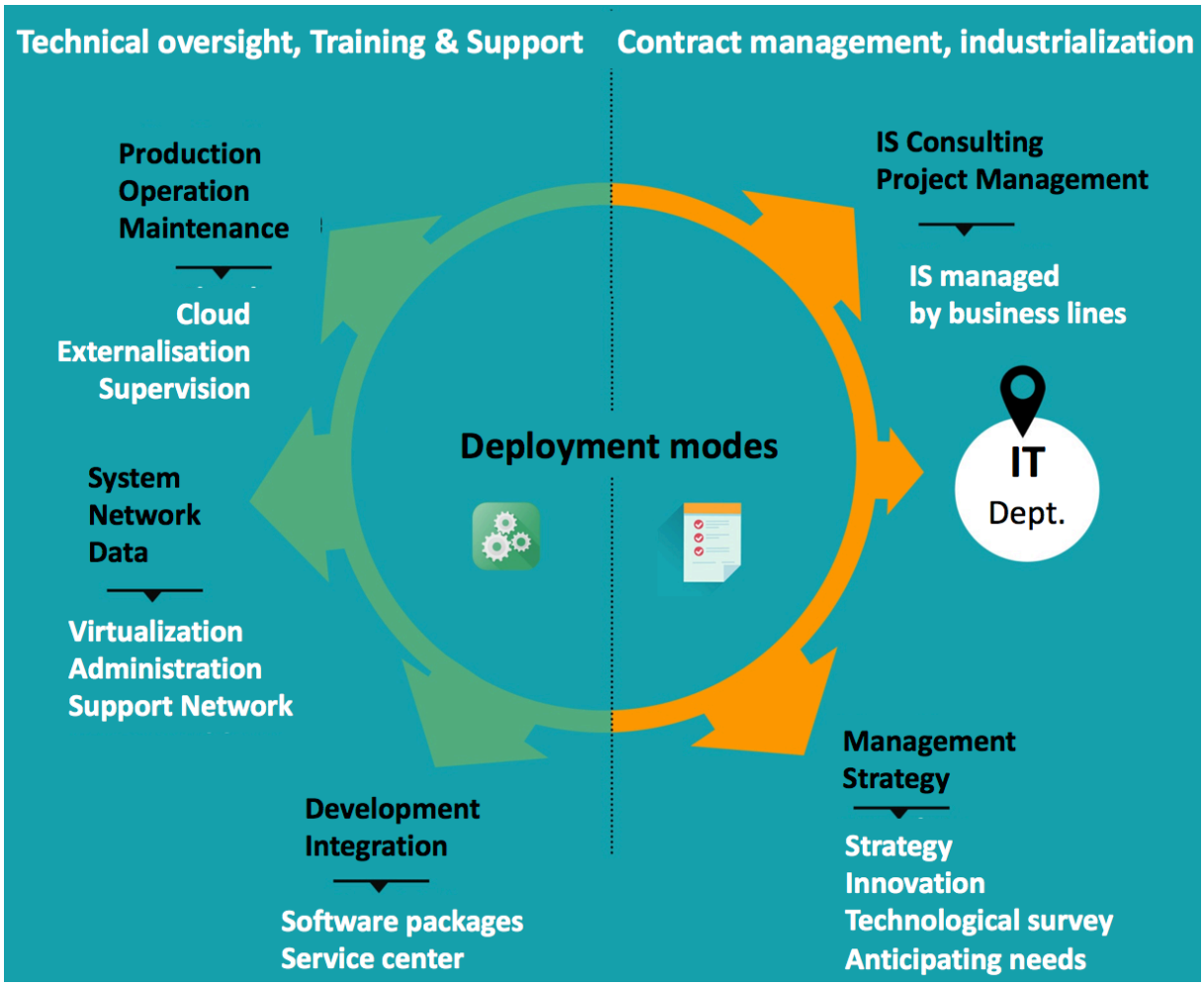


Figure 13: The changes in IT department competencies

2. The cloud changes IT departments' positioning

The emergence of cloud solutions has had a significant impact on information systems architecture and planning. New services will continue to emerge, and CIOs and IT staff will need to manage the IS so as to integrate them into the existing system. However, the cloud is an extension of pre-existing trends; virtualization prepared IT departments for the cloud.

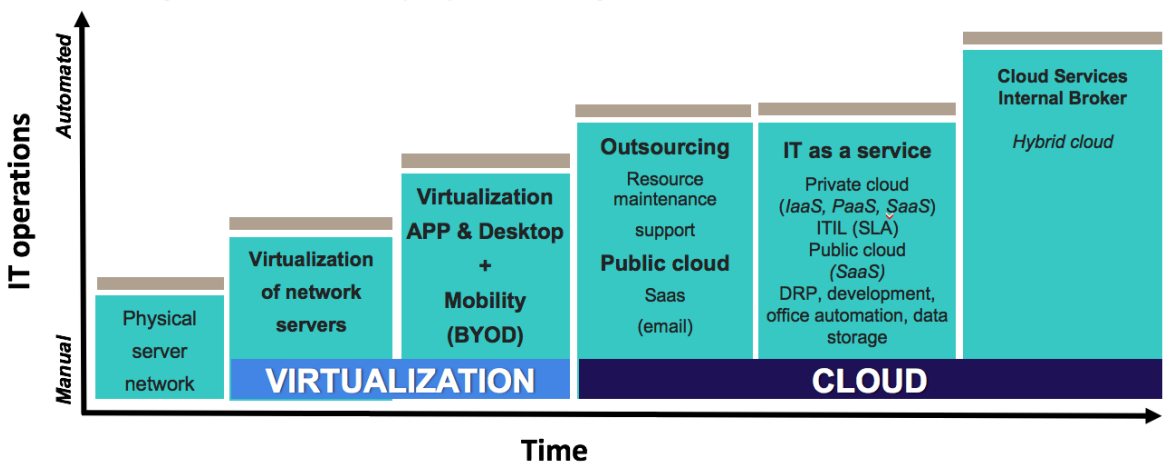


Figure 14: Technological changes caused by the cloud in IT departments

Initially in companies, the private cloud mainly hosted centralized applications, but it has evolved to include the workstation and offer collaborative applications.

The public cloud was introduced into companies either through business departments or through the decisions of CIOs.

Today, the services offered in companies (IaaS, PaaS, SaaS) invariably come from both the public and private clouds. A hybrid cloud model has appeared that blends the two worlds.

As a service broker, the IT department is responsible for integrating and unifying the various services, compliance with commitments in the service contract (availability, performance, etc.), and setting up integration tools.

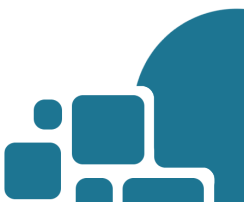
The main benefit of the cloud and SaaS is to reduce low layer resources by pooling.

3. Charting cloud-related competencies

Although the data is hosted elsewhere, IT departments must be able to manage the cloud services within their organization and take control of the costs. IT departments remain the guarantors of the continuity of IS processes (interface between the IS and cloud applications) and of the IS's overall security.

With the cloud, certain competencies gain in importance for IT departments:

- technical system management;
- user support;
- software configuration;
- functional management;
- billing;
- production of reports;
- cloud management;



B. The changing relationship between lines of business and IT

1. The position of IT departments is different in companies and universities.

In companies, the common failing of IT departments comes mainly from taking on "tools" and projects by default. IT departments end up engaging in activities that are not traditionally part of their remit:

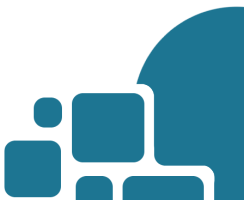
- training users;
- formalization of processes, rules and data;
- management of projects, programs and the project portfolio;
- change management, etc.

But in companies, the arrival of cloud computing enabled business departments to acquire solutions quickly, focusing more on the choice of the solution than on the implementation process. These operations, which look simple on the face of it, are sometimes undertaken without consulting IT. For example, when mapping the applications in an organization, IT departments often realize that business departments have acquired an application without consulting them.

IT departments have to rethink the relationship with business departments.

It is therefore important to rethink the relationship with business departments, in terms of process management, project management, data quality, standards, expression of needs, IS governance, etc. Each entity must have a well defined scope of responsibility.

In universities, the relations between lines of business and IT departments are different. IT is not a profit center, and maintains its role of assisting with project management while controlling technology costs. Nonetheless, the issues raised by changing relationships with lines of business are the same, and form part of governance and management concerns at the highest level of the institution.



SURF: in the Netherlands, a collaborative organization dedicated to ICT in higher education

What is SURF?
SURF is a cooperative organization for ICT in higher education and research in the Netherlands. It is the equivalent of JISC in Britain (an association that supports universities in the choice of digital solutions). It recommends that member universities adopt a "cloud first" approach for choosing technologies.

What is its offering and its position in the cloud?
SURF is positioned as a cloud broker. It offers cloud services to higher education and research institutions based on open standards.
SURF is also a cloud integrator. It provides infrastructure (open collaborative infrastructure) that gives universities access to more than fifty applications and collaborative services (document sharing, content management, video conferencing system, etc.) based on open standards from different providers, using a single environment. It has over a million users.
SURF offers to integrate cloud services into the institution's environment. This gives new opportunities for collaboration between institutions, thanks to secure access to the cloud through the identity federation. The offering also provides centralized group management.
It is also possible for a university to share its services with other institutions.
Finally, SURF proposes collaborative activities between institutions both nationally and internationally.

What are the innovative services offered by SURF?
SURF offers to manage the relationship with CSPs and/or publishers. The organization takes care of the relationship with CSPs and handles licenses and business negotiations.
SURF supports universities for cloud service implementation.

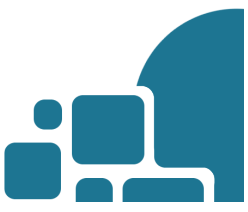
Box 13: SURF

2. It is the IT department's role to educate users about new technology and cloud issues

With regard to the cloud, like other emerging tech topics, IT departments must take a proactive attitude towards the other university divisions.

Here are some examples of topics on which IT departments may need to provide answers or actionable insights:

- MOOCs;
- Big data;
- Internet of things;
- Data visualization (to accompany the rise of Big Data, data visualization solutions will help to push back the boundaries of traditional reporting);
- SDn (Software-Defined Anything): This acronym includes several others (SDN, SDI, SDDC, etc.) that share the same idea: the software that defines or controls the IT infrastructure;
- API: application programming interface for using data from one service in another (e.g., Amazon's Product Advertising API);
- CYOD: in 2014, Choose Your Own Device will be favored over BYOD. With CYOD, IT departments can offer several approved devices, which will be easier to manage and integrate into the SI.



Cloud use in British universities

Three questions for Peter Tinson, Executive Director of UCISA (Universities and Colleges Information Systems Association)

How is the cloud used for email?

Many universities use Office 365 or Google Apps for email as well as applications and data storage for students and staff. However, some universities use pay ISPs for staff email, or at least solutions that are differentiated from those for students. This also applies to administrative applications like SAP or LMSs likes Moodle or Blackboard.

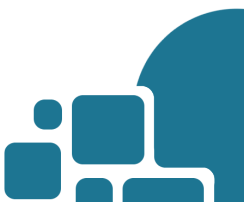
How are universities outsourcing their data?

Some universities rely on outside companies for their data center. One of the first to do so was City University (London), which moved its data center to a commercial operator in 2002. Others followed. Most of these universities are based in London, where they had difficulties with maintaining data centers because the power supply can fluctuate. These are experiences of renting storage space in commercial data centers. About four years ago, Loughborough University embarked on a hybrid cloud model, in which the infrastructure was hosted within the university while the applications were stored by a private operator that provided flexible storage space as needed.

What existing projects are there in terms of IT resource pooling?

There is a data center project in northeast Scotland, shared between two universities and a faculty. Another project is being set up in London. It will involve four universities and two IT research centers. Other facilities shared between several institutions are set to emerge in the coming months across the UK.

Box 14: Cloud use in British universities



Chapter 5: Economic and Financial Impact of the Cloud

The cloud changes the economic and financial model of IT departments. The private cloud requires a large investment, whereas the public cloud offers a huge range of functionalities for a reasonable price. To understand the advantages of the community cloud, this chapter concludes with a case study.

A. Private clouds require a large investment

1. The principle

As a reminder, the infrastructure of a private cloud is reserved for the exclusive use of a single organization. It may be owned, managed, and operated by the organization or a provider. It may exist on or off premises.

In the university sector, some CIOs have decided to build their own infrastructure and platforms for their own users. The implementation costs are obviously very high.

In the Paris region, only two institutions are equipped with Tier 3 data centers.[17] In addition to the machines and engineers, they include the related monitoring services.

2. Economic and financial impact

The investment is considerable and requires external funding.

Implementing a private cloud means an increase in organizations' operating budget which, in the current context, seems untenable. Indeed, the private cloud operates on a pay-per-use pricing model.

The bill is likely to grow given the growing consumption of digital services.

B. Public clouds: ample functionalities for a low cost

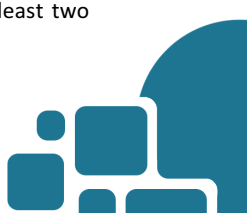
1. The principle

In the public cloud, cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a private or public organization. It exists on the premises of the cloud provider.

For example, the public cloud corresponds for IT departments to using a virtual machine or an email solution, etc. Operating costs are low and the balance between cost and functionality is very advantageous.

However, the public cloud has one major drawback: it poses a real data privacy issue. Many organizations will not consider letting their data move outside their region or city.

[17]The Uptime Institute's classification by tiers corresponds to a certain number of guarantees on the type of equipment deployed in the data center to ensure its redundancy. Downtime is less than two hours per year, there are at least two electrical networks, an emergency backup supply, etc.



To solve the data confidentiality problem, government public cloud projects or even Renater's service "Partage" may be a solution. So far, these solutions have been far more expensive with less functional scope than American cloud services. Confidentiality comes at a price.

Data center project at the University of Montpellier

Four questions for Claude Bagnol, Chief Information Officer at the University of Montpellier

Could you present the project in a few words?

It was the Montpellier education authority which, when it needed a new machine room in 2012, decided to initiate a collaborative project for Montpellier. An opportunity study was conducted by RENATER, involving a strategic, technical, economic and legal analysis of solutions for hosting the pooled computing resources of Montpellier's education and research institutions: the education authority, University of Montpellier (originally University of Montpellier 1 and 2), University of Montpellier 3, Montpellier School of Chemistry, the Institute for Development Research (IRD), the French agricultural research and international cooperation organization (CIRAD) and the regional student services organization (CROUS).

What hosting arrangements are planned?

The idea is to optimize the infrastructure using the hosting capacity which is already available at CINES (the National Higher Education Computer Center), and to build a shared data center that will cater to the needs of all the partners. We also explored the possibility of converting an existing computer room in one of the institutions to establish a DRP (disaster recovery plan).

RENATER plans to acquire infrastructure for providing cloud services, although these have not yet been determined (IaaS, PaaS and probably SaaS).

Which services will be offered?

The list of hosted services has not yet been finalized. For the institutions, the priority is to relocate their machine rooms to a place with high standards of security, power supply and environmental controls.

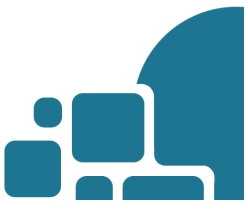
Box 15: Data center project at the University of Montpellier

2. Economic and financial impact

With a public cloud, the provider takes on the capital expenditure and cost of depreciation. Under this deployment model, the infrastructure caters to a large number of users, which means economies of scale and a much lower cost overall than a private cloud. Operating costs are also lower.

Because the resources are shared between a very large number of users, the public cloud offers small or medium-sized institutions a lot of functionality at a relatively low cost. Plus, these institutions have no depreciation costs (since they have not had to invest anything).

However, the "pay-per-use" pricing model means that spending is certain to increase given the growing use of digital services.



C. Community cloud: the financial advantages of pooling

1. The principle

The cloud infrastructure is provisioned for exclusive use by a specific community with shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community or a third party. It may exist on the community's premises or be hosted by a third party.

2. Economic and financial impact

Hardware, software, financial and human resources are shared between all members of the community cloud.

Pooling reduces costs. The community cloud is cost-effective, particularly for smaller institutions which also get to benefit from high functional coverage.

Depending on how it is implemented, there may be no initial investment or depreciation, and an operating budget that is expected to remain constant.

Services are provided under the "pay-per-use" pricing model, which means that spending is certain to increase given the growing use of digital services.

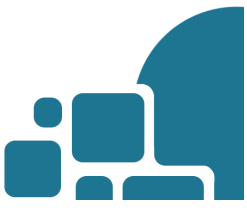
3. Case studies: cost of joining a cloud for a university (depending on its size)

The community cloud presupposes the consolidation of infrastructure and associated services for use by several institutions.

For a university today, if there is no existing community cloud, there are three ways to envisage setting up a cloud offering, regardless of its content:

- The first possibility is to rent space in a data center and offer a range of related services;
- The second possibility is to combine proprietary infrastructure and outsourced infrastructure. This option ensures business continuity. The second infrastructure is outsourced either to a service provider or to a community member;
- The third possibility is to have a single proprietary infrastructure and an outsourced backup. This option ensures business continuity (except in the event of total network failure or destruction of the building).

This scenario is the least expensive of the three: the decision to invest in new infrastructure rather than using existing server rooms is financially motivated. Refitting existing rooms to meet security standards (redundant power supply, networks, etc) is actually more expensive than investing in new facilities.



Rental costs fluctuate from year to year because of the variables that affect the cost of renting the data center: the number of servers (price), the number of bays (price), the backup system, and rents.

The costs incurred concern leasing the building, purchasing equipment and the costs of developing the service offering. The biggest expense is putting the infrastructure in place, and this is one of the major parameters of the model.

The DISIC's cloud and data center projects

Four questions for Paul Braida, Director of the ICT program at DISIC (Interministerial Directorate for Information and Communications Systems)

What course of action is DISIC taking in terms of the cloud?

We should separate the issue into two parts: data centers and infrastructure services.

For data centers, the objective over ten years is to consolidate the number of data centers from 117 to 17. We are currently examining potential combinations.

A series of projects have been defined to achieve these goals. In some cases, these will be interministerial groupings.

Are there any shared projects?

Data center standards are constantly being raised. That is why consolidation is the best option. Our recommendations are for a minimum of 500 m2, air conditioning and energy efficiency, and most importantly, the data center must be full. There are currently initiatives being implemented at customs, for example. Renovation projects are the most common. Many data centers were established in the 1990s and they need upgrading. This is what was done at customs, and now they can offer services to other ministries. There are also a few expansion projects. The aim is to set up optimized, energy efficient facilities that bring fixed costs down. It is easier to take this first step than to move everyone onto the cloud straight off.

What are the project's various stages?

The first stage is to build up the range of services to include IaaS. There is a keen interest in infrastructure as a service, but there is also a lot of difficulty getting it underway. For the moment there are no plans for a major investment in national infrastructure.

We have been working on the launch of an interministerial public cloud. This will give access to a public cloud offering at an attractive rate. The public cloud is a great way to concentrate efforts on a single contract. The project has been conducted jointly with the state procurement office. It concerns all the ministries, and a few public institutions that participated in the process.

Later on, if other organizations are interested, it would be perfectly feasible for them to make use of the cloud services from the state procurement office.

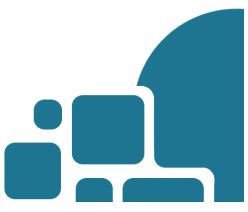
Have you considered other possible forms of organization?

We are also looking into the private cloud. The idea is to federate initiatives so that we can offer standardized technology, with a preference for openstack solutions. We are organizing a seminar in October to combine the various ministry initiatives and decide on shared solutions.

We are working with ANSSI on the security aspects.

This cloud-based approach is also scalable.

Box 16: The DISIC's cloud and data center projects



Chapter 6: The Cloud's Impact on Regions

The cloud is prosaically described as the hosting of data, applications, and development platforms in the cloud, to be accessed over the Internet. In principle, you would think that cloud computing can be set up anywhere in France, as long as there is access to a network infrastructure. Yet in practice, there are many criteria that circumscribe the possible locations.

The government plays an important role in regional technology planning by giving the political impetus needed to start certain projects, the latest of which is the France High Speed Broadband Plan. By setting targets for very high speed connections, the plan may indirectly influence the future map of the cloud across the country.[18]

For universities, having a cloud is often associated with having a data center. Yet as opposed to the cloud, a data center's location is very sensitive to the conditions of the electrical grid. The RENATER network operator offers institutions quality end-to-end services using regional high-speed networks. In any case, the existence or lack of cloud infrastructure in different regions redraws the map in terms of urban and regional planning and of jobs.

A. Geography of data centers

1. Selection criteria for the location of a cloud or data center

Over the last ten years, numerous studies have shown that regions' competitiveness and attractiveness depends on their ability to promote the emergence of pooled, sector-specific hardware and software platforms (for research, higher education, health, etc.)

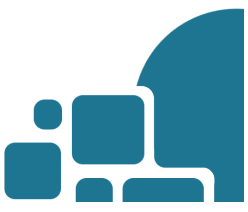
Tech companies have therefore focused on certain parameters when choosing a location, mainly based on the area's potential for economic development.

- The presence of very high speed network facilities;
- proximity to education institutions;
- the presence of competitiveness clusters and research centers;
- population density (which indicates the market potential for an operator, with a view to pooling).

In parallel, other criteria have gradually gained in importance, given the issue of energy efficiency and the economic environment.

- tax benefits;
- property prices;

[18] For more details on this initiative, visit the website http://www.francethd.fr/ (accessed May 29, 2015)



- energy prices;
- the possibility of setting up positive energy systems (e.g., the heat generated by the equipment is used to heat the neighboring town).

The Paris region, where most companies have traditionally been concentrated, has now lost its systematic advantage, particularly because labor and overhead costs are higher than elsewhere. For example, OVH, an Internet service provider, first began operating in Paris in 2003 and established data centers there. It later spread its operations throughout Europe, including in Poland and northern France, to take advantage of lower property prices.

Nevertheless, the Paris region remains the area with the densest broadband infrastructure, along with Lyon and its suburbs.[19]

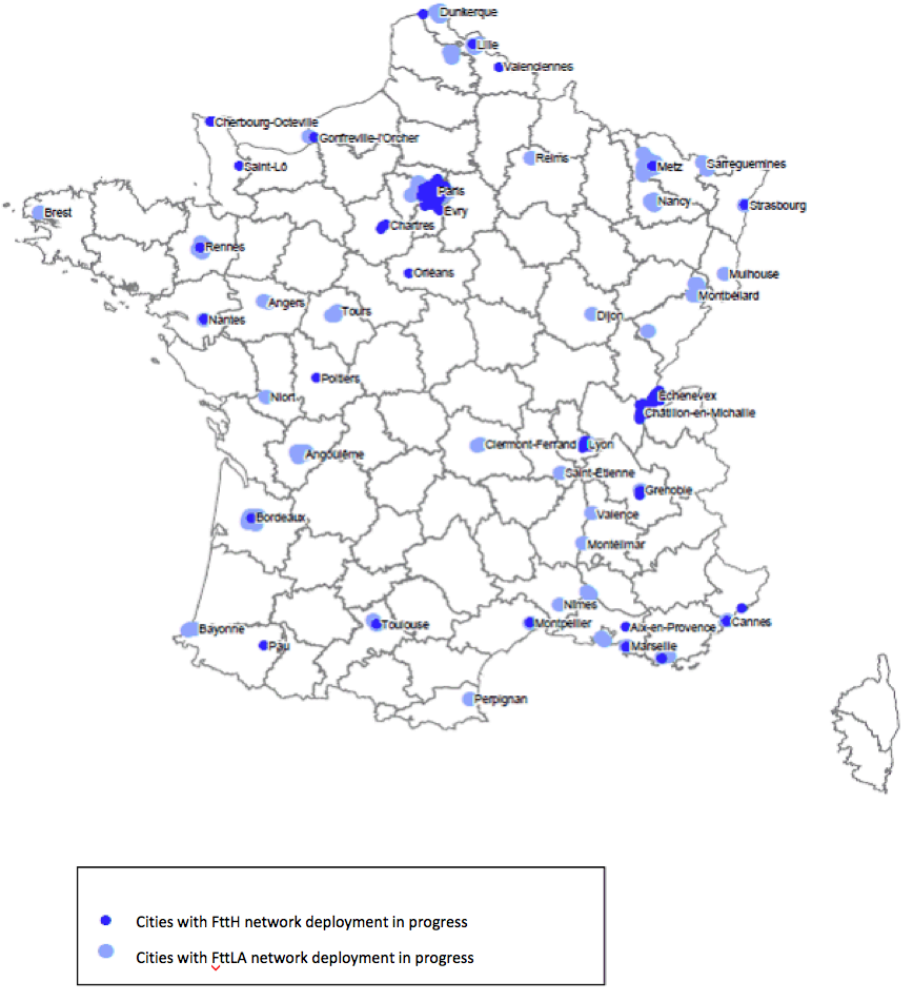


Figure 15: Map of fiber optic network deployment (source: ARCEP)

[19] A data center map is also provided in the Guide to Cloud Computing and Data Centers for local authorities, available here: http://www.entreprises.gouv.fr/files/files/directions_services/secteurs-professionnels/numerique/guide-cloud-computing-et-datacenters-2015.pdf (p. 25)

2. The issue of distance between the facility and the user

Behind the sales pitches, which talk about data being hosted in a cloud with no fixed location, lie extremely concrete realities. Data centers are connected to end users by cables. They might be copper or fiber-optic, but they are still cables.

The maximum distance between the facility and the end user depends on the type of connection.

Type of cable	Recommended distance to users
ADSL	4 km
SDSL	8-10 km
Fiber optic	50-100 km

Source: operators estimate / Infhotep

Universities use a fiber optic connection, so the distance criteria are more flexible. Symmetric bandwidth (equal downstream and upstream – i.e., download and upload – data rates) is also an advantage of fiber optics, at a time when the volume of data transmission is constantly on the rise.

B. Benefits of a digital facility in the region

1. The stakes of regional connectivity

The economic and societal changes caused by digital technology are both undeniable and irreversible. In a report presented to the Minister of Housing in September 2013, Claudy Lebreton analyzed these implications.[20]

- Digital technology entails significant changes in work and production methods: working from home, coworking, collaborative modes of production, etc. (*FabLabs*)
- It changes our perception of time and engenders a feeling of acceleration (due in part to being constantly connected)
- It creates a new relationship to knowledge: open data, new interactions between students and teachers, etc.
- It reinvents the role of governments
- It affects economic growth (although experts are divided about its exact impact).

The map of the regions needs to be redesigned to ensure fairness in digital relations

All of these consequences naturally have an effect on France and its regions. The map of the regions has to be redesigned so that digital hubs are distributed as fairly as possible.[21]

[20] *Les territoires numériques de la France de demain*, Claudy Lebreton, 2013. Available at http://www.strategie.gouv.fr/publications/territoires-numeriques-de-france-de-demain (accessed April 24, 2015)
[21] *Ibid*., p. 65

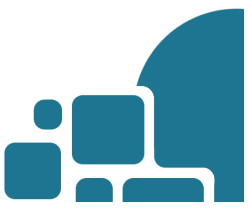
Increasingly, initiatives need to bring together the various different stakeholders, such as with the public initiative networks (*Réseaux d'initiatives publiques* or RIP) put forward by the Caisse des Dépôts, which aim to reduce "white areas" by connecting business parks and public institutions. In practical terms, RIPs make fiber optic broadband available to regions and the economic stakeholders they support.[22]

In regions that have implemented a real strategy to install fiber optic communications, the first findings indicate the following trends:

- **Economic gains**. These are evidenced by an increase in the number of new businesses, particularly tech firms; they also include stronger growth in wage employment than in regions that have not put an RIP in place (once again, more so in technology-related sectors);
- **Learning gains for local authorities.** As they get to know the technical specificities of the networks better, they end up being able to manage their development more effectively.
- **A good deal for users.** The rates offered are regulated, so companies that set up in these regions have a real incentive to stay put.
- **Innovative new practices.** In this regard, primary, secondary and higher education are inexhaustible testing grounds.

Connectivity issues are not confined to the general public. They are also of concern to the universities in the region. In terms of regional technology planning, the quality of end-to-end services across the network is critical. For universities, this is provided by Renater, and to a certain degree by regional high-speed networks. In the case of a community cloud for higher education and research, it is important to ensure that the quality of service is consistently high across all university sites.

[22] See *Synthèse de l'impact territorial des* RIP (Summary of the regional impact of RIPs), 2010. Available at http://www.valoffre.caissedesdepots.fr/IMG/pdf/RIP_synthese_10p.pdf (accessed April 24, 2015)



The University of Burgundy's green data center

This building is expected to house the appropriate cluster computing, networking equipment and physical infrastructure to host all the business applications necessary for everyday campus activities (staff, students, researchers, teachers). It will be operational in August 2015.

The data center was designed by a firm called Jerlaure. These are the main features of the building:

- Tier III green data center

- Total surface area: 675 m²

- Cooling system designed so that the heat produced by the IT equipment can be used in the existing academic heating network. Eventually, the University of Burgundy is expected to recover about 400 kW of heat to heat its premises.

- This green data center will centralize all the IT infrastructure (management, computing, learning and networks) of the University of Burgundy campus

- It is also intended eventually to operate as a regional data center, hosting data for public or private infrastructures.

Source: Interview with Alain Tabard, Vice President for the digital campus, information systems and learning centers at the University of Burgundy, available at http://www.u-bourgogne.fr/vie-des-campus/668-green-data-center-du-numerique-vert.html (accessed on May 19, 2015)

Box 17: The University of Burgundy's green data center

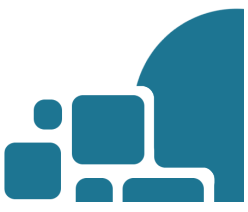
2. A good understanding between partners is essential

Among the success factors of a digital infrastructure project, the agreement between the partners is decisive.

Understanding must first be reached among the local partners closest to the organization leading the project (COMUE, universities, local authorities, etc.), and potentially be expanded to other authorities or institutions. The earlier that stakeholders – schools, hospitals, universities, etc. – are involved in the project, the greater their implication.

The aim is to associate businesses that have a strategic importance for the region with these public bodies, and to work on the project together. This concentration of energy can in some cases be a valuable catalyst for bringing in less well-equipped areas, which would not have been able to initiate a digital project on their own.

Cooperation between stakeholders also includes the relationship between the group of partners and the operator. As in any relationship between a customer and service provider, this requires mutual trust, a clear division of roles, and rigorous monitoring of the entire project cycle. It may be worth seeking the help of professional consultants, so that the project leaders can incorporate digital project management methods.



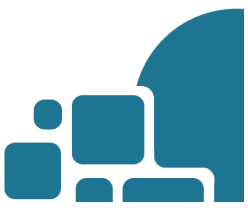
Conclusion

As work on this guide was coming to an end, the final elements of the Snowden affair were revealed in the press, France passed a new intelligence law, and the issue of data sovereignty was high on the government's agenda.

Because of their research mission, universities are the first concerned by these issues, hence the need to build a body of knowledge specific to the establishment of pooled, community-based and secure cloud applications.

This guide, apart from presenting the basics of the cloud, also sought to clear up some misconceptions and show that higher education and research is particularly conducive to community cloud initiatives. Here is a brief summary:

- ✓ There is not one, but many definitions of the cloud, which can sometimes create confusion between cloud computing and simple outsourcing. It is important to remember the five main characteristics from the NIST guidelines when talking about the cloud: the notion of services, elasticity, pooling, measured capacity, and broad network access.
- ✓ The fact that data is outsourced to the cloud is not a security risk in itself. However, the issue of access control is essential. When the contract is being established with the provider, questions such as the availability of data, integrity and confidentiality, the SLA, the audit clause and the reversibility plan all help customers guard against data security risks.
- ✓ Universities are no exception to the widespread adoption of cloud computing; in fact, their business practices and business models have been fundamentally transformed by it. The boxes provided throughout this guide illustrate the abundance of projects being implemented in higher education institutions, both in France and abroad. Similarly, the cloud entails a new role for IT departments, which are positioning themselves more as service brokers.
- ✓ Cloud computing not just about virtual services. It also involves physical infrastructure, which has a real impact on regional development. In this respect, the state has an urban and regional planning role to play and must try to mitigate inequalities (except that no map of infrastructure can ignore geography). Increasingly, organizations are grouping together thanks to innovative cloud projects or shared data centers.
- ✓ The cloud is a means for organizations to share infrastructure, services and expertise while keeping control of their data and their ability to exploit and develop it individually.
- ✓ The pooling made possible by the cloud is a way to have new services for little cost.



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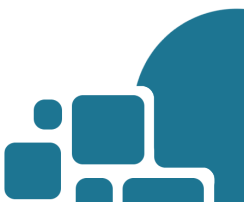

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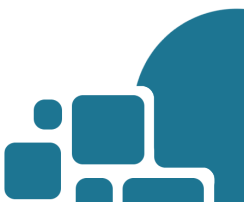

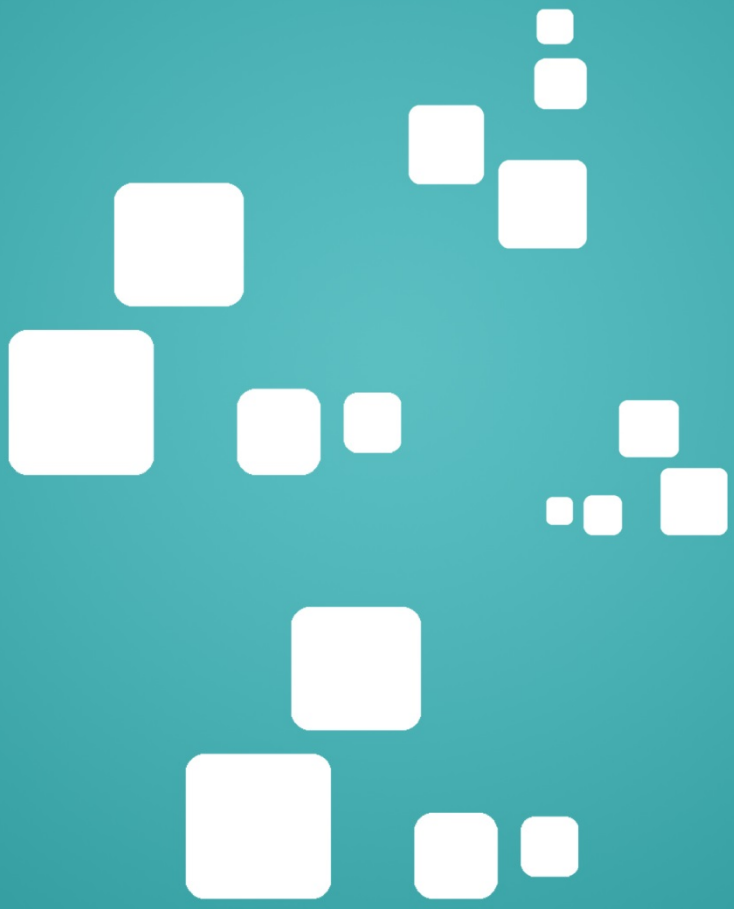

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