FI4VDI project (Federation Infrastructure for VDI): Unified Cluster Storage prototype

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Abstract. This paper presents an analysis of the FI4VDI project, the goal of which is to develop an innovative model of service provision using cloud computing in order to create an infrastructure suite aims at large companies and SMEs alike, educational institutions, universities and/or research centres that would contribute to competitiveness and provide an efficient solution to reducing the carbon footprint derived from the use of information technology.

The penetration of Cloud Computing in sectors as public administration and industry is resulting slow, consequently it is missing the competitive advantages that this technology can provide for both ICT-provider companies and end users thereof. For encouraging the use of cloud computing, from the R+D Centers and services involved in this project, the experience and knowledge of this technology could be transferred and the use of virtual desktops to the clusters of ICT companies, thus including in this way a differentiating service in their portfolios products and also contributing to the development of the economy and the society.

The aim of the FI4VDI project is: to develop a federated infrastructure network for the creation of virtual desktop services. Firstly, by evaluating the position and perception of public and private organisations in the SUDOE Space as regards the desirability of the virtualising IT operating environments, and secondly, by promoting the spread of cloud computing as a means to achieve savings, efficiency and simplicity with the primary objective of ensuring improved productivity. The project aims to use available resources to generate highly innovative services through a PAAS (Platform as a Service) and SaaS (Software as a Service) to enable the generation of virtualization services jobs for users of public and private sector inside southwest Europe. The development of this infrastructure ensures users data protection and compliance with the rules relating to safety information and established SLAs. The launch of this service will result in an improvement through technological innovation and cost savings in targeted sectors thereof.

The provision of cloud computing services by supercomputing centres has a positive effect on the ecological footprint; dependence on physical ICT infrastructures is reduced when these are replaced by virtual ones,

and this in turn produces a marked reduction in energy consumption in these institutions.
With a federated cloud computing model, desktops can be connected to dedicated servers with high rates of effective utilisation, greatly increasing energy efficiency and reducing the carbon footprint associated with the service. The goal of the project is to develop a federated infrastructure network for the creation and management of energy efficient ICT services.
The FI4VDI project is defined as a capitalization project as is based on the adaptation results of projects already developed and the use and enhancement of infrastructure, in this case supercomputing (Spanish supercomputing centers owned by regional authorities or university and European research centers, storage (project UCS-Unified Cluster Storage, developed by the Fundacin Centro de Supercomputacin de Castilla y Len and CATN Sistemas Alternativos, S. L, with which it has strategic partnerships in R+D+i, and the University of Granada, and communications (Spanish project RedIRIS-Nova).
This paper describes both FI4VDI and UCS projects and its contribution to the federated network of centers that aim to provide cloud services to companies and organizations.
Organizations involved in the project FI4VDI
Organisations that participated actively as infrastructure providers included

- The Supercomputing Centre Castile and Leon
  Castile and Leon Region ES41 (Spain)
- The Computing and Advanced Technologies Centre Extremadura
  Extremadura Region ES43 (Spain)
- The University of Lerida Faculty of Arts Computer Centre Ponent
  Catalonia Region ES51 (Spain)
- The University of Montpellier 2 Sciences et Techniques
  Languedoc-Roussillon Region FR81 (France)

Organisations that participated actively as business associations included

- The Innovative Business Association for Network Security and Information Systems (Spain)
- Aveiro Association of Companies for an Innovation Network
  Central Region PT16 (Portugal)
- The Science and Technology Park Agri-Food Consortium Lerida
  Catalonia Region ES51 (Spain)

Keywords: Storage (NAS-DAS-SAN), VDI, Big Data Centre, Cloud Computing.

1 FI4VDI-SUDOE PROJECT

1.1 Objectives

The aim of the FI4VDI project was to develop a federated infrastructure network for the generation of virtual desktop services, and to promote sustainable

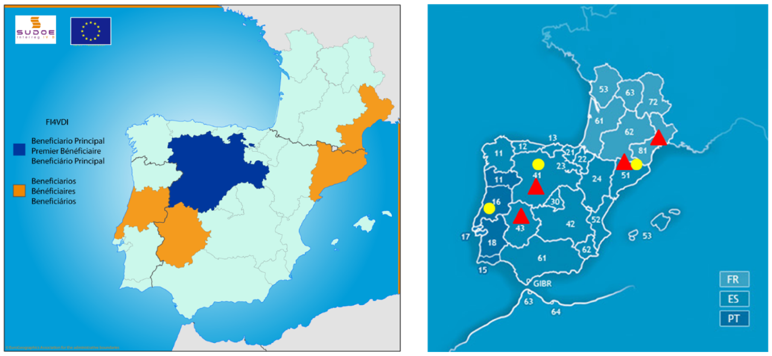

Fig. 1. Scope of the FI4VDI project in the SUDOE Space `www.sudoe.eu`. Setting of the FI4VDI project: profile of the partners participating in the project.

development by leveraging the benefits deriving from transnational cooperation. In brief, the project proposed the creation of a private cloud infrastructure using the resources available in various supercomputing centres located in different SUDOE regions, with the goal of ensuring protection of users' data and compliance with regulations pertaining to information security and the service-level agreements established. Implementation of this service would entail improved competitiveness and cost savings in the sectors targeted, where energy savings and efficiency are a distinguishing feature.

The problem addressed by the project was the need to determine the position and perception of public and private entities located in the SUDOE Space as regards the desirability of virtualisation of IT operating environments, and to promote the spread of cloud computing as a means to achieve savings, efficiency and simplicity with the primary objective of ensuring improved productivity.

The origin of the project: The provision of cloud computing services by supercomputing centres has a positive effect on ecological footprints; dependence on physical ICT infrastructures is reduced when these are replaced by virtual ones, and this in turn produces a marked reduction in energy consumption in these institutions.

Project objectives and results: With a federated cloud computing model, desktops can be connected to dedicated servers with high rates of effective utilisation, greatly increasing energy efficiency and reducing the carbon footprint associated with the service.

Project strategy and structure:

- Task group 0. Preparation
- Task group 1. Project coordination and management
- Task group 2. Technical infrastructure development
- Task group 3. Adapting applications to the cloud environment
- Task group 4. Integration. Prototypes
- Task group 5. Project monitoring and evaluation
- Task group 6. Publicity and information. Market capitalisation

1.2 Virtual Desktop Infrastructure-VDI as a technology proposal [1] [2]

The term desktop virtualization was introduced in the 1990s to describe the process of separation between the desktop, which encompasses the data and programmes that users employ for their work, and the physical machine. A "virtual" desktop is stored remotely on a central server rather than on the hard disk of an individual personal computer. This means that when users work on their desktop from their laptop or PC, all their programmes, applications, processes and data are stored and run centrally, allowing users to access their desktops from any device that can connect remotely to the central server, such as laptops, PCs, smartphones, or thin clients.

Through desktop virtualisation, the entire environment of an information system or the environment itself is encapsulated and delivered to a remote device. This device can be based on a completely different hardware architecture from the one used by the projected desktop environment. It can also be based on a completely different operating system.

Desktop virtualisation consists of the use of virtual machines to enable multiple network users to maintain their individual desktops on a single server or host computer. The central computer may be located in a residence, in the company or in a data centre. Users may be geographically dispersed and connected to the central computer via a local area network (LAN), wide area network (WAN) or via the Internet.

Desktop virtualisation offers advantages over the traditional model, in which each computer functions as a complete and independent unit with its own operating system, peripherals and applications. Energy costs are reduced because resources can be shared and allocated to users according to their needs, and the integrity of user information is enhanced because the data centre stores and safeguards all data and backups. Furthermore, software conflicts are minimised by reducing the total number of programmes stored on computers, and although the resources are distributed, all users can personalise and customise their desktops to meet their specific needs. Thus, desktop virtualisation provides greater flexibility than the client/server paradigm.

The limitations of desktop virtualisation include the possibility of security risks if the network is not well managed, the loss of user autonomy and privacy, the challenges involved in creating and maintaining drivers for printers and other peripherals, difficulties in managing complex multimedia applications and problems in maintaining the addresses of virtual machine users consistent with those held by the data centre.

Benefits and advantages of VDI technology

Benefits

Like any other technology, desktop virtualisation provides a number of key benefits that render this technology the first choice for a large number of users:

- Enhanced security and reduced desktop support costs [3]
- Reduced general hardware costs [4]
- Ensured business continuity [5]

- An eco-friendly alternative [6]
- Improved data security

Advantages
The main advantages are [7] as follows:

- Instant implementation of new desktops and use of applications
- Virtually zero downtime in the case of hardware failure
- Significant reduction in the cost of new deployments
- Sound capacity for managing the desktop image
- The PC replacement cycle is extended from 2-3 years to 5-6 years or more
- Existing desktops include multiple monitors, bidirectional audio/video, video streaming, USB port supports, etc.
- Company employees can access their virtual desktops from any PC, including a PC in the employee's home
- Resources tailored to desktop needs
- Multiple desktops on demand
- Free provision of desktop computers (controlled by the policies of each corporation)

1.3 Indicators of FI4VDI project

Indicators of Performance, Outcome and impact of FI4VDI project
Performance indicators

- R+D projects with added value from an environmental perspective (num.)
- Companies and SMEs that have been part of innovation partnerships funded (num.)
- Projects of telecommunications networks and for encouraging the application of ICTs (num.)
- Deployment Type: Private/Public/Hybrid/Community
- Participation in Conferences, Workshops and Working day diffusion

Outcome indicators

- New technologies developed (num.)
- Transnational cooperation in innovative networks created
- Tools (applications and services) for technological transfer between companies and technological centers and SMEs adopted in SUDOE countries/regions (num.)
- Companies and SMEs that have benefited from project results conducted (num.)
- SUDOE area with improved access to ICTs (Km^2)
- Publications resulting from the project

Impact indicators

- New technologies transferred to enterprises, SMEs and/or managing entities (num.)

- Permanent networks of cooperation established (num.)
- Agents (institutions, enterprises, SMEs, etc.) connected to telecommunication networks created (num.)
- Rate of adoption of Cloud computing model
- Rate of knowledge of Cloud computing and virtualization technology

2 UCS: Unified Cluster Storage

2.1 Introduction

In the mid 90s, there was a change in the paradigm in systems for intensive calculations that tried to solve the main problems that the systems were having: the high cost, proprietary architectures and their limited scalability.
This precedent laid the basis behind the development of new technologies for scientific computing by creating parallel-based computing clusters commodites: a) use of standard personal computers or servers, low cost commodites, providing the same power of calculation a mainframe, b) use of standard hardware and software, and c) the easy scalability of parallel computing clusters.
Currently are being detected problems similar to those experienced in the past again due to the storage needs that grow exponentially reappearing again associated problems of high cost, low scalability and proprietary architectures.
Keep in mind that supercomputers have high storage demands because of the huge volumes of data they work with and the fact that the nodes of clusters are accessing the same files simultaneously, representing a neck bottle. It becomes, therefore, to raise the issue of storage. To this demand storage cloud computing phenomenon adds storage as a new paradigm aimed at finding an answer on this line.

2.2 Objectives

UCS seeks to solve the problems of efficient implementation of distributed files systems and thus to bridge the gap between the bandwidth of high-performance networks and applications used by providing a distributed model that reduces the usual bottlenecks of centralized systems, incorporating replication mechanisms that ensure a reliable and tolerant operation falls node systems.
Keep in mind that is increasing considerably the demand for intensive data management applications (data- intensive applications) accessible through web interfaces that allow to take advantage of the resources of the respective data centers.
The data generated by tools used in the investigation may involve the handling of files or databases of several terabytes, so that the availability of efficient solutions for processing large volumes of data is a challenge and great opportunities for the computer industry.
With the introduction of "cloud computing" as a technology that enables virtualization of data centers to increase the flexibility of use of resources, a major

paradigm shift occurs in the Information Technology and Communications. But for their development requires a very massive storage system that is shared by the cluster of servers dedicated to provide IaaS. In addition, the requirements are extremely demanding, because the capacity binds the need for this storage is accessed simultaneously by large farms and server clusters.
By automating the identification of resources and administration tasks will be achieved to reduce the configuration complexity of these systems.
With UCS response times for applications that require intensive data access and be able to offer performance input/high output is improved. For UCS achieving a distributed file system that reduces bottlenecks, a model of decentralized distributed of UCS that is transparent to users, and thus achieve a symmetric files system.
Achieving these objectives leads to the creation of a new product category in terms of storage systems is concerned, since the achievement of the objectives is eminently innovative.

2.3 Methodology

To improve response times observed in applications that require intensive data access, and offer a high performance in/out, it must be assumed as a base file system for UCS cluster computers, expanding and improving it for an effective and efficient function, and able to offer competitive benefits.
This development UCS distributed, scalable system oriented clusters, reducing bottlenecks and open new possibilities for applications that require intensive data access file system is proposed. It is a shared, not centralized and symmetrical system, where any cluster node can make its available storage space by creating a global space shared by all (store aggregation), as seen on figure 2, and allowing access to the storage node located in other nodes (NAS, Network Attached Store) and global because a file will have the same name and path for all customers.
The distributed decentralized of UCS model is totally transparent to users, and

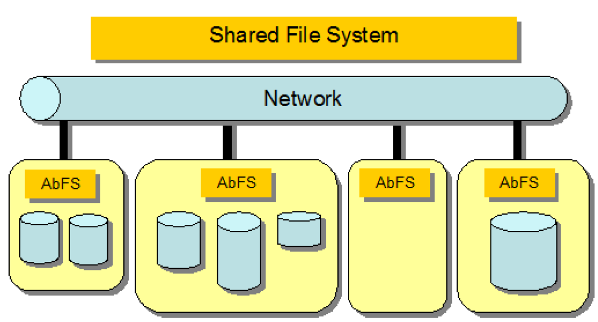

Fig. 2. Configuration of UCS using various resources.

as you add new servers, they will have more free space, which may be used by all the nodes (that is a distributed file system oriented clusters).
UCS is designed as a symmetrical files system in which any node in the system may be a metadata server, even if is client simultaneously. Was also considered the possibility of implementing several file systems on servers and clients so that each will have its own data and share resources while communication channels. Initially the system is designed to take advantage of storage DAS (Direct Attached Store), but can also adapt well to storage SAN (Storage Area Network), because is accessed a block level rather than file (actually could be described as a storage sharing file system, rather than the data servers).

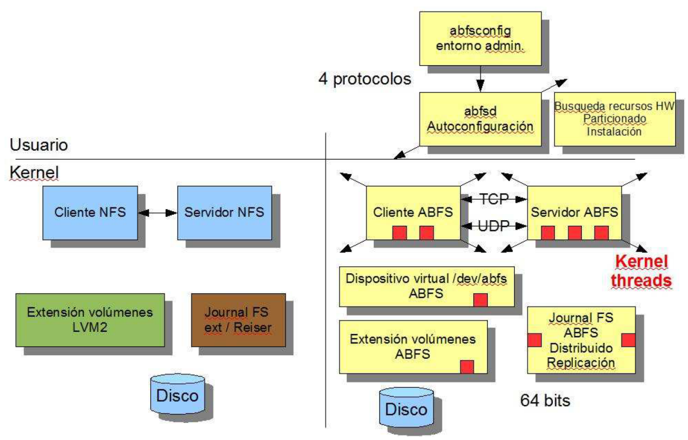

Fig. 3. Comparison: EXT4 and NFS on LVM (left) versus UCS (right).

To appreciate the complexity of a full development of UCS, Figure 3 compares UCS with equivalent NAS system, which encompassed LVM (Logical Volume Manager), EXT4 (based file system Extent), NFS (client and server files in network) and a configuration environment. The development of UCS would develop from scratch all the elements, so the system does not need any other external element, with the advantage of avoiding the constraints posed by each of these elements separately as UCS architecture implements 64-bit, access direct to resources, cache, etc).
To provide solutions to these challenges, it is intended to achieve the following scientific and technological objectives:

1. **UCS reliability**
   It is intended to give greater strength and reliability to the system set, because ensuring the proper functioning is vital for applications. There are many file systems proposed that are actually not used in real systems in companies due to unreliability.
   Casuistry displayed is huge because the system is based on multiple servers

and clients, each with multiple threads of execution, so that the degree of parallelism and concurrency is high.
This objective translates into: a) develops mechanisms to improve quality, b) improving reliability, c) development of test for verifying correct operation, and d) implement the system parameter extraction of real-time execution.

2. **Optimization and development of new internal mechanisms to improve the overall speed and performance of the characteristics of the architecture**
Current systems increasingly offer internal elements that improve the operational performance if it is properly exploit their capabilities. Communication systems such as Infiniband can provide optimal performance when the RDMA (Remote DMA) and incorporating messaging system is used. InfiniBand can offer a system of IP (IP over IB) to ensure compatibility with the sockets-based applications, but penalizes latency and bandwidth that can be obtained. Thus, directly accessing to their resources can bring a better performance.
The main alternatives that have been adopted to reduce the "overhead" software have been the optimization of layers of TCP/IP protocols and replacing them for others less heavy. Special attention should be paid on how to extract models of the communication process, to allow the simulation tools being use to address the study of scalability. This defines a) study methodology to improve communication processes, b) implementation of communication layers in UCS to properly leverage the capabilities of InfiniBand, c) optimizing internal processes execution.
Moreover, there is an interesting line of research directly related to the deduplication and compression techniques. Although compression algorithms are well defined, we must adapt to models that allow compression and decompression anywhere in the file, and define fast and efficient deduplication techniques.
3. **Adjust in the system for applications requiring low response time**
This research line enables then be applied in computer-based cluster systems, giving applications not only better response-time but also access to larger volumes of information and that the proposed model is distributed and scalable.
In this sense is defined: a) study the application requirements, b) extraction of traces that reveal the operating conditions in real time, and c) the optimization of these applications from the trace information.

3 Expected Results

3.1 FI4VDI-SUDOE PROJECT

Creation of a Platform as a Service (PaaS) for mass deployment of virtual desktops. Federation of the participant supercomputing centres infrastructures.
Creation of an innovative cloud computing service aimed at users in the public and private sectors.

Enhanced competitiveness and cost savings in the sectors targeted by the service created.
The UCS project complements the platform as a service (PaaS) generated in FI4VDI with an infrastructure as a Service (IaaS) developed in UCS that optimizes quality and reliability in storage systems and management thereof.
Establishment of strategic recommendations: definition of reliable models for cloud computing (service levels, system capacity, system restoration, interoperability through shared service infrastructures, migration models), identification of service areas and evaluate and promotion of cloud computing as a tool for achieving cost savings and technological optimisation.
Establishment of technological recommendations: identification of existing solutions and possibilities, assessment of the real capacity of suppliers, selection of an applications and systems map, initiation of a cloud computing strategy by adopting private clouds and infrastructure and platform services, establishment of system migration plans and identification of cloud computing as a model that fosters other technologies which are either emerging or in the process of expansion, such as energy sustainability in the area of IT or open source solutions.
Establishment of management recommendations: definition of systems for assessing investment returns, analysis of organisational impact and identification of change management models, development of new contracting models and practices, standardisation and organisation of common services and definition of risk analysis models.

4 Conclusions

4.1 FI4VDI-SUDOE PROJECT

The spread of cloud computing in the Spanish public sector is still limited, and is more common among local authorities than among regional and state institutions.
In general, the most common mode of deployment is private.
Savings, efficiency and simplicity are the reasons that have prompted public authority institutions to contract cloud computing services.
Those public institutions that decided to adopt cloud computing did so after carrying out a legal analysis focused primarily on data protection legislation.
According to the public authority bodies that have adopted cloud computing, the principle benefits of this model are the savings in costs and time it represents, whilst integrity of services and data was identified as the main difficulty.
The Spanish public sector perceived the cloud as a technological and, above all, operational advantage which has met their initial expectations regarding cloud computing.
Among the public authority bodies already using cloud computing, the future prospects are very bright: they intended to continue working in the cloud, they would recommend this technology to other institutions and they expected to continue to obtain future benefits from using the cloud.
However, those public institutions that are not yet using the cloud were more

wary: few intended to incorporate technological solutions, and only a minority of these would consider cloud computing.

4.2 UCS: Unified Cluster Storage

UCS represents significant improvements for the ICT sector, as well as a significant paradigm shift from current storage technologies.
The ICT sector improves day by day, that's indisputable. However, since the apparition of the Information Technologies and Communications, every ten to fifteen years there are major paradigm changes: transition from mainframe to minicomputer, arrival of the PC, etc.
These transitions require four factors: concept, capability, technology and attitude. And these four are given today for the transition to Cloud, which requires a drastic change in storage systems.
The proposed objectives of UCS are eminently innovative. And they are from two points of view:

1. **From a technological point of view**
   They represent an innovation, because at not being the first parallel file system on the market, make easy the study of parallel file systems and on the other, the study of the activity in the field of supercomputing is promoted, which provides the necessary knowledge on the needs of users.
2. **From a point of view of positioning of product**
   Is pretended a paradigm shift. That is, creating a new product category, targeting the global market for storage systems.
   UCS is oriented to storage systems, and this is a goal that must be addressed in several phases:
   (a) In the first phase, once solved ideally the problems of specific groups of users, you can be directed to:
   1) Members of supercomputing. The first address is the niche of supercomputing to be the ideal solution for this user group.
   2) Service Providers of Cloud Computing. The Cloud is a derivative of supercomputing. Cloud providers have the problem of where to store the virtual disk machines (in a scheme of hundreds or thousands of virtual machines). Therefore the system used must be reliable, economical and scalable.
   3) Alternative to existing virtualization techniques. Along with OpenNebula tools, a parallel file system can become a real existing platforms Enterprise virtualization (VMWare vSphere type), with the advantage of avoiding the limitations of these systems with large numbers of virtual machines alternatives.
   4) Very mass storage system Tier-2 or Tier-3 system for general purpose organizations. Those organizations that have a need for distributed storage of very high capacity, capable of reusing existing hardware resources.
   (b) During the second phase, appliances are designed for general-purpose embedded systems. These appliances will be the managers of all the existing

storage, ie, it should automate the task of configuring and implementing the service to global file system.

Acknowledgments
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Fig. 4. Ref. SOE4/P3/E804-FI4VDI. Project FI4VDI-SUDOE corporate logo.

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