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Cloud Computing & Big Data in Higher Education and Research: African Academic Experience

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Outline

- Challenges in Education and Research

- Cloud services for Education and Research

- Success stories of Cloud and Big data deployment in Tunisia

- Case study: Sfax University

Challenges in Education and Research

- **Higher cost of IT resources**
  - The need for IT resources and services are drastically growing
  - Managers and technical staff mainly host their IT services (compute, storage, software, collaboration tools...) on premises.
  - They allocate important budget and time to perform complex management operations

  Challenge: Budget restrictions, shrinking revenues and limited funds for research and development

Challenges in Education and Research

- **Lack of efficiency**
  - Teachers, students, researchers and faculty members
    - require technical skills to set up the experimental environment
    - focus the effort on peripheral tasks more related to system administration than to the course topics.

- **Challenge**: Lack of concentration on the "core business" of education and research.

Challenges in Education and Research

- **Emergence of new communication, collaboration and mobile platforms**

  - **Bring Your Own Device (BYOD)**
    - Students increasingly come to schools and universities with their own mobile devices
    - Access to course content and educational services from anywhere and at anytime.

  - **Collaboration and communication tools**
    - Faculty members increasingly rely on multimedia, communication and collaboration services

  Challenge: Traditional educational services and models can not meet these requirements

Challenges in Education and Research

- **Virtual learning environments**
    - Interactive Multimedia Learning Environments
        - Distance Learning platforms, Moodle…
        - MOOC – Massive Open Online Courses

    Challenge: Important compute resources are required for media (video, voice, …) processing, broadcasting, storing and analysis.

Cloud Computing solution

SaaS for Higher Education and Research

- SaaS is a software distribution model in which applications are hosted by a service provider and made available to customers over the Internet.
 - Example: Google Apps, Microsoft Office 365

PaaS for Researchers

- PaaS offers services to help developers throughout the whole life cycle of an application, from design to test and production.

IaaS for Education and Research

- Provides students, researchers and teachers the ability to provision processing, storage, networks where the consumer is able to deploy and run software, which can include OS and applications
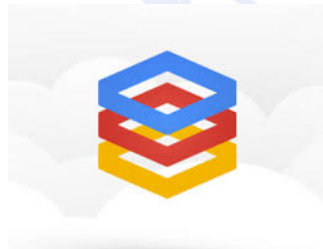
IaaS Services: Three types

- IaaS-hosted Virtual Server
  - **Server virtualization**
  - Research sector and Business Workflow: **Big Data**

- IaaS-hosted Virtual Desktop
  - **Desktop virtualization**
  - Higher Education sector

- IaaS-hosted Storage
  - **Storage virtualization**
 - Education and Research sectors

Success story: IaaS services for Sfax University (Tunisia)

- **Objective**: set up a private IaaS cloud that offers
  - IaaS-hosted Virtual Servers
    - Support **Big Data** technologies and advanced analytics applications

  - IaaS-hosted Virtual Desktops
    - The ENIS School has replaced traditional PCs with cloud based VDI solutions.
    - 10 classrooms are equipped with 30 thin clients connected via a local area network to a private cloud.

IaaS-hosted Virtual Desktops:
Virtual Desktop Infrastructure (VDI)

- "**virtual desktop infrastructure (VDI)**: A desktop as a service (DaaS) solution enabling the hosting of a desktop operating system within a virtual machine."
  - NOTE – In this Recommendation, VDI means that the virtual machine hosting the desktop operation system is running in a cloud computing environment.

    Source: Recommendation ITU-T Y.3503 : Requirements for desktop as a service, approved in May 2014

Virtual Desktop Infrastructure (VDI)

VM   VM   VM

1:1   1:1   1:1

Operating System & Applications

Applications

Operating System & Applications
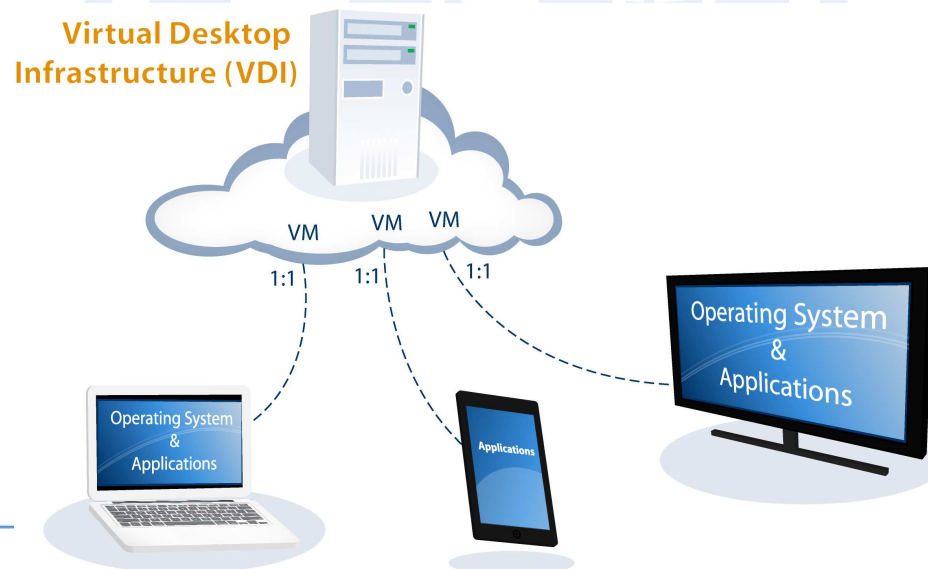
VDI for Virtual Computing Classrooms Sfax University

Before

After

Thin Clients

Cloud Computing

Cloud Infrastructure in ENIS (Sfax University)

- **Hardware**
  - 4 servers acting as controller nodes (redundancy mode)
  - 8 servers for computing
    - XEON Processor, 6 cores, 2.4 Ghz, 128 Go RAM
  - Storage server: 40 To SAS
  - Programmable Switch Node (10 Gbit/s)

- **Software**
  - Hypervisor: KVM and Hyper-V (MS)
  - Cloud Manager: OpenStack
  - CloVER VDI
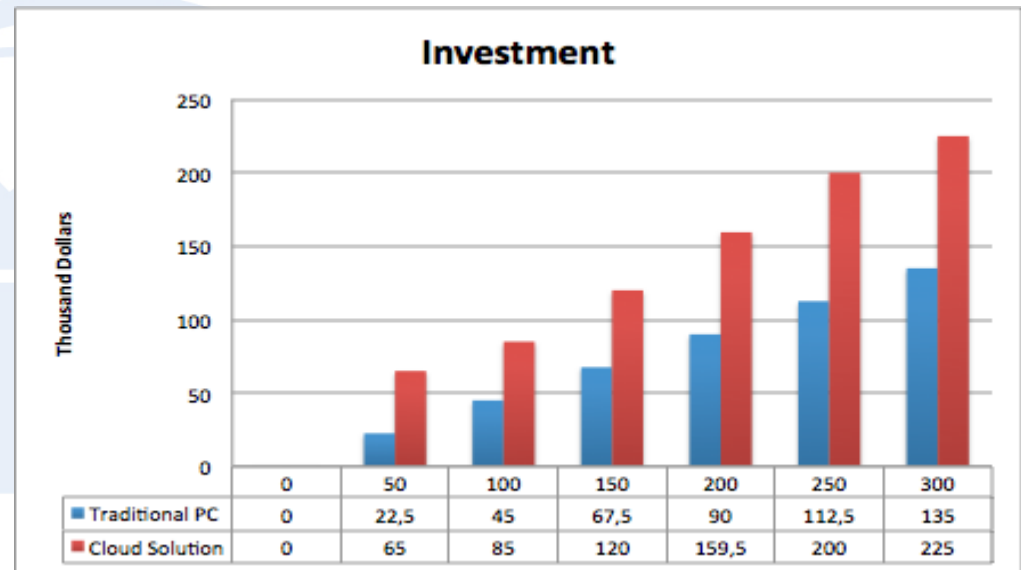   - an OpenStack appliance offering VDI capabilities over the cloud infrastructure.

- **The VDI servers offer 300 virtual desktops for students**.
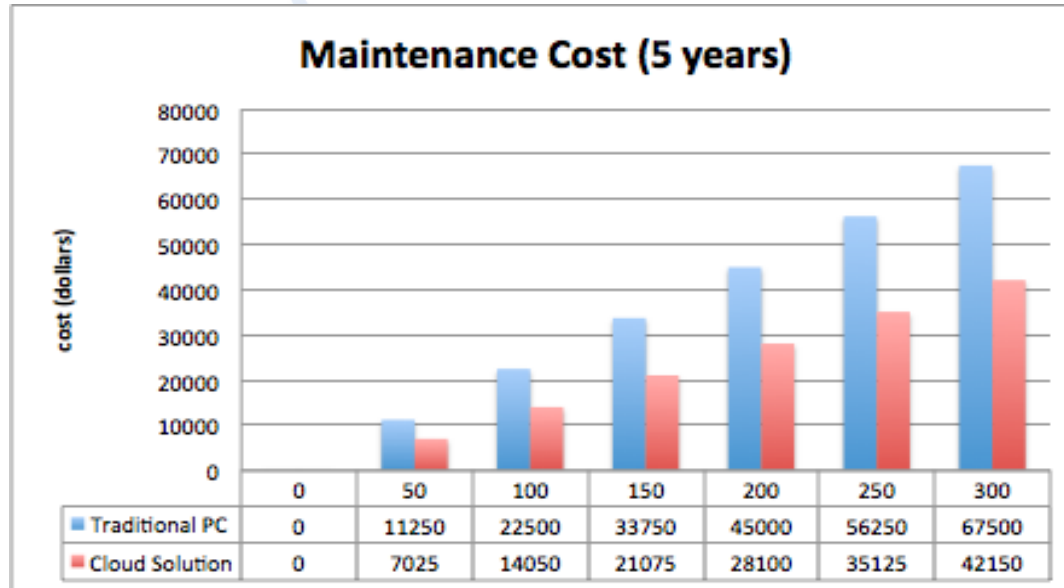 - Each one is composed of 2 Go RAM and 10 Go of storage.

Initial Investment

- Cloud composed of
  - thin clients (250 $ per unit)
  - servers (10.000 $ per unit).

- The initial investment (around 225.000$) required to set up a cloud offering 300 virtual desktops is higher compared to the total price of 300 physical computers (around 135.000$).

Investment

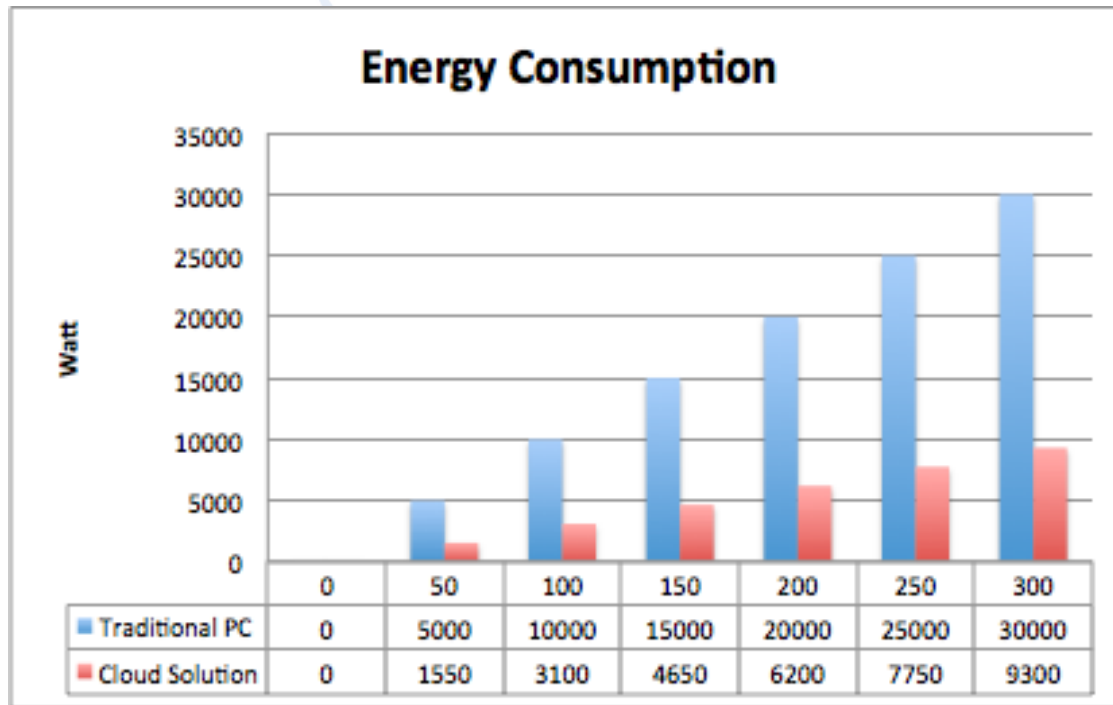|	0	50	100	150	200	250	300
■ Traditional PC	0	22,5	45	67,5	90	112,5	135
■ Cloud Solution	0	65	85	120	159,5	200	225

Thousand Dollars

- Although the capital invested in the cloud is higher than that invested in traditional PC platform, an estimation of the Return on investment (ROI) over 5 years shows the gain and efficiency of the cloud solution.

Maintenance Cost

Maintenance Cost (5 years)

	0	50	100	150	200	250	300
■ Traditional PC	0	11250	22500	33750	45000	56250	67500
■ Cloud Solution	0	7025	14050	21075	28100	35125	42150

- Annual software and hardware maintenance cost is assumed to be
  - 10% for traditional PC
  - 5% for Thin Client
  - 14% for server

- **Cloud can reduce maintenance costs of around 40%**

Energy Consumption

Energy Consumption

	0	50	100	150	200	250	300
Traditional PC	0	5000	10000	15000	20000	25000	30000
Cloud Solution	0	1550	3100	4650	6200	7750	9300

- Thin clients consume an average of 7 watts compared to a 100 watt PC.
- The average energy consumption of a server: 1200 watt

- **Cloud can significantly reduces energy consumption to almost 70%.**

IaaS-hosted Virtual Servers:
Cloud-based big data analytics

- Big data environments require clusters of servers to support the tools that process the large volumes, high velocity, and varied formats of big data.

- Clouds are already deployed on pools of server, storage, and networking resources and can scale up or down as needed.
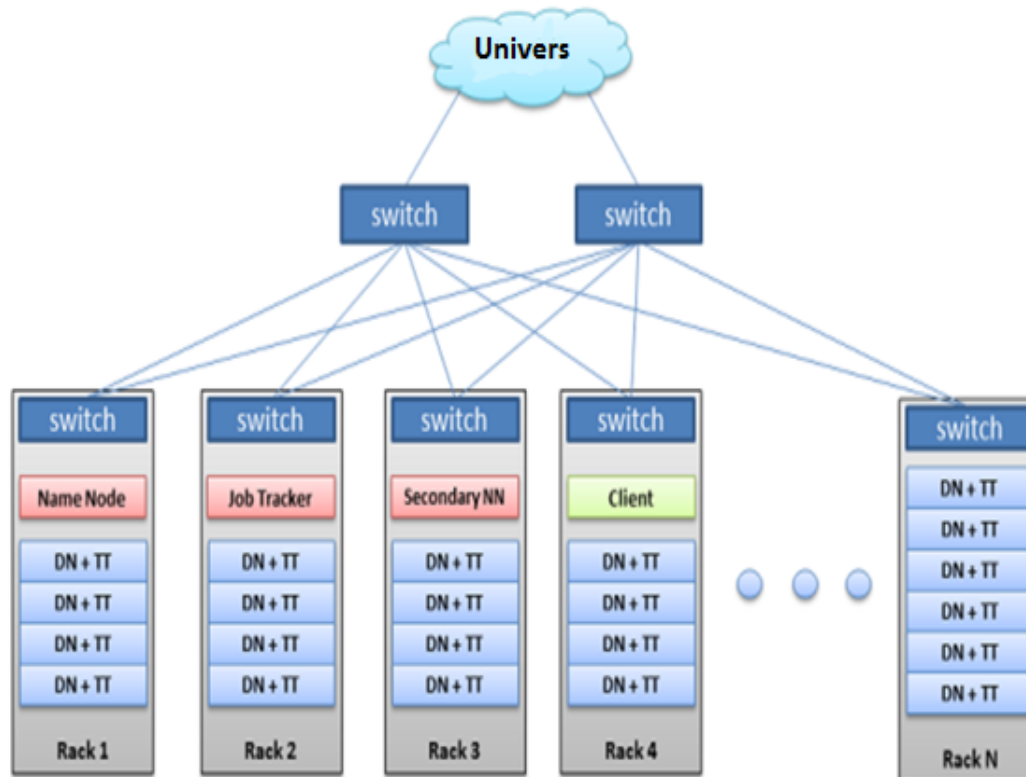
Big data: Hadoop as a Service

- Hadoop (Apache) is a software that provides the high-performance compute power needed to analyze vast amounts of data efficiently and cost-effectively.

- Hadoop is offered as a service using a private Cloud deployed in Sfax university

- **Research Fields in Sfax University using Hadoop**
  - Machine learning
  - Neural networks
  - Robotics
  - Computational mathematics
  - Artificial intelligence
  - **Smart cities**

Conclusions

- In the next five years, institutions of education expect to cut 20 percent of their IT budget by moving applications to the cloud

- Hybrid cloud: where an organization might use a public cloud for some functions (basic business applications) and their private cloud for others (storage for personnel data that is very sensitive).

- Cloud and big data technologies are converging to offer a cost-effective delivery model for cloud-based big data analytic especially in research field.