UNIVERSIDADE
BEIRA INTERIOR

Virtualization For Data Center Automation

Tecnologias Cloud e Data Center
Mestrado em Engenharia Informática

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Credits

- These slides are partly based on the book:

  Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Kai Hwang, Jack Dongarra, Geoffrey C. Fox (Authors), Morgan Kaufmann, 1st edition, 2011, ISBN-13: 978-0123858801, 672 pages.

Agenda

- Introduction to Data Center Automation
- Server Consolidation in Data Centers
- Virtual Storage Management
- Virtual Infrastructure Managers for Virtualized Data Centers

Introduction to Data Center Automation

- Data centers have grown rapidly in recent years, and all major IT companies are pouring their resources into building new data centers.
- In addition, Google, Yahoo!, Amazon, Microsoft, HP, Apple, and IBM are all in the game. All these companies have invested billions of dollars in datacenter construction and automation.
- **Data-center automation means** that **huge volumes of** hardware, software, and database **resources** in these data centers **can be allocated dynamically** to millions of Internet users simultaneously, with guaranteed QoS and cost-effectiveness.

Introduction to Data Center Automation

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- In other words:
  - Data center automation is the process of managing and executing tasks within a data center without human intervention.
  - This extends from server provisioning/deprovisioning and configuration to workload management and monitoring as well as configuring and monitoring network devices.
  - It's about utilizing technology or *using software* to automate tasks in a data center that are repetitive, routine, or prone to error, and make data center operations more efficient.
  - Reducing human interaction can help to improve efficiency, reduce costs, and improve uptime.

Fontes:
https://www.stonebranch.com/blog/data-center-automation
https://granulate.io/blog/data-center-automation-benefits-types-best-practices/

Introduction to Data Center Automation

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- In other words:
  - As an example, tasks or jobs commonly automated include:
    - Provisioning and deploying virtualized workloads
    - Configuration management of servers
    - Patching or updating operating systems
    - Moving data between applications
    - Application deployment

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Introduction to Data Center Automation

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- What are the Most Common Automation Categories?
  - **Infrastructure Automation**
    - Infrastructure automation refers to the use of technology to manage and control the elements of a data center's physical and virtual infrastructure. This includes servers, storage systems, networking devices, and other hardware components. Automation in this area helps in configuring, managing, and scaling these resources efficiently.
    - The key advantage of infrastructure automation lies in its ability to rapidly provision and configure hardware resources. For example, when a new server is needed, automation tools can quickly deploy it with the required operating system and applications, based on predefined templates. This reduces the time and effort required for manual setup.

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Introduction to Data Center Automation

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- What are the Most Common Automation Categories?
  - **Network Automation and Management**
    - Network automation and management involves using software to automate the processes of configuring, managing, testing, deploying, and operating network devices and services. This category of automation helps in reducing manual configuration errors, improving network reliability and efficiency, and speeding up the deployment of network services.
    - Automated network management tools can dynamically adjust network configurations based on current needs. For example, they can automatically reroute traffic in case of congestion or network failure, and scale network resources up or down based on demand.

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Introduction to Data Center Automation

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- What are the Most Common Automation Categories?
  - **Data Center Infrastructure Management (DCIM)**
    - Data Center Infrastructure Management (DCIM) tools provide an integrated view of a data center's physical infrastructure. They help in optimizing the performance, efficiency, and space utilization of data centers. DCIM tools combine information technology (IT) and facility management to enable seamless operation of systems across the data center.
    - A key function of DCIM applications is to monitor monitor equipment utilization, environmental variables like temperature, humidity, and power usage, and facility infrastructure components. This information is crucial for optimizing cooling systems (e.g., air conditioners) and power consumption, leading to significant energy savings as well as to provide real-time insights into the data center's operations, enabling better decision-making and planning for future capacity needs.

Fontes:
https://www.stonebranch.com/blog/data-center-automation
https://granulate.io/blog/data-center-automation-benefits-types-best-practices/

Introduction to Data Center Automation

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- What are the Most Common Automation Categories?
  - **(Remote) Monitoring and Management**
    - Remote Monitoring and Management (RMM) is focused on overseeing and controlling IT infrastructure remotely. It includes monitoring the health and performance of servers, storage, networks, and other devices from a central location. RMM tools can detect and alert IT staff to potential issues/problems before they escalate into serious problems.
    - RMM is especially valuable for data centers that manage resources distributed across multiple locations. It enables centralized management of all assets, regardless of their physical location. These tools can also automate routine maintenance tasks, such as patch management and software updates, ensuring that all systems are current and secure.
    - A class of tools that discover & manage devices, monitor for problems, and take automated action.

Fontes:
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https://granulate.io/blog/data-center-automation-benefits-types-best-practices/

Introduction to Data Center Automation

- This automation process is triggered by the growth of virtualization products and cloud computing services.
- The latest virtualization development highlights high availability (HA), backup services, workload balancing, and further increases in client bases jointly with automation, service orientation, policy-based, and variable costs in the virtualization market.
- The major market share moves to the areas of HA, utility computing, production consolidation, and client bases.
- Next slides will discuss server consolidation, virtual storage, OS support, and trust management in automated data-center designs.

Server Consolidation in Data Centers

- In data centers, a large number of heterogeneous workloads can run on servers at various times.
- These heterogeneous workloads can be roughly divided into two categories: chatty workloads and noninteractive workloads.
- Chatty workloads may burst at some point and return to a silent state at some other point. A web video service is an example of this, whereby a lot of people use it at night and few people use it during the day.
- Noninteractive workloads do not require people's efforts to make progress after they are submitted. High-performance computing is a typical example of this.

Server Consolidation in Data Centers

- At various stages, the requirements for resources of these kinds of workloads are dramatically different.
- To guarantee that a workload will always be able to cope with all demand levels, the workload is statically allocated enough resources so that peak demand is satisfied.
- Therefore, it is common that most servers in data centers are underutilized.
- A large amount of hardware, space, power, and management cost of these servers is wasted.
- Server consolidation is an approach to improve the low utility ratio of hardware resources by reducing the number of physical servers.

Server Consolidation in Data Centers

- Among several server consolidation techniques such as centralized and physical consolidation, virtualization-based server consolidation is the most powerful.
- Data centers need to optimize their resource management.
- Yet these techniques are performed with the granularity of a full server machine, which makes resource management far from well optimized.
- Server virtualization enables smaller resource allocation than a physical machine.

Server Consolidation in Data Centers

- Server consolidation is an approach to the efficient usage of computer server resources in order to reduce the total number of servers or server locations that an organization requires.

- The practice developed in response to the problem of server sprawl, a situation in which multiple, under-utilized servers take up more space and consume more resources than can be justified by their workload.

Server Consolidation in Data Centers

- Server consolidation techniques pack a number of VMs on a fewer number of physical machines to optimize resource utilization and reduce power consumption by letting the physical machines run in optimally efficient energy and more energy-proportional state.
- The important feature that makes the server consolidation technique even more attractive is VM live migration.
- Using VM live migration, one can transfer a running VM from a physical machine to another physical machine without considerable service downtime.
- This consolidation can be done in different ways considering various parameters.

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Server Consolidation in Data Centers

- Possible step-by-step guide on how to consolidate your IT infrastructure. Fonte: https://phoenixnap.com/blog/server-consolidation
- **1. Assess Your Current Environment**
  - **Analyze usage patterns and resource utilization.** Dive deep into each server's workload and resource consumption. Identify underutilized or over-utilized servers to understand potential consolidation opportunities.
  - **Identify bottlenecks.** Look for servers experiencing performance bottlenecks that impact application responsiveness and user experience. Prioritize consolidation of these servers.
  - **Classify workloads.** Categorize servers based on their workloads to determine their compatibility. Servers running similar applications or functions are good candidates for efficient merging.

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Server Consolidation in Data Centers

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- **2. Identify and Group Servers**
  - **Leverage automation tools.** Employ cloud management and automation tools to streamline workload analysis and server grouping.
  - **Consider resource compatibility.** Ensure the target server or cluster has sufficient resources to handle the combined workloads effectively.
  - **Prioritize business-critical applications.** Analyze the impact of consolidation on critical applications and prioritize their placement on dedicated or high-performance servers for guaranteed uptime and performance.

Server Consolidation in Data Centers

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- **3. Plan the Consolidation**
  - **Virtual Infrastructure Managers or Cloud management platforms.** Consider leveraging VI/cloud management platforms to automate workload migration and server provisioning.
  - **Resource scaling strategy.** Define a clear strategy for dynamically scaling resources as workload demands fluctuate.
- **4. Test and Validate**
  - **Pre-migration testing.** Perform comprehensive testing in a trial environment to validate the plan and identify potential issues before migrating workloads to the consolidated server.
  - **Performance monitoring tools.** Use server monitoring tools to track the consolidated server's behavior and ensure it's running smoothly after migration.

Server Consolidation in Data Centers

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- **5. Consolidate**
  - **Migrate workloads.** Transfer the previously identified workloads to the consolidated server or cluster.
  - **Shutdown and decommissioning.** Once migrated, shut down and decommission the old servers to reduce energy consumption and maintenance costs.
  - **Post-migration verification.** Verify the functionality of migrated applications and services on the consolidated server. Ensure there is no performance degradation or service disruptions.

Server Consolidation in Data Centers

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- **6. Monitor and Maintain**
  - **Continuous performance monitoring.** Proactively monitor the consolidated server's performance, resource utilization, and application health to identify potential issues early.
  - **Regular maintenance tasks.** Perform regular maintenance like software updates, security patching, and hardware upgrades to keep the consolidated servers running smoothly and securely.
  - **Resource optimization.** Regularly review and adjust resource allocation to optimize performance and prevent bottlenecks.
- **7. Optimize the Environment**
  - **Workload rebalancing.** Periodically rebalance workloads across the consolidated server or cluster to ensure optimal resource utilization and minimize bottlenecks.
  - **Right-sizing resources.** Continuously assess resource needs and adjust server configurations to ensure cost efficiency without compromising performance.

Virtual Storage Management

- In system virtualization, virtual storage includes the storage managed by hypervivors and guest OSes.
- Generally, the data stored in this environment can be classified into two categories: VM images and application data.
- The VM images are special to the virtual environment, while application data includes all other data which is the same as the data in traditional OS environments.

Virtual Storage Management

- The most important aspects of system virtualization are encapsulation and isolation.
- Traditional operating systems and applications running on them can be encapsulated in VMs. Only one operating system runs in a virtualization while many applications run in the operating system.
- System virtualization allows multiple VMs to run on a physical machine and the VMs are completely isolated.
- To achieve encapsulation and isolation, both the system software and the hardware platform, such as CPUs and chipsets, are rapidly updated. However, storage is lagging. The storage systems become the main bottleneck of VM deployment.

Virtual Storage Management

- In virtualization environments, a virtualization layer is inserted between the hardware and traditional operating systems or a traditional operating system is modified to support virtualization.
- This procedure complicates storage operations.
- On the one hand, storage management of the guest OS performs as though it is operating in a real hard disk while the guest OSes cannot access the hard disk directly.
- On the other hand, many guest OSes contest the hard disk when many VMs are running on a single physical machine. Therefore, storage management of the underlying VMM is much more complex than that of guest OSes (traditional OSes).

Virtual Storage Management

- The storage primitives used by VMs are not nimble.
- Hence, operations such as remapping volumes across hosts and checkpointing disks are frequently clumsy and esoteric, and sometimes simply unavailable.
- In data centers, there are often thousands of VMs, which cause the VM images to become flooded.
- Many researchers tried to solve these problems in virtual storage management.
- The main purposes of their research are to make management easy while enhancing performance and reducing the amount of storage occupied by the VM images.

Virtual Infrastructure Managers for Virtualized Data Centers

- Data centers must be virtualized to serve as cloud providers.
- Next table summarizes four virtual infrastructure (VI) managers and Operating Systems.
- These VI managers and OSes are specially tailored for virtualizing data centers which often own a large number of servers in clusters.
- These VI managers are used to create VMs and aggregate them into virtual clusters as elastic resources.
- Nimbus and Eucalyptus support essentially virtual networks.

Virtual Infrastructure Managers for Virtualized Data Centers

- OpenNebula has additional features to provision dynamic resources and make advance reservations.
- All three public VI managers apply Xen and KVM for virtualization.
- vSphere 4 uses the hypervisors ESX and ESXi from VMware.
- Only vSphere 4 supports virtual storage in addition to virtual networking and data protection.

Virtual Infrastructure Managers for Virtualized Data Centers

Manager/ OS, Platforms, License	Resources Being Virtualized, Web Link	Client API, Language	Hypervisors Used	Public Cloud Interface	Special Features
Nimbus Linux, Apache v2	VM creation, virtual cluster, www .nimbusproject.org/	EC2 WS, WSRF, CLI	Xen, KVM	EC2	Virtual networks
Eucalyptus Linux, BSD	Virtual networking (Example 3.12 and [41]), www .eucalyptus.com/	EC2 WS, CLI	Xen, KVM	EC2	Virtual networks
OpenNebula Linux, Apache v2	Management of VM, host, virtual network, and scheduling tools, www.opennebula.org/	XML-RPC, CLI, Java	Xen, KVM	EC2, Elastic Host	Virtual networks, dynamic provisioning
vSphere 4 Linux, Windows, proprietary	Virtualizing OS for data centers (Example 3.13), www .vmware.com/ products/vsphere/ [66]	CLI, GUI, Portal, WS	VMware ESX, ESXi	VMware vCloud partners	Data protection, vStorage, VMFS, DRM, HA

In: Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Kai Hwang, Jack Dongarra, Geoffrey C. Fox, Morgan Kaufmann, 1st edition, 2011, ISBN-13: 978-0123858801, 672 pages.

Outras Ferramentas de Automação usadas em Data centers

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- Infrastructure Provisioning and Deployment:
  - Automation tools can automate the provisioning and deployment of hardware resources such as servers, networking equipment, and storage devices. This includes tasks such as server provisioning, network configuration, and storage allocation.
  - Infrastructure as Code (IaC) tools like **Terraform**, **Ansible**, and **Puppet** enable administrators to define infrastructure configurations using code, which can then be automatically deployed and managed.
- Orchestration and Workflow Automation:
  - Orchestration tools automate complex workflows and processes by coordinating tasks across multiple systems and services.
  - Workflow automation platforms like **Jenkins**, **Kubernetes**, and Apache Airflow enable administrators to define, schedule, and execute workflows involving tasks such as software deployments, data processing, and batch jobs.

Outras Ferramentas de Automação usadas em Data centers

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- Monitoring and Management:
  - Automated monitoring solutions continuously monitor the health, performance, and availability of data center resources.
  - Monitoring tools such as **Nagios**, **Zabbix**, and **Prometheus** can automatically detect and alert on issues such as server failures, network congestion, and storage capacity constraints.
- DCIM:
  - Representative Tools: Ansys Fluent, Nlyte, StruxureWare