



Software Defined Systems

Week 2

Architecture of Software Defined Systems

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Architecture of Software Defined Systems

Learning objectives

- Understand the fundamental concepts of Software Defined Architecture.
- Identify key components and their functions within SDA.
- Analyze the benefits and challenges of implementing SDA.
- Explore real-world applications and use cases of SDA.

Introduction

- In the realm of IT infrastructure, two primary architectural approaches are commonly used:
 - Hardware-centric architectures and
 - Software-defined architectures.



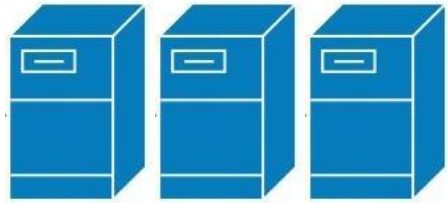
Hardware-Centric Architectures

Hardware-Centric Architectures

- Hardware-centric architectures are traditional systems where the **hardware components** (servers, switches, routers) dictate the capabilities and performance of the IT infrastructure.
- These systems are characterized by fixed functions and high performance.
- The management and configuration of resources are typically performed manually and are closely tied to the physical devices.

Hardware-Centric Architectures

Physical IT Infrastructure



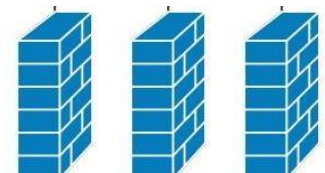
Server



Router



Switch



Firewall

- Each of them running a separate control software.
- Vendor specific proprietary software
- Heavily on hardware configurations
- ASICs (Application-Specific Integrated Circuits)
- FPGAs (Field-Programmable Gate Arrays)

Hardware-Centric Architectures

Physical IT Infrastructure



Source: <https://www.verdict.co.uk/what-are-data-centres/>

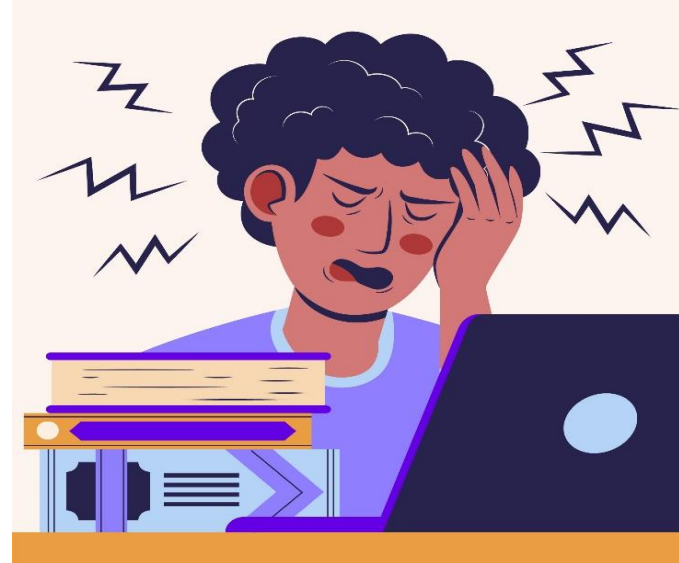
- Scalability
- Energy Consumption
- Reliability and Redundancy
- Resource Management
- Cooling and Thermal Management
- Network Congestion
- Security Vulnerabilities
- Maintenance Complexity

Hardware-Centric Architectures

Physical IT Infrastructure



Source: <https://www.verdict.co.uk/what-are-data-centres/>



Source: <https://www.freepik.com/free-vector/>

Hardware-Centric Architectures

Characteristics

- **Fixed Resources** - Resources are dedicated to specific tasks and cannot be easily reallocated.
- **Manual Configuration** - Network and system configurations are often performed manually, leading to potential human errors.
- **Tightly Coupled** - Hardware and software are closely integrated, making changes difficult and time-consuming.

Hardware-Centric Architectures

Advantages

- **Performance** - Optimized for specific tasks, often resulting in high performance for dedicated applications.
- **Reliability** - Well-established technologies with predictable performance characteristics.
- **Simplicity** - Easier to understand for traditional IT staff familiar with hardware configurations.

Hardware-Centric Architectures

Disadvantages

- **Lack of Flexibility** - Difficult to adapt to changing business needs without significant hardware changes.
- **High Costs** - Upgrading or scaling hardware can be expensive and time-consuming.
- **Complex Management** - Manual processes can lead to inefficiencies and increased operational overhead.



Software Defined Architecture

Software Defined Architecture

- Software Defined Architecture (SDA) refers to an approach that **abstracts** the **management** and **control** of IT resources through software, allowing for centralized management and dynamic resource allocation.
- This architecture separates the **control plane** (management) from the **data plane** (resource handling).
- This separation enhances flexibility and enables easier updates to network configurations without disrupting data flows [\[1\]](#).

Software Defined Architecture

Control Plane

- This is the brain of the architecture, responsible for making decisions about where traffic is sent.
- It operates through software controllers that maintain the network's state and policies.

Data Plane

- The data plane consists of the physical hardware (e.g., switches, routers) that forwards traffic based on the rules established by the control plane.

Software Defined Architecture

Applications

- These are software programs that leverage the SDN (Software-Defined Networking) architecture to automate network management, enforce policies, and optimize performance.

API Interfaces

- Application Programming Interfaces (APIs) enable communication between the control plane and applications, allowing for dynamic configuration and management.

Software Defined Architecture

Characteristics

- **Virtualization** - Resources are virtualized, enabling multiple logical instances to run on a single physical device.
- **Centralized Control** - A centralized controller manages the resources, simplifying configuration and management.
- **API-Driven** - Integration and communication are facilitated through APIs, allowing for programmability and automation.

Software Defined Architecture

Advantages

- **Flexibility** - Quickly adapt to changing business requirements without significant hardware modifications.
- **Scalability** - Easily scale resources up or down based on demand, leading to improved resource utilization.
- **Cost Efficiency** - Reduces capital expenditures on hardware by maximizing resource use and enabling automation.
- **Increased Agility** - SDAs enable rapid deployment of new services and applications without significant hardware changes. Organizations can quickly adapt to market demands.

Software Defined Architecture

Disadvantages

- **Complexity** - Transitioning to an SDA can be complex, requiring a shift in mindset and processes.
- **Security Concerns** - Centralized control may introduce vulnerabilities if not properly managed.
- **Integration Challenges** - Integrating SDA with existing hardware and legacy systems can pose difficulties.

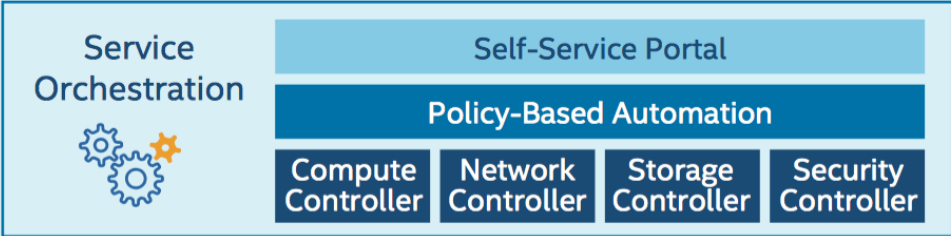
Hardware Centric Vs SDA

Feature	Hardware-Centric Architecture	Software Defined Architecture
Resource Allocation	Fixed, dedicated resources	Dynamic, virtualized resources
Management	Manual, hardware-dependent	Centralized, software-driven
Flexibility	Low	High
Scalability	Limited, expensive	Easily scalable
Cost	Higher due to hardware investments	Lower due to improved resource utilization
Complexity	Simpler for traditional setups	More complex due to abstraction
Performance	Optimized for specific tasks	Variable, dependent on resource allocation

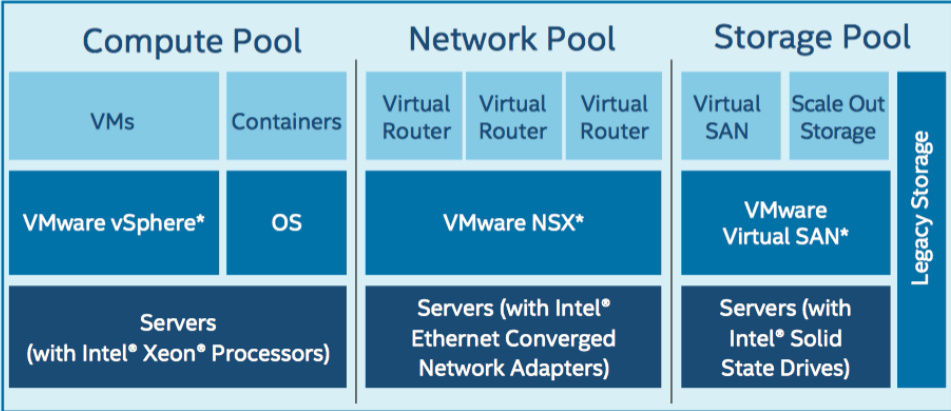


Software Defined Infrastructure

Software Defined Infrastructure



Infrastructure Attributes



- Software-defined infrastructure is the use of software to provide data center functions, including network, compute and storage.

https://www.insight.com/en_US/content-and-resources/2017/06152017-software-defined-infrastructure-and-software-defined-storage-in-vmware-environments.html

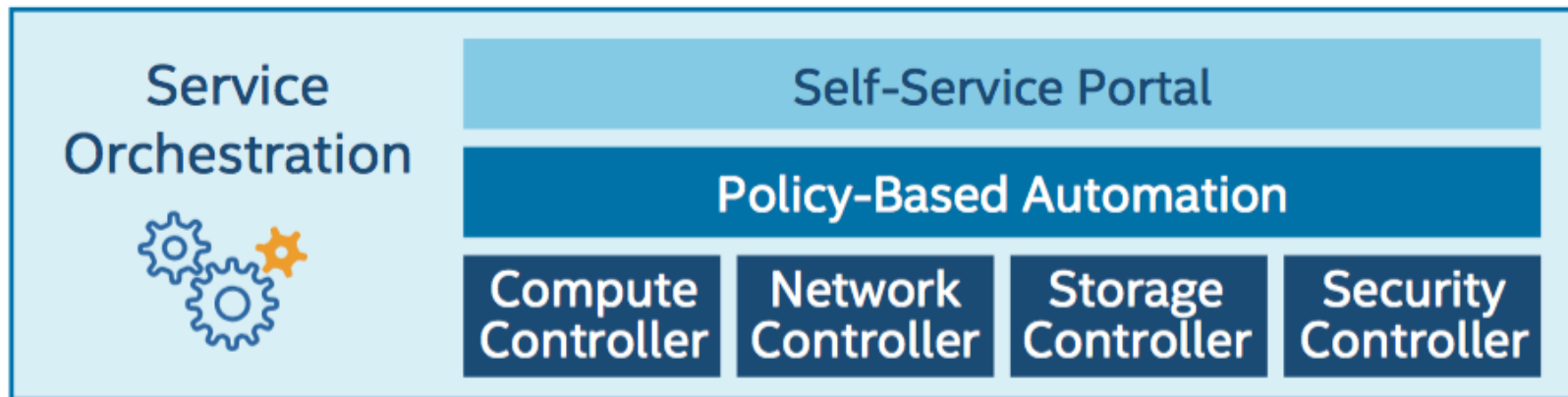
Software Defined Infrastructure

Infrastructure Attributes



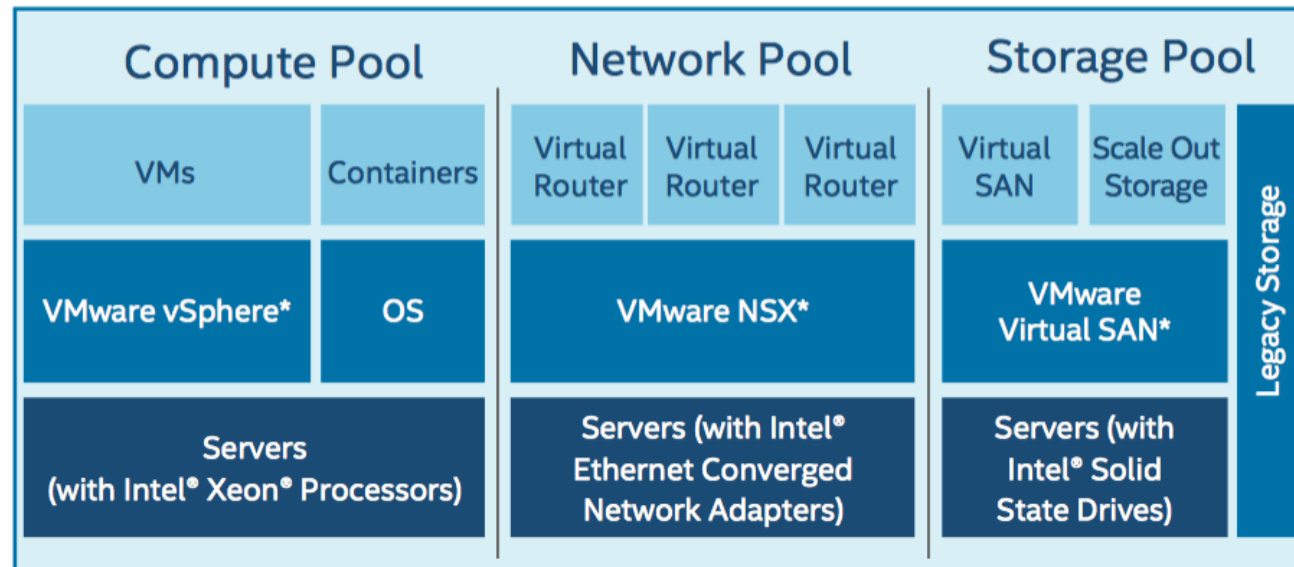
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Software Defined Infrastructure



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Use Cases of Software Defined Architecture

Use Cases of Software Defined Architecture

1. Data Center Networking

- SDAs enable dynamic management of data center traffic, optimizing resource allocation and facilitating multi-tenancy.
- Increasing adoption of hyper-converged infrastructure and automation tools.
- **Google** - uses SDN to manage its vast data centers, optimizing network traffic and improving resource utilization.
- **Microsoft Azure** - implements SDN to enhance scalability and flexibility in its cloud services.

Use Cases of Software Defined Architecture

2. Cloud Computing

- SDAs facilitate the deployment of virtualized resources, allowing for rapid provisioning and scaling of services.
- Shift towards hybrid and multi-cloud environments, leveraging SDN for seamless integration and management.
- **Amazon Web Services (AWS)** - uses SDN for its Elastic Compute Cloud (EC2) services, providing customers with flexible networking options.
- **IBM Cloud** - Employs SDN to enhance its cloud offerings, enabling efficient resource management and orchestration.

Use Cases of Software Defined Architecture

3. Network Function Virtualization (NFV)

- SDAs support NFV by enabling network functions to be virtualized and deployed as software, reducing hardware dependency.
- Growing interest in telco cloud transformations, where traditional network functions are moved to virtualized environments.
- **AT&T** - Implements NFV through SDN to enhance its network flexibility and reduce operational costs.
- **Vodafone** - Leverages SDN and NFV to innovate service delivery and improve network performance.

Use Cases of Software Defined Architecture

4. Internet of Things (IoT)

- SDAs manage the diverse and dynamic nature of IoT devices, allowing for flexible integration and communication.
- Increasing deployment of edge computing and improvements in IoT protocols supported by SDN.
- **CISCO** - Uses SDN to optimize IoT connectivity and management, enhancing security and performance across devices.
- **GE Digital** - Implements SDN to facilitate the management of industrial IoT applications, ensuring efficient data flow and processing.

Use Cases of Software Defined Architecture

5. Enterprise WAN and SD-WAN

- SDAs enable organizations to manage wide area networks (WAN) more efficiently, reducing costs and improving performance.
- Rapid adoption of Software-Defined WAN (SD-WAN) solutions for improved connectivity and centralized management.
- **VMware** - Offers SD-WAN solutions that leverage SDN principles to optimize network performance and reduce costs.
- **Cisco Meraki** - Provides SD-WAN solutions that enhance network agility and simplify management for enterprises.

Use Cases of Software Defined Architecture

6. Security and Policy Management

- SDAs allow for centralized security policy management, enabling dynamic responses to threats and vulnerabilities.
- Increasing focus on integrating security into network management through SDN-driven solutions.
- **Palo Alto Networks** - Utilizes SDN to enhance security features in its cloud-delivered security services.
- **Fortinet** - Implements SDN to provide integrated security solutions that adapt to changing network conditions.

Challenges and Considerations

Security Risks

Interoperability

Complexity in Implementation

Performance Overheads



Transitioning from Legacy Systems to Software-Defined Architectures

Transitioning from Legacy Systems to SDA

- Assess Current Systems
- Define Objectives
- Develop a Transition Strategy
- Design the New Architecture
- Data Migration Plan
- Pilot Testing
- Full Migration
- Training and Support
- Review and Optimize
- Documentation

Case Study : Alibaba

- Alibaba Group required a robust infrastructure to support its rapidly growing e-commerce platform, particularly during peak shopping events.

Challenges

- The legacy systems struggled to manage significant traffic spikes, especially during major sales like Singles' Day, leading to potential service disruptions.

Transition

Alibaba adopted a microservices architecture and leveraged cloud-native technologies to improve scalability and flexibility.

Case Study : Alibaba

Benefits

- **Elastic Scalability** - Successfully managed over **500** million transactions in a single day without any downtime.
- **Agility** - Enabled faster development and deployment of new features, enhancing the overall user experience.
- **Cost Efficiency** - Improved resource allocation through real-time demand analysis, reducing operational costs.

Test Your Knowledge

1. Which of the following is a disadvantage of Hardware-Centric Architectures?
 - A) High flexibility in resource allocation
 - B) Long development cycles for custom hardware
 - C) Low initial investment costs
 - D) Easy integration with cloud services

Test Your Knowledge

1. Which of the following is a disadvantage of Hardware-Centric Architectures?

- A) High flexibility in resource allocation
- B) Long development cycles for custom hardware**
- C) Low capital expenditure
- D) Easy integration with cloud services

Reason: Hardware-Centric Architectures often involve lengthy development cycles, particularly for custom solutions like ASICs, which can delay deployment.

Test Your Knowledge

2. What is one of the main challenges of implementing Software-Defined Architectures?

- A) Simplified network management
- B) Reduced hardware dependency
- C) Interoperability issues with legacy systems
- D) Enhanced security features

Test Your Knowledge

2. What is one of the main challenges of implementing Software-Defined Architectures?

- A) Simplified network management
- B) Reduced hardware dependency
- C) Interoperability issues with legacy systems**
- D) Enhanced security features

Reason: Transitioning to SDAs can lead to compatibility challenges with existing legacy systems, requiring additional resources and planning.

Test Your Knowledge

3. Which of the following best describes the primary function of the control plane in an SDA?

- A) Forwarding data packets to their destinations
- B) Making decisions about network policies and configurations
- C) Providing physical connectivity between devices
- D) Monitoring network traffic for security threats

Test Your Knowledge

3. Which of the following best describes the primary function of the control plane in an SDA?

- A) Forwarding data packets to their destinations
- B) Making decisions about network policies and configurations**
- C) Providing physical connectivity between devices
- D) Monitoring network traffic for security threats

Reason: The control plane is responsible for managing the network's state and policies, while the data plane handles the actual data forwarding.

References

- [1] F. Hu et al., "A Survey on Software-Defined Networking," IEEE Communications Surveys & Tutorials, vol. 17, no. 4, pp. 2364-2396, 2015.



Thank you!

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