Software Defined Systems

Week 13 Emerging Trends in Software Defined Systems

Lecturer: Biniam Behailu

Addis Ababa Science and Technology University

Addis Ababa, Ethiopia

Contents

Emerging Trends in Software Defined Systems

Learning objectives

- Overview of emerging trends in Software Defined Systems.
- Describe the architecture, benefits, and use cases of NFV, Edge Computing, and Serverless Computing.
- Identify the challenges and limitations associated with these technologies.
- Explore emerging trends and their potential impact on the future of IT.
- Engage in discussions about practical applications and implications of these technologies.

Overview of Key Technologies

- **Network Function Virtualization** (**NFV**) - Virtualizes network functions traditionally performed by hardware.
- **Edge Computing** - Processes data closer to the source, minimizing latency.
- **Serverless Computing** - Allows developers to run applications without managing servers.

Network Function Virtualization (NFV)

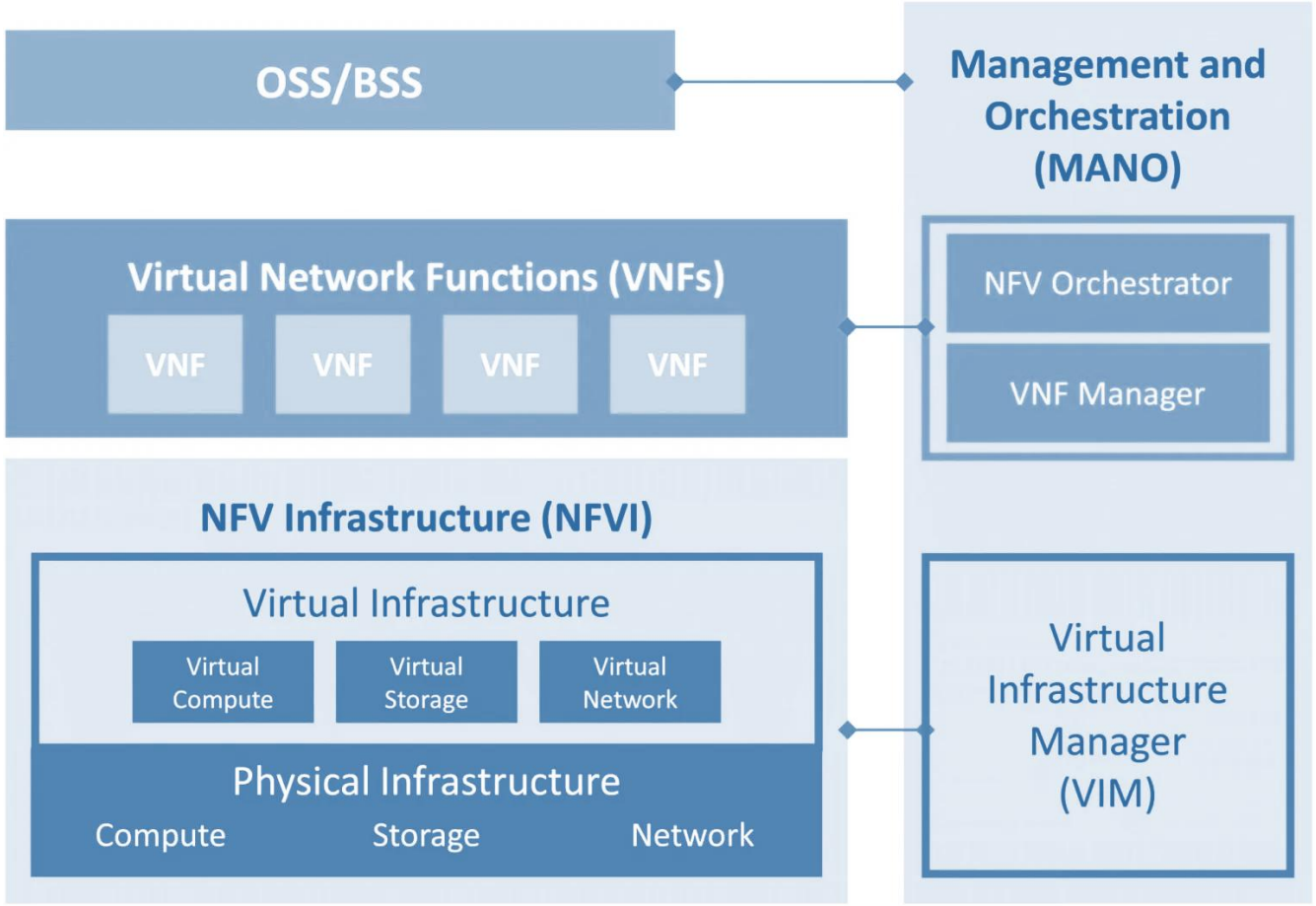
Network Function Virtualization (NFV)

- NFV separates network functions from proprietary hardware.
- Runs network functions on generic, commodity hardware.
- Enables rapid service innovation and deployment.

Network Function Virtualization (NFV)

- NFV virtualizes entire classes of network functions.
- Key components
  - Virtual Network Functions (VNFs),
  - NFV Infrastructure (NFVI), and
  - Management and Orchestration (MANO).

NFV Architecture



Source: https://dgtlinfra.com/network-functions-virtualization-nfv/

Key Components

- **VNFs** - Implement specific network functions.
- **NFVI** Comprises physical resources and virtualization layer.
- **MANO** - Manages and orchestrates VNFs.

Virtual Network Functions (VNFs)

- Virtual Network Functions (VNFs) are at the heart of NFV, representing a significant shift in how network services are delivered.
- Software-based network functions can be scaled on-demand.
- Support various network services like firewalls, load balancers, and more.
- Enable quicker deployment and reduced time-to-market.

NFV Infrastructure (NFVI)

- NFV Infrastructure (NFVI) is the backbone that supports the deployment and operation of VNFs
- Standardized x86 hardware for cost efficiency.
- Virtual and physical resource management for VNFs.
- Supports cloud environments and on-premises solutions.

Management and Orchestration (NFV-MANO)

- Coordinates resource allocation and management for VNFs.
- Automates provisioning and lifecycle management.
- Ensures efficient operation across the network.

Benefits of NFV

1. **Lower Total Cost of Ownership** - Reduces CapEx and OpEx.
2. **Flexibility in Deployment** VNFs can be deployed on-demand.
3. **Elasticity to Meet Demand** - Scales resources dynamically.
4. **Faster Time-to-Market** - Quick deployment of new services.
5. **Open Ecosystem** - Prevents vendor lock-in and promotes innovation.

Challenges of NFV

1. **Scalability Issues** - Difficulties in managing large-scale deployments.
2. **Interoperability with Existing Systems** - Integration challenges with legacy systems.
3. **Performance Monitoring** - Ensuring consistent performance across VNFs.
4. **Security Vulnerabilities** - New attack vectors in virtual environments.
5. **Resiliency Concerns** - Maintaining reliability in the face of component failures.

Use Cases of NFV

- **Telecommunications** - Virtualized routers and firewalls enable dynamic service delivery.
- **Data Centers** - Efficient resource utilization through virtualization.
- **Enterprise Networks** - Quick deployment of virtualized security services.

NFV in Telecom

- Major carriers like Verizon and AT&T are implementing NFV.
- Enhances service flexibility and cost efficiency.
- Facilitates rapid response to market demands and traffic increases.

NFV vs. SDN

- **NFV** - Focuses on virtualizing network functions.
- **SDN** - Separates network control from data forwarding.

Aspect	**NFV**	**SDN**
Purpose	Virtualize network functions	Decouple control/data planes
Key Benefit	Run network apps on COTS servers	Centralized network programming
Technology	VNFs/Containers	OpenFlow, APIs
Use Cases	5G vRAN, virtual firewalls	Traffic engineering, SD-WAN
Performance	~80Gbps per server	Microsecond flow updates

NFV and 5G Networks

- **Role of NFV in 5G Deployment** - Facilitates rapid service deployment.
- **Enhanced Service Delivery** - Ultra-low latency and high-speed connectivity.
- **Future Implications** - New applications in IoT, AR, and smart cities.

Future of NFV

5G and Edge Integration

NFV will enable efficient service delivery at the edge with the rollout of 5G networks.

AI-Driven Optimization

AI and machine learning will optimize network management and fault resolution in NFV.

Cloud-Native Evolution

Continued shift to cloud-native functions using microservices for agility and resilience.

Automated Networks

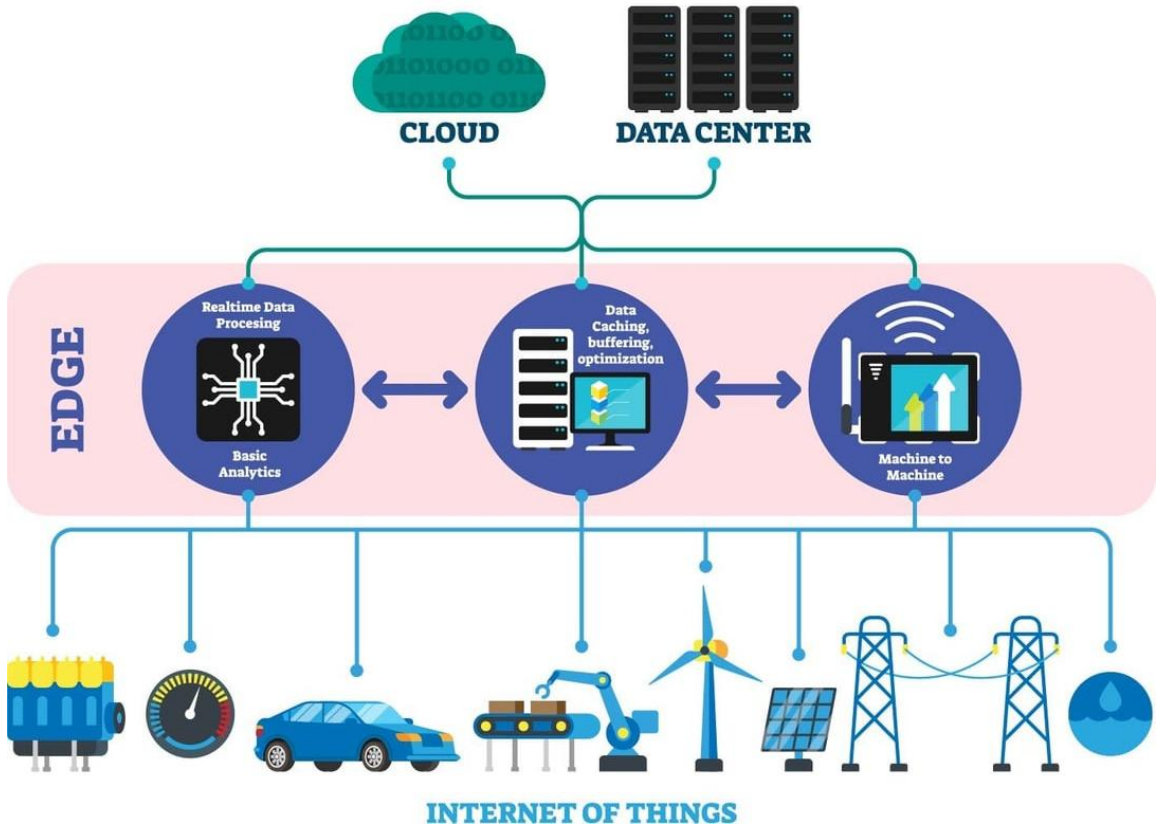
NFV will support self-healing, automated networks, reducing operational costs.

Edge Computing

Edge Computing

- A distributed computing paradigm that processes data closer to the source.
- Minimizes latency and bandwidth use, enhancing performance for real-time applications.
- Its key characteristics include Local processing, real-time analytics, decentralized architecture.

Edge Computing Architecture



Source: https://www.trentonsystems.com/en-us/resource-hub/blog/what-is-edge-computing-why-does-it-matter

Layers of Edge Computing

- **Cloud Layer** - Centralized data storage and processing.
- **Device Layer** - IoT devices generating data.
- **Edge Layer** - Edge nodes processing data locally.

The Edge Computing Scenario

Real-World Example

- A military vehicle driver relies on IoT for navigation.
- Cloud delays caused by network congestion lead to latency.
- Edge computing provides timely information and reduces risks.

What is an Edge Server?

- An edge server is a specialized computing device located close to data-generating sources in an edge computing architecture.
- Edge servers process data near the source.
- Filter unimportant data before sending to the cloud.
- Serve as intermediaries between IoT devices and cloud data centers.

Benefits of Edge Computing

1. **Reduced Bandwidth Use** - Local processing minimizes data transfer.
2. **Latency Reduction** - Faster response times for critical applications.
3. **Cost Savings** - Less bandwidth translates to lower costs.
4. **Improved Security and Reliability** - Decentralized data processing enhances security.

Use cases of Edge computing

- **Military Wearables** - Real-time health and situational data processing.
- **Offshore Oil Rigs** - Localized processing to avoid latency in remote locations.
- **Self-Driving Vehicles** - Instantaneous decision-making for safety.
- **Security Cameras** - On-site video analytics to reduce bandwidth usage.

Edge vs. Cloud Computing

- Edge computing complements rather than replaces cloud computing.
- Ideal for real-time applications while cloud remains essential for storage.

Aspect	Edge	Cloud
Location	Near data source	Remote data centers
Latency	Ultra-low (<10ms)	Higher (50-200ms)
Best For	Real-time processing (IoT, AI)	Heavy computation, storage
Cost	Higher hardware cost	Pay-as-you-go

Emerging Trends in Edge Computing

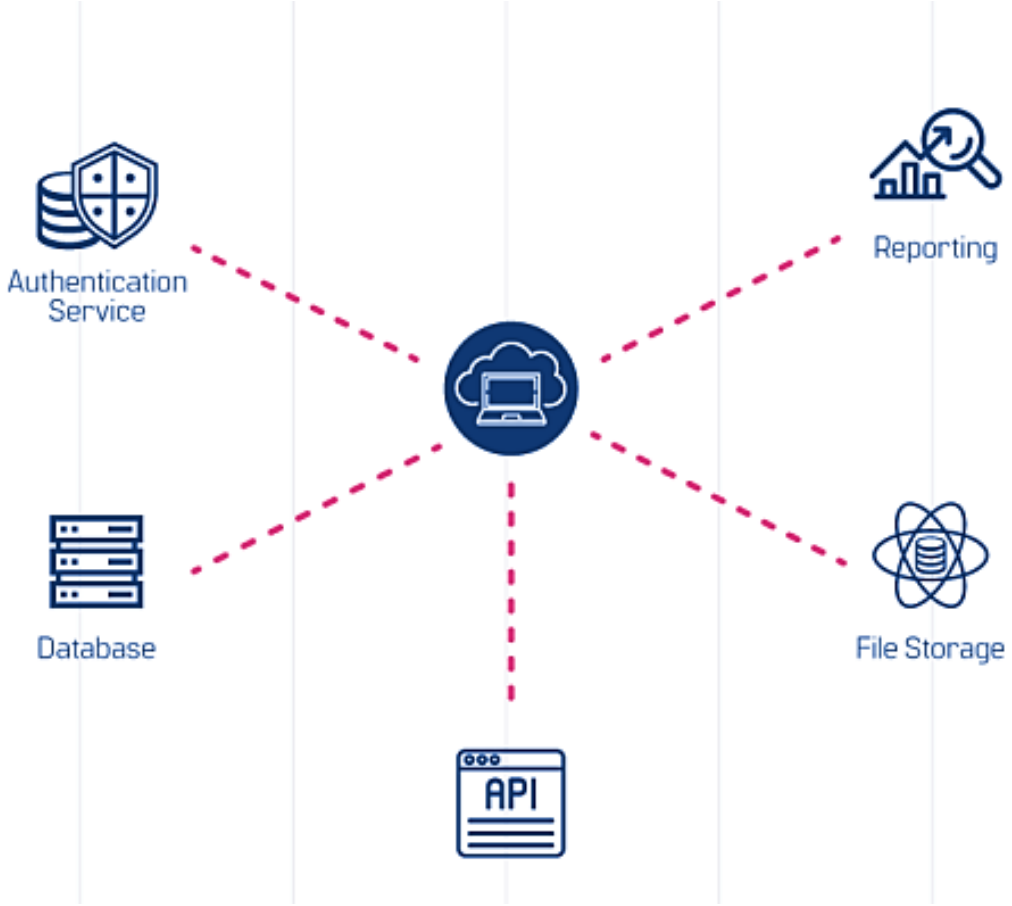
- **AI at the Edge** - Enabling real-time decision-making and analytics.
- **5G Integration** - Supporting faster data transmission and lower latency.
- **Decentralized AI Models** - Processing data locally for privacy and efficiency.

Serverless Computing

Serverless Computing

- A cloud computing model that allows developers to build applications without managing server infrastructure.
- Key features include
  - Event-driven execution,
  - Automatic scaling, and
  - Pay-as-you-go pricing.
- Cloud providers automatically manage infrastructure resources.

Serverless Architecture



Serverless components

- **API** - Enables communication between services.
- **Authentication Service** - Manages user access and security.
- **Database** - Stores and retrieves data efficiently.
- **File Storage** - Manages file uploads and access.
- **Reporting** - Provides data insights and analytics.

Source: https://www.cloudnowtech.com/blog/serverless-architecture-the-what-when-and-why/

Benefits of Serverless Computing

1. **Cost Savings** - Only pay for the compute time used, reducing idle resource costs.
2. **Automatic Scaling** - Handles demand spikes seamlessly without manual intervention.
3. **Reduced Operational Complexity** - Frees developers from managing infrastructure.

Use cases of Serverless Computing

Web & API Backends	Rapid deployment of APIs and microservices.
Data Processing	Event-driven processing of data streams for analytics.
Real-time file handling	Automatic handling of file uploads, such as image processing.

Serverless Computing Limitations

1. **Cold Starts** - Delay in execution for infrequently used functions.
2. **Limited Control** - Less control over the underlying infrastructure.
3. **Vendor Lock-in** - Dependence on specific cloud providers for services.

Emerging Trends in Serverless Computing

- **Multi-Cloud Strategies** - Avoiding vendor lock-in by utilizing multiple cloud providers.
- **Improved Monitoring Tools** - Enhancing visibility into serverless applications.
- **Event-Driven Architectures** - Increasing adoption for real-time processing needs.

AI and ML in NFV

- Predictive maintenance of network functions.
- Automated resource allocation and scaling.
- Improved reliability and reduced downtime.
- Enhanced operational efficiency.

AI and ML in Edge Computing

- Real-time data analytics at the edge.
- Intelligent decision-making for IoT devices.
- Faster response times and reduced latency.
- Improved data security through localized processing.

AI and ML in Serverless Computing

- Dynamic scaling based on usage patterns.
- Automated function optimization.
- Cost efficiency and resource optimization.
- Enhanced application performance.

Challenges of Integrating AI and ML in SDS

- **Data Quality and Availability** - Ensuring high-quality data for training models.
- **Skill Gaps** - Need for expertise in AI and ML technologies.
- **Ethical Considerations** - Addressing biases in algorithms.

Future Trends of AI and ML in SDS

- **Increased Automation** - Greater reliance on AI for autonomous operations.
- **Enhanced Security Measures** - AI-driven threat detection and response.
- **Personalized User Experiences** - Tailoring services based on user data.

Case Study: Serverless Computing in Media

- **Company** - Netflix
- **Project** - Use of serverless architecture for content delivery.
- **Results** - Enhanced scalability and improved user experience.

Conclusion and Call to Action

Network Function Virtualization (**NFV**)

- Revolutionizes network management by virtualizing hardware functions, enhancing flexibility and reducing costs.

Edge Computing

- Processes data closer to the source, significantly reducing latency and improving real-time application performance.

Serverless Computing

- Frees developers from infrastructure management, allowing a focus on code and rapid application deployment.

Test Your Knowledge

1. Which of the following is a key benefit of Edge Computing?

    A) Increased hardware costs

    B) Reduced latency

    C) Centralized data processing

    D) Slower decision-making

Test Your Knowledge

1. Which of the following is a key benefit of Edge Computing?

   A) Increased hardware costs

   B) Reduced latency

   C) Centralized data processing

   D) Slower decision-making

Reason: Edge Computing processes data closer to the source, significantly reducing latency, which is crucial for real-time applications.

Test Your Knowledge

2. What is a common challenge in implementing NFV?

A) Increased physical hardware costs

B) Complexity of migration

C) Simplicity of integration

D) Abundant skill availability

Test Your Knowledge

2. What is a common challenge in implementing NFV?

A) Increased physical hardware costs

B) Complexity of migration

C) Simplicity of integration

D) Abundant skill availability

Reason: Transitioning from traditional hardware-based systems to virtualized environments can be complex and requires careful planning to avoid service disruptions.

Test Your Knowledge

3. What is a primary advantage of using Serverless Computing for an e-commerce platform?

A) Increased operational costs

B) Inflexibility in scaling during peak times

C) Ability to handle high transaction volumes seamlessly

D) Dependence on physical servers

Test Your Knowledge

3. What is a primary advantage of using Serverless Computing for an e-commerce platform?

A) Increased operational costs

B) Inflexibility in scaling during peak times

C) Ability to handle high transaction volumes seamlessly

D) Dependence on physical servers

Reason: Serverless Computing allows e-commerce platforms to scale automatically during peak times, ensuring a smooth user experience.

Thank you!

Lecturer: Biniam Behailu

Addis Ababa Science and Technology University

Addis Ababa, Ethiopia