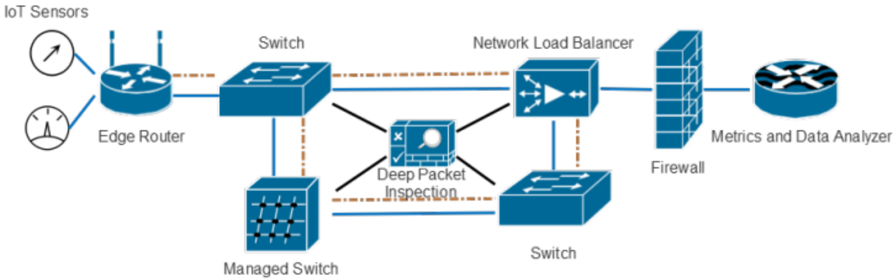
Software Defined Network

Internet of Things

Rahul Shandilya

Traditional internetworking

In this configuration, the data plane and control plane are unified. When the system needs to add or remove another node or set up a new data path, many of the dedicated systems need to be updated with new VLAN settings, QoS parameters, access control lists, static routes, and firewall pass-throughs.



Limitations of the conventional network architectures

- **Complex Network Devices**: Conventional networks are getting increasingly complex with more and more protocols being implemented to improve link speeds and reliability. Interoperability is limited due to the lack of standard and open interfaces. The conventional networks were well suited for static traffic patterns and had a large number of protocols designed for specific applications. For IoT applications which are deployed in cloud computing environments, the traffic patterns are more dynamic.

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- **Limited Scalability**: The virtualization technologies used in cloud computing environments has increased the number of virtual hosts requiring network access. The analytics components of IoT applications run distributed algorithms on a large number of virtual machines that require huge amounts of data exchange between virtual machines. Such computing environments require highly scalable and easy to manage network architectures with minimal manual configurations, which is becoming increasingly difficult with conventional networks.

Software Defined Network

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- The separation of concerns introduced between the definition of network policies, their implementation in switching hardware, and the forwarding of traffic, is key to the desired flexibility
- By breaking the network control problem into tractable pieces, SDN makes it easier to create and introduce new abstractions in networking, simplifying network management and facilitating network evolution.

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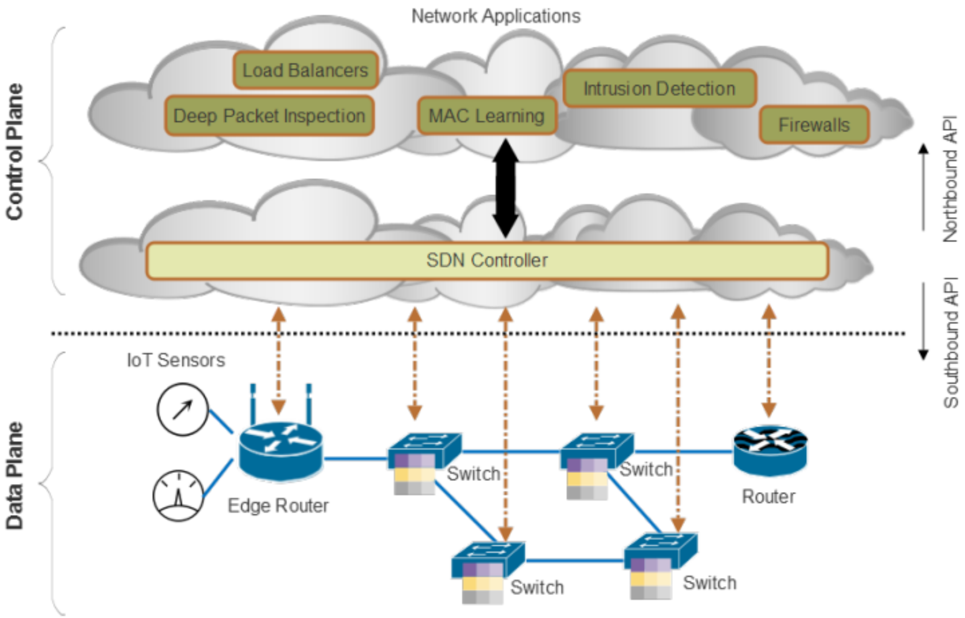
- Network application software can reside over the SDN controller through a northbound interface. This software can interact and manipulate the data plane with services such as deep packet inspection, firewalls, and load balancers.



Network Applications
Load Balancers
Deep Packet Inspection
MAC Learning
Intrusion Detection
Firewalls
Control Plane
Northbound API
SDN Controller
Southbound API
Data Plane
IoT Sensors
Edge Router
Switch
Switch
Router
Switch
Switch

Key Elements

- *Centralized Network Controller*: With decoupled control and data planes and centralized network controller, the network administrators can rapidly configure the network, SDN applications can be deployed through programmable open APIs. This speeds up innovation as the network administrators no longer need to wait for the device vendors to embed new features in their proprietary hardware.

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- Standard Communication Interface (OpenFlow): SDN architecture uses a standard communication interface between the control and infrastructure layers (Southbound interface). OpenFlow, which is defined by the Open Networking Foundation (ONF) is the broadly accepted SDN protocol for the Southbound interface. With OpenFlow, the forwarding plane of the network devices can be directly accessed and manipulated.

SDN Benefits

- **Service chaining**: This allows a customer or provider to sell services a la carte. Cloud network services such as firewalls, deep packet inspection, VPNs, authentication services, and policy brokers can be linked and used on a subscription basis. Some customers may want a full set of features, others may not choose any or may change their configuration routinely. Service chaining allows for significant flexibility in deployments.

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- **Dynamic load management**: An SDN enjoys the flexibility of cloud architecture, and by design it can scale resources dynamically depending on load. This type of flexibility is crucial for the IoT as architects need to plan for capacity and scale as the number of things grows exponentially. Only virtual networking in the cloud provides the ability to scale capacity when needed.

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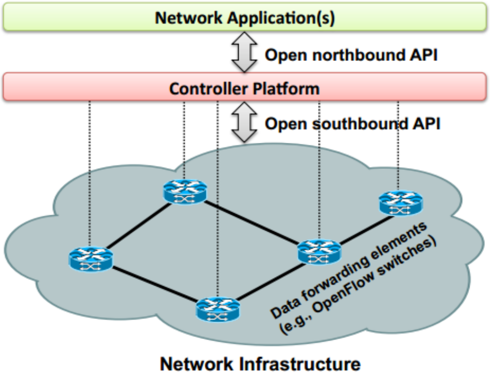
- **Bandwidth calendaring**: This allows an operator to partition data bandwidth and usage to specified times and days. This is pertinent to IoT as many edge sensors only report data periodically or at a certain time of day. Sophisticated bandwidth sharing algorithms can be constructed to time slice capacity.

SDN Architecture



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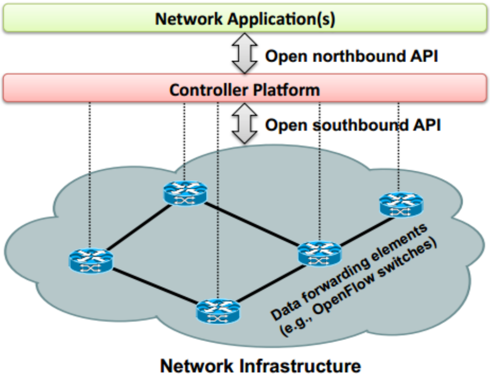

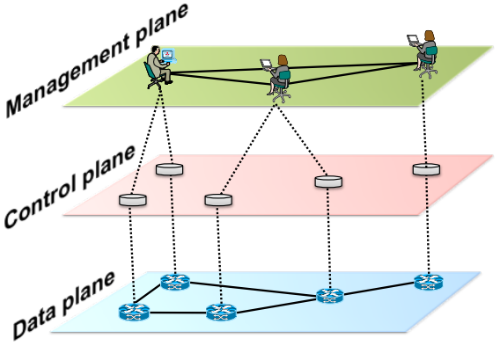

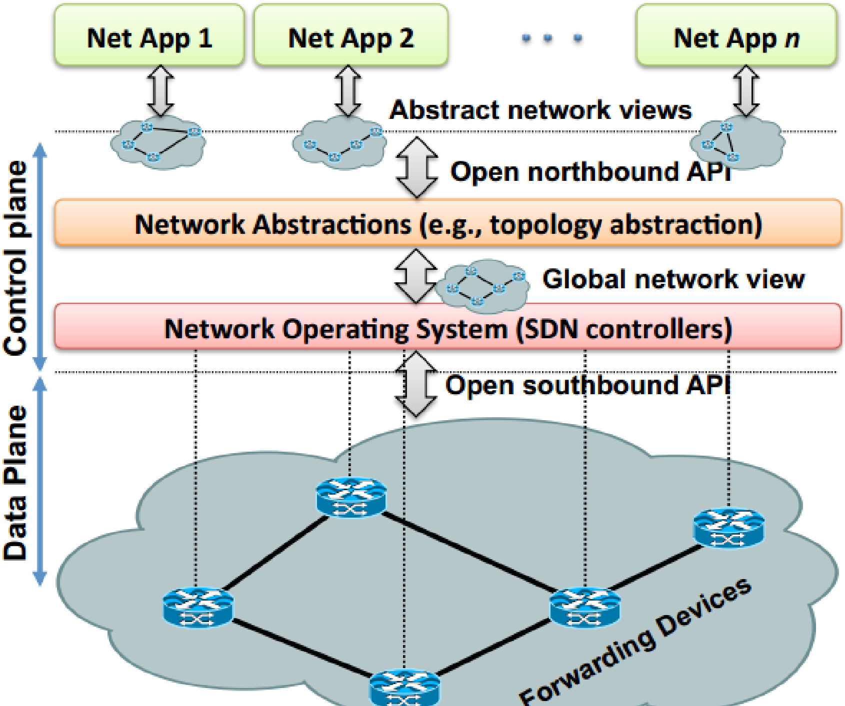
Net App 1
Net App 2
Net App n
Abstract network views
Open northbound API
Network Abstractions (e.g., topology abstraction)
Global network view
Network Operating System (SDN controllers)
Open southbound API
Control plane
Data Plane
Forwarding Devices

Elements of SDN

Forwarding Devices (FD):

Hardware- or software-based data plane devices that perform a set of elementary operations. The forwarding devices have well-defined instruction sets (e.g., flow rules) used to take actions on the incoming packets (e.g., forward to specific ports, drop, forward to the controller, rewrite some header). These instructions are defined by southbound interfaces (e.g., OpenFlow, ForCES) and are installed in the forwarding devices by the SDN controllers implementing the southbound protocols.

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Southbound Interface (SI):

The instruction set of the forwarding devices is defined by the southbound API, which is part of the southbound interface. Furthermore, the SI also defines the communication protocol between forwarding devices and control plane elements. This protocol formalizes the way the control and data plane elements interact.

Control Plane (CP):

Forwarding devices are programmed by control plane elements through well-defined SI embodiments. The control plane can therefore be seen as the "network brain". All control logic rests in the applications and controllers, which form the control plane.

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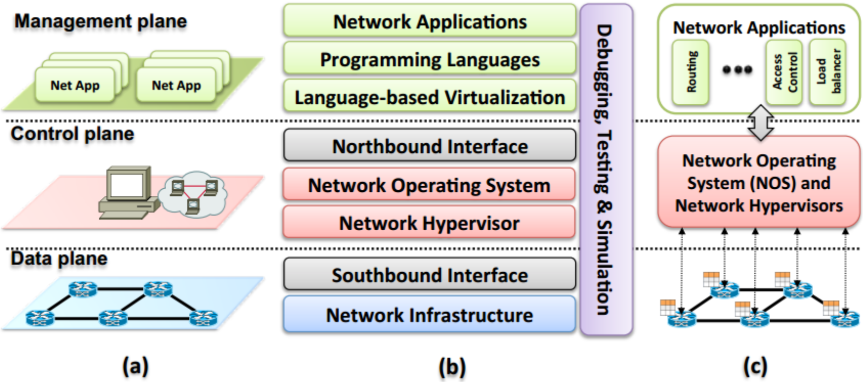
Management Plane (MP):

The management plane is the set of applications that leverage the functions offered by the NI to implement network control and operation logic. This includes applications such as routing, firewalls, load balancers, monitoring, and so forth. Essentially, a management application defines the policies, which are ultimately translated to southbound-specific instructions that program the behavior of the forwarding devices

SDN Layered Architecture

An SDN architecture can be depicted as a composition of different layers. While some of them are always present in an SDN deployment, such as the southbound API, network operating systems, northbound API and network applications, others may be present only in particular deployments, such as hypervisor- or language-based virtualization.



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- As a central component of its design the southbound APIs represent one of the major barriers for the introduction and acceptance of any new networking technology therefore standard SDN southbound API like OpenFlow Emerges .

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- Unfortunately, virtualization has been only partially realized in practice.

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- Generic functionality as network state and network topology information, device discovery, and distribution of network configuration can be provided as services of the NOS.
- With NOSs, to define network policies a developer no longer needs to care about the low-level details of data distribution among routing elements, for instance

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- These objects consist of an abstract network topology and the sets of policies applied to it. Network objects simultaneously hide information and offer the required services.

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- foster the development of network virtualization.

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- Other examples include fail-over and reliability functionalities to the data plane, end-to-end QoS enforcement, network virtualization, mobility management in wireless networks, among many others.
- The variety of network applications, combined with real use case deployments, is expected to be one of the major forces on fostering a broad adoption of SDN