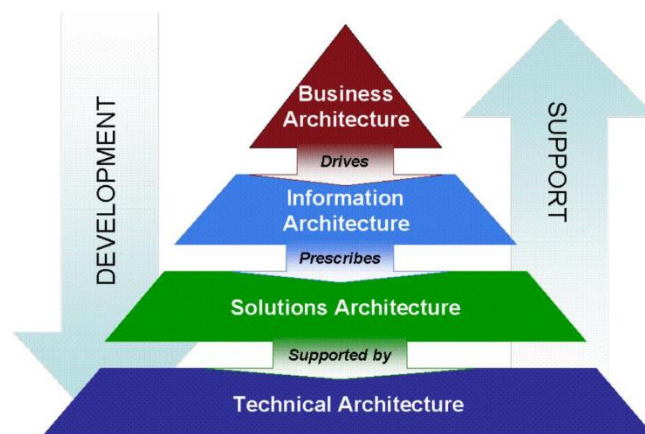# Enterprise Architecture Technical Brief

Software Defined Networking (SDN)

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Contents

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SDN Recommendation

VITA recommends implementing software defined networking (SDN), which is an approach to network virtualization that optimizes network resources allowing the quick adaption of networks to rapidly changing business needs, applications, and traffic.

For any comments, questions, and/or concerns with this technical brief, please contact VITA EA: ea@vita.virginia.gov

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Background

SDN by AT&T[1]

Recent AT&T related SDN responses to Virginia Information Technologies Agency RFI 2017-14 for Server, Data Center, and Security Services AT&T indicate the following:

- The server/storage industry is rapidly moving toward software defined networking (SDN)
  - Driving this trend is the recent viability of open source/open standards-based software for broad network applications.
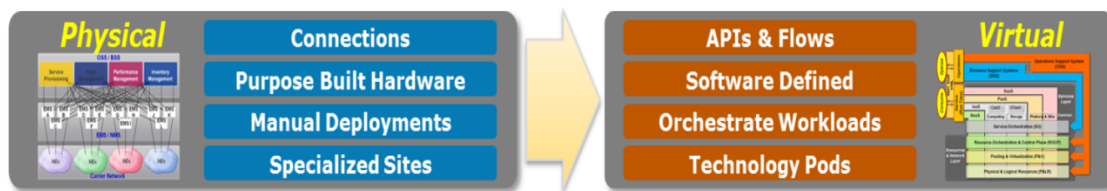

Figure 5 – Physical to Virtual Operations Transformation

- VITA should give consideration to the important trend of SDN and Network Function Virtualization (NFV) functionality for the broader telecom network.
- SDN and NFV concepts were proven in the data center **more than a decade ago**.
  - Concepts allowing transition from specialized network equipment, which is more expensive and less flexible, to a network that runs on flexible, nimble software and virtualized equipment.
  - SDN's require much less total hardware acquisition and deployment resources while the software handles delivery of network services and functionality.
  - Benefits include:
    - More "virtualized" platform and agile functions.
    - Workloads more elastic, distributed and efficient.
    - "Plug and play" and "Near Real Time" availability of service at scale become the norm.
- Turning legacy network appliances into software running on standard servers is called network function virtualization (NFV).
  - AT&T's goal is to virtualize 75% of their network by 2020.
  - Controlling the actions of those virtual functions available via software is known as SDN.
  - Managing all those virtual network functions (VNFs) and other software-centric network capabilities is much easier when they run on what's called a VNF automation platform. (AT&T's ECOMP solution.)

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[1] A Network Built on Software: Using Software to Put Customers in Control by AT&T. Retrieved from https://www.att.com/Common/about_us/pdf/AT&T%20Domain%202.0%20Vision%20White%20Paper.pdf on June 26, 2017.

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SDN by VMware[2]

- Networking has not changed substantially in 15 years.
- Most network devices are manually configured one at a time.
- SDN is a new paradigm for network virtualization.
- SDN is about virtualizing the whole data center.
- Better intelligence with a global view of the network instead of each network element looking at the network from its own viewpoint.
- Network and security administrators networking skills are transferrable to an SDN environment.
- Traditional physical demarcation and lines of responsibility blur with SDN and Network Function Virtualization (NFV)
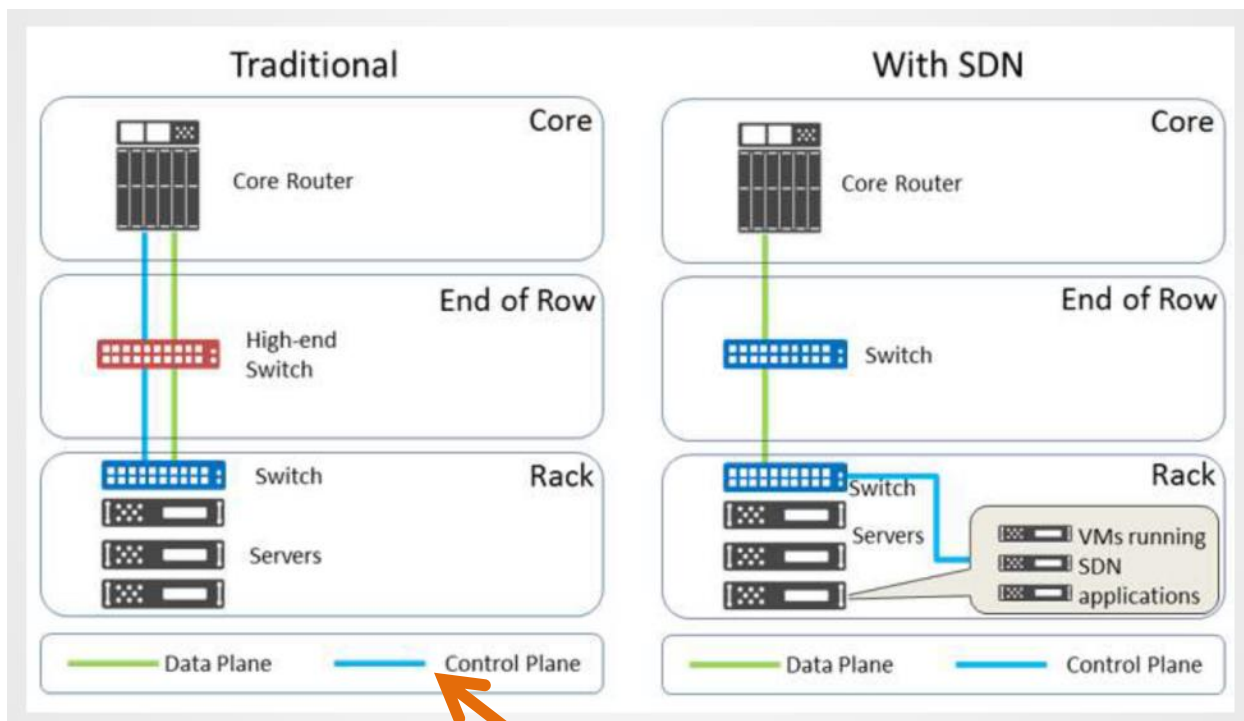

Figure 2: What is SDN.[3]

Keep track of this control plane in the two examples above.

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Five (5) differences between SDN and NFV.[4]

- **SDN makes the network programmable** by separating the system that decides where traffic is sent (the control plane) from the underlying system that pushes packets of data to specific destinations (the data plane).

- **SDN** is designed to offer users a way to manage network services through software that makes networks centrally programmable, which allows for **faster configuration**.

- **SDN is built on switches that can be programmed through an SDN controller utilizing an industry standard controller like OpenFlow.**
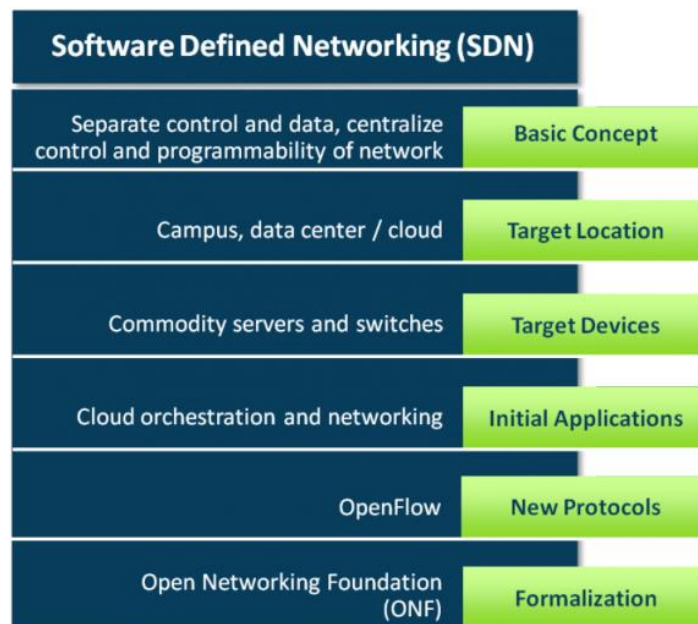

Software Defined Networking (SDN)	
Separate control and data, centralize control and programmability of network	**Basic Concept**
Campus, data center / cloud	**Target Location**
Commodity servers and switches	**Target Devices**
Cloud orchestration and networking	**Initial Applications**
OpenFlow	**New Protocols**
Open Networking Foundation (ONF)	**Formalization**

Figure 5: Software Defined Networking (SDN). [5]

SDN by Juniper. [6]

- SDN is an approach to network virtualization that seeks to optimize network resources and quickly adapt networks to changing business needs, applications, and traffic.

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[4] 5 Differences between SDN and Network Functions Virtualization by Ingram Micro Advisor. Retrieved from http://www.ingrammicroadvisor.com/data-center/5-differences-between-sdn-and-network-functions-virtualization on May 22, 2017.

[5] What is the difference between SDN, NFV, and network virtualization? Retrieved from http://blog.kostecky.cz/2016/01/rozdil-mezi-sdn-nfv-sitova-virtualizace.html on May 22, 2017.

[6] What is SDN? Juniper. Retrieved from https://www.juniper.net/us/en/solutions/sdn/what-is-sdn/ on May 22, 2017.

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- SDN works by separating the network's control plane (logic that controls packet forwarding), and data plane (routers and switches), creating software-programmable infrastructure that is distinct from physical devices.
    - In other words, not all processing happens inside the same device.
- With SDN, the functions of network orchestration, management, analytics, and automation become the job of SDN controllers.
    - Control path decisions are taken out of the switch and managed by software on a centralized server.
    - Because these controllers are not networking devices, they can take advantage of the scale, performance, and availability of modern cloud computing and storage resources.
- Increasingly, SDN controllers are built on open platforms, using open standards and open APIs, enabling them to orchestrate, manage, and control network equipment from different vendors.
- SDN delivers a wide array of business benefits such as:
    - Separation of the control and transport layers increases flexibility and accelerates time-to-market for new applications.
    - Ability to respond more swiftly to issues and outages improves network availability.
    - Programmability makes it easier for IT organizations to automate network functions, reducing operating costs.

Figure 3: Goals of SDN.[7]

- SDN allows standard switch hardware to be controlled centrally via OpenFlow through an SDN controller.
    - SDN does not equal OpenFlow, rather OpenFlow is one flavor or a subset of SDN. See page 11 for an OpenFlow background.

- Vendors can and are developing their own proprietary versions of SDN and OpenFlow, delivering hybrid and centralized control in a vertically integrated fashion.

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[7] SDN by the Numbers from Innovity Network Solutions, Inc. Retrieved from http://innovity.ca/ on May 22, 2017.

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o For instance, Cisco, HP, IBM and Dell are selling converged infrastructure solutions that package servers, storage, networks, and orchestration software in a single rack.

SDN and NetDevOps.[8]

- The SDN buzzword gets overused and confused by acronym and/or marketing jargon.
- Based on Mr. Cavanaugh's experiences in the networking industry, he defines SDN more broadly as a highly automatable and programmable network infrastructure.
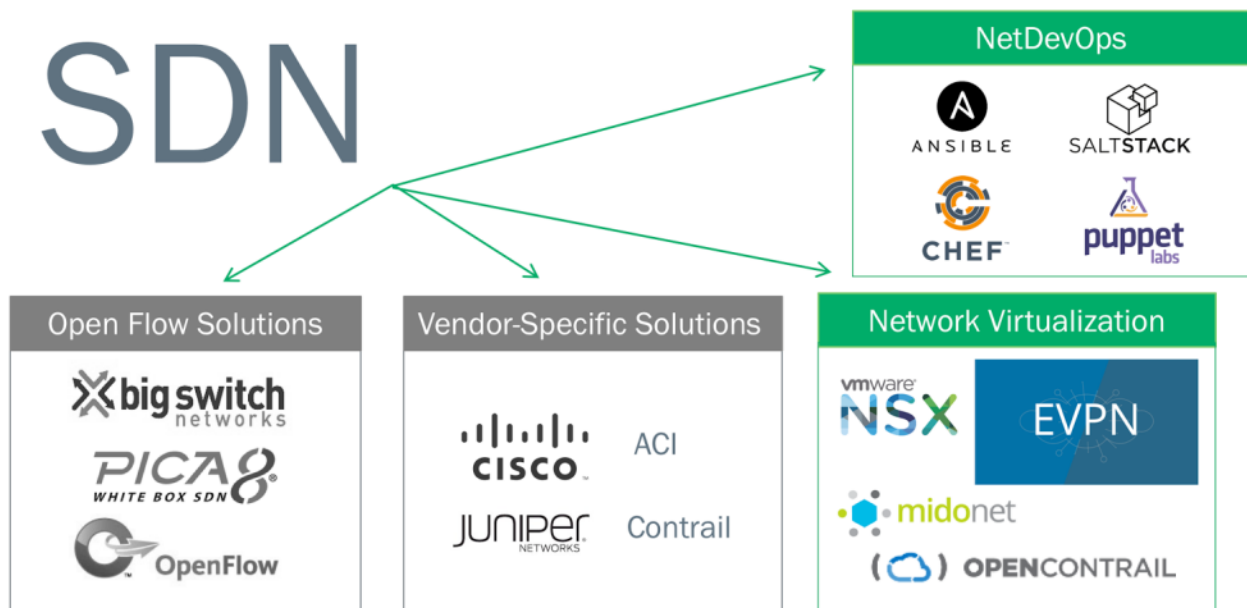

Figure 4: SDN Providers from Cumulus Networks – 2017.

Reference Information

What is an SDN OpenFlow Controller?[9]

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[8] SDN and NetDevOps by Sean Cavanaugh, Senior Consultant at Cumulus Networks. Retrieved from https://cumulusnetworks.com/blog/linux-sdn-networking/ on May 22, 2017.
[9] What is an OpenFlow Controller by SDX Central. Retrieved from https://www.sdxcentral.com/sdn/definitions/sdn-controllers/openflow-controller/ on May 22, 2017.

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- An OpenFlow Controller is a type of SDN Controller that uses the OpenFlow Protocol.
  - The **OpenFlow protocol is designed to increase flexibility** by eliminating proprietary protocols from hardware vendors.
  - OpenFlow Controllers create a central control point to oversee a variety of OpenFlow-enabled network components.
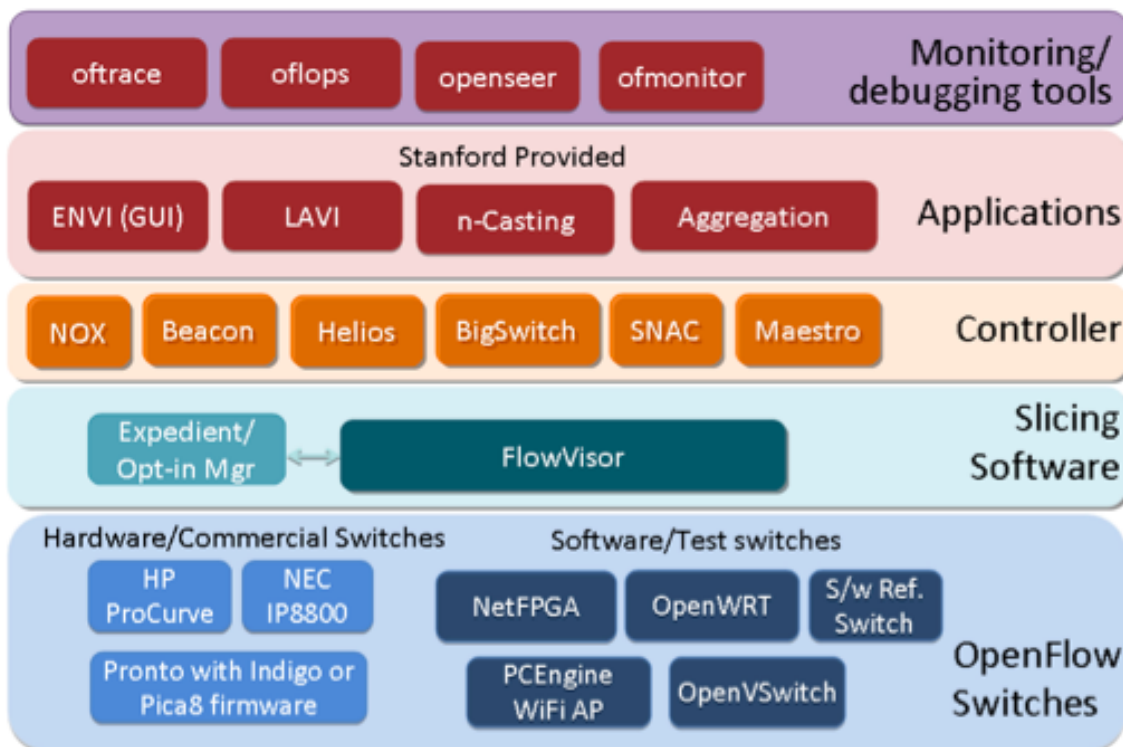

Figure 11: OpenFlow enabled network components model by SDX Central.

- An SDN Controller is the strategic point in software-defined network (SDN).
  - An OpenFlow Controller uses the OpenFlow protocol to connect and configure the network devices (routers, switches, etc.) to determine the best path for application traffic.
    - There are also **other SDN protocols** that a Controller can use such as OpFlex, Yang, and NetConf, to name a few.

- SDN Controllers can simplify network management, handling all communications between applications and devices to effectively manage and modify network flows to meet changing needs.
  - When the network control plane is implemented in software, rather than firmware, administrators can manage network traffic more dynamically and at a more granular level.

- An SDN Controller relays information to the switches/routers (via southbound APIs) and the applications and business logic (via northbound APIs).

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SDN Statistics

Figure 6: SDN being discussed.[10]
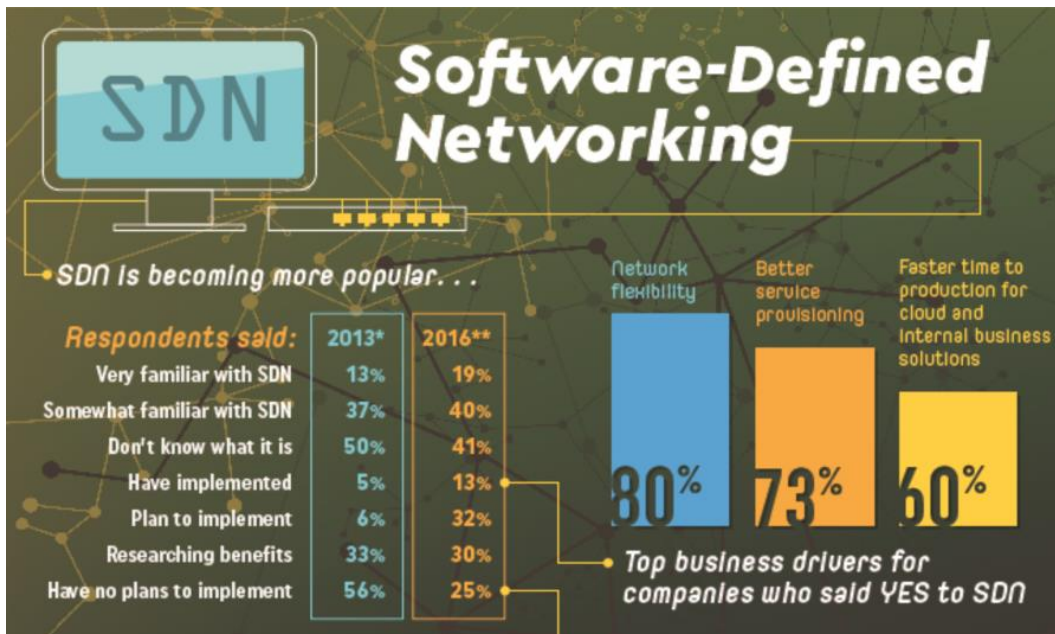
Figure 7: Top SDN Business Drivers.[11]

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[10] SDN by the Numbers from Innovity Network Solutions, Inc. Retrieved from http://innovity.ca/ on May 22, 2017.
[11]Companies want flexibility and faster production time from software defined networking. And they get it (ZDNet Article by Amy Talbott on June 1, 2016. Retrieved from http://www.zdnet.com/article/infographic-companies-want-flexibility-and-faster-production-time-from-software-defined-networking/ on May 22, 2017.

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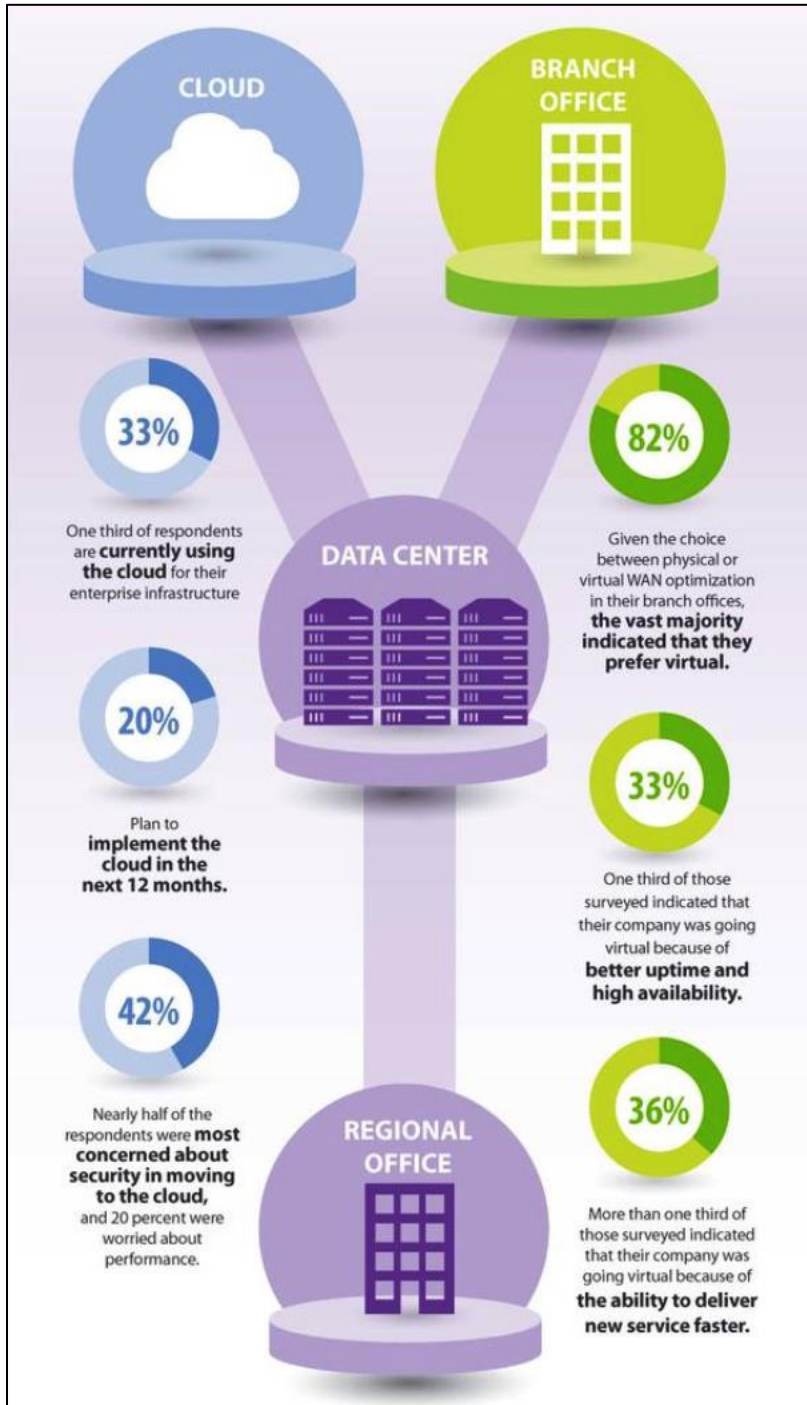
Figure 8: SDN statistics in the Data Center.[12]

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SDN and NFV

- SDN is often associated with Network Function Virtualization (NFV). Following is a general understanding of each:

  - The Basic Idea:
    - **SDN** separates control and data, and **centralizes control and programmability of the network**.
    - NFV transfers network functions from dedicated appliances to generic servers.
  - Areas of Operation
    - SDN operates in a campus, data center, and/or cloud environment.
    - NFV targets the service provider network.
  - Initial Application Target.
    - **SDN software targets cloud orchestration and networking**.
    - NFV software targets routers, firewalls, gateways, WAN, CDN, accelerators and SLA assurance.
  - Protocols
    - SDN: OpenFlow
    - NFV: None
  - Industry Standards Supporting Organization
    - SDN: Open Networking Foundation (ONF)

Figure 12: Open Networking Foundation (ONF).[13]

    - NFV: European Telecommunications Standards Institute (ETSI) NFV Working Group

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[13] Logo retrieved from https://image.slidesharecdn.com/onfsoftwaredefinednetworkingsdngo-to-market-160205103809/95/sdn-associate-from-the-open-networking-foundation-6-638.jpg?cb=1454669066 on May 22, 2017.

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Figure 13: European Telecommunications Standards Institute (ETSI).[14]

Figure 14: Software Defined Networking (SDN) vs Network Function Virtualization (NFV)[15]

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[14] Logo retrieved from
http://slideplayer.com/slide/6185677/18/images/1/ETSI+%E2%80%93+European+Standards+for+Global+USE.jpg
on May 22, 2017.
[15] SDN vs NFC: What is the difference between SDN, NFV, and network virtualization? Retrieved from
http://blog.kostecky.cz/2016/01/rozdil-mezi-sdn-nfv-sitova-virtualizace.html on May 22, 2017.

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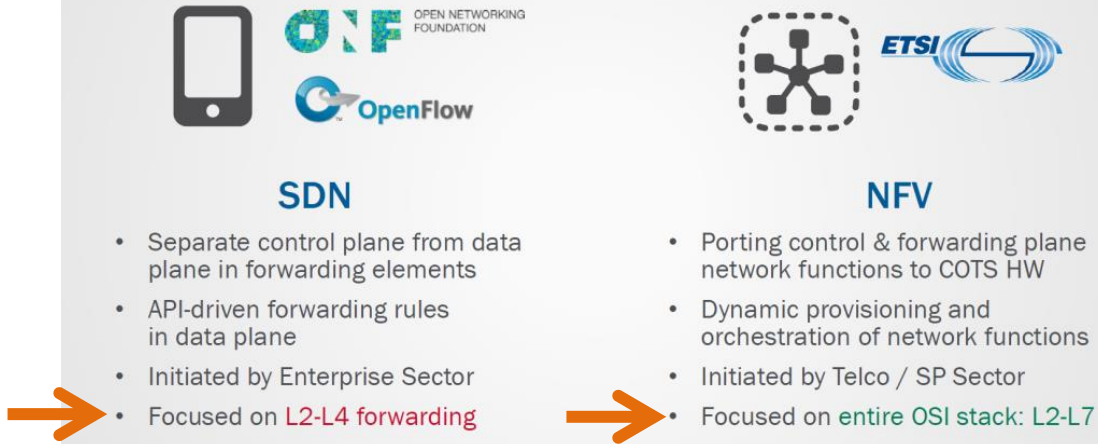
Figure 15: SDN vs NFV – F5 Networks.[16]

Category	SDN	NFV
Reason for Being	Separation of control and data, centralization of control and programmability of network	Relocation of network functions from dedicated appliances to generic servers
Target Location	Campus, data center / cloud	Service provider network
Target Devices	Commodity servers and switches	Commodity servers and switches
Initial Applications	Cloud orchestration and networking	Routers, firewalls, gateways, CDN, WAN accelerators, SLA assurance
New Protocols	OpenFlow	None yet
Formalization	Open Networking Forum (ONF)	ETSI NFV Working Group

Figure 16: SDN and NFV Key Points.

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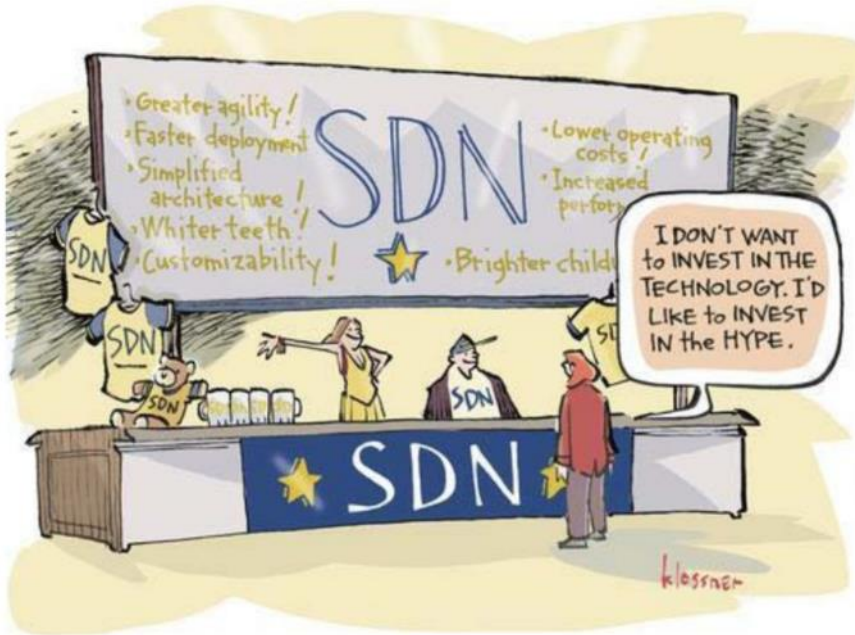- What is driving the rise in SDN?[17]

Figure 9: SDN Drivers.

Figure 1: SDN hype.[18]

- According to the Gartner Hype Cycle for Emerging Technologies, 2016:

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[17] SDN Market Size to reach $35B by 2018 by SDX Central. Retrieved from
https://www.sdxcentral.com/reports/sdn-market-size-infographic-2013/ on May 22, 2017.
[18] SDN Hype Comic from unknown source. Retrieved from Google search on May 22, 2017.

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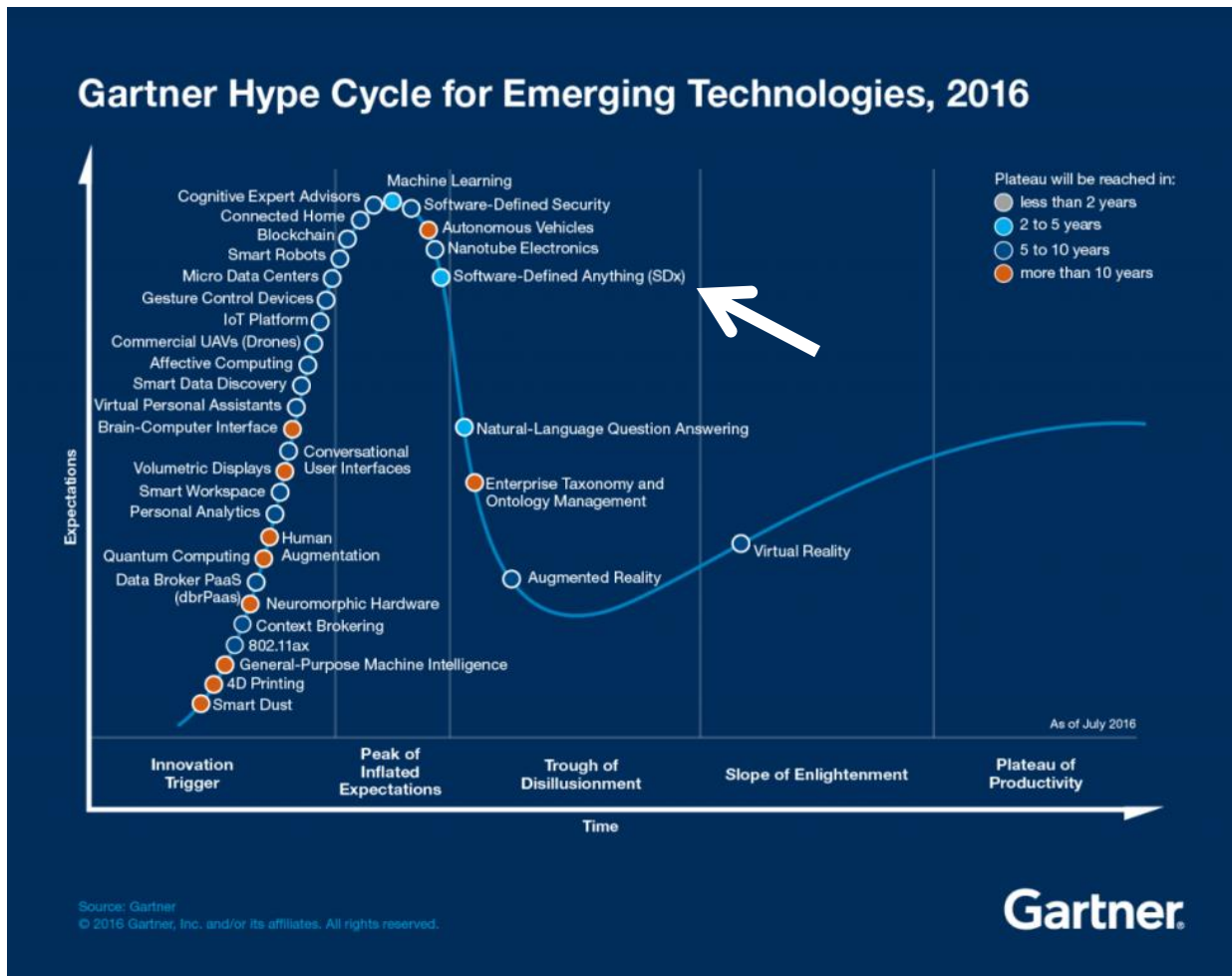o   Software Defined Anything (SDx) has left the peak of inflated expectations and has entered the trough of disillusionment.

Figure 10: Gartner Hype Cycle for Emerging Technologies.

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