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Software Defined Networking Technology – Perspectives and Challenges

(focus on Standardization Aspects)

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SDN - standardization aspects

- **Topic:**
  - **Software Defined Networking (SDN) technology - standardization aspects**
  - **Motivation of this talk**
    - SDN – emergent, promising technology for clouds, WANs, SP networks, etc.
    - Standards bodies, Industry associations, Research, etc., work on SDN
    - This shows a real interest and promising perspectives
    - However, some overlapping and even (partially) not- compatible approaches happen
    - **Additional effort is needed, to:**
      - **produce complementary consistent work**
      - **avoid duplicate work and incompatible standards**
  - **Acknowledgement:**
    - **This presentation has been compiled by using several sources- see Reference list**
    - Good reference on the subject: [1] J.M. Halpern, "Standards Collision around SDN", IEEE Comm. Magazine — Communications Standards Supplement, Dec. 2014, pp.10-15

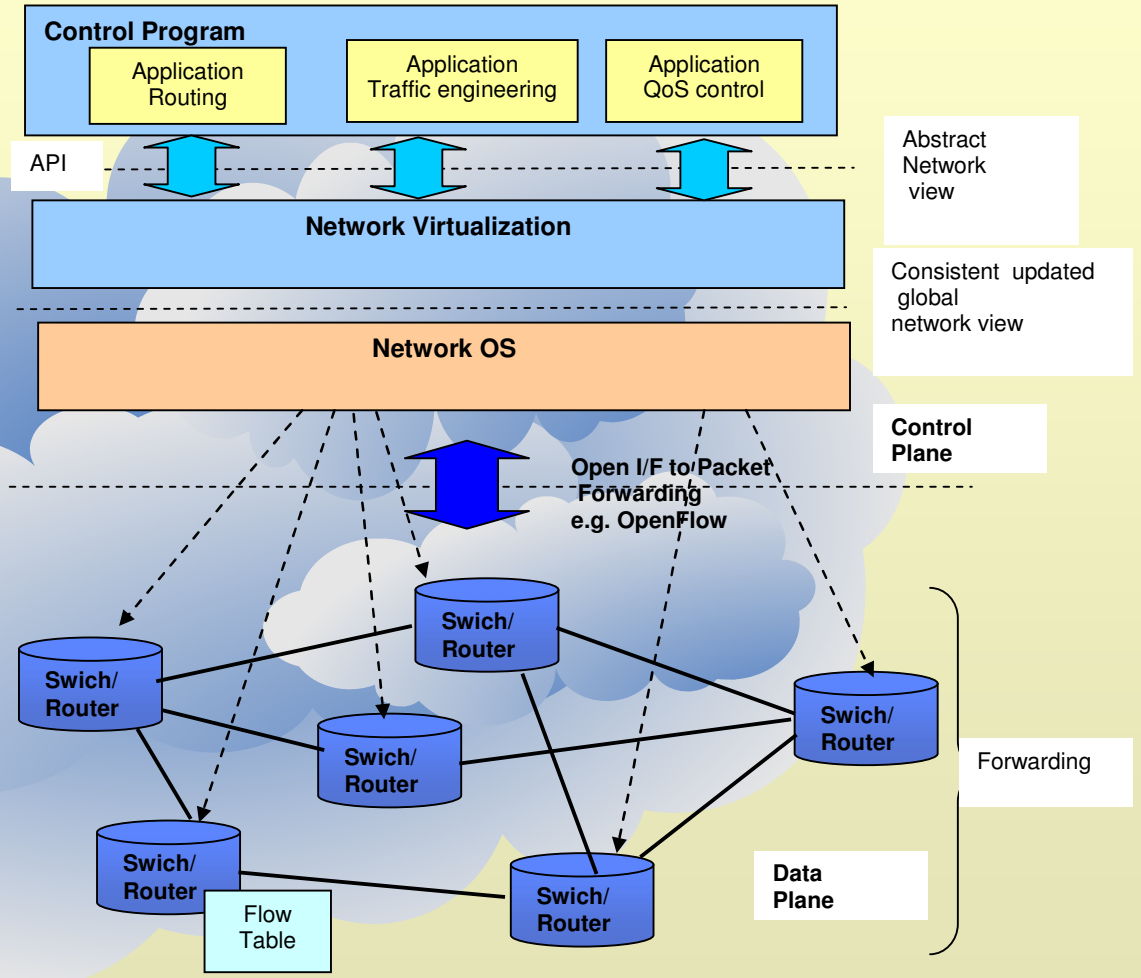
SDN - standardization aspects

- **SDN main characteristics - (from Open Networking Foundation - ONF)**
  - **Separation of Control Plane from Data (Forwarding) Plane**
    - CPI/DPI Decoupling: Network control is directly programmable
  - **Centrally managed:** Network intelligence is (logically) centralized in SDN controllers
    - CPI maintains a global network view
    - Network appears to applications and policy engines as a single, logical switch
  - **Agility:** Abstracting CPI from DPI allow to dynamically adjust/adapt network-wide traffic flow conforming the current needs.
  - **SDN: based on open standards, vendor-neutral:**
    - SDN simplifies network design
    - Operation instructions provided by SDN controllers and not multiple, vendor-specific devices and protocols
    - The control programs do not depend on proprietary software
  - **Programmatic configuration**:
    - Better management : network can be quickly - configured, managed, secured, and optimized (in terms of resources) based on automated SDN programs
  - **NexComm 2015 Conference, April 19-24, Barcelona**

1. Software Defined Networking

- SDN Basic Architecture

- Network OS:
  - Distributed system that creates a consistent, updated network view
  - Executed on servers (controllers) in the network
  - Examples: NOX, ONIX, HyperFlow, Floodlight, Trema, Kandoo, Beacon, Maestro,..
- Uses forwarding abstraction in order to:
  - Collect state information from FE
  - Generate commands to FE



SDN - standardization aspects

- **SDN main standardization organizations**
  - OPEN NETWORKING FOUNDATION - ONF
  - EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE
    - INDUSTRY SPECIFICATION GROUP FOR NETWORK FUNCTION VIRTUALIZATION (ETSI NFV ISG)
  - ITU-T Study Group 13
  - INTERNET ENGINEERING TASK FORCE (IETF)s, IRTF
  - IEEE
  - OPEN DAYLIGHT (project)
  - ….

SDN - standardization aspects

- **OPEN NETWORKING FOUNDATION - ONF**
  - User-driven org. to promote and adopt the SDN through open standards development
  - Origin - Stanford University + OpenFlow protocol
  - 2014 - industry consortium with about 150 member companies
  - ONF is divided into 10 working groups (WG)
  -
  - **Extensibility WG** — defines and maintains the OpenFlow (OF) protocol specs
    - Earlier releases : OpenFlow 1.0 ,1.3, 1.4 spec.
    - Start work on OpenFlow 1.5.
    - The OF protocol specs – based on the the concept of *match-action-tables.*
      - The protocol allows the controller to specify entries for these tables
      - The semantics of matching fields continuously evolved

SDN - standardization aspects

- **OPEN NETWORKING FOUNDATION - ONF (cont'd)**
- **Configuration and Management WG**
- Defines and maintains protocols to manage OF switches.
  - Assumption on the common OF case; forwarder devices are strictly controlled via OpenFlow.
  - Earlier versions : 1.0, 1.1, 1.1.1 specs; working on 1.2.
  - The specs rely on the IETF *NetConf Configuration* protocol [RFC 6241] for its communication mechanism.
  - The specs use XML; the work was driven from the YANG work of IETF NetMOD WG

- **Architecture & Framework WG**
  - It describes SDN architecture and the role of the OpenFlow
  - It should be better correlated collaboration with other standards bodies

- **Forwarding Abstraction WG**
  - OpenFlow protocol uses a single abstraction for interacting with everything.
  - The Forwarding Abstraction work intends to enable pre-runtime description of the needed forwarder behavior

SDN - standardization aspects

- **OPEN NETWORKING FOUNDATION - ONF (cont'd)**

- **Optical Transport WG**
  - OpenFlow specs for control of optical transport networks
  - This work relies on ITU-T-developed models of optical transport networks to define the relevant components

- **Northbound Interface WG**
  - It defines the I/Fs of an OF-based SDN controller exposed to other policy and control elements e.g. operating at a higher level of abstraction

- **Wireless and Mobile WG (early stages)**
  - It extends the ONF-based work to wireless and mobile domains
  - Examples: *Evolved Packet Core* mobile processing (EPC), Mobile Backhaul, enterprise wireless networks

- **Migration WG**
  - It defines hybrid device operation (structuring and using a device which supports simultaneously OF and other operating paradigms)

SDN - standardization aspects

- **OPEN NETWORKING FOUNDATION - ONF** (cont'd)
  - **Other Activities in development**
  - **Testing and Interoperability WG** : test cases , interoperability events, certification aspects
  - **Marketing and Education WG:** white papers and solutions briefs, etc.
  - Work on defining mechanisms for service chaining (applying OpenFlow to layers 4–7).

SDN - standardization aspects

- **EUROPEAN TELECOMM. STANDARDS INSTITUTE INDUSTRY SPECIFICATION GROUP FOR NETWORK FUNCTION VIRTUALIZATION (ETSI NFV ISG)**
  - **ETSI - Operator driven organization (200 members)**
  - NFV ISG goals:
    - To define the reqs. and architecture for the **virtualization of network functions**
  - NFV is not strictly linked to SDN
  - However, SDN provides a powerful tool to enable many of the use cases of interest
  - **Structure: Technical Steering group + 6 WGs**
  - **Architecture of the Virtualization Infrastructure (NFV INF WG)**
    - - reference architecture for a virtualization infrastructure, and the Reference Points (RP) for components interconnection

SDN - standardization aspects

- **(ETSI NFV ISG) (cont'd)**

- **Management and Orchestration WG**
  - **-** It describes the deployment, instantiation, configuration, and management of network services based on the NFV
  - - integration : network service delivery – operational support systems (OSS) - business support systems (BSS)
  - The work sometimes overlaps with other standards

- **Software Architecture** WG
  - It defines
    - the reference SW arch. of network functions to be deployed
    - the detailed requirements of the interfaces and mechanisms defined by other WGs.

SDN - standardization aspects

- **(ETSI NFV ISG) (cont'd)**

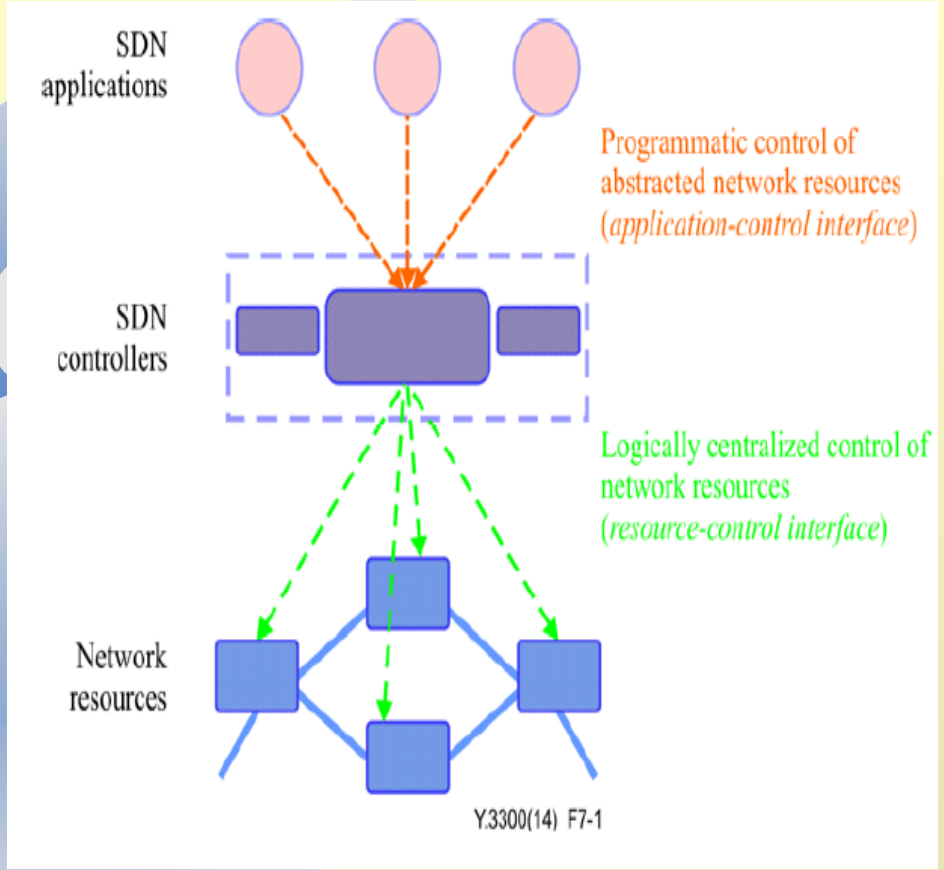
- **Reliability and Availability WG**
  - It defines the reliability and availability requirements in a NFV environment.
  - New approach needed if considering the replacement of traditional telecomm. equipment with more data-center-oriented equipment and with dynamic and virtualized instantiation of service functions

- **Security Expert WG**
  - security review and advices to the broader ETSI NFV activity.

- **Performance and Portability Expert WG**
  - The perf and the portability requirements in the new NFV environment changed significantly
  - This WG advises other WGs on perf. issues, constraints, capabilities, and potential advantages - of different architectural or deployment choices

SDN - standardization aspects

- **INTERNATIONAL TELECOMMUNICATIONS UNION TELECOMM. STD. SECTOR (ITU-T)- SG13**
  - Active in defining architectures and requirements for the use of SDN in transport networks.
  - These networks have important requirements different from other networks
  - Y.3300 Recommendation
    - They describe the fundamental SDN framework: definitions, objectives, high-level capabilities, requirements, and high-level architecture of the of SDN.



ITU-T SDN Architecture

SDN - standardization aspects

- **IETF**
- **Interface to Routing Systems (I2RS) WG**
  - It addresses a gap in the SDN. approach
  - The SDN controllers must interact with routing protocols, and SDN control must to be able to apply policy to actual routers.
  - Routers could be: integrated devices, or may themselves be decomposed; also they might be SDN capable
- I2RS general goal:
  - allow applications to learn from and request changes of the routing system.
- **Result expected:**
  - **classic distributed routing and centralized, policy- and application-driven SDN, can cooperate**

SDN - standardization aspects

- **IETF (cont'd)**
- **Interface to Routing Systems (I2RS) WG (cont'd)**

- Specifically, I2RS:
  - facilitates real-time or event-driven interaction with the routing system through a collection of protocol-based M&C I/Fs

  - allow information, policies, and operational parameters to be injected into and retrieved from the routing system
    while retaining data consistency and coherency across the routers and routing infrastructure

- Open issue: compatibility/cooperation with
  - **ForCES,**
  - **NetConf with YANG,**
  - **RESTCong with YANG**

SDN - standardization aspects

- **IETF (cont'd)**
- **Service Function Chaining (SFC) WG**
  - standards for the DPI component of service chains → improve the traffic-direction problem
  - It defines an SFC architecture including the protocols (extensions) extensions to convey the SFC and SF Path information to nodes involved
  - It defining a range of carriage mechanisms, e.g., to allow the use
    - Layer 2 encapsulations (Eth., VLANs) to identify service paths, or
    - Intermediate such as as MPLS, or IP encapsulations
  - SFC does not mandate specific control mechanisms
    - However it is expected that dynamic SFC will use of SDN technologies to control and classify and forwarding functions in the service paths.
  - **Comments:**
    - SFC-WG- Work in progress
    - Still open issues: approaches, what to be defined in the arch. or left to implementation

SDN - standardization aspects

- **IEEE**
  - IEEE 802.1 began recently work on
    - 802.1CF (network reference model work) including defining interfaces with SDN.
    - Ongoing Work on enhancements to path control.
- The above are important components for industrial SDN and virtualization solutions
- The interaction between 802.1CF --- other SDN standards , is discussed between the OmniRAN Task Group and at ONF, IETF.
- New Research Group on Software Defined and Virtualized Wireless access

SDN - standardization aspects

- **OPEN DAYLIGHT**
  - Linux foundation → An open source SW activity
  - 2014: 36 member companies
  - Why open?

  - **General goal:**
  - for SDN and NFV early adoption, the industry would benefit of establishing an **open, reference framework** for programmability and control through an **open source SDN and NFV solution**
  - develop an SDN controller for a wide range of applications

  - **Aim** :
  - to maintain the flexibility and choice to allow organizations to deploy SDN and NFV at will,
    - but reducing risks of adopting early-stage technologies and integrating in existing infrastructure investments.

SDN - standardization aspects

- **OPEN DAYLIGHT (cont'd)**
- SW characteristics:
  - **JAVA,** supporting a wide range of I/Fs to applications, principally using REST technologies.
  - Includes a CLI to allow human interaction,
- It supports
  - JAVA RMI for closer coupling to the software.
  - a wide range of protocols for interacting with the network: *NetConf, SNMP, Open Virtual Switch Data Base (OVSDB), OpenFlow, BGP, Path Computation Engine Protocol (PCEP) , Locator/Identifier Separation Protocol (LISP).*
  - The arch. also explicitly allows adding new I/Fs, e.g. proprietary.
  - The system core is based on YANG models to describe the services, I/Fs, data storage.
  - This enables automatic code generation (not fully) and a common model-driven dispatch mechanism to support the flexibility needed.

SDN - standardization aspects

- **Interactions, collaboration, overlaps, conflicts …**
  - Facts:
    - (+) Related technologies, partially common goals, need for cooperation and synergy, ..
    - (+/-)Competition, different specific objectives, different communities, …
    - **ETSI NFV ---- ONF:** formal collaboration to enhance SDN support of NFV needs.
    - **ETSI NFV -----IETF**
      - NFV reqs : inputs the requirements work in the I2RS and SFC WGs
    - **ETSI ---- Open Daylight:** ETSI NFV defines PoC activities – some of them expected use of Open Daylight SW
    - Usually the other standards body collaborates with ETSI to analyze the needs and gaps in the current specifications.

SDN - standardization aspects

- **Interactions, collaboration, overlaps, conflicts …(cont'd)**
- ONF ----IETF
  - ONF progressed quickly but did not start a strong cooperation with IETF.
  - They founded a new standards body, and developed a specs focused on specific needs.
  - (+) specs developed quickly
  - (-) specs are rather narrow
    - -need more work to define how to utilize them in a broader area.
  - (-) difficulty in allowing the IETF to use ONF products.
  - (-) competition between ONF and other standard bodies- complicates the interactions…
- Example :ONF OFConfig protocol for managing OF switches.
  - (-) Currently the the market has failed to adopt this protocol.
  - More agreed is the proprietary protocol known as **OVSDB**
  - (-) Adopting YANG models for OF-Config- difficult

SDN - standardization aspects

- **Interaction, collaboration, overlaps, conflicts …(cont'd)**
- **ONF ----IETF (cont'd)**
  - RFC: 7047, The Open vSwitch Database Management Protocol, December 2013
  - Open vSwitch Database (OVSDB) is a management protocol in SDN environment.
  - OVSDB was created by the Nicira team and later acquired by VMware.
  - OVSDB is part of Open vSwitch (OVS) (feature-rich, open source virtual switch designed for Linux-based hypervisors).
  - In comparison with legacy SNMP,OVS created a modern, programmatic management protocol interface – and OVSDB can be a solution
  - Conclusion: a better cooperation ONF-IETF would be useful for everybody

SDN - standardization aspects

- **Interaction, collaboration, overlaps, conflicts …(cont'd)**
- **OPEN DAYLIGHT- interaction with standards**
  - Open Daylight includes people from the ONF and IETF
  - It built software using protocols from both ONF and IETF
  - This provided valuable feedback on :clear/not-clear, work/non-work useful/useless non-specified items in the standards,
  - Care should be taken – to not draw general conclusions from particular implementation- given some particular choices adopted in the implementation.
- **Other Industrial Fora involved in SDN specification activities**
  - BroadBand Forum (BBF)
  - Metro Ethernet Forum (MEF)
  - Optical Interface Forum (OIF).

SDN - standardization aspects

- **CONCLUSIONS**
  - The landscape of SDN standardization set of specs is broad, but contains duplicates (e.g. Forces/ONF)
  - More collaboration, is needed (no single org. can do all tasks)
  - **There are proposals**
    - to more clearly define the responsibilities and consider previous work when a std. body starts new std. effort
    - to allow participation to multiple groups
    - improve the interoperability
    - avoid the tendency of one body to expand into adjacent spaces of others
  - Emergence of open-source software, also has some own challenges.
    - Need that standards bodies and open-source communities cooperate better
    - Note that implementations, and standards are not the same thing

- Thank you !

SDN - standardization aspects

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SDN - standardization aspects

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