

Impact of Virtualization and SDN on Emerging Network Coding

<https://datatracker.ietf.org/doc/draft-khasnabish-nwcrg-impact-of-vir-and-sdn/>

(Current Version: draft-khasnabish-nwcrg-impact-of-vir-and-sdn-02.txt)

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IETF-91, SPRING WG Mtg. (9 AM - 11:30AM)

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Friday, 14 Nov. 2014

Outline

- **Updates** since IETF89 (Feb. 2014)
- **Plan** for next version (ver.-03) of the draft
- **Request** for further Comments, Thoughts, Suggestions, Guidance, Volunteers, etc.
- **Q & A**, and **THANKS!**

Updates Since IETF89

- Initiated a draft (version zero)
- Added discussion on distributed control of Transport (both L2 and L3) scenarios/options
 - Objective is to explore how virtualization can be supported (coded) with/without common APIs
- Added discussion on separation of control (SDN architecture)
 - Objective is to align this draft with the Architecture and terminology with SDN RG's base draft (<http://tools.ietf.org/html/draft-irtf-sdnrg-layer-terminology-01>)
 - This document is well aligned with [I-D.irtf-sdnrg-layer-terminology]
 - Depending on where the network coding entity is located, in the forwarding or operational plane or as a service in the control plane different abstraction layers and interfaces are involved
- Added Senthil Sivakumar, and Evangelos Haleplidis as co-authors

Plan for version 03

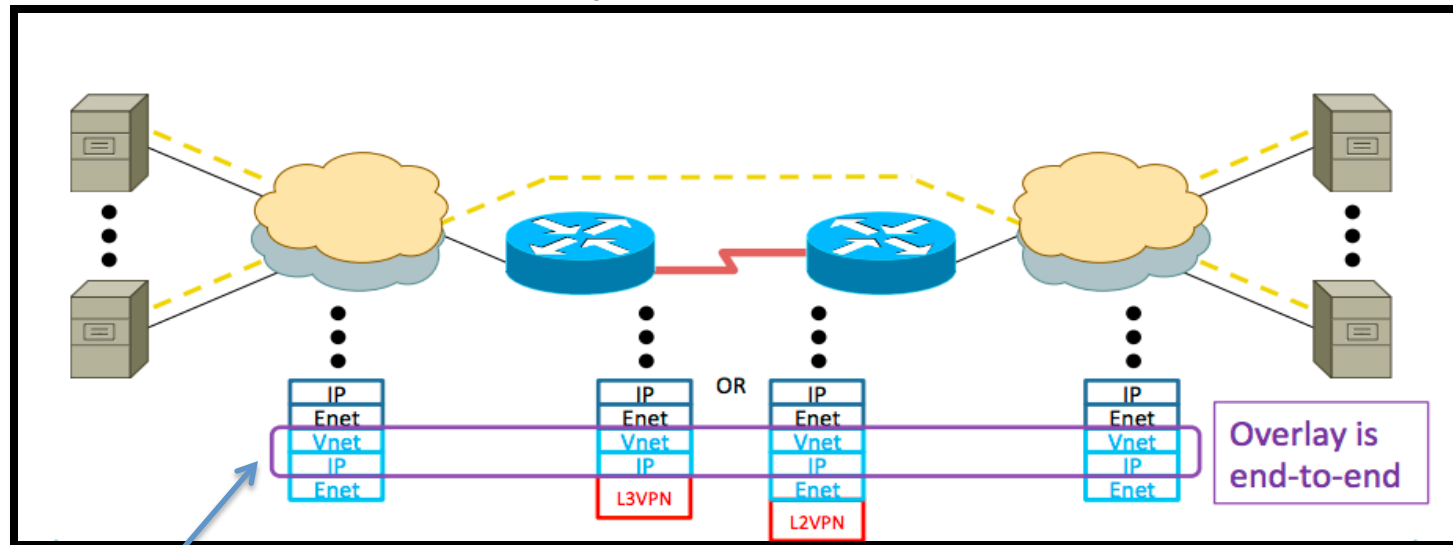
- Will be adding Cedric Adjih as a co-author
- Start: identify the place(s) of Network Coding in SDN architecture
 - NC is possible at different layers (as in current proposals without SDN)
 - Can analyze different SDN archi. (including full virtualization [w/ storage])
 - Identify use cases, benefits of NC, suitable mapping to SDN architectures
- Participate in and contribute to the extended and interactive discussion on Network Coding architecture of the research group
 - Explore the role and evolution of Network coding controller (the intelligence behind a *possible* dynamic network coding)
 - What exactly is the purpose of the coding controller?
 - How does it reflect on the network coding?
- Advance things from very abstract to solidifying the definition of the network coding controller in the Architecture (that is being developed)

Plan for version 03

- SDN might have an impact on the Network Coding RG from the architectural view points
 - By virtualizing the network, NC might also be introduced transparently within the SDN architecture
 - There are other good proposals that aim to do network coding transparently (as in COPE, but it is possibly more natural in SDN)
 - <http://groups.csail.mit.edu/netmit/wordpress/projects/network-coding/cope/>
 - Possibly start from use cases, and analyze what happens with SDN
 - And maybe compare with Notional Network Coding architecture from the RG and see/show how the two relate

Plan for version 03

- Example: the IETF's NVO3 architecture
 - Virtualization overlay, inter-data-center connectivity



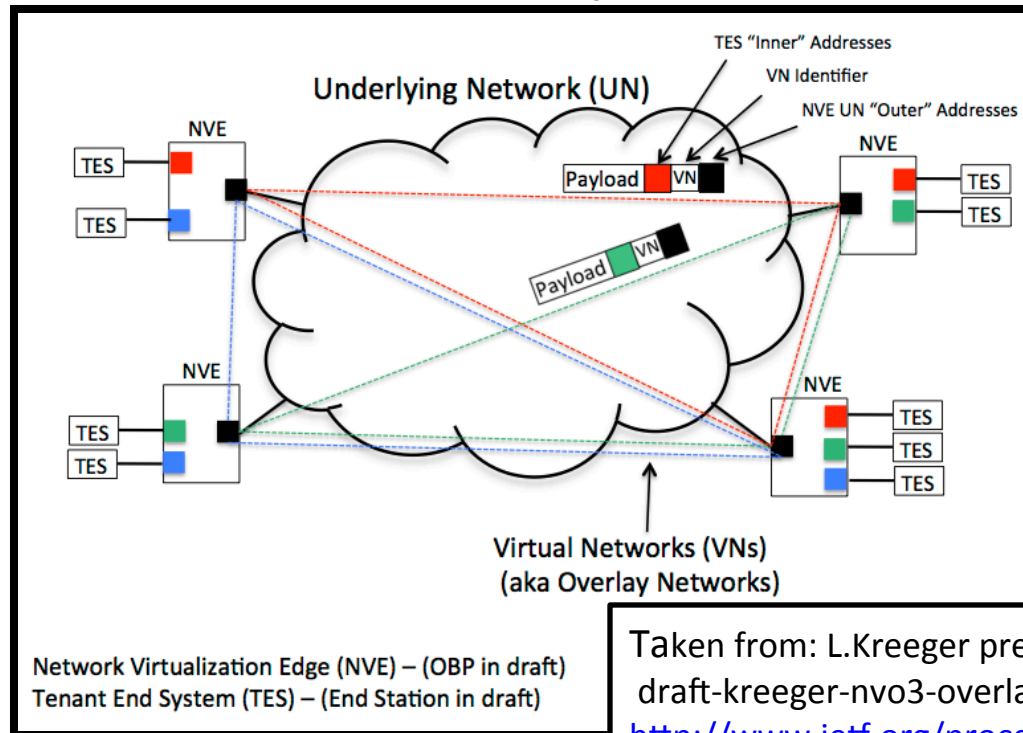
- Original payload (packets) at the edges are encapsulated in other IP packets w/ header
- sent on an overlay

Taken from: D. Black presentation at NVO3 BOF, IETF-83
<http://www.ietf.org/proceedings/83/slides/slides-83-nvo3-1.pdf>

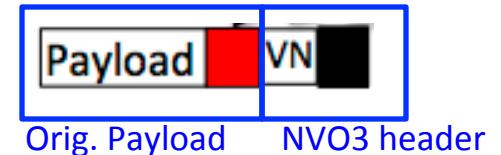
- Network coding could be done between ingress and egress
- NC benefits? reliability? trade latency for bandwidth? butterflies?

Plan for version 03

- Example: the IETF's NVO3 architecture
 - Virtualization overlay, inter-data-center connectivity



- Packets at the edges are encapsulated in other IP packets w/ header



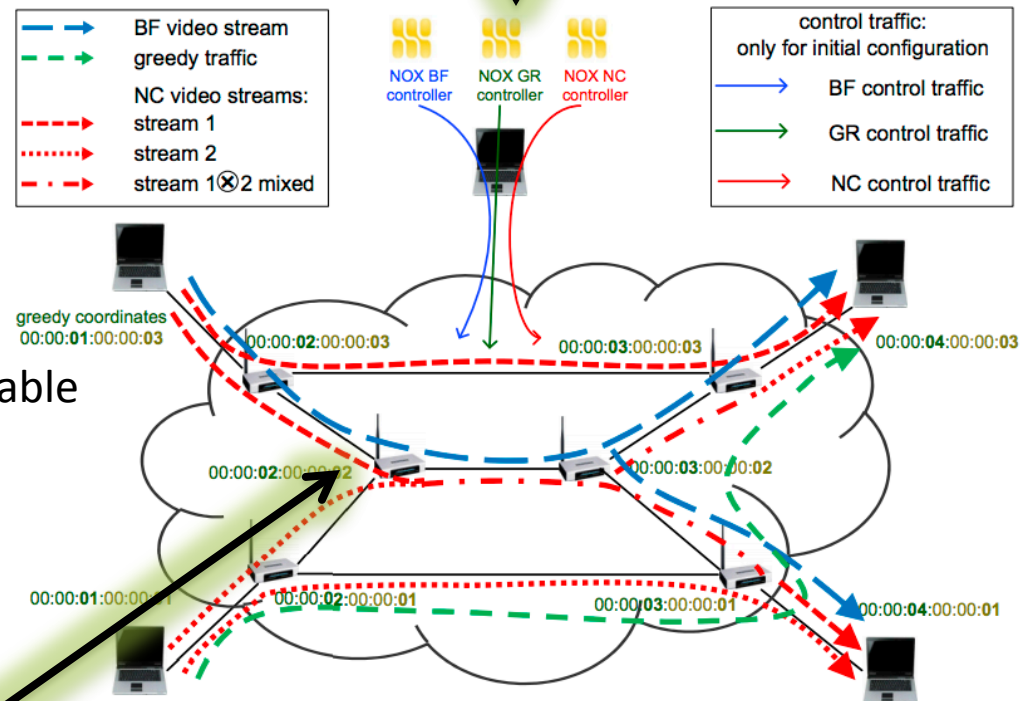
- sent on an overlay

- Network coding could be done between ingress and egress
- NC benefits? reliability? Trade latency for bandwidth ?

Plan for version 03

- In order to support network coding, it may be necessary to introduce it in SDN architectures, e.g., for OpenFlow.

SDN centralized control plane (NC aware)



- Without SDN:

T. Biermann et al., Networking 2009, "Creating butterflies in the core [...]"

- With SDN:

Németh et al. "Towards SmartFlow: Case Studies on Enhanced Programmable Forwarding in OpenFlow Switches", demo SIGCOMM 2012

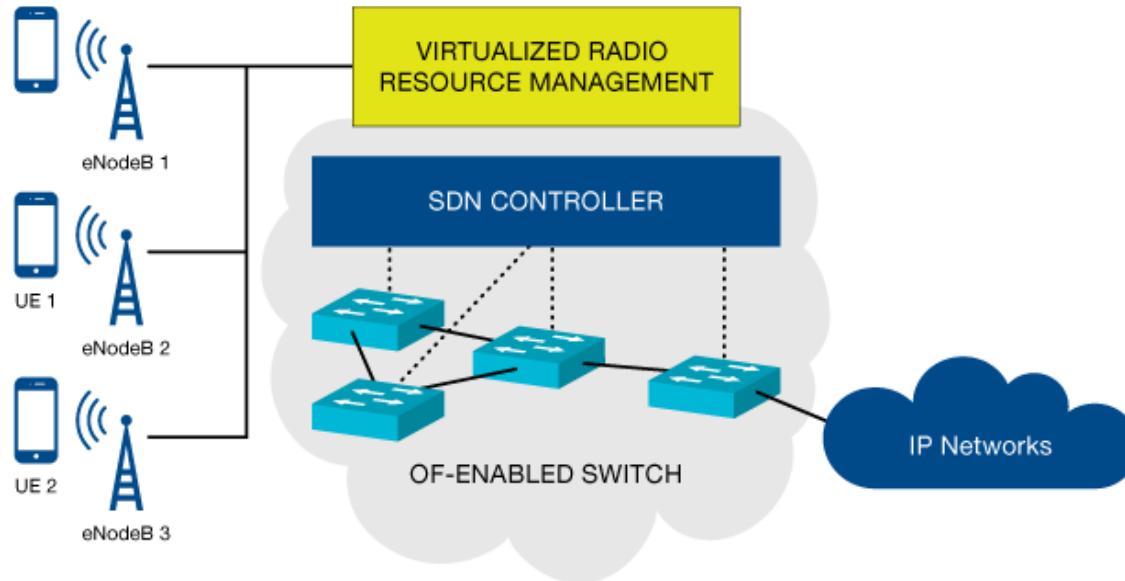
Extension of the OpenFlow Protocol with (3) actions for XOR-based mixing

Source: http://qosip.tmit.bme.hu/~gulyas/personal_page/openflow_demo.pdf

Switch (OpenFlow+ext): matches packet labels, action = xor packets, output=coded

Plan for version 03

- Example architecture for virtualizing RAN (here LTE):



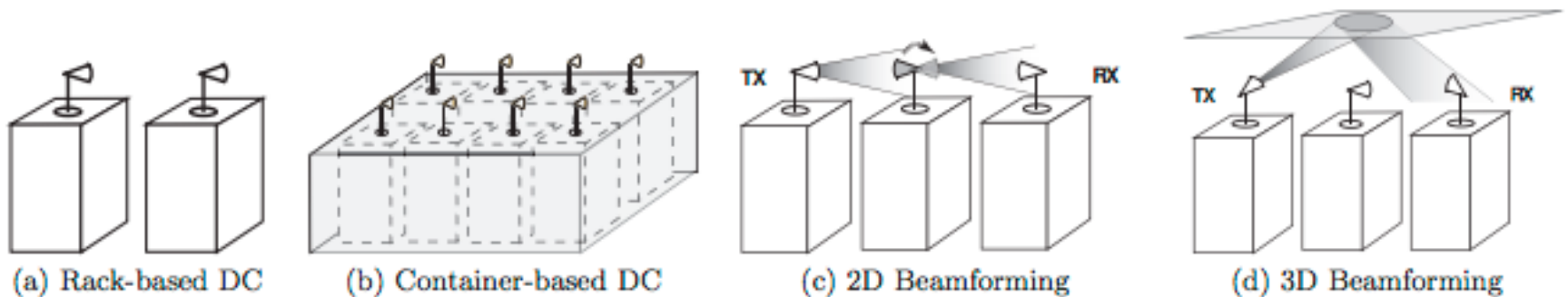
Source: Open Networking Foundation

<https://www.opennetworking.org/solution-brief-openflow-enabled-mobile-and-wireless-networks>

- Possibly consider these architectures for network coding in RG:
 - especially if they handle inter-cell interference, or even, cooperative transmissions (physical layer network coding)
 - -> inspiration for the network coding controller

Plan for version 03

- Possible corresponding NC use-case in the data-center
 - (several) propositions of 60 GHz wireless data-centers
 - Incl.: Xia Z. et al, “Mirror Mirror on the Ceiling: Flexible Wireless Links for Data Centers”, SIGCOMM, 2012



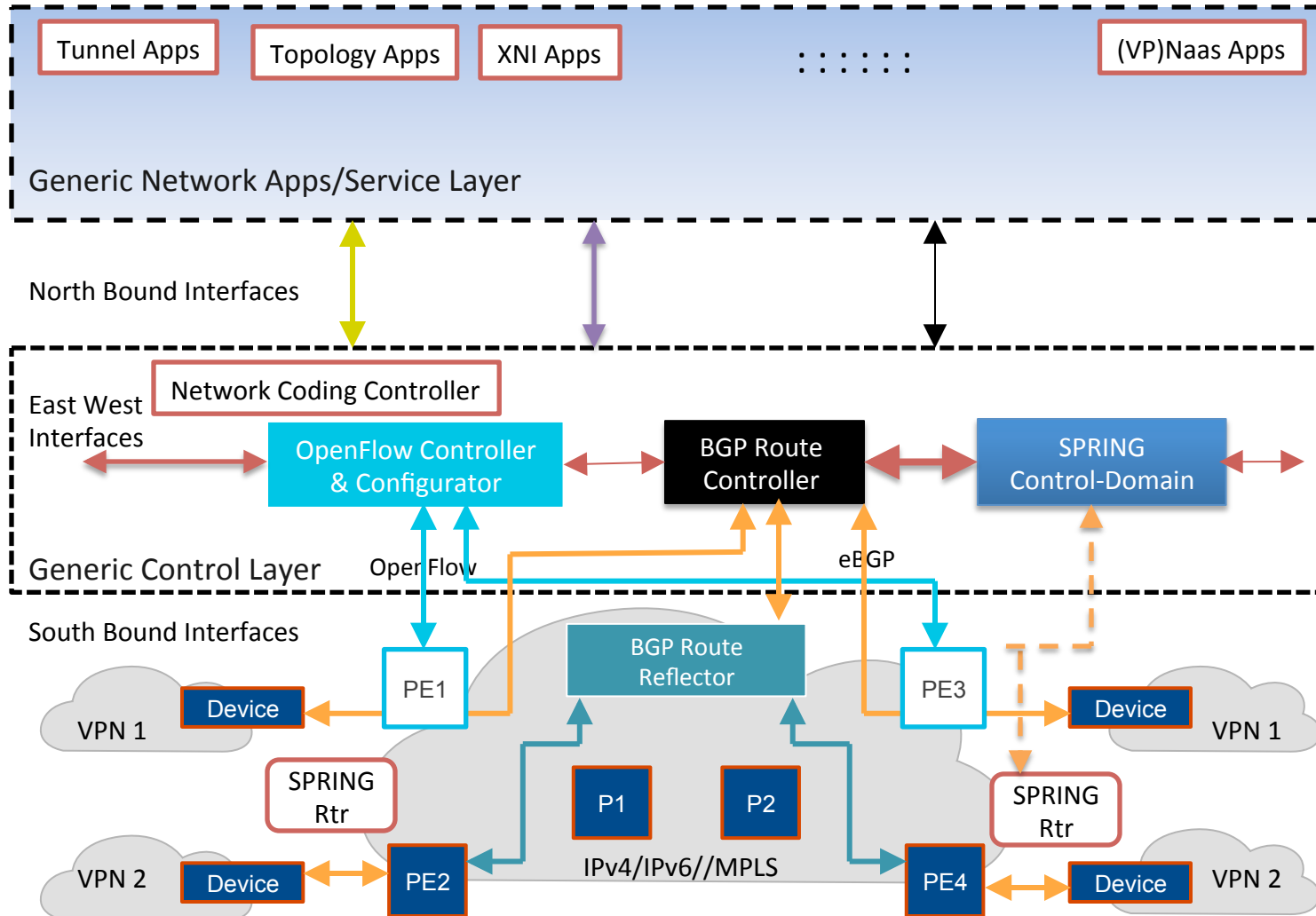
Source: <http://conferences.sigcomm.org/sigcomm/2012/paper/sigcomm/p443.pdf>

- Network coding (and much more) is possible
- Where is coding, and possibly **recoding**, done ?
- What is the architecture (SDN architecture) ?

Plan for version 03

- For SDN applications
 - one use of network coding could also be to improve latency (for big inter-data center data exchanges) at the expense of some bandwidth; would it be worth exploring further ?
- Network Functions Virtualization (NFV); Use Cases from ETSI GS NFV 001, could have nice use cases/scenarios for thinking about utilizing network coding
 - http://www.etsi.org/deliver/etsi_gs/NFV/001_099/001/01.01.01_60/gs_NFV001v010101p.pdf
- :::: :::: ::::

An Example of where **Controlled Network Coding** can be Helpful for **Graceful Multi-Domain/-Technology Scaling/Operation/Orchestration** for e.g., **NaaS** [SDN-Based SPRING OpenFlow Interworking (Generic Architecture)]



What's Next?

- Comments
- Thoughts
- Suggestions
- Guidance
- Volunteers / Contributors / Reviewers,
- etc. etc.

Q & A,

THANKS.

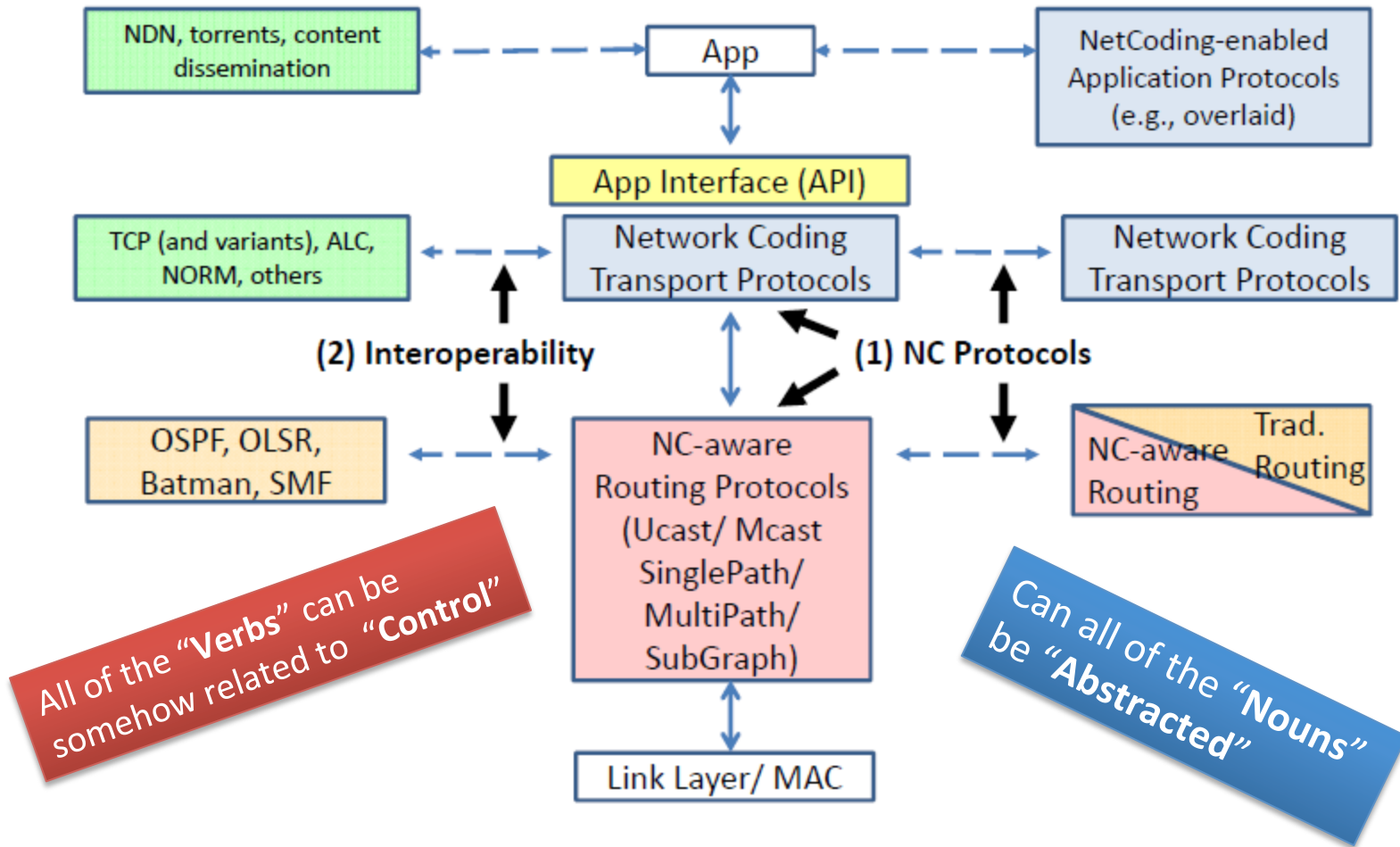
Backup and Background Slides

(<http://www.ietf.org/proceedings/89/slides/slides-89-nwcr-0.pdf>)

Outline

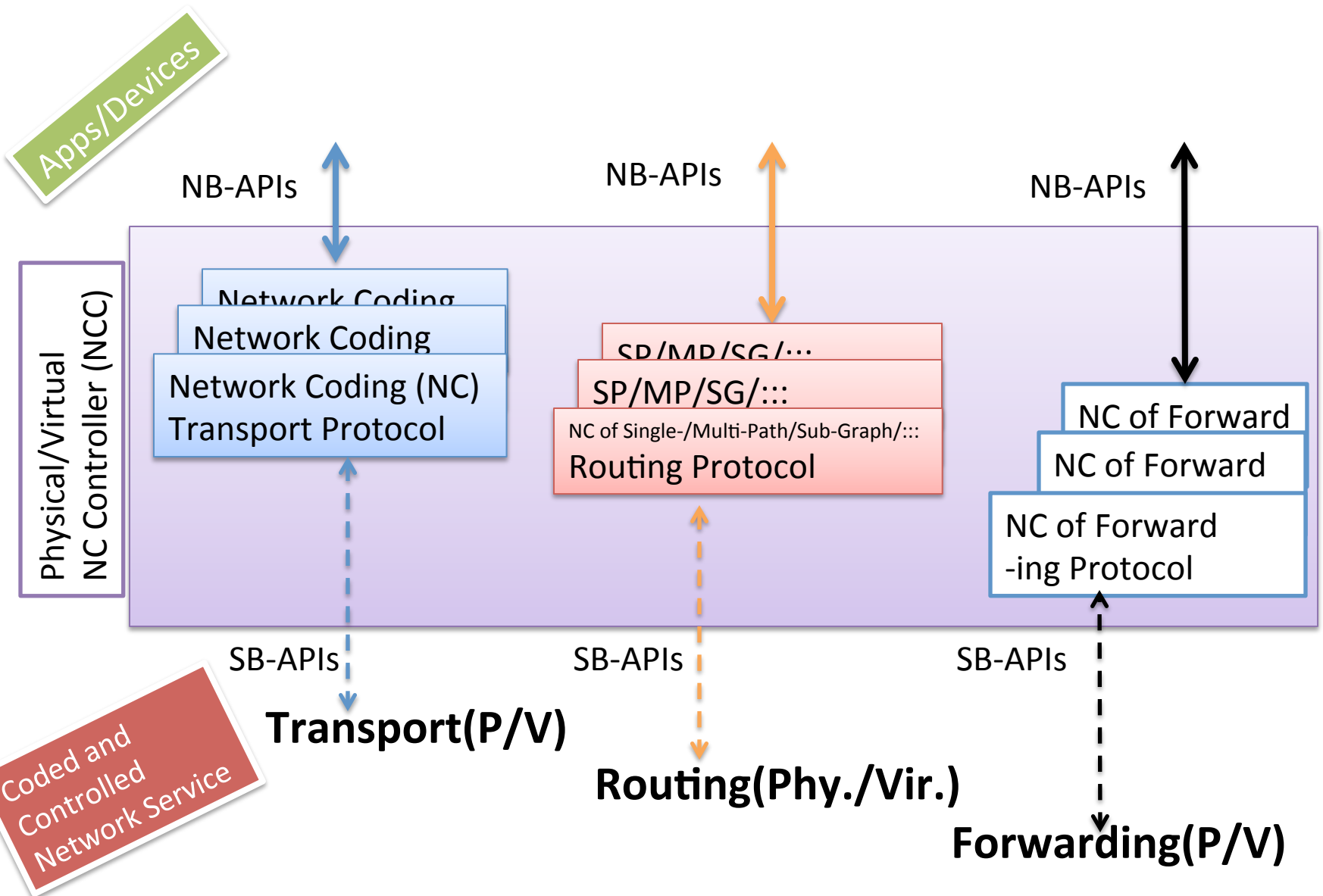
- Background
- Abstraction/Virtualization of the <elements> of Network (focus on **L3** entities only)
 - node, route, topology, RIB, service (policy, security, quality, etc.), address, transport, etc.
- Control of Network Coding
 - **Where** does it reside
 - How to **virtualize** and **centralize** logically
- APIs
 - Address, transport, routing, etc.
- Other thoughts/suggestions for discussion

Notional Network Coding Architecture

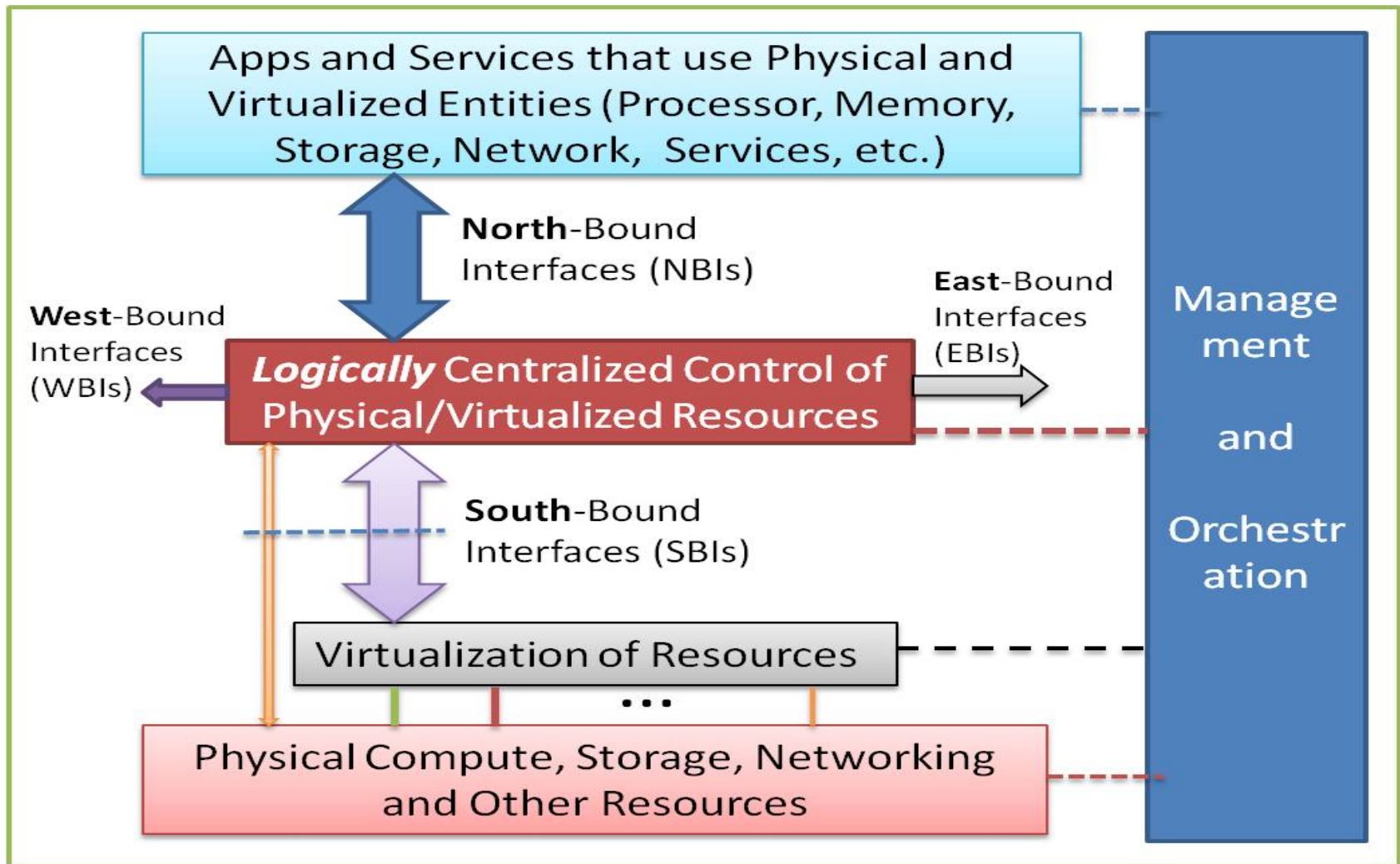


Source: Network Coding Taxonomy (Victor & Brian);
<http://www.ietf.org/proceedings/88/slides/slides-88-nwcr-6.pdf>

Separation of Control for Transport, Routing, Forwarding, etc.



A High-Level Architecture for Network/Service Function Virtualization and Software-Defined Networking



Source: ZTE Communications (Dec. 2013) <http://www.zte.com.cn/endata/magazine/ztecommunications/2013/4/>

Virtualization

- Computing Resources Virtualization (*Software-defined Computing resources*)
 - ***DMTF and Open Compute/Cloud/Stack Specs may be useful***
- Network Function Virtualization (*Software-defined Network functions*)
 - ***ETSI/ISG NFV started developing the Requirements and gaps in the Industry and Standards***
- Storage Virtualization (*Software-defined Storage resources*)
 - ***SNIA specs may be useful***
- Service Function Virtualization (*Software-defined Service function*)
 - ***ETSI/ISG NFV started developing the Requirements and gaps in the Industry and Standards***

Virtualization of Network-Level Resources

- Network Node virtualization
 - *This refers to developing Templates for Deploying (Allocating, Managing, and Releasing the Functions that Reside in Network Nodes; the Functions may include Addressing, Forwarding, Monitoring, Management, etc.)*
- Router virtualization
 - *This refers to developing Templates for Deploying (Allocating, Managing, and Releasing the Functions that Reside in Routers; the Functions may include Route creation and management for packets/flows, etc.)*
- Network Topology virtualization
 - *This refers to developing Templates for physical (and virtual) interconnection among the network nodes (routers and others) and utilizing them for networked services*
- RIB/TIB (Routing /Topology information base) virtualization
 - *These refer to virtualizing (developing the templates and utilizing the instances) the databases that store Topology and Routing information*
- Network service (policy, security, quality, load-balancer , etc.) virtualization
 - *This refers to developing Templates for advanced network services and utilizing instances of those templates in general COTS servers for services*

Virtualization of Network Coding

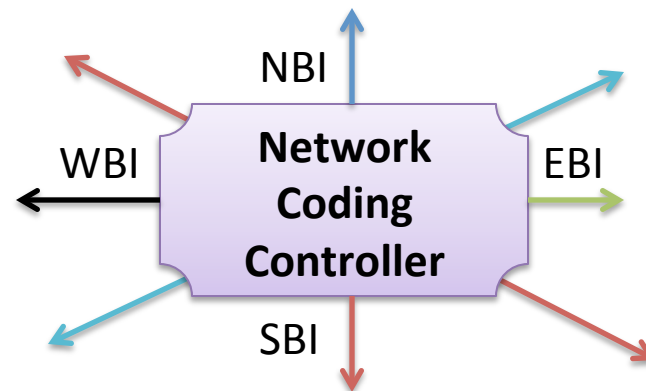
- Network Coding support of virtualization
 - *Network codes that can utilize both physical and virtual Transport, Routing, Forwarding, etc. entities*
- Virtualization Support in Network Coding
 - *Virtualization of Network codes for any combination of Transport, Routing, Forwarding, etc. entities*

Network Coding Controller (NCC)

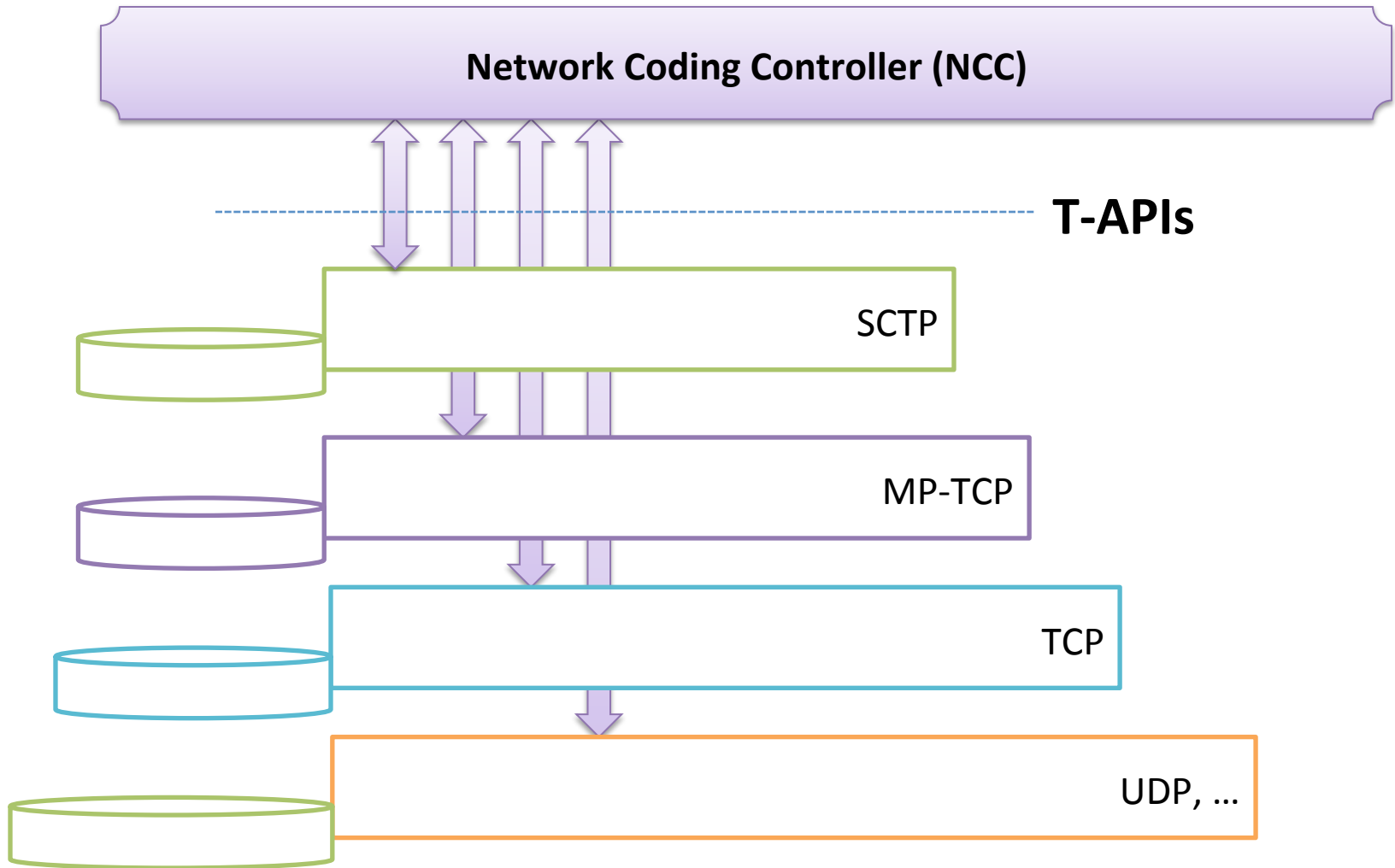
- Logically Centralized Physically Distributed
 - *Clustered or Hierarchically organized NCCs (physical and/or virtual)*
- Physical NCC
 - *A Physical device/host that contains the NCC functions*
- Virtual NCC
 - *A virtual machine that hosts/contains an instance of the NCC function*

APIs

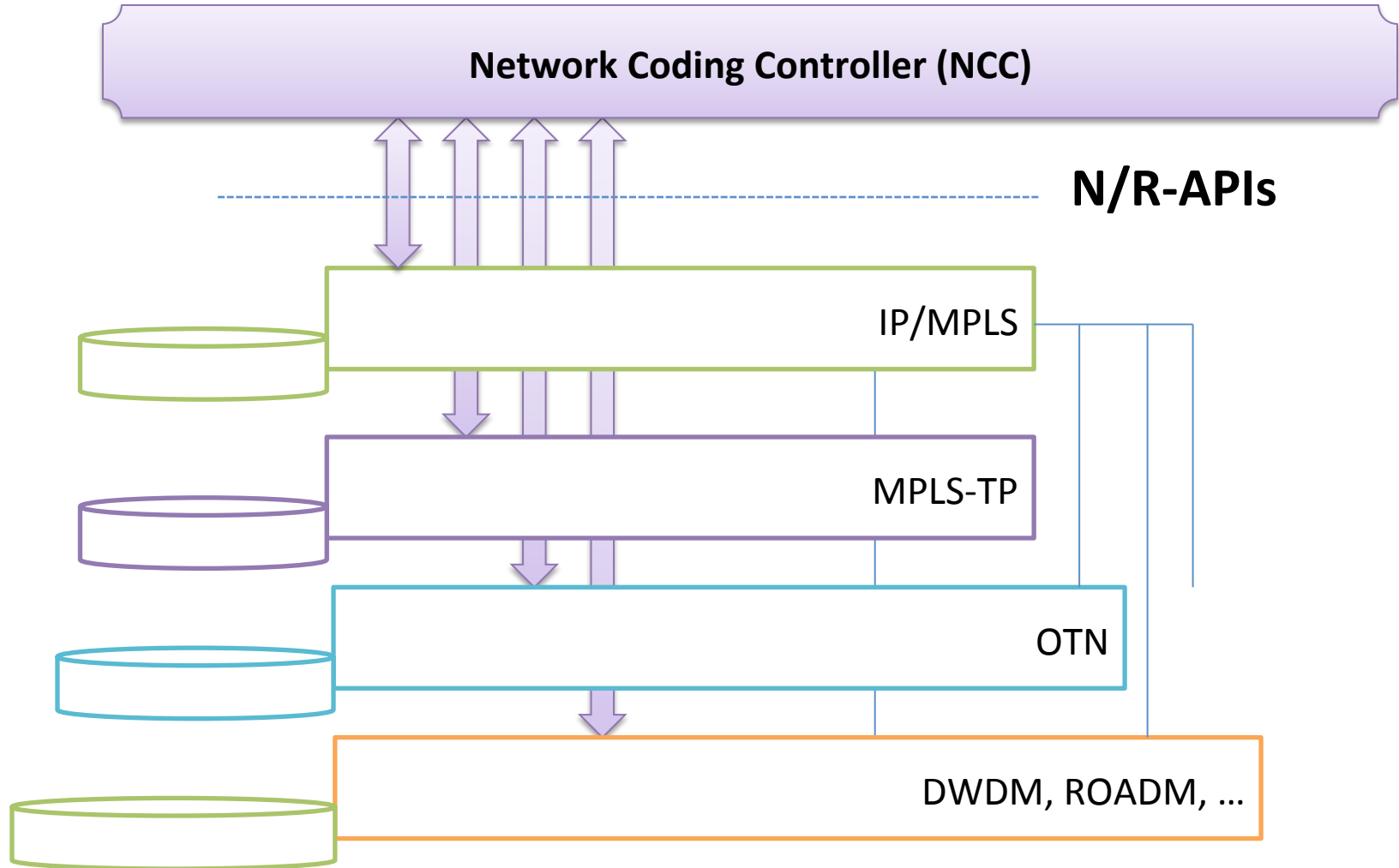
- North-Bound APIs (NBIs)
 - *Interfaces to/from Applications and Services*
- South-Bound APIs (SBIs)
 - *Interfaces to/from {Transport, Network, Forwarding, Physical Devices/Links, Location, etc.}*
- East-Bound APIs (EBIs)
 - *Interfaces to/from Management and Orchestration*
- West-Bound APIs (WBIs)
 - *Interfaces to/from Access-Network (Consumer Device)*
- Other APIs
 - North-East
 - Surveillance Interface
 - North-West
 - *In progress ... Alien intelligence service*
 - South-East
 - Counter Surveillance Interface
 - South-West
 - *In progress ... Native Intelligence Service*



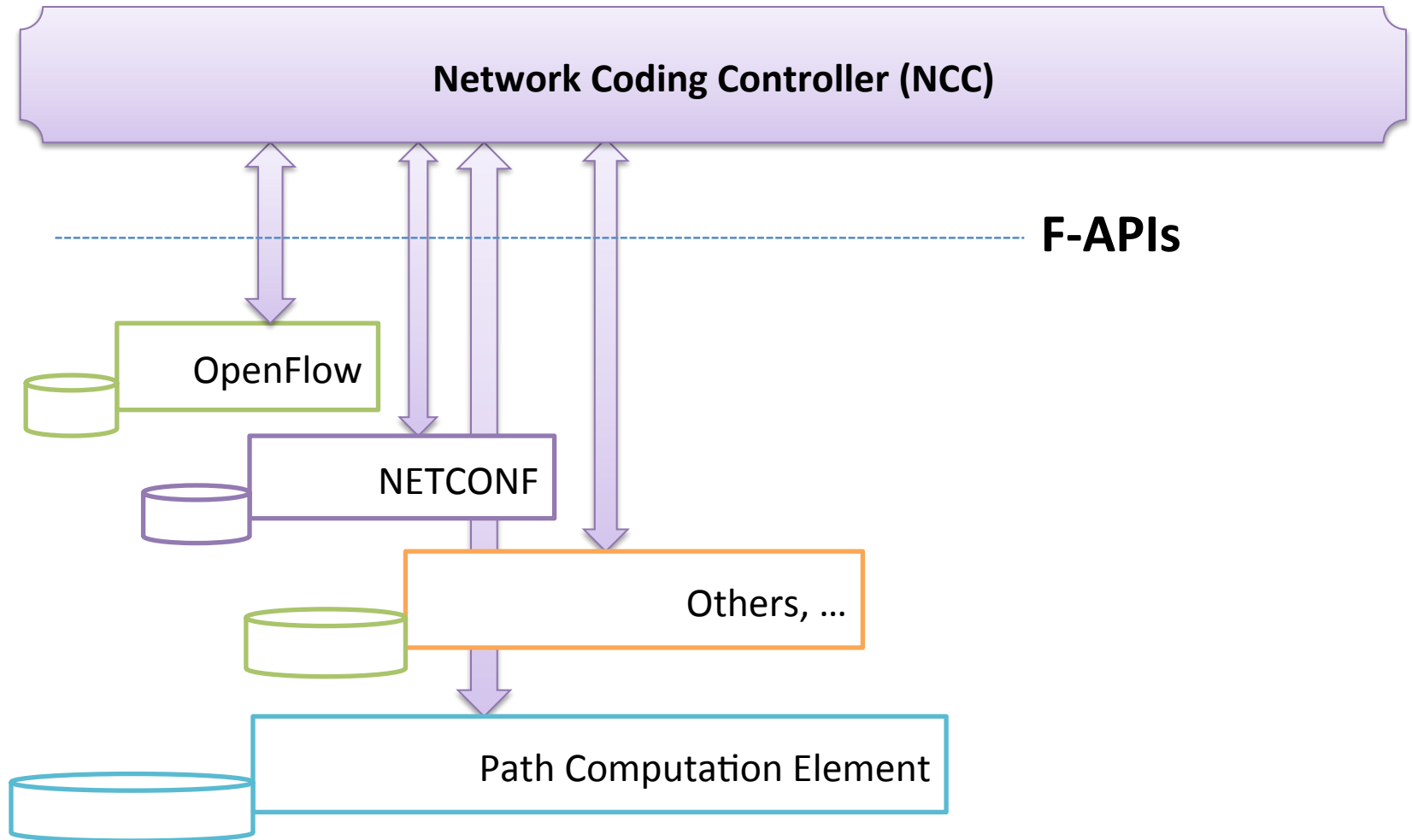
Transport Plane API(s)



Network/Routing Plane API(s)



Forwarding Plane API(s)



Next Steps

- **Initiate a draft, and Invite others to Contribute/Participate**

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- **Comments/Suggestions**

Q&A, and Discussion

THANKS!