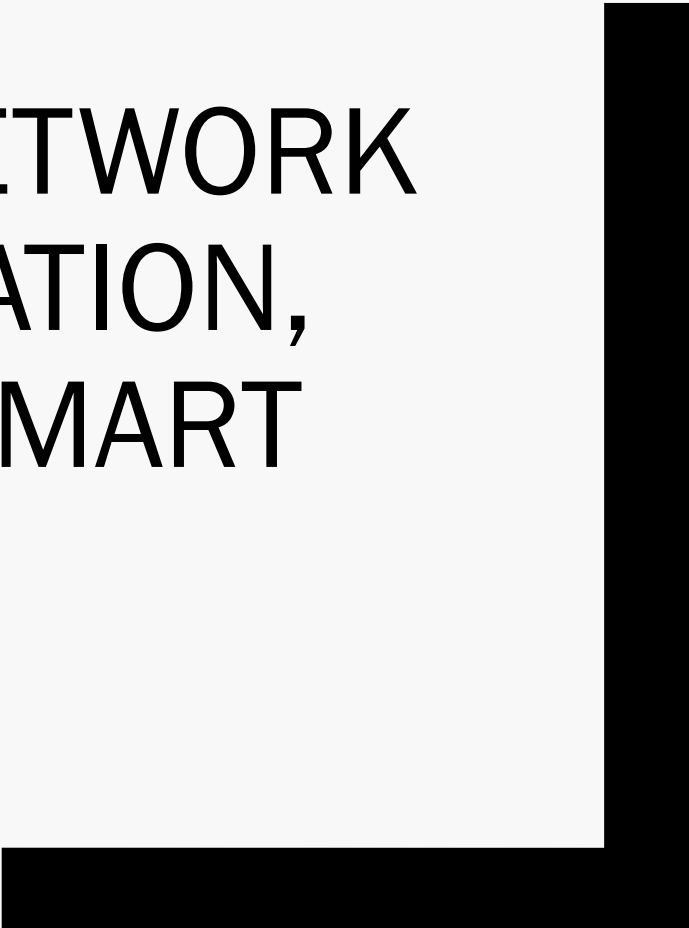




COMMONALITIES OF NETWORK FUNCTION VIRTUALIZATION, BLOCKCHAINS AND SMART CONTRACTS

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Content (1/2)

- Network Functions
- Network Function Virtualization
 - *Functionality*
 - *Advantages*
 - *Examples*
- State of Network Function Virtualization
 - *Standardization*
 - *Industry examples*

Content (2/2)

- Challenges of Network Function Virtualization
- Addressing challenges of NFV with blockchain
 - *Improving NFV technology*
 - *Implemented Examples*
- Discussion

Contextualization

Network Functions: Traditional approach

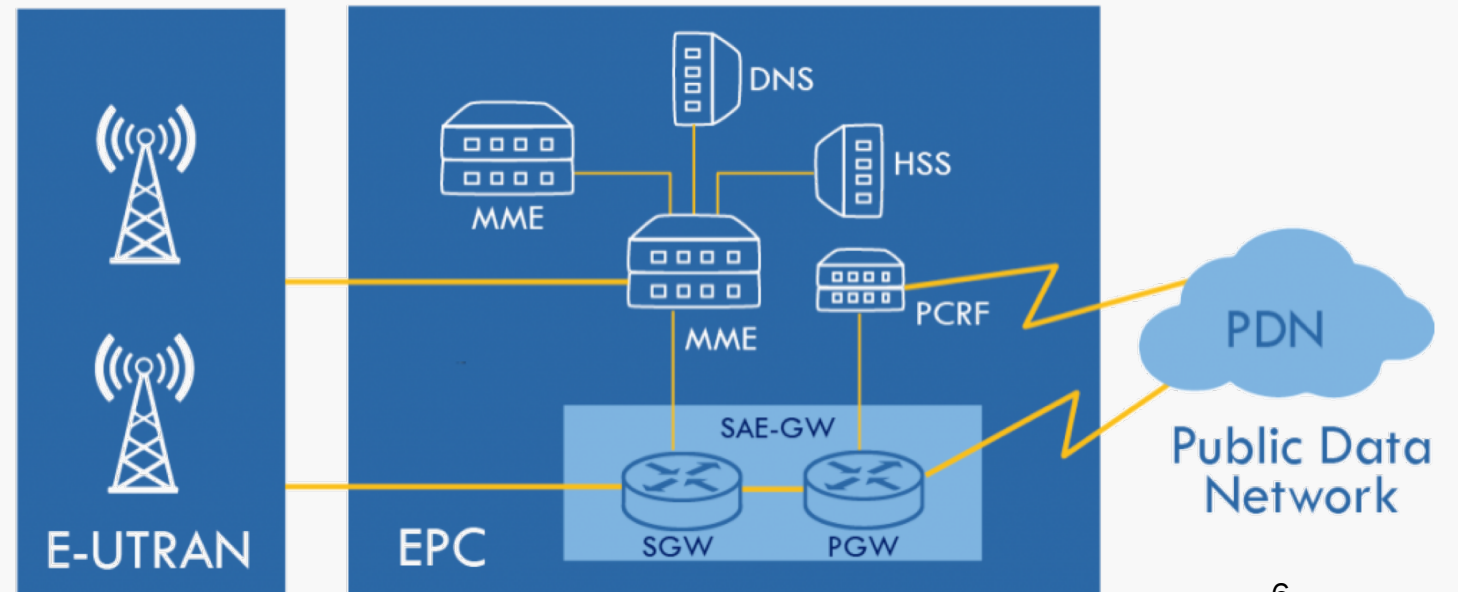
- Physical devices providing network functions



And more

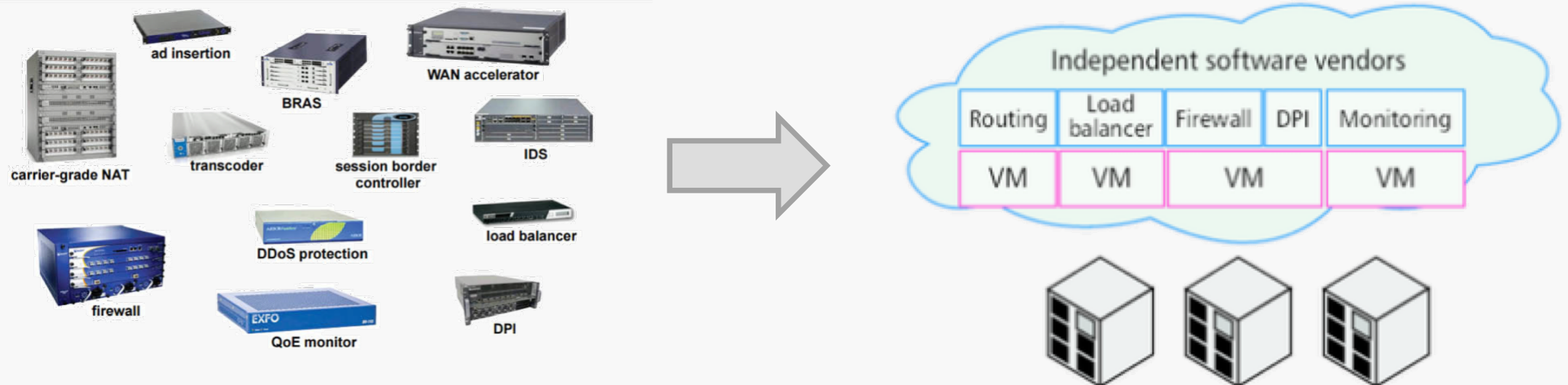
Network Functions: Traditional approach (e.g. LTE)

- MME: Mobility Management Entity
- PCRF: Policy and Charging Rules Function
- DNS: Domain Name System
- Gateways
- Radio Controller



Network Function Virtualization: The new approach

- Decouple service functions from hardware
- Use virtualization
- Running on generic server infrastructure



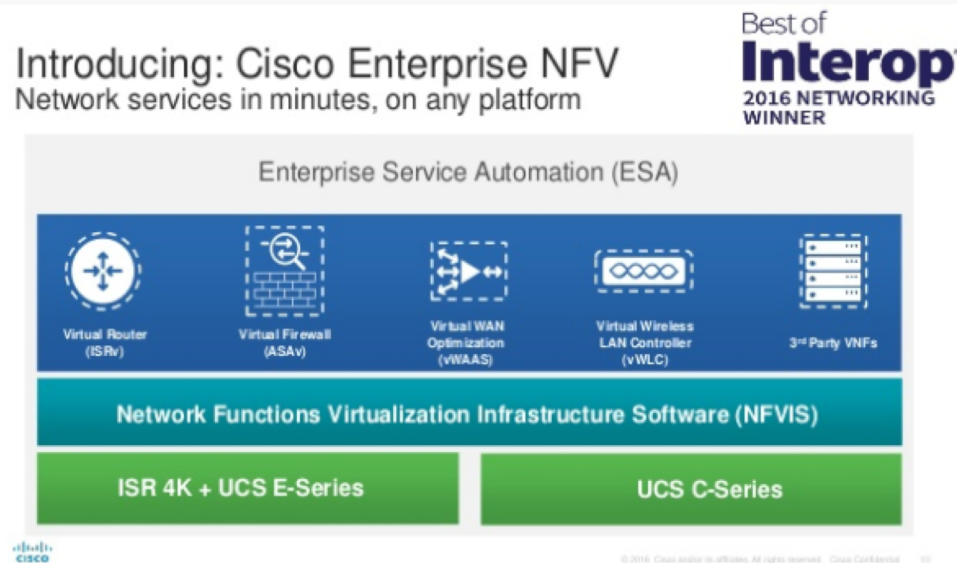
Network Functions: Traditional approach

- Highly specialized, proprietary physical devices
- Traffic statically directed through all necessary network functions
- Normally located on service provider's premises
- Effects:
 - *Slow hardware cycles*
 - *Expensive hardware*
 - *Space requirements*

Network Function Virtualization: Advantages

- Scalability
- Flexibility
- Cost advantage
- Security
- Faster product lifecycle / Upgradeability

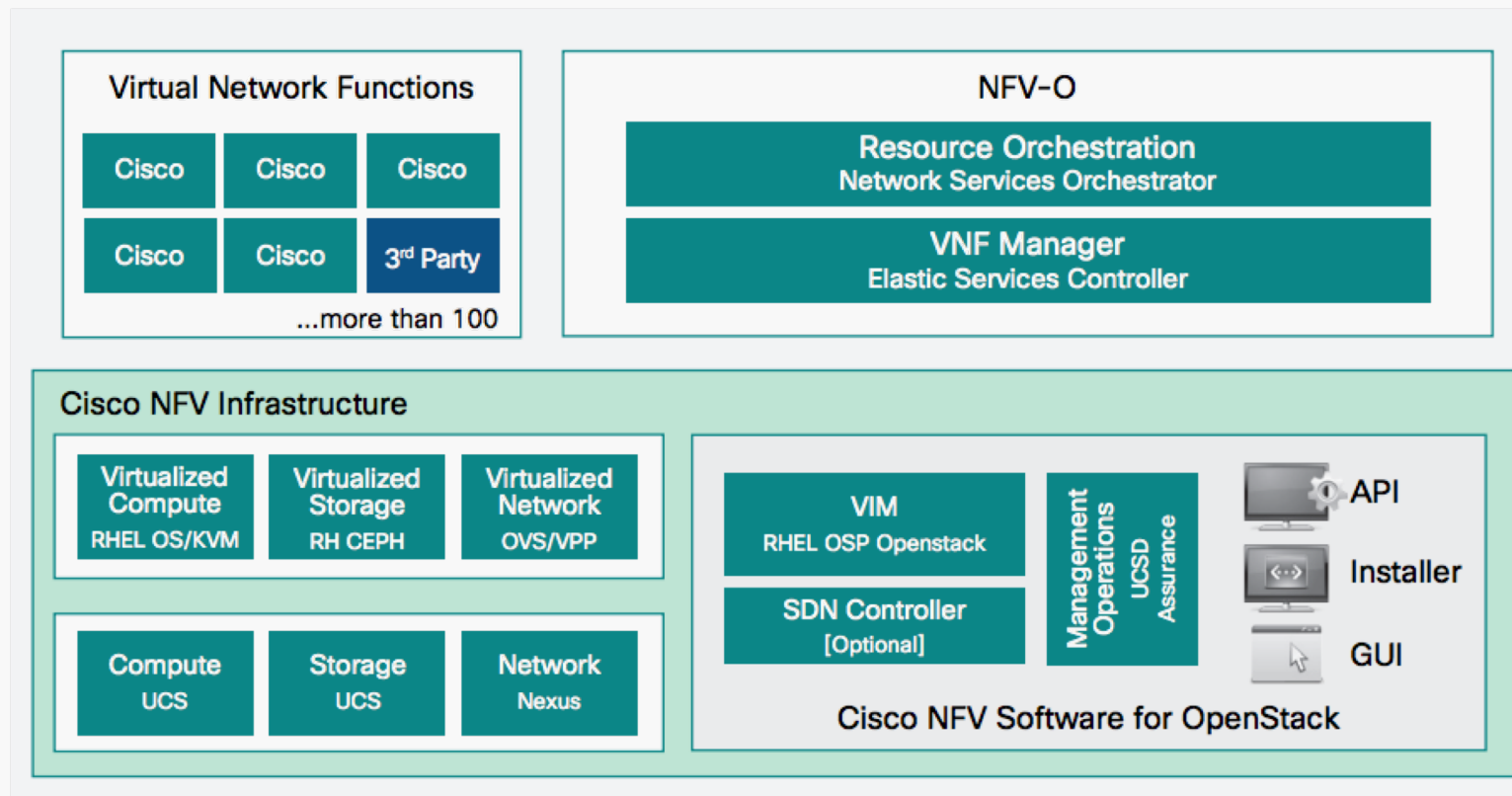
Network Function Virtualization: Examples



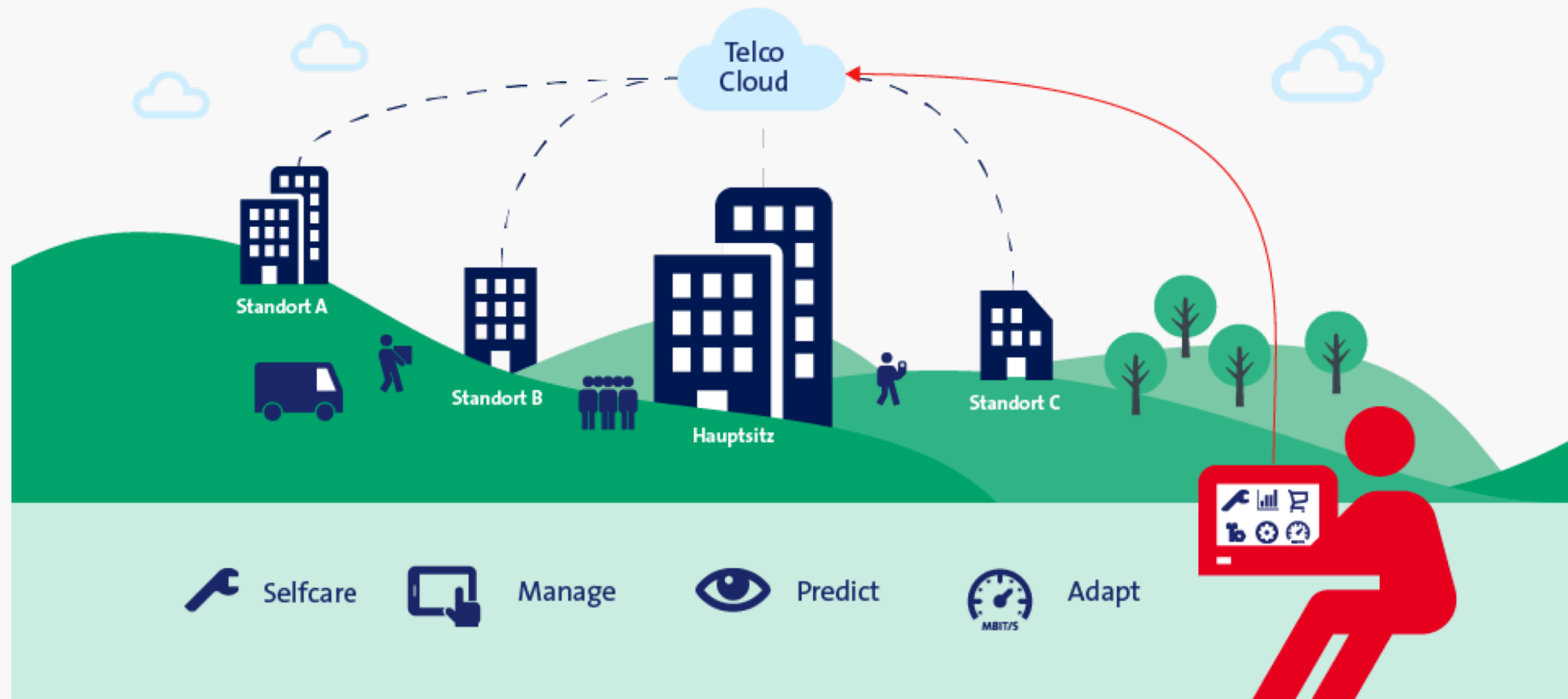
Network Function Virtualization: Example Cisco

Cisco SON Suite, a leading multi-vendor multi-technology (MVMT) self-optimizing network (SON) solution

Cisco NFV Infrastructure Architecture



Network Function Virtualization: Example Swisscom

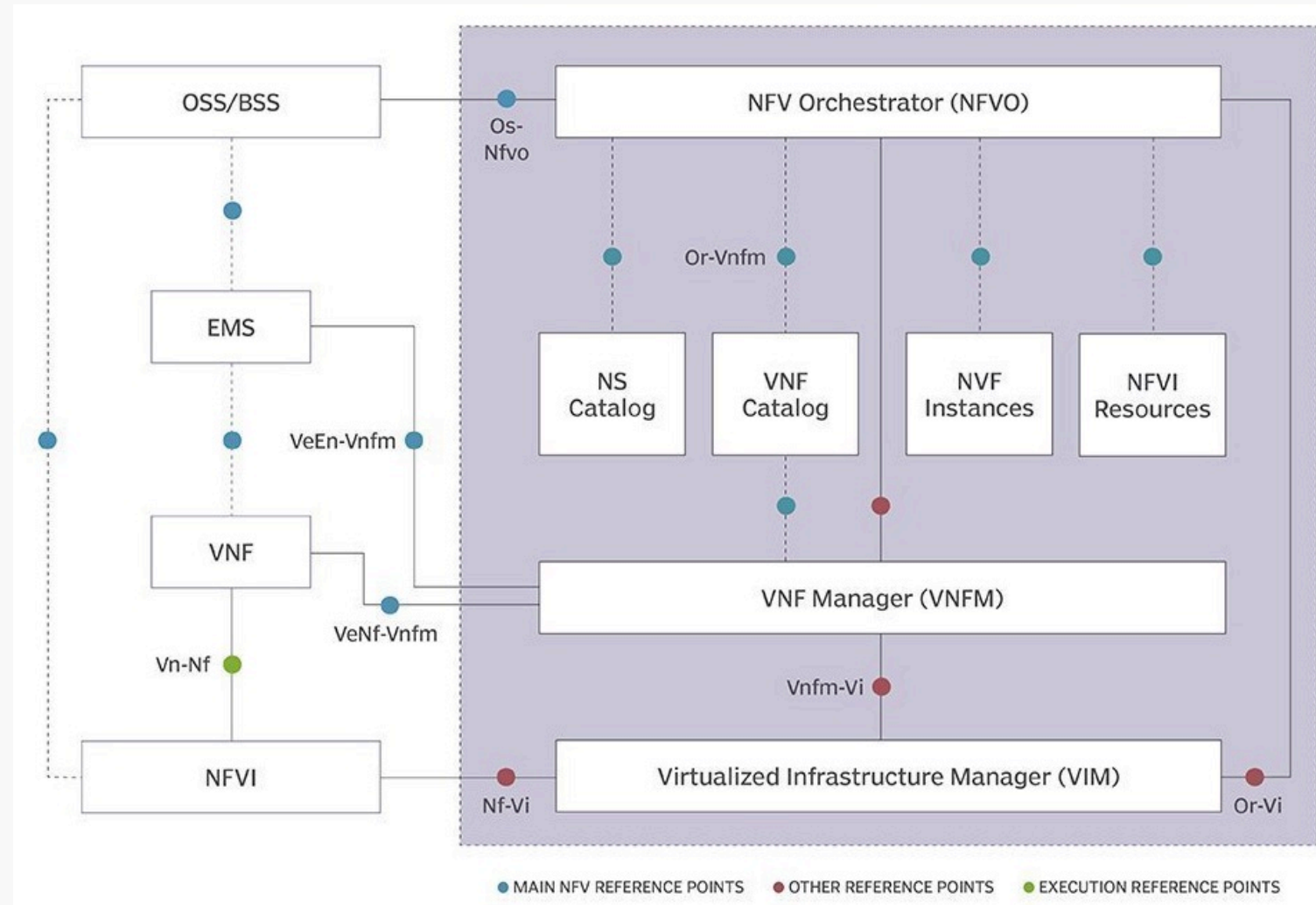


State of Network Function Virtualization

- Relatively new development
- Finished solutions are available
- First deployments are made
- Network service providers are slow moving industry
- Standardization in progress

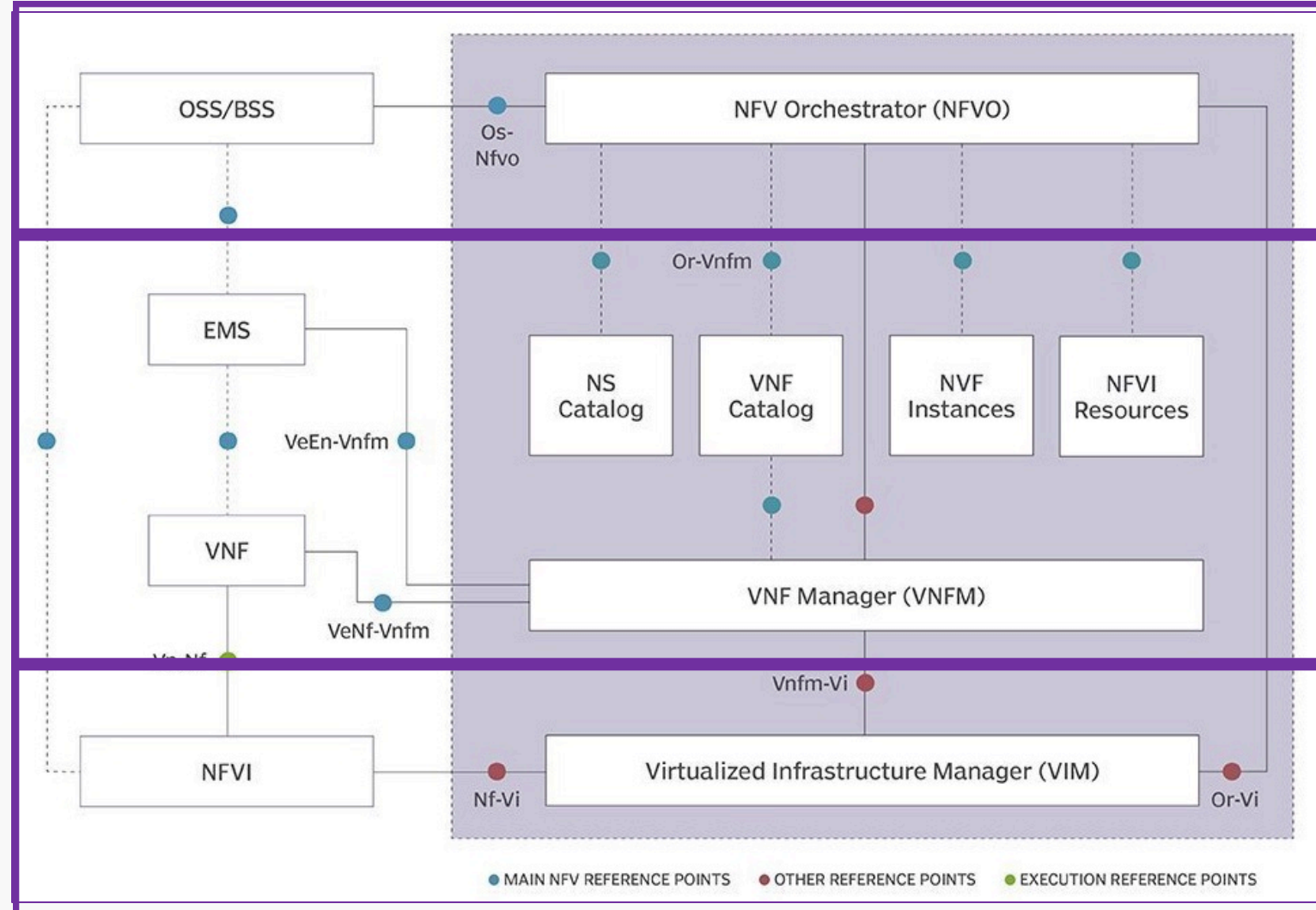
Standardization of Network Function Virtualization

- ETSI MANO
 - *Industry group*
- NFV Orchestrator
- NFV Manager
- VIM
- Targets: create a specification to ensure compatibility, flexibility



Standardization of Network Function Virtualization

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Challenges of NFV

NVF Challenges: Orchestration and Management

- Easy to manage
- Ensuring smooth operations
- Flexibility
 - *Network function chaining*
- Policy-based Network Management
 - *Dynamically reconfigure service graphs*

NVF Challenges:

Interoperability / Compatibility

- Compatibility with legacy systems
- Interoperability with different vendors
- Interoperability with future systems / developments
- High importance for communication providers

NVF Challenges:

Assurances (system stability)

- Resilience to failure
- VNF performance
- Load balancing
- Fallback systems

NVF Challenges: Security

- Incorporating trust into the NFV environment
 - *Ensuring NFVI security against intrusion attacks*
 - *Ensure integrity of all components*
 - Hypervisor, VNF image, updates, NFVI
 - *Ensure security when using different vendors*
- Providing security services efficiently



NVF Challenges: Monitoring & Auditing

- Ensure auditability of system state
- Secure, auditable way of implementing configuration changes
- Forensic logs
- Monitor compliance with data privacy laws and service level agreements

#	▲	Level	Count	Signature
1		info	1069	INFO [10-11 0*] Commit new mining work number=* txs=0 uncles=0 elapsed=*
2		info	1054	INFO [10-11 0*] Successfully sealed new block number=* hash=* *
3		info	1037	INFO [10-11 0*] mined potential block number=* hash=* *
4		info	1030	INFO [10-11 0*] block reached canonical chain number=* hash=* *
5		info	82	INFO [10-11 03:*] Mining too far in the future wait=2s

Table of challenges

Challenge	Description	
Orchestration & Management	Reliable, easy and flexible orchestration of VNF services	
Compatibility	Compatibility with legacy and future systems as well as competitors' systems	
Assurances	System resilience and performance	
Security	Secure delivery of network functions and system integrity	
Monitoring & Auditing	Monitoring of system state and auditability of changes and compliance	

Use Cases: Addressing challenges with Blockchain

Addressing challenges with blockchain

Challenge	Description	Can blockchain help with these challenges?
Orchestration & Management	Reliable, easy and flexible orchestration of VNF services	Yes
Compatibility	Compatibility with legacy and future systems as well as competitors' systems	<i>Maybe</i>
Assurances	System resilience and performance	No
Security	Secure delivery of network functions and system integrity	Yes
Monitoring & Auditing	Monitoring of system state and auditability of changes	Yes

Approaches

Orchestration, Management and Auditability

- Requirements for the Configuration (and updates) of NFV system
 - *Confidential*
 - *Anonymous (in the sense of tenant identity)*
 - *Traceable*
 - *Accountable*
 - *Permanent*
 - *Highly available*
- Blockchain's immutability and cryptographic principles ensure these properties

Orchestration, Management and Auditability

- Store system and VNF configuration on blockchain
- Store configuration changes and system logs on blockchain
- Use blockchain for authentication
- High availability because of blockchain

Security and Monitoring

- Safe storage of configurations on blockchain
- enables comparison of running configurations of VNF with stored information
- Using distributed apps / smart contract for attesting integrity

Compatibility

- Maybe specifically designed and specified sidechains could ensure compatibility between vendors
- No solution for legacy
- Introducing new compatibility issues?
 - *Blockchain systems may become obsolete / replaced*

Other potential uses of blockchain

Challenge	Description
Service billing and payment	Using smart contracts instead of traditional invoicing
Stimulation of competition	Using smart contract based auctions in near-real time auctions

Billing and stimulating of competition

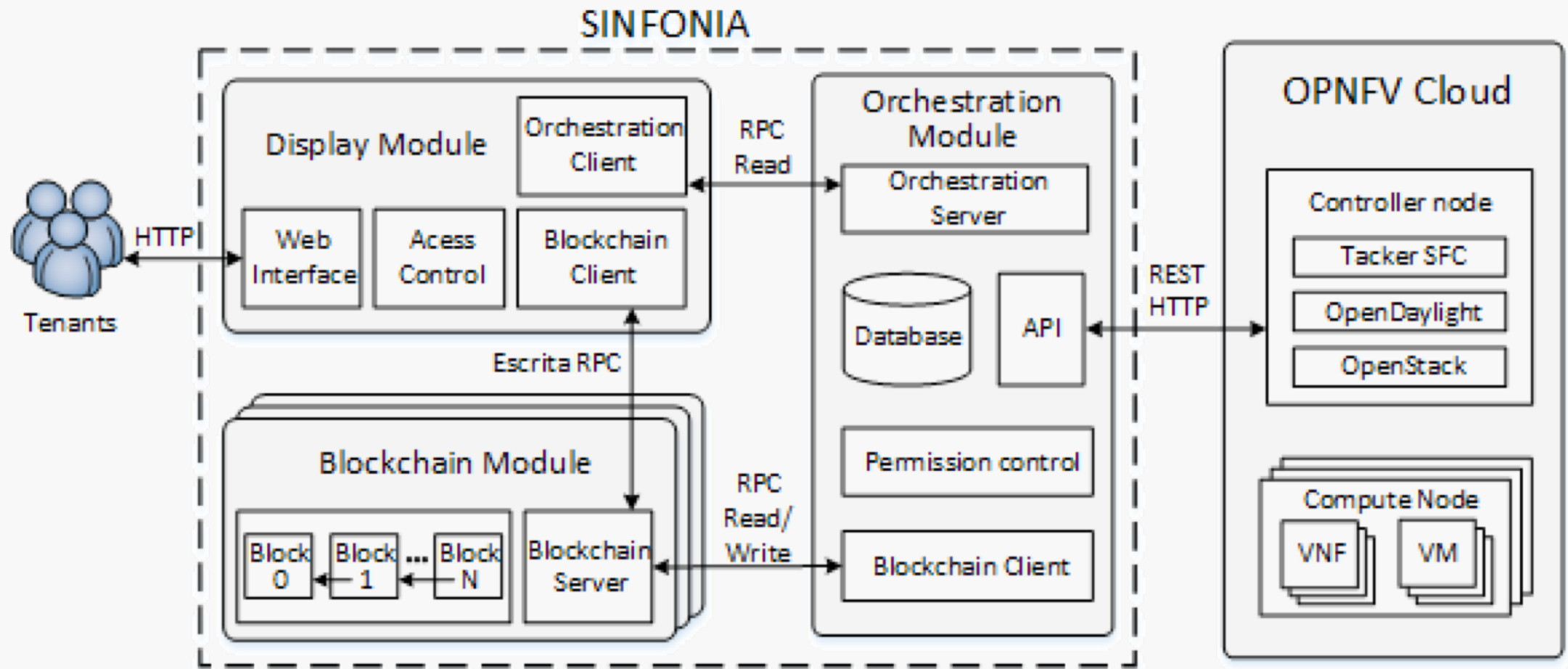
- Billing with smart contracts
 - *Fair billing*
 - *Automatic and fast*
 - *Ensure compliance with contract / SLA*
- More competition through bigger market
 - *VNF bought from anywhere*
 - *New providers apart from service provider*
 - *Smart-contract based auctions*
 - Maybe real-time

Examples

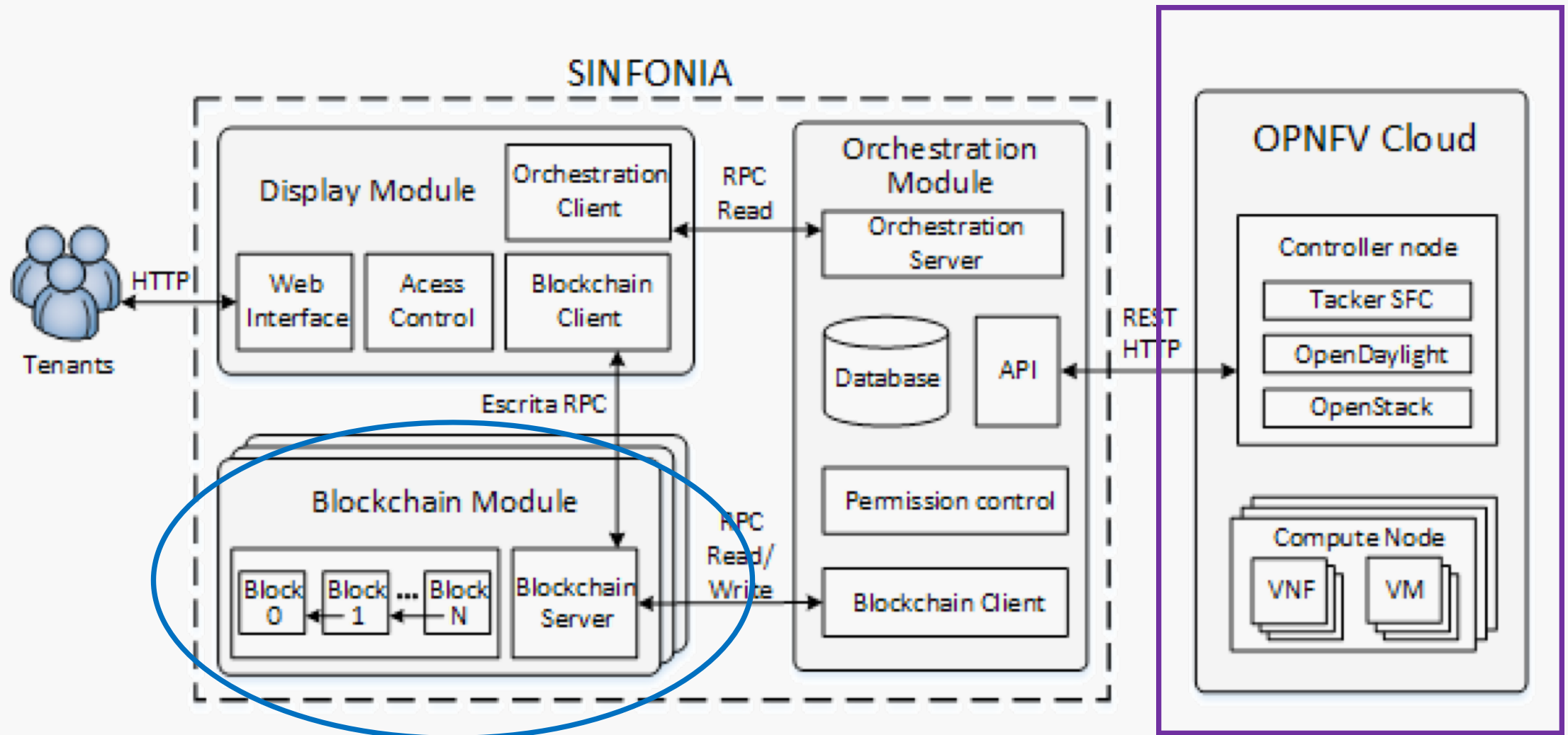
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- Brazilian project for blockchain-based orchestration and management
- **Secure v**irtual **N**etwork **F**unction **O**rchestrator for **N**on-repudiation, **I**ntegrity, and **A**uditability
- Using blockchain like discussed, for configuration storage and monitoring

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Conclusion

- NFV and VNF
- NFV adoption and challenges
- Applications of blockchain in NFV challenges
- Future works
 - *More research on blockchain challenges*
 - *More research on NFV challenges*
 - *More adoption of NFV in practice*
 - *ETSI Mano*
 - *Sinfonia: complete release*

Questions?

Discussion

Question 1

- What are potential roadblocks for companies wanting to replace their network infrastructure with NFV solutions?

Question 2

- Do you think it makes sense to address the challenges with Blockchain technology or would other technology work better?

Question 2

■ Which of the challenges of NFV do you see as the most urgent to solve?

- *Orchestration & Management*
- *Compatibility*
- *Assurances*
- *Security*
- *Monitoring & auditability*

Question 4

- Do you have other ideas to leverage blockchain technology to improve NFV?