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Network Functions Virtualization (NFV): Research Trends and Market Opportunities

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Zürich^{UZH}**



Agenda

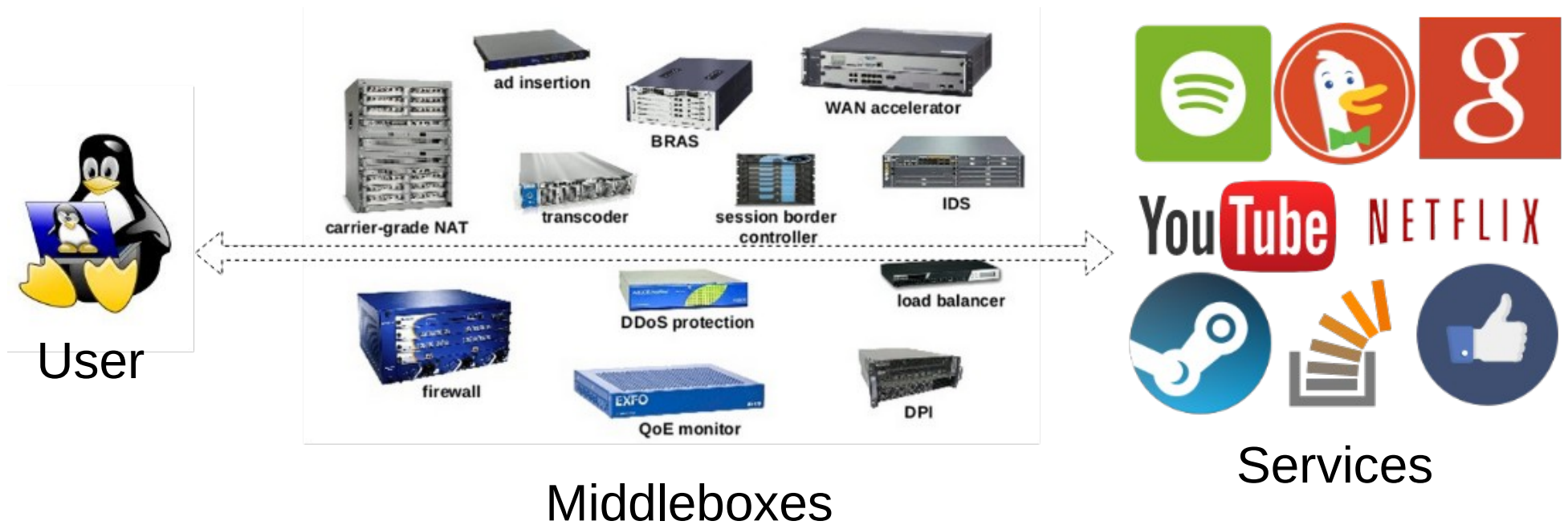
- ❑ Introduction
- ❑ General Challenges
- ❑ Research Trends
- ❑ Market Opportunities
- ❑ Conclusions

Basics

□ A Network Function is ...

- ... determined as a network node or physical appliances (middleboxes) with a well-defined functional behavior
 - Security: IDS, Firewall, IPS, DPI
 - Performance: Video Cache, Proxy, QoE Monitor, Load Balancer
 - Translating: NAT, DNS
 - Connection: Router, Gateway, MME, SGW, PGW
- ... able to execute crucial actions in the network infrastructure to guarantee the service provisioning

Introduction (1)



Introduction (2)

- Additionally a **Network Function Virtualization (NFV)** ...
 - ... decouples packet processing from dedicated hardware middleboxes for Virtual Network Functions (VNF) running on commercial off-the-shelf-servers
 - ... show main benefits, since it can virtualize network services and, thus, enables operators to:
 - Deliver agility and flexibility
 - Accelerate time-to-market
 - Reduce costs (Both CAPEX and OPEX)

Introduction (2)

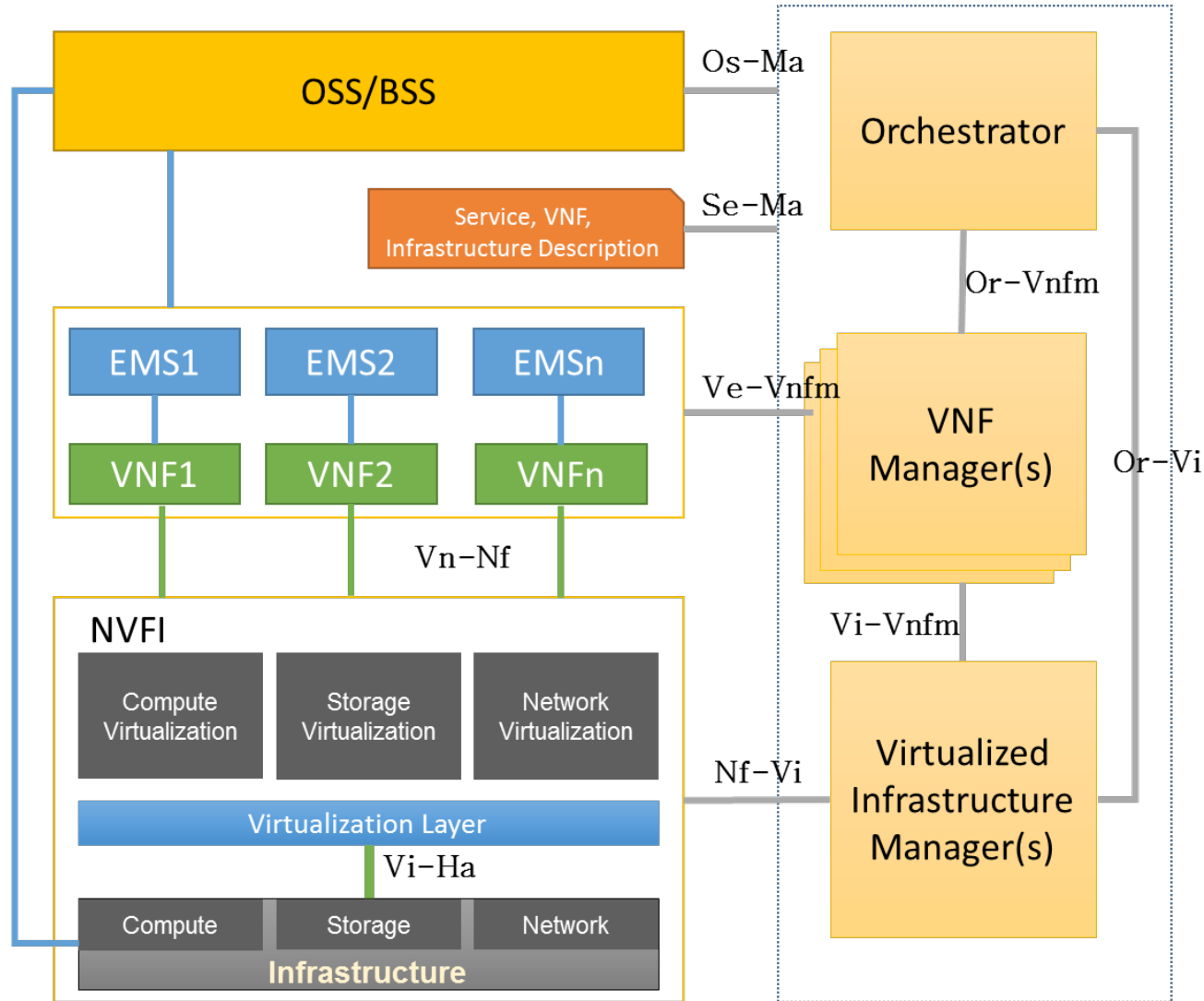
- Additionally a Network Function Virtualization (NFV) ...
 - ... decouples packet processing from dedicated hardware
 - ... **But it is not simple!** ...
 - ... Efforts are required to provide an efficient deploy, orchestration, and management of VNFs ...
 - ... services
- and, thus, enables operators to:
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ETSI Standard for NFV

- The European Telecommunications Standards Institute (ETSI) released the NFV white paper in October 2012 [1]

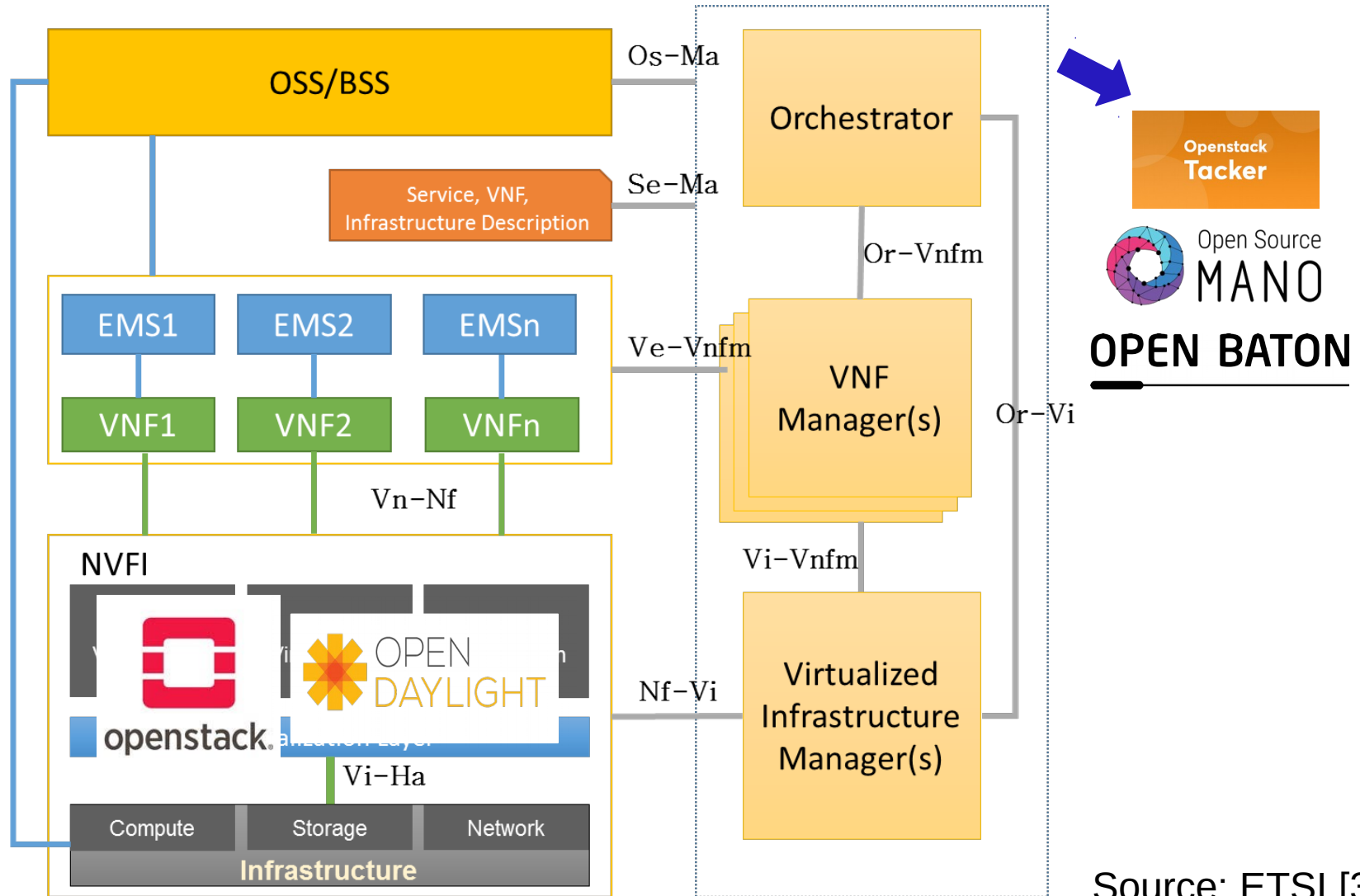
- Additional documents are available to define the **NFV environment**
 - Use Cases (ETSI GS NFV 001)
 - in 2013 [2]
 - Architectural Framework (ETSI GS NFV 002)
 - in 2013 [3]
 - Management and Orchestration (ETSI GS NFV-MAN 001)
 - in 2014 [4]

NFV Architecture



Source: ETSI [3]

NFV Architecture



General Challenges

Placement
Management and Orchestration
Security

General Challenges

□ Placement

- Where is the best place to deploy a VNF or a SFC?
 - Latency, QoS, resources available, and monetary costs should be considered

VNF: Virtual Network Function, SFC: Service Function Chaining

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❑ Placement

- Where is the best place to deploy a VNF or a SFC?
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❑ Management and Orchestration

- How to orchestrate and monitor VNFs? When migrate it?
- Techniques to identify misbehaviors, bottlenecks, and other VNF-related problems

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❑ Security

- Trust communication among NFV components
 - Interoperability integrity among different vendors
 - Threats and Countermeasures
- VNF: Virtual Network Function, SFC: Service Function Chaining

Research Trends (RT)

Management and Orchestration-related
NFV/5G Networks
Business Models

RT: Management and Orchestration (1)

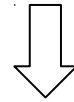
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 - Identify performance bottlenecks

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 - Real-time monitoring solutions [5] [6]

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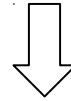
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Naik *et. al* “**NFVPerf: Online Performance Monitoring and Bottleneck Detection for NFV**”, IEEE NFV-SDN 2016

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Bonfim et. al “Identifying Performance Bottlenecks in Software Data Planes for Cloud-based NFV Services”, IFIP/IEEE NOMS 2018

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Ayoubi *et. al* “**Machine Learning for Cognitive Network Management**”, IEEE Communications Magazine, January 2018

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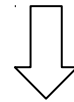
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 - Dynamic and secure composition [9] [10]

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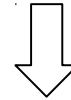
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Mechtri *et. al* “**NFV Orchestration Framework Addressing SFC Challenges**”, IEEE Communications Magazine, June 2017

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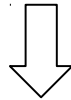
Yurchenko *et. al* “**OpenNetVM: A Platform for High Performance NFV Service Chains**”, ACM SIGCOMM 2018

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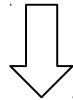
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Eichelberger *et. al* “**SFC Path Tracer: A Troubleshooting Tool for Service Function Chaining**”, IFIP/IEEE IM 2017

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Peuster *et. al* “**Containernet 2.0: A Rapid Prototyping Platform for Hybrid Service Function Chains**”, IEEE NetSoft 2018

RT: Management and Orchestration (3)

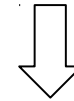
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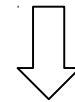
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Yasukata *et. al* “**HyperNFV: Building a High Performance, High Utilization and Fair NFV Platform**”, ACM SoCC 2017

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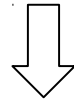
Eramo *et. al* “**Computing and Bandwidth Resource Allocation in Multi-Provider NFV Environment**”, IEEE Communications Letters, October 2018

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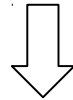
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Zeng *et. al* “**Cost Efficient State-Aware Function Placement and Flow Scheduling for NFV Networks**”, IEEE SmartWorld 2018

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Xu *et. al* “**Energy-Efficient Virtual Network Function Placement in Telecom Networks**”, IEEE ICC 2018

RT: NFV as a 5G Enabler

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 - NFV to support mobile edge computing and provide a extremely fast service access to user equipment [20]

RT: Business Perspectives

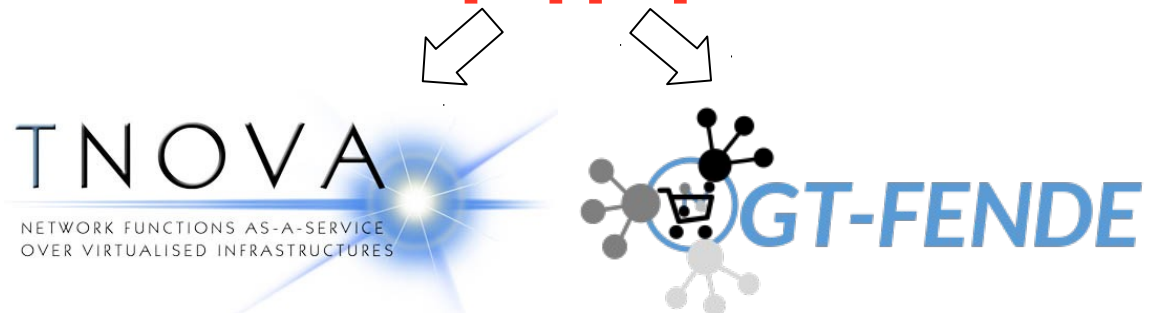
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 - Solutions to maximize the social welfare, which include benefits for end-users, service providers and infrastructure providers

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- ❑ NFV as a Service
 - Infrastructure Supply
 - Distribution and Instantiation of VNFs [21] [22]

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Market Forecast

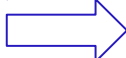
USD ~5 billion
2017

➔

USD ~71 billion
2024

Source: Global Market Insights

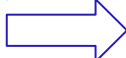
Market Forecast

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Sector	Percentage
IT and Telecom	33.42%
BFSI	21.06%
Healthcare	13.63%
Retail and Consumer Goods	11.15%
Government	8.34%
Manufacturing	7.71%
Others	4.69%

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Hardware - 48.21%

Software - 37.02%

Service -14.77%

Source: Global Market Insights [3]

Market Opportunities

VNF-as-a-Service
Infrastructure Supply
Smart Cities and IoT Applications

VNF-as-a-Service

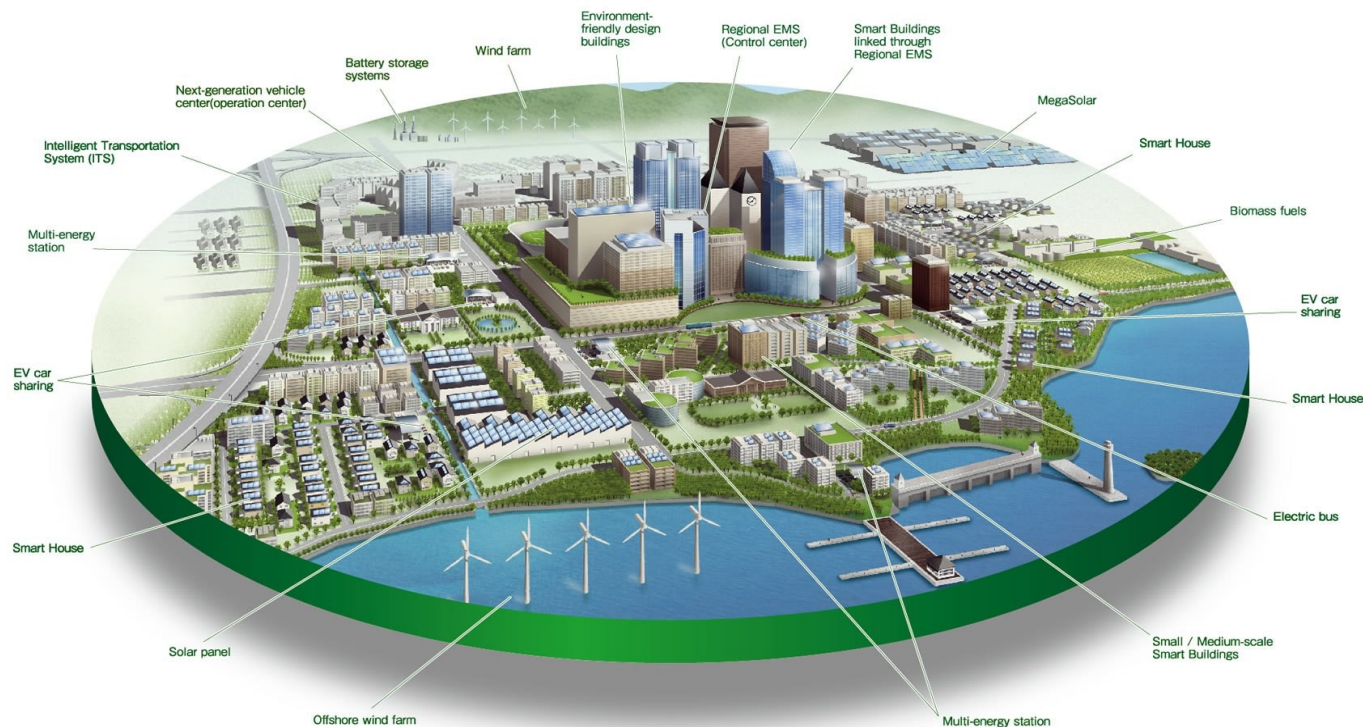
- Marketplaces for VNFaaS
 - Developers
 - Development of innovative services
 - End-Users
 - Contract services on demand
 - Service Providers
 - Build profitable business models to offer, distribute and manage VNFs

Infrastructure Supply

- ❑ NFV-enabled Infrastructures available to sustain high specific demands from each end-user
- ❑ Infrastructure Providers can be paid
 - Provide the substrate
 - Ensure the resources to deal with dynamic demands of a contracted services (e.g., a DPI should require more resources than a simple Firewall)
 - Monitoring and problem identification

Smart Cities and IoT Applications

- **Costs reduction, Scalability and Agility** to sustain needs and trends of future digital societies
 - *E.g.*, Sensor Networks, Vehicular Networks, Healthcare



Future Steps

- NFV fully operational in the next years
 - Integrating with the Software-defined Networks (SDN)
 - Ultra-low latency and dynamic applications will fastly delivered to network edge and end-users
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- ❑ NFV can take advantage from the Blockchain hype
 - Auditing, accouting and trustworthy without need to each node (e.g., VNF and NFVI) rely in a central authority
- ❑ More solutions to simplify the life cycle management of a huge number of VNFs
 - Artificial inteligence and Information Visualization

Thank You for Your Attention!

Questions?
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