Network Virtualisation Trends: Virtually Anything is Possible by Connecting the Unconnected!

Dr. Eleni Patouni$^1$, Dr. Andreas Merentitis$^2$, Mr. Panagiotis Panagiotopoulos$^1$, Mr. Aristotelis Glentis$^1$ and Prof. Nancy Alonistioti$^1$

$^1$National & Kapodistrian University of Athens, Athens, Greece
$^2$AGT International, Darmstadt, Germany
Outline

- Motivation: SDN, NFV & Internet of Everything Vision
- Related Work
- Case Study 1: SDN controlled wireless integration service
- Case Study 2: Virtual cell management
- Case Study 3: Sensor Virtualization
- Conclusions
Motivation

Future networks are becoming highly dynamic and distributed.

- High level of interconnections through middle boxes
  - NAT
  - performance-enhancing-proxies
  - other application-specific gateways

- The Internet of Things is reaching maturity
  - Now: Estimated # of interconnected devices ~10 billion
  - In 2020: ~50-100 billion (est. CISCO)
  - M2M communications (e.g., Smart grid)
In this hyper-connected world that is full of data, how to connect the Unconnected?
Motivation

SDN & NFV form emerging solutions..

- SDN (Software Defined Networks)
  - full decoupling of the network control and data planes,
  - third party software running in external dedicated or distributed servers control the network.
- NFV (Network Functions Virtualisation)
  - distinguish logical services from physical resources,
  - move resources to other network locations.
Motivation

Our servers are using too much electricity. We need to virtualize.

I did my part by reading about virtualization in a trade journal. Now you do the software part.

Why is your part taking so long?

There’s no need to worry about the server virtualization project.

In phase one, a team of blind monkeys will unplug unnecessary servers.

In phase two, the monkeys will hurl software at whatever is left.

Voilà!

I hired a consultant to help with our virtualization project because I don’t trust employees with anything important.

I will do the heavy thinking while each of you performs your usual duties as obstacles to progress.

You said this is my project! I’ll let him unplug something.

Technical Challenges:
- Isolation?
- Quickness?
- Open Control?
- Scalability?
- Resource Efficiency?
- Cost?
- Overall Management?
Virtualisation Levels

An Approach for the Overall Management Challenge

• Network Virtualisation
  o same network location: the physical resources of a single network element are partitioned to form virtual resources,
  o different network locations
    o move the functions of a specific network element to a standard hardware server anywhere in the network,
    o separate between physical resources/ logical services of network elements.

• End-user Virtualisation
  o interconnecting user hardware appliances/things
  o sensor virtualisation
Virtualisation Levels View

- Human-to-Network interface
- SDN Control Layer
- Network Infrastructure Virtualisation Layer
- Thin Software Virtualisation Layer
Challenges for SDN going Wireless

**Technical Requirements**
- Wireless plane with a single data aggregation point from the wireless infrastructure
- Support node mobility
- Solve wireless links reliability issues
- Underlying hardware support

**Market Adoption**
- Preserve the network operation in case of failures
- E.g. in the SDN host server/connecting switch to the network,
- Realistic migration to protect investments in existing infrastructures
- Security issues, e.g. with respect to the SDN protocol operation
CASE STUDY 1: SDN CONTROLLED WIRELESS INTEGRATION SERVICE

- Goal: introduce SDN capabilities in WLAN

- Assumptions:
  - deployment of the core SDN management functionality in a single network element within the same network location.
  - distinguish logical services from physical resources
  - physical resources partitioning using resource slides
  - resources sharing using existing approaches, e.g. reconstruction algorithms for on-demand allocation.
CASE STUDY 1: SDN CONTROLLED WIRELESS INTEGRATION SERVICE

Technical Solution

• The Network Operator uses the Human-to-Network Interface to;
  • Dynamically change the data rules on the fly.
  • Control network traffic per application/host/time
• The SDN Control Layer realizes the traffic flow shaping within a resource slide or between the resource slices
  • Use of rule-based offloading schemes
  • Create new SSIDS and assigned them to SDN flows .

Implementation

o SDN control layer implementation through the OpenFlow Controller
o Multiple ESSID using a single antenna; each ESSID assigned at a VLAN that ends at an Openflow switch
o Openflow controller handles virtual slices
**Case Study 1: SDN Controlled Wireless Integration Service**

**Scenario**

- The Human-to-Network interface has been implemented as a control panel embedded in a web-based application.
- User will be able to configure the whole network through a web server.
- Controller will send the requests to the Openflow Controller.
- Openflow Controller will send the commands to the openflow switch and to the access points.
SDN controlled wireless integration service - Overview of the WLAN prototype system
Virtual Cell Management

• “Virtual cells” for eliminating the physical boundaries between the wireless resources.

• Need for supporting mechanisms:
  – resource pooling for the unification of the physical AP layer towards the application connected to the virtual cell.
    • E.g. use of Greedy heuristic approaches with link mapping.
  – Resource partitioning mechanisms driven by NO policies.
  – Decision-making functionality for controlling the virtual resources pooling and partitioning
  – Virtual resources management schemes:
    • cross-system algorithms to improve the common resource usage
    • scheduling algorithms for traffic handling over the unified resource
    • reservation procedures for resource portioning.
Virtual Cell Management

- Small virtual cells using an LTE BS
- BS antennas distribution using fiber connection and C-RAN.
- Goal: Improved coverage
- Challenges:
  - optimal distribution of L1, L2, and L3 functions between Radio Unit (RU) and Digital Unit (DU) nodes.
  - Evaluate different architectural configurations wrt tradeoffs
    - flexibility/responsiveness of resource sharing,
    - energy consumption
    - burden posed in the optical network.
Virtual Sensor Networks - Definitions

**Virtual Sensor Network:**

- Main differentiator of VSNs to overlays is that the latter are typically realized in the application layer only.
- A VSN can be formed by providing logical connectivity among collaborative sensors.
- Nodes are grouped based:
  - on the phenomenon they track (e.g., number of cars vs. NO\textsubscript{2} concentration)
  - or the task they perform (e.g., environmental monitoring vs. traffic control).
- Can evolve into a dynamically varying subset of sensor nodes.
Virtual Sensor Networks

Sharing the same physical infrastructure between different applications and even different stakeholders

Virtualization in IT domain

- Web traffic
- Video traffic
- Backup traffic

Virtualization in the industrial sensor domain

- System maintenance & security view
- Day-to-day operational view
- Mid-term operational view

Shared physical infrastructure
Virtual Sensor Networks

**Trend:** operational and security integration for efficiency and reusability

**But:** different requirements, different people

**Solution:** the right information to the right person, VSNs logical separation
Virtual Sensor Networks - Definitions

• Virtual Sensor:
  – Software entity that serves as aggregation point for multiple sensors, using physical sensors and a computational model
  – Exists in-field as a thin layer of virtualization software executed on physical sensors or as a mathematical model for aggregating information residing in a sensor management platform
  – Does more than interpolating values of physical sensors measuring the same phenomenon, supporting also metric translation
Taxonomy of Virtualization in the Sensor Domain
Conclusions – The vision for Tomorrow

- F&S report on top 9 game changing ICT technologies, 2013:
  - Network & data **virtualization** “… offers the ability to deliver unique network attributes to the point that each application can have its own logical network and ultimately increases the performance of mission-critical applications”.
Thank you for your attention!!!

Is the puzzle solved?