SDN/SDx/SDX, NFV, 5G …: What's Next?

Panel discussion

SDN/SDx/SDX, NFV, 5G

- Software-Defined Networking
- Software-Defined (whatever)
- SDN exchange point (like Internet eXchanges)
- Network Function Virtualization
- 5G mobile

Topics from the panelists

- Eugen Borcoci (University Politehnica – Bucharest): SDN and NFV combined concepts and architectures to support for 5G networks and related services
- Kanstren Teemu (VTT): 5G – shiny new network, how to fill it with traffic
- Padma Pillay-Esnault (Huawei): 5G: Identity Oriented Networking for IP2020. Why and How? Why ID Oriented Networking is the way to go?
- Gyorgy Kalman (NTNU/mnemonic): How one could use 5G in creating control loops for automation and use of SDN in automation

5G and automation

- 5G opens the mobile network torwards automation
- Could be a natural choice since a long time
- Time source
- Resource reservation protocols and exchange of QoS parameters across networks
- Cover the last mile as primary or backup solution
- Create a stable traffic baseline for 5G investments

SDN and NFV in automation

- M2M communication is a good candidate to «any» kind of automatic configuration/monitoring/management
- Reason: much less variable and random than systems with humans
- Limited «world» to model, static setup
- Traffic management, system health and security functions can be implemented
- Cost reduction in engineering and extensions
- Better integration of legacy systems

Panel on AICT / ICIMP / ACSSE

Topic: SDN/SDx/SDX, NFV, 5G …: What's Next?

Software Defined Networking and Network Function Virtualization , Cloud cooperation - to support 5G

Eugen Borcoci
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DataSys 2016 Conference, Valencia, May 22-26

SDN, NFV, Cloud - cooperation to support 5G

Contents

- SDN
- NFV
- SDN+NFV
- Cloud- 5G: CRAN, H-CRAN
- 5G: SDN + NFV + CRAN support
- Open research issues- in 5G environment

SDN, NFV, Cloud - cooperation to support 5G

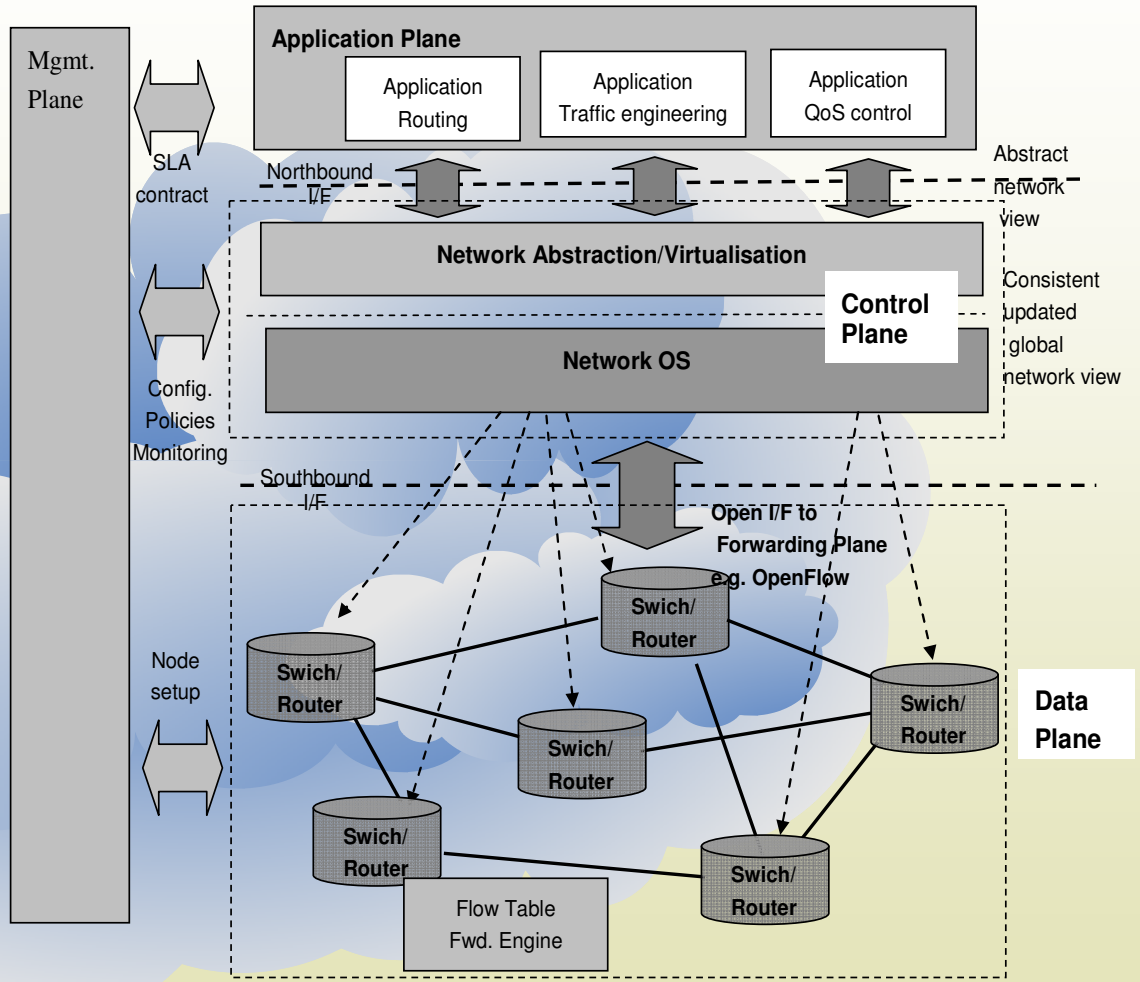
- **SDN – concepts and advantages:**
  - **Control Plane (CPI) and Data Plane (DPI) separation**
  - A centralized logical control and view of the network
    - underlying network infrastructure is abstracted from the applications
    - **common APIs (northbound I/F)**
  - Open I/Fs Southbound I/F CPI (controllers - DPI elements)
    - E.g. OpenFlow
  - Network programmability: by external applications including network management and control
  - Independency of operators w.r.t. network equipment vendors
  - Technology to be used in Cloud data centers as well in Networking
  - Increased network reliability and security

SDN, NFV, Cloud- cooperation to support 5G

- **SDN Basic Architecture**

- **Network OS:**
  - Distributed system that creates a consistent, updated network view
  - Executed on servers (controllers) in the network
  - Eg.: NOX, PoX, ONIX, HyperFlow, Floodlight, Trema, Kandoo, Beacon, Maestro,..

- **SDN controller uses forwarding abstraction in order to:**
  - Collect state information from forwarding nodes
  - Generate commands to forwarding nodes



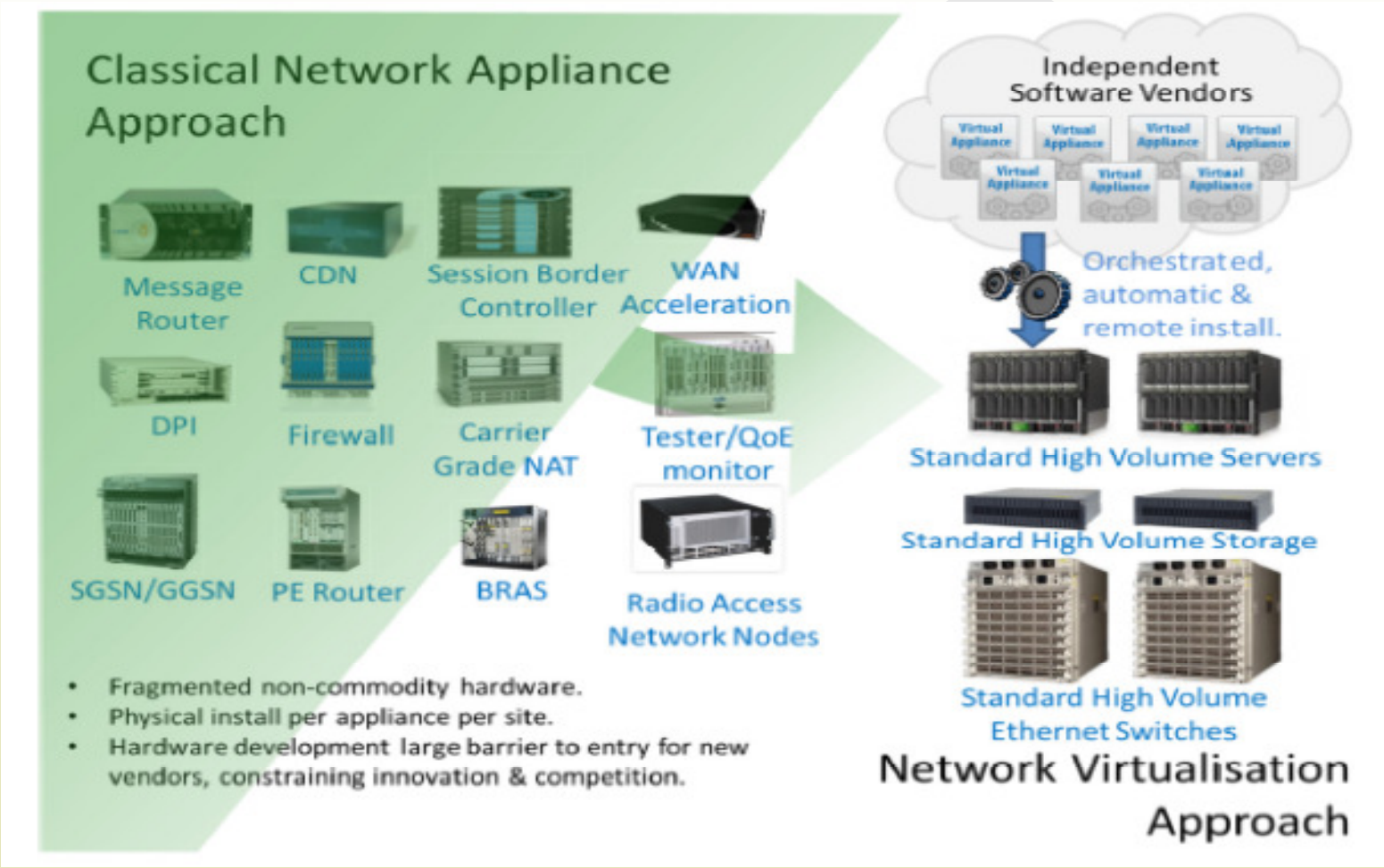
SDN,NFV, Cloud - cooperation to support 5G

Network Function Virtualization : concepts and advantages

- Using COTS computing HW to provide **Virtualized Network Functions (VNFs)** through **SW virtualization techniques**
  - Sharing of HW and reducing the number of different HW architectures
- **Improved flexibility in assigning VNFs to HW**
  - better scalability
  - decouples functionality from location
  - enables time of day reuse
  - **Virtualization-** →flexibility and resource sharing
- **Rapid service innovation** through SW -based service deployment
- Common automation and operating procedures ⇒ **Improved operational efficiencies**
- **Reduced power consumption**
  - (migrating workloads and powering down unused HW)
- **Standardized and open I/Fs**: between VNFs infrastructure and mgmt. entities

SDN,NFV, Cloud - cooperation to support 5G

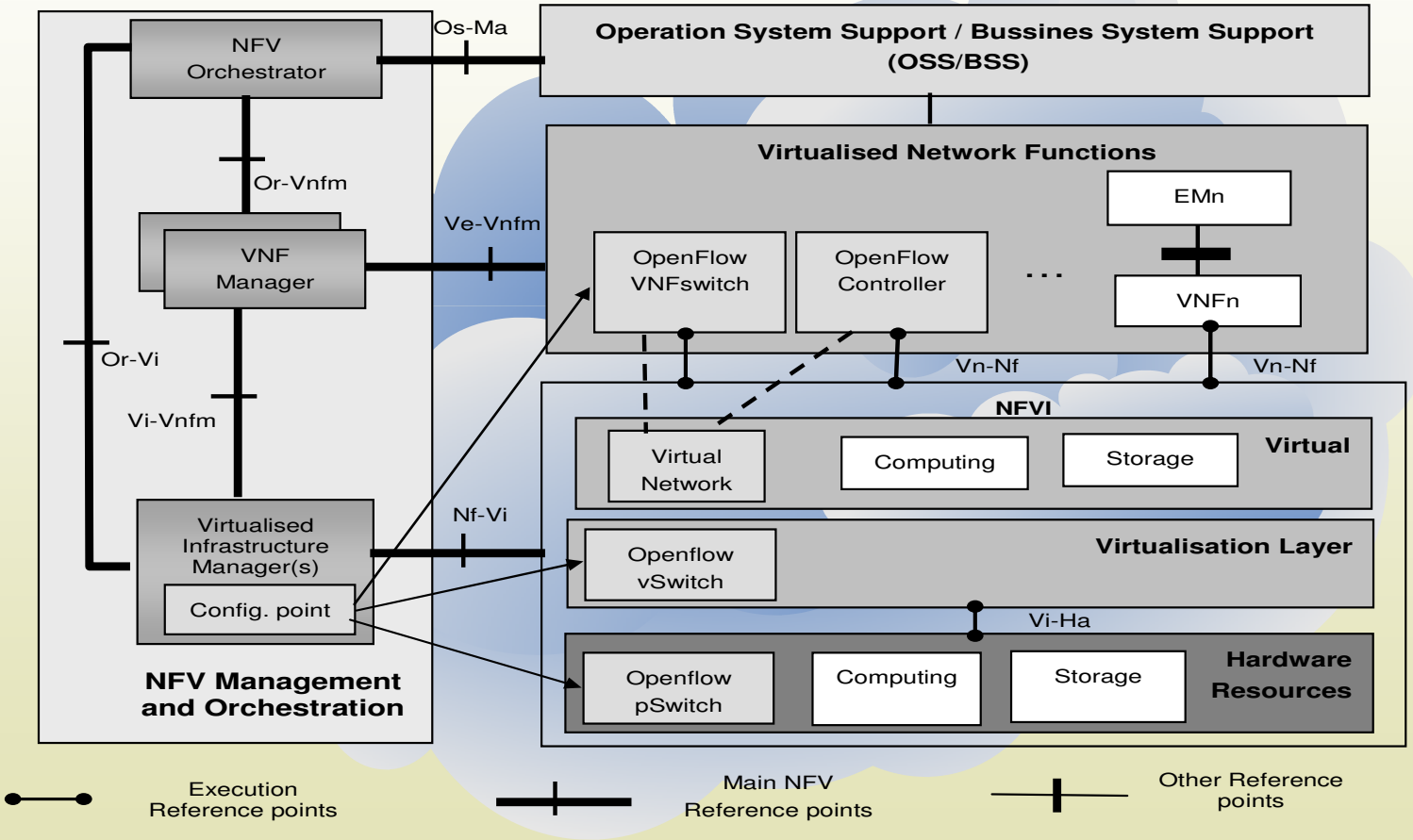
- **NFV vision (source : ETSI)**



SDN,NFV, Cloud - cooperation to support 5G

- **NFV, SDN - complementary**
  - **NFV + SDN- architectural example**

Source: "SDN and OpenFlow World Congress", Frankfurt, October 15-17, 2013



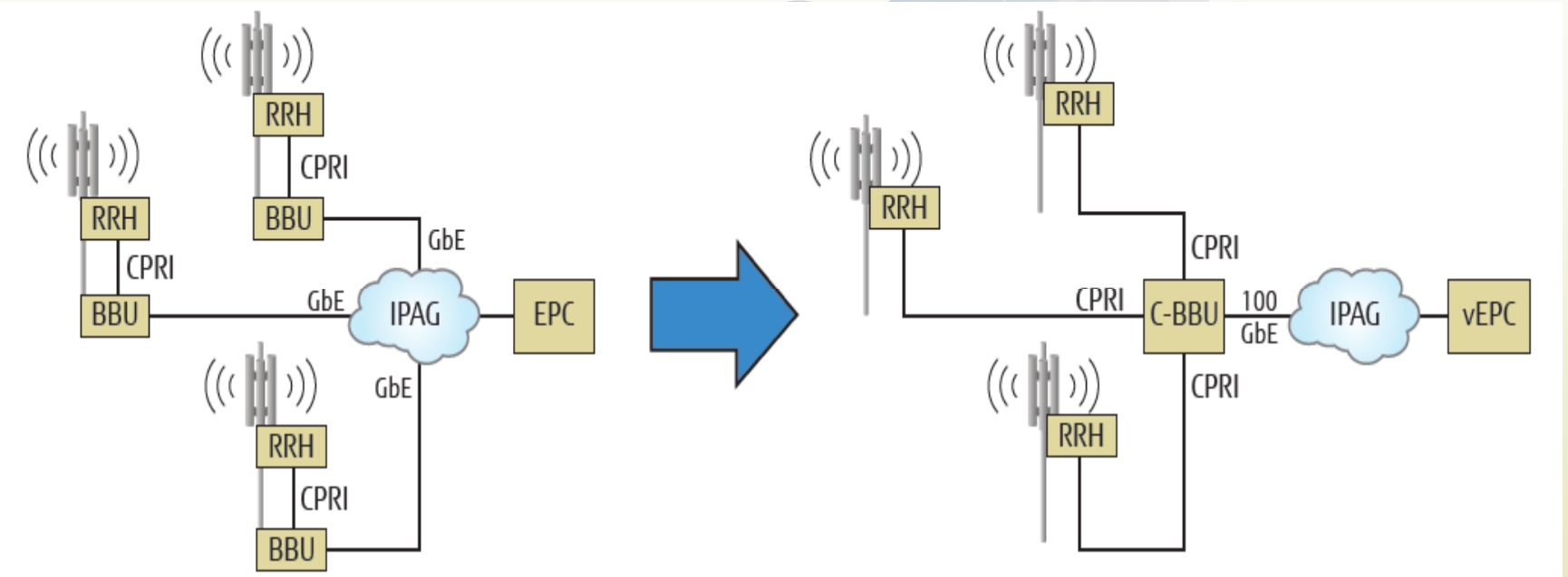
SDN,NFV, Cloud - cooperation to support 5G

- **Current status: Several proposal, not stable architectures**
- **CRAN : Cloud Radio Access Networks- solution for 5G**
  - **CRAN (interest for industry and academia)**
    - large number of low-cost
      - **Remote Radio Heads (RRHs),** randomly deployed and connected to
      - **Base Band Unit (BBU)** pool through the fronthaul links
    - **Advantages:**
      - **RRHs closer to the users → higher system capacity, lower power consumption**
      - the **baseband processing centralized at the BBU pool** → cooperative processing techniques to mitigate interferences
      - CC capabilities → resource pooling and statistical multiplexing gain
    - **Drawbacks:**
      - **fronthaul network overload(DPI + CPI traffic)**
      - **scalability: How many RRHs can be controlled by a BBU**

Checko A., et al. 'Cloud RAN for Mobile Networks—A Technology Overview',
EEE Communications Surveys & Tutorials, VOL. 17, NO. 1, First Quarter 2015, 405

SDN,NFV, Cloud - cooperation to support 5G

- **CRAN : Cloud Radio Access Networks- solution for 5G**

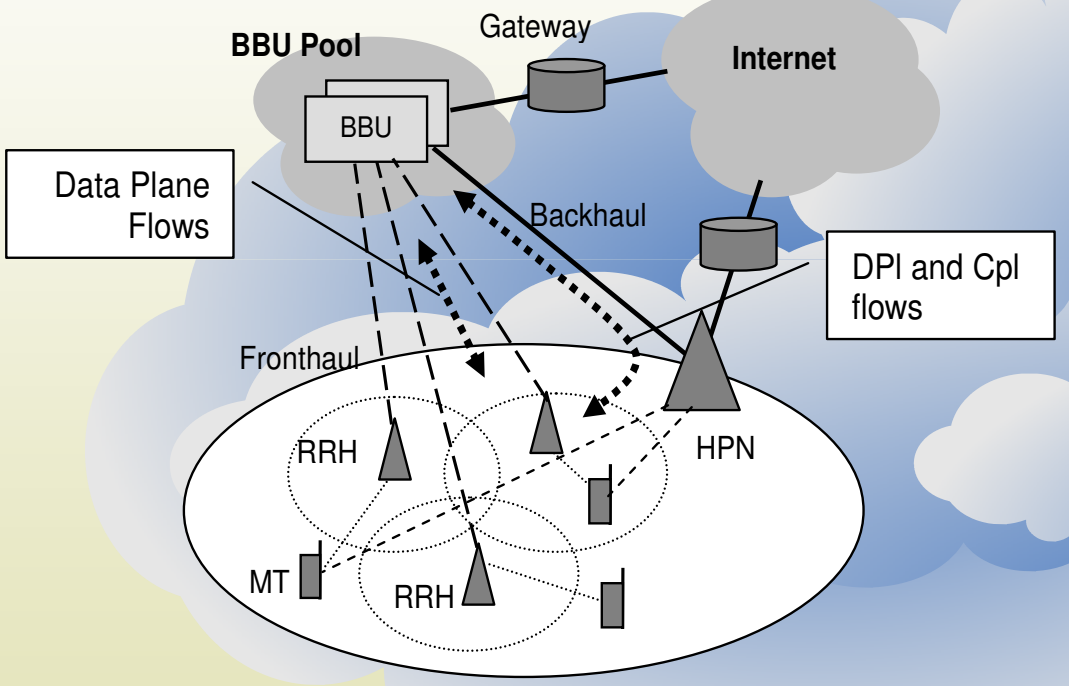


Legacy RAN to C-RAN architecture evolution

Ref.: Fujitsu Network Communications, Inc., "The Benefits of Cloud-RAN Architecture in Mobile Network Expansion," white paper, Aug. 2014.

SDN,NFV, Cloud - cooperation to support 5G

- **Heterogeneous –Cloud RAN**
  - **Solves some CRAN problems (less traffic on fronthaul)**
  - **Assure the backward compatibility (HPNs…)**



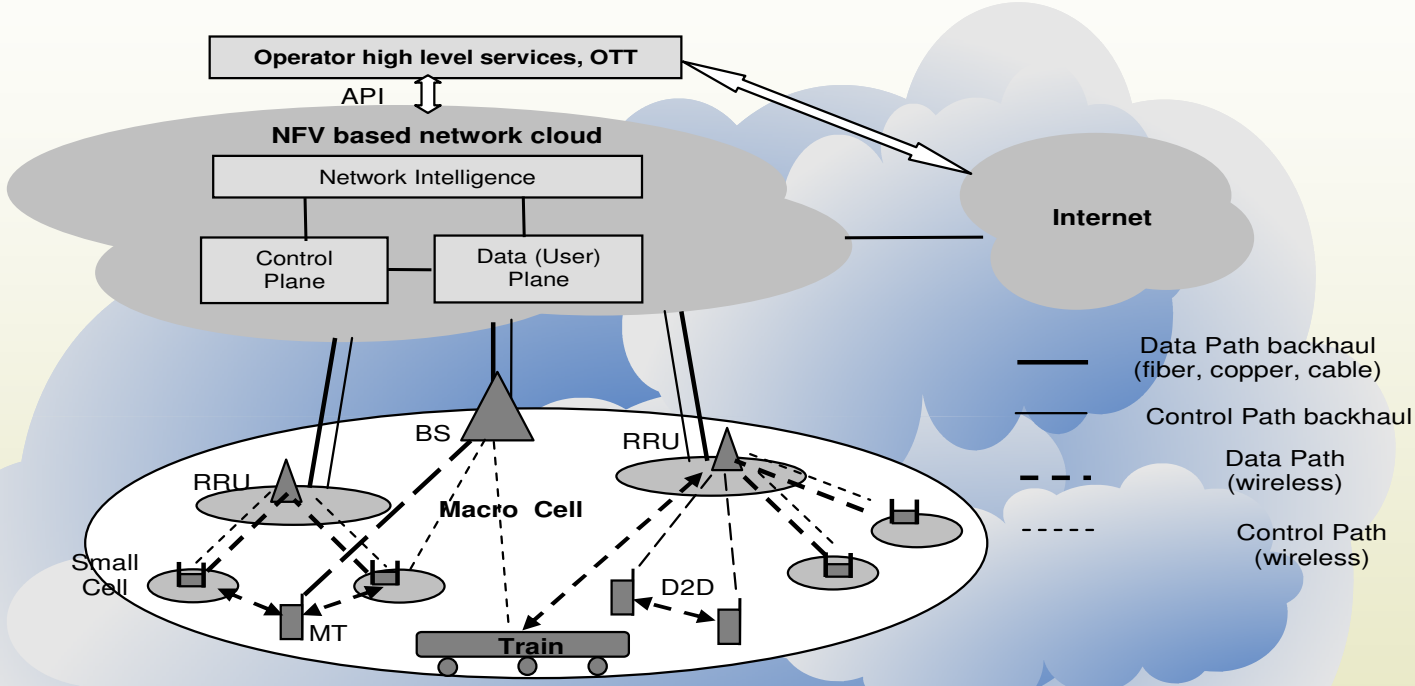
RRH – Remote Radio Head;
HPN – High Power Node
LPN- Low Power Node
BBU- baseband (processing) unit

RRHs include only partial PHY functions

H-CRAN generic architecture - example

SDN,NFV, Cloud - cooperation to support 5G

- **SDN/NFV - 5G network generic architecture- example**



RRU –Remote Radio Unit; D2D – Network controlled Device to Device; MTC – Machine type Communication; OTT- Over the Top; MT – Mobile Terminal; NFV- Network Function Virtualisation; API- Application Programmer Interface

Ref. : Agyapong P.K., Iwamura M., Staehle D., Kiess W., Benjebbour A. ' Design Considerations for a 5G Network Architecture'. IEEE Communications Magazine, November 2014, pp. 65-75

SDN,NFV, Cloud - cooperation to support 5G

- **Open research topics**
- **SDN/NFV**
  - the centralised SDN nature → bottlenecks (resilience and scalability)
  - balance: centralised logical control and actual distributed infrastructure of controllers should be found
  - flat or hierarchical architecture of SDN control plane – with multiple controllers in 5G Core and RANs?
  - different reconfiguration policies to be applied to the network elements in a dense environment, at different time scales
    - due to the dynamicity and density of this network
    - this can also result in high signalling overhead

SDN,NFV, Cloud - cooperation to support 5G

- **Open research topics (cont'd)**
- **SDN/NFV**

  - RAN link quality can be unreliable and unstable → communication (controller- forwarders) can be down (if in-band signalling)
    - isolated wireless networks problem to solve

  - 5G network might have cells with particular configuration needs – different policies for the SDN controllers.

  - Optimized partition of functions to be implemented in each plane ? SDN/NFV/5G, particularly in the RAN area.

  - the edge heterogeneity (+ D2D, M2M, and V2V) ->
  - (+ dynamic topologies + distinct mobility models and HW constraints) → complexity in SDN and NFV functions planning
    - (e.g., the SDN controller should instruct the switches or network hypervisor which terminal node should forward packets)

SDN,NFV, Cloud - cooperation to support 5G

- **Open research topics (cont'd)**
- **SDN/NFV**
  - **integrating SDN and NFV**
    - the SDN programmability needs standardising the N/S interfaces between physical and virtual network functions that form a single network service chain.
  - virtualisation might negatively impact the virtual LTE and Wi-Fi services -> the VNFs r.t. perf. should be analysed (to decide about physical/virtual implementation option.
  - **standardisation of NFV/SDN is still in-progress**
    - a unified cellular programmable interface for implementing SDN and NFV is under development, including a service chain through the integration of SDN and NFV

SDN, NFV, Cloud- cooperation to support 5G

- **Open research topics**
- **C-RAN/H-CRAN/Fog(Edge)**
  - two major problems in both CRANs and H-CRANs
    - high transmission delay and heavy burden on the fronthaul
    - they do not use processing and storage capabilities in edge devices, such as RRHs and even 'smart' Ues
  - **use SDN style of control in F-RAN environment?**
    - The combination of the MAC functions and L1 functions for edge devices in F-RANs is still not yet clarified
    - SDN centralisation –w.r.t. F-RAN distribution
    - using SDN control for F-RANs-> need to carefully define slices to isolate the signal processing from resource management in edge devices,
  - If SDN controllers are located in cloud computing network layer -> control traffic overhead (CPI --DPI) over fronthaul links -> decreasing the advantages of F-RANs.
  -
  - **Fog/Edge computing versus Mobile Edge computing (ETSI) ?**

- **Thank You !**

Mobile Edge Computing

- **References**

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2. M.Mendonca, et. al., A Survey of Software-Defined Networking: Past, Present,and Future of Programmable Networks, http://hal.inria.fr/hal-00825087/
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11. Li L. E., Mao Z. M., and Rexford J.'Toward Software-Defined Cellular Networks'. European Workshop on Software Defined Networking (EWSDN), 2012.
12. China Mobile Research Institute, 'CRAN White Paper: The Road Towards Green RAN'. June 2014 Available from: http://labs.chinamobile.com/cran/wp-content/uploads/2014/06/20140613-CRAN-WP-3.0.pdf

5G: Identity Oriented Networking for IP2020. Why and How?

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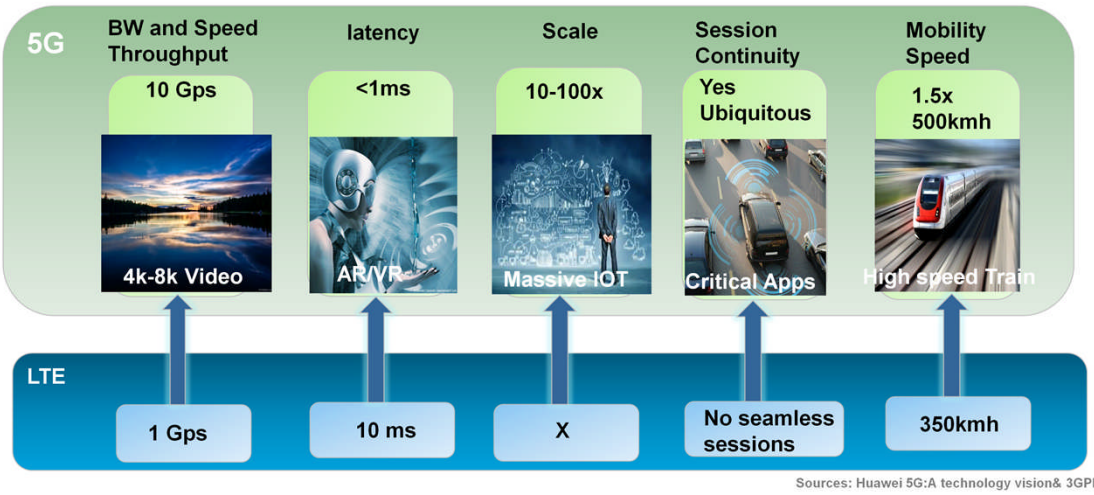
12th AICT - Valencia, May 2016

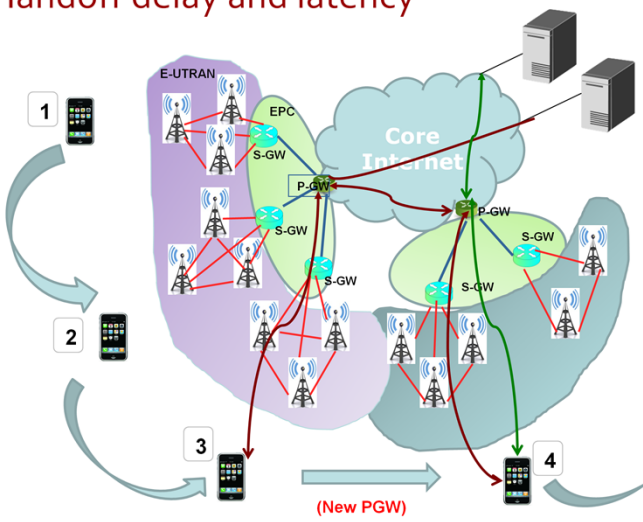
HUAWEI TECHNOLOGIES CO., LTD.

5G - Redefining Mobility in Future Networks



Sources: Huawei 5G:A technology vision& 3GPP

Handoff delay and latency



The change of P-GW and change of ip address pool will

- Cause change in IP address in UE
- no TCP session continuity possible
- Significant latency due to mobility ancho
- Newer sessions are optimized

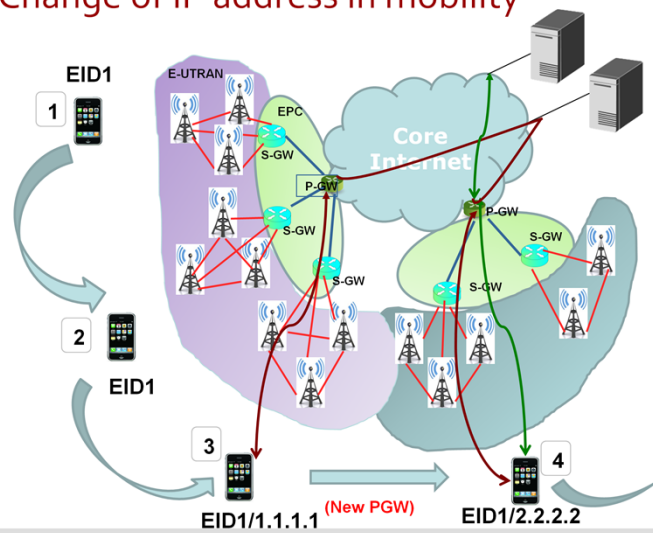
ID Oriented Networks - Basics

- Simple Principle : Need to dissociate the name and location and make them independent.
- ID can be the name of a node, an app or anything
- The Identifier movement is transparent to the higher layers.
- The forwarding is achieved by binding the ID with an ip address or locator. Usually there are mapping servers that bind the ID to a location.
- One user can have multiple IDs or fixed known as needed

ID Oriented Networks

- Native mobility – It does not matter where “Bob” is
- Apps can be based on ID
- Addresses multi-homing ID have global significance(scope),
- Context awareness based on ID profile
- Security also can be ID based
- Fast deployment – Reuses already deployed and working (if IP)

Change of IP address in mobility



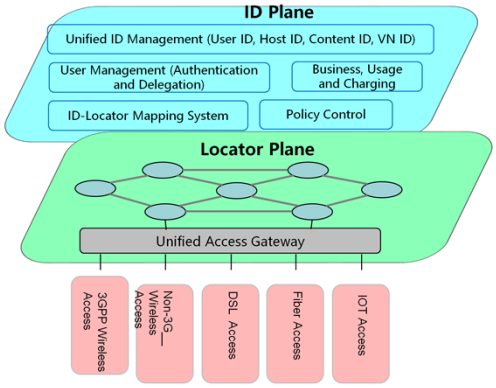
The change of P-GW and change of ip address pool will

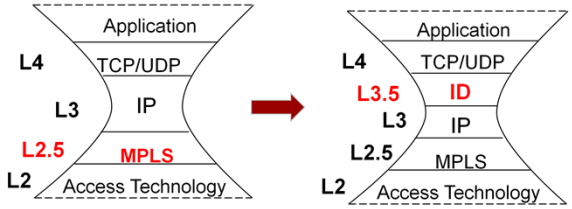
- Cause change in IP address in UE
- IP address change is transparent to apps
- TCP ID based session continuity possible

Mapping Servers - Scalability

- All ID Oriented network solutions use some form of mapping servers that bind the ID to a locator
- The characteristics of these mapping servers are
  - Need to register ID when they appear at a location (registration)
  - Need to be able to resolve (resolution)
  - Handle very rapid changes in id/locator changes (updates)
  - Need to be distributed/ Local cached (for scalability)
  - Hierarchy
  - Conceptually similar to DNS which scales really well

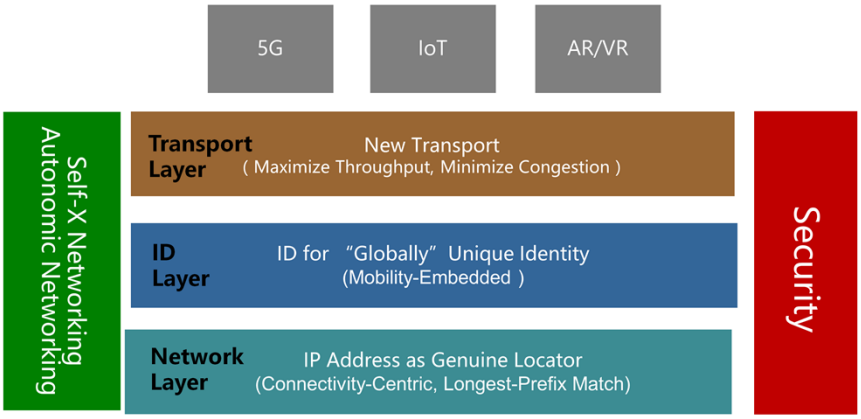
ID-Oriented Networking (ION)





- No need for clean slate
- Reduced Capex and Opex
- Global Reachability Possible: Everything, allocated with a unique ID,
- Innovation Speedup : Locator plane as a transport layer, while ID plane as a service and business layer. New services and business can be developed on top of ID without changing the underlying locator plane.
- Map and Encapsulate packets which can run on an IP core

Protocols for IP 2020: A Summary

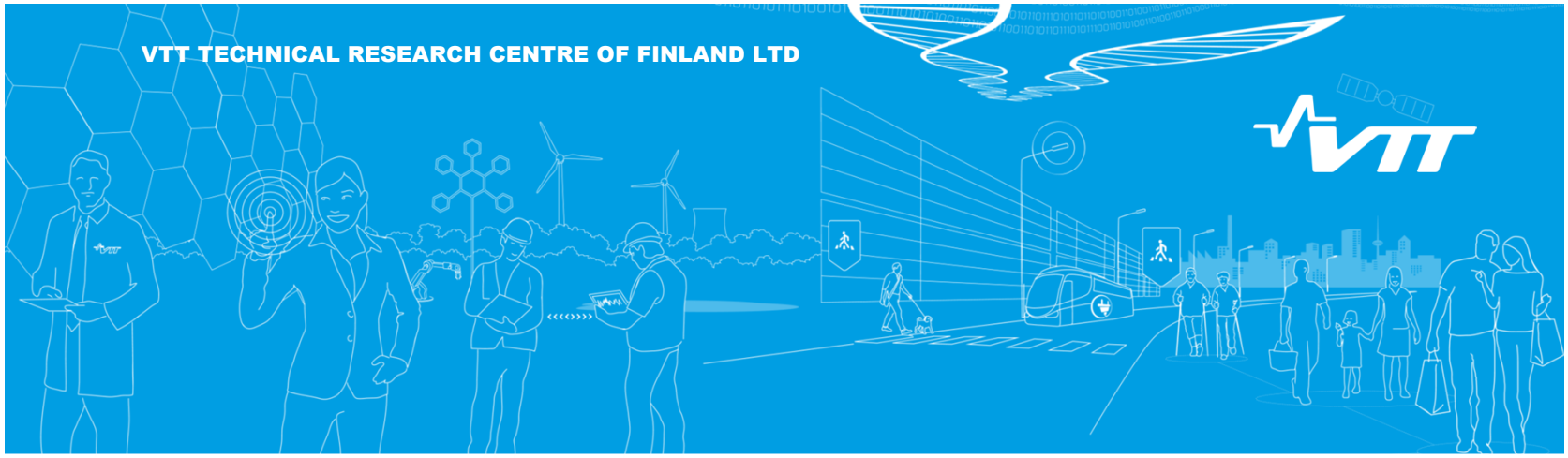


Thank you

www.huawei.com

Overview of standardized mobility solutions

SDO	Solution	Methodology	Advantages	Limitations	Market Proven
IETF	Mobile IPv4	Home Agents, Home Address, Care-of addresses	Use of IPv4, retain same ip address	Handover latency, signaling overheads in transition, suboptimal triangular routing, Limited QOS	
IETF	MIP V6	Address Autoconfig, autodiscovery of neighbors, Care-of-Addresses use of ipv6 hdr options for destination options	Always On Use of IPv6 Session persistence	Handoff latency, Limited awareness of heterogeneity, requires kernel changes,Security issues -	
3GPP	3G/GTP	Tunnels through eNB, S-GW and P-GW	Fast handoff	Tunnel re-creation on move, no session continuity.	Yes
3GPP	4G/LTE/GTP	Tunnels through eNB, S-GW and P-GW	Fast handoff	Tunnel re-creation on move. Service continuity is limited within a P-GW	Yes
IETF	Proxy Mobile IPv6 (PMIPv6)	Mobile Access Gateway (MAG) and Location Mobility Anchor (LMA)	Fast handoff retain same ip address	Session continuity limited to local administrative domain, centralized LMA may not scale well.	Yes
IETF	Distributed Mobility Management (DMM)	Mobility anchors, partial session distribution	Fast handoff	Triangular routing only for on-going sessions same as Mobile IP. Optimized for new sessions only. No RFC yet	
IETF	LISP	ID separation from location. Both ID and locator are IP address based	Use of ID over IP	Under Research	Experimental, ongoing trials through beta-network, waiting for multi-vendor market adoption.



5G… Whats next?

12th AICT Panel discussion, Valencia, Spain, May 2016
Teemu Kanstrén, Senior Scientist, VTT, Oulu, Finland
& CTO, KaTe SC, Oulu, Finland

http://www.katesc.com

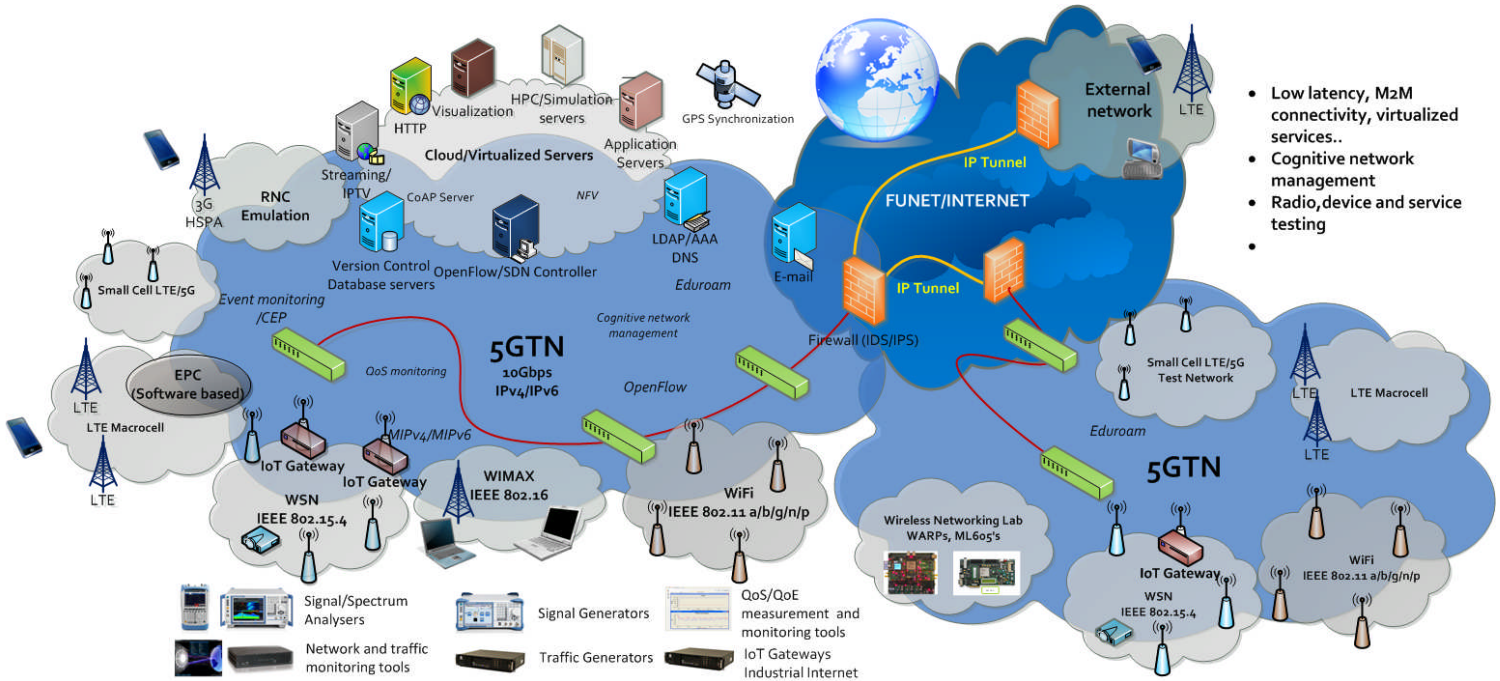
5GTN Background

www.5gtn.fi

- The 5GTN project started early 2015, with VTT, UoO and 15 industry partners, evolves over time
- Partners from different domains
  - HW providers
  - Test & monitoring tool vendors
  - Research & Analytics
  - Business & NW operations

5GTN big picture

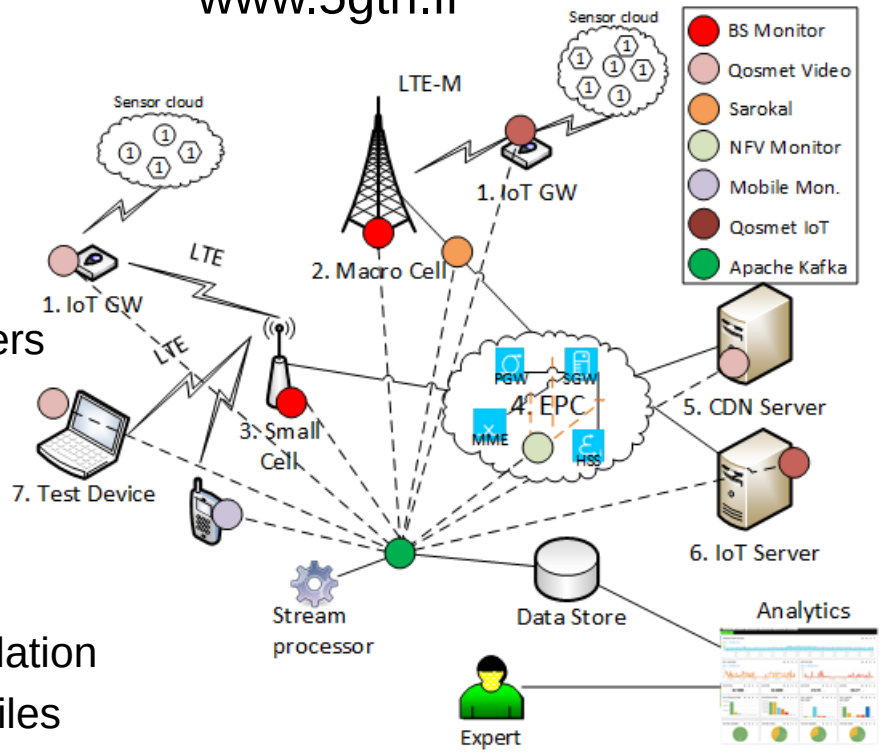
www.5gtn.fi



5GTN @ VTT

www.5gtn.fi

- Technical tests
- Monitor various nodes
  - IoT devices
  - Video clients and servers
  - Application servers
  - Network nodes
  - EPC interfaces
- Generate tests/traffic
  - App specific user simulation
  - Various NW traffic profiles



- High bandwidth
- Low latency
- IoT

http://5gfwd.org

- Daily life security
- Health & 5G
- Smart city
- Shopping

http://5gfwd.org

5GFWD

OULU 5G INNOVATION CHALLENGE

- Daily life security
- Health & 5G
- Smart city
- Shopping

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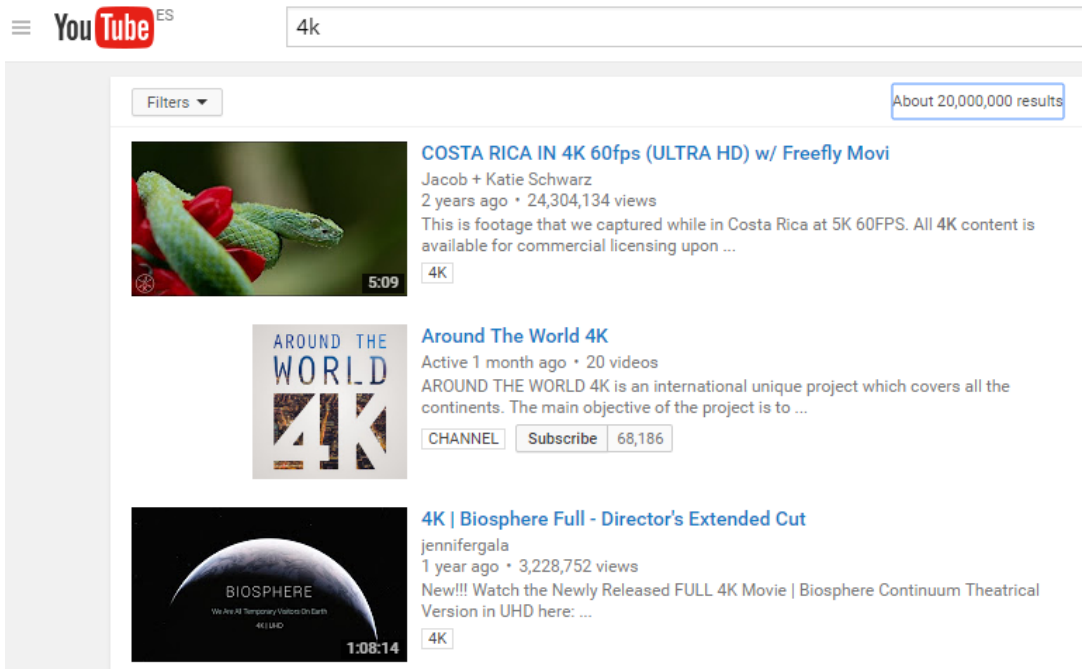
http://www.katesc.com

5G domains?

- Video
- Mining
- Sports
- Health
- Robotics
- Gaming
- Others



http://www.youtube.com

5G domains?

- Video
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http://mining.sandvik.com

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5G domains?

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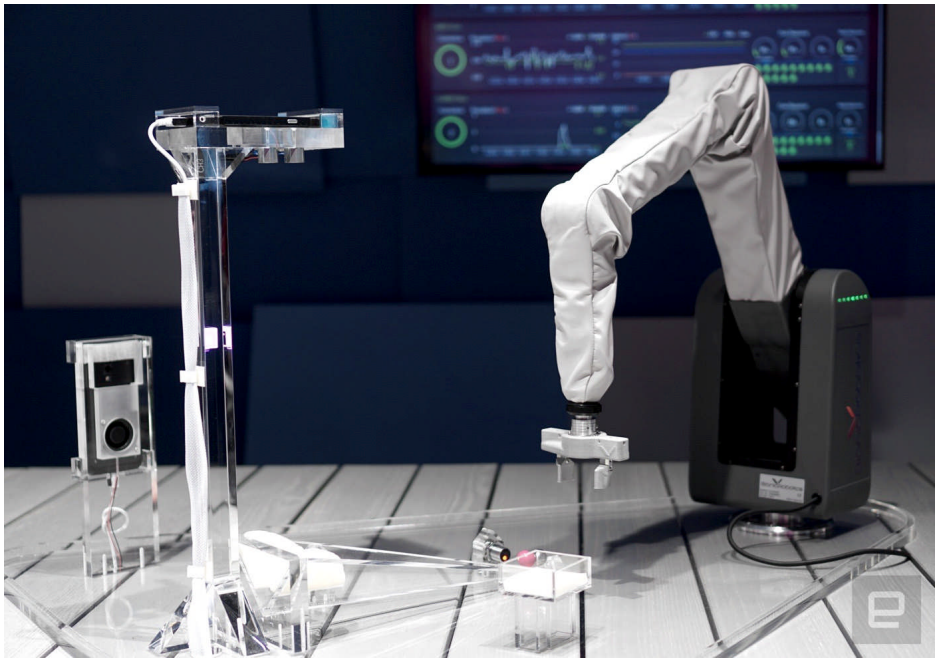

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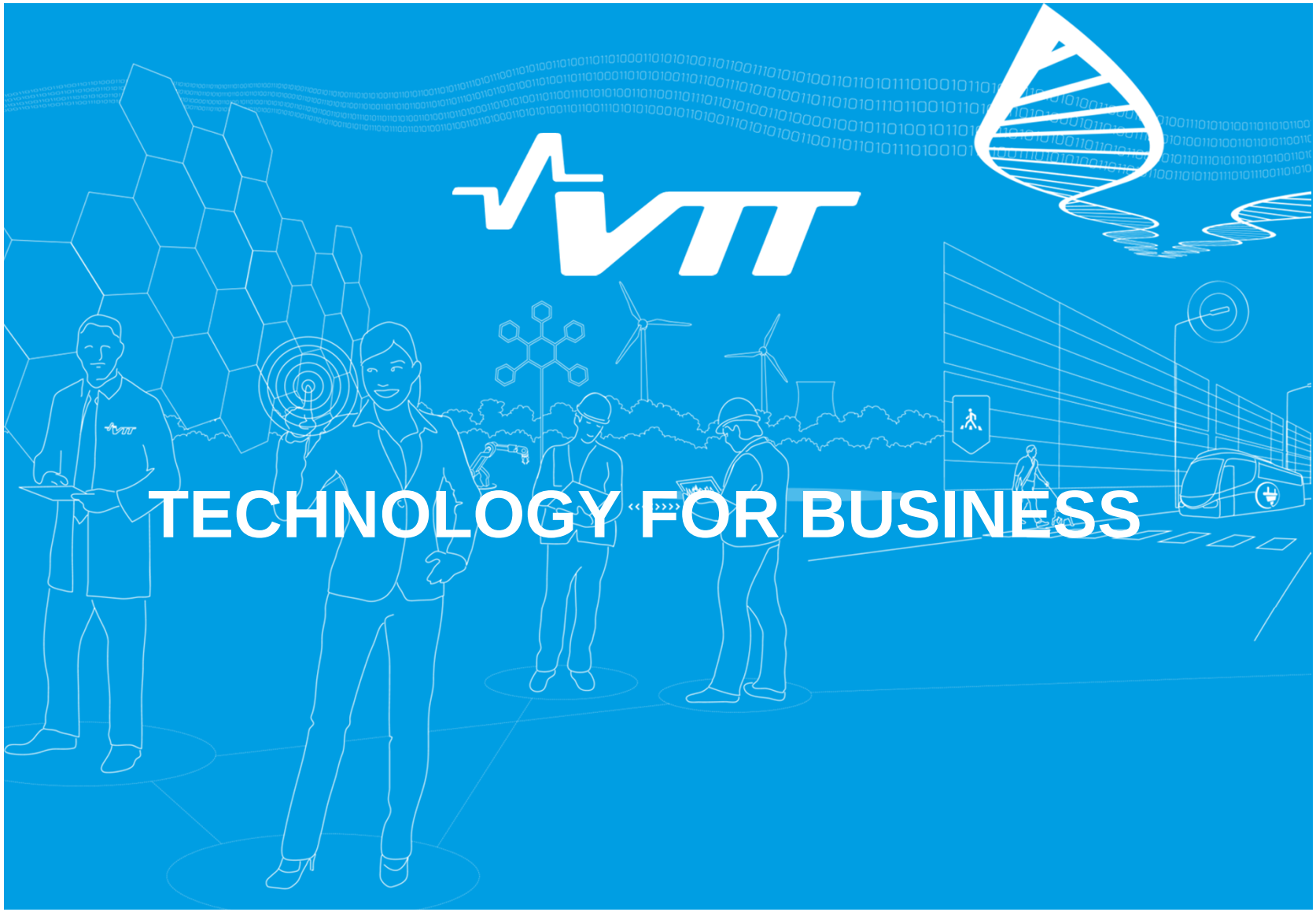
TECHNOLOGY FOR BUSINESS