Panel
ICN/COCORA/CTRQ/SOFTNETWORKING

Topic: Quality and Global Resource Utilization in the Internet of Things Environments

NexComm 2016 Lisbon, 20-25 February 2016

PANEL IoT

Moderator

Eugen Borcoci, University "Politehnica"of Bucharest (UPB), Romania

Panelists

- **Seppo Yrjölä, Nokia Networks, Finland**
- **Richard Li, Huawei Technologies, USA**
- **Mohammed Rajabali Nejad, Universiteit Twente, the Netherlands**
- **Nageswara Rao, Oak Ridge National Laboratory, USA**
- **Eugen Borcoci, University "Politehnica"of Bucharest (UPB), Romania**

Panel IoT

- **IoT environment, resources, quality, ..**
  - IoT : emerging topic of high technical, social, and economic significance
  - Products, durable goods, transportation entities, industrial and utility components, health equipments, sensors, …and many other objects are combined with Internet connectivity
  - Powerful data analytic capabilities - support the processing of huge amount of data
  - Forecast: more than 50 billion connected IoT devices and a global economic impact of more than $11 trillion by 2025
  - **Significant challenges**
    - **Development of a large range of applications**
    - **Technical aspects - Integration in the Future Internet**
    - **Socio-economical aspects**

Panel IoT

- **Possible subjects for this panel:**
  - ***What are the most important challenges and open areas of research in the domain?***
    - ***Scalability, security, heterogeneity, inter-operability, integration, ..***
    - ***Big Data –related issues***
    - ***Candidate for supporting technologies:***
      - ***Heterogeneous networking***
      - ***Cloud/edge computing, SDN, NFV?***
  - ***What types of "resources" are involved in IoT?***
  - ***Novel areas of application?***
    - ***E.g. From V2X+ Manually Driven Vehicle –to Autonomous Driving Vehicle***
      - ***New applications for cooperative autonomous driving***
  - ***What means "quality of services" in IoT?***
    - ***Are there some special QoS/QoE aspects in IoT?***

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- **Thanks !**
- **Floor for the speakers…..**

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Quality and Global Resource Utilization in the Internet of Things Environments

From VANET to Internet of Vehicles

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NexComm 2016, Lisbon, February 20-25, 2016

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- **IoT**
- IoT: Major trend in Internet development
- Very large range of applications [1, 2]
  - In all segments of the society

[2] Source: Ala Al-Fuqaha, et.al "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications", IEEE Comm. Surveys & Tutorials, Vol. 17, No. 4, 2015

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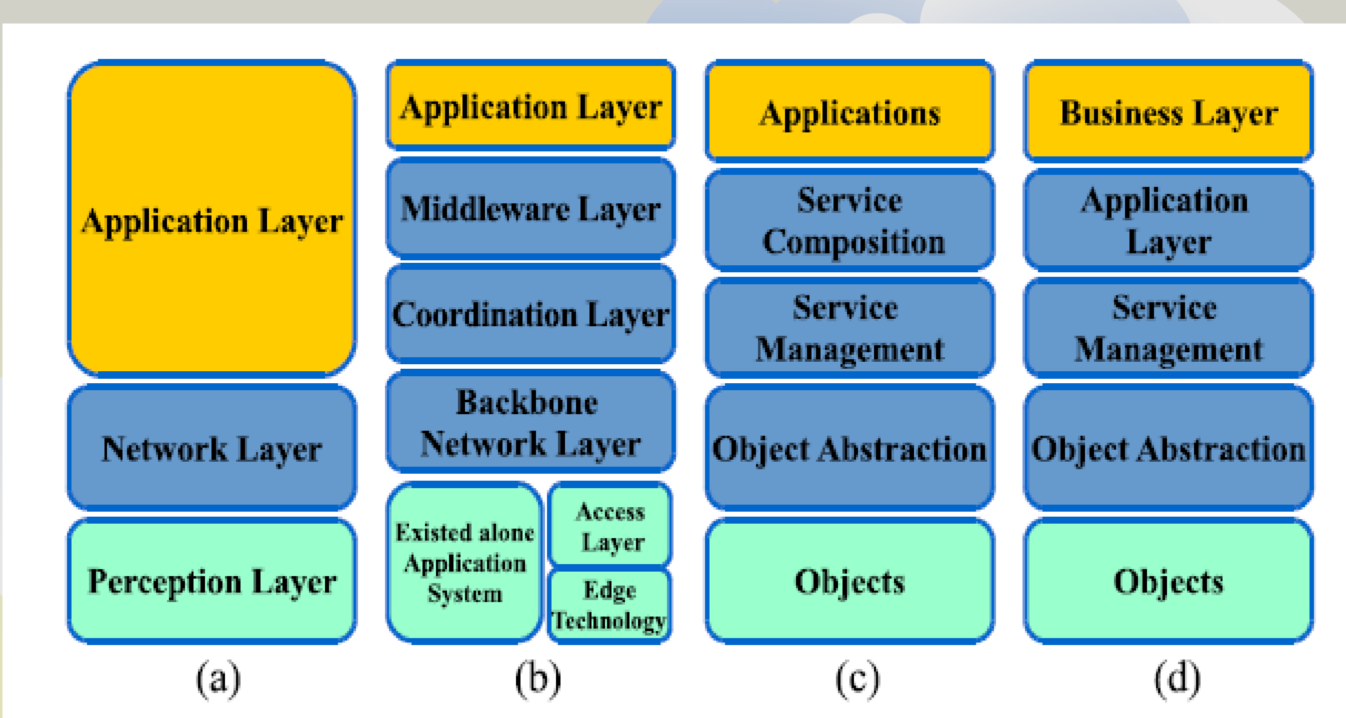
- **IoT:**
- Different views on functional architecture [2]



(a).Three layers *(b) Middleware* *(c) SOA* *(d) five layers*

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- **IoT**
  - Elements &
  - Examples [2]

Access technologies

IoT Elements		Samples
Identification	Naming	EPC, uCode
	Addressing	IPv4, IPv6
Sensing		Smart Sensors, Wearable sensing devices, Embedded sensors, Actuators, RFID tag
Communication		RFID, NFC, UWB, Bluetooth, BLE, IEEE 802.15.4, Z-Wave, WiFi, WiFiDirect, , LTE-A
Computation	Hardware	SmartThings, Arduino, Phidgets, Intel Galileo, Raspberry Pi, Gadgeteer, BeagleBone, Cubieboard, Smart Phones
	Software	OS (Contiki, TinyOS, LiteOS, Riot OS, Android); Cloud (Nimbits, Hadoop, etc.)
Service		Identity-related (shipping), Information Aggregation (smart grid), Collaborative-Aware (smart home), Ubiquitous (smart city)
Semantic		RDF, OWL, EXI

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- **Vehicular Networks** [3,4,5]
- **Early development: > 1990, long before IoT concepts**
- **Communication types V2V, V2R, V2I, V2X**

- **Applications and use cases**
  - ***Active road safety applications***
    - Warning: Intersection collision, Overtaking vehicle, Head/Rear-end collision risk, Emergency vehicle, Pre-crash, Stationary vehicle, Traffic condition, Signal violation, Control loss..
    - Assistance: Lane change, Co-operative merging
    - Emergency electronic brake lights
  - ***Traffic efficiency and management applications***
    - Speed management, Co-operative navigation
  - ***Infotainment applications***
    - Co-operative local services, Global Internet services:

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- **Vehicular Networks**
- **Rich set of requirement**
  - a) Strategic
  - b) Economical
  - c) Legal
  - d) Standardization
  - e) System (technical) capabilities requirements
    - Functional: security, privacy, reliability, connectivity (V2V, V2I, V2X), positioning, mode (unicast, geocast, broadcast)
    - Performances: bandwidth, delay, QoS, (depending on classes of applications)
- **Organizations and Standards**
  - ITS, IEEE , ITU, ISO, ARIB, ETSI, …
  - IEEE 802.11p, WAVE, IEEE 1609.x, ISO CALM, …
- **Access technologies**
  - Bluetooth, ZigBee, WiFI, WiMAX, 3G/4G- LTE, 5G, ….

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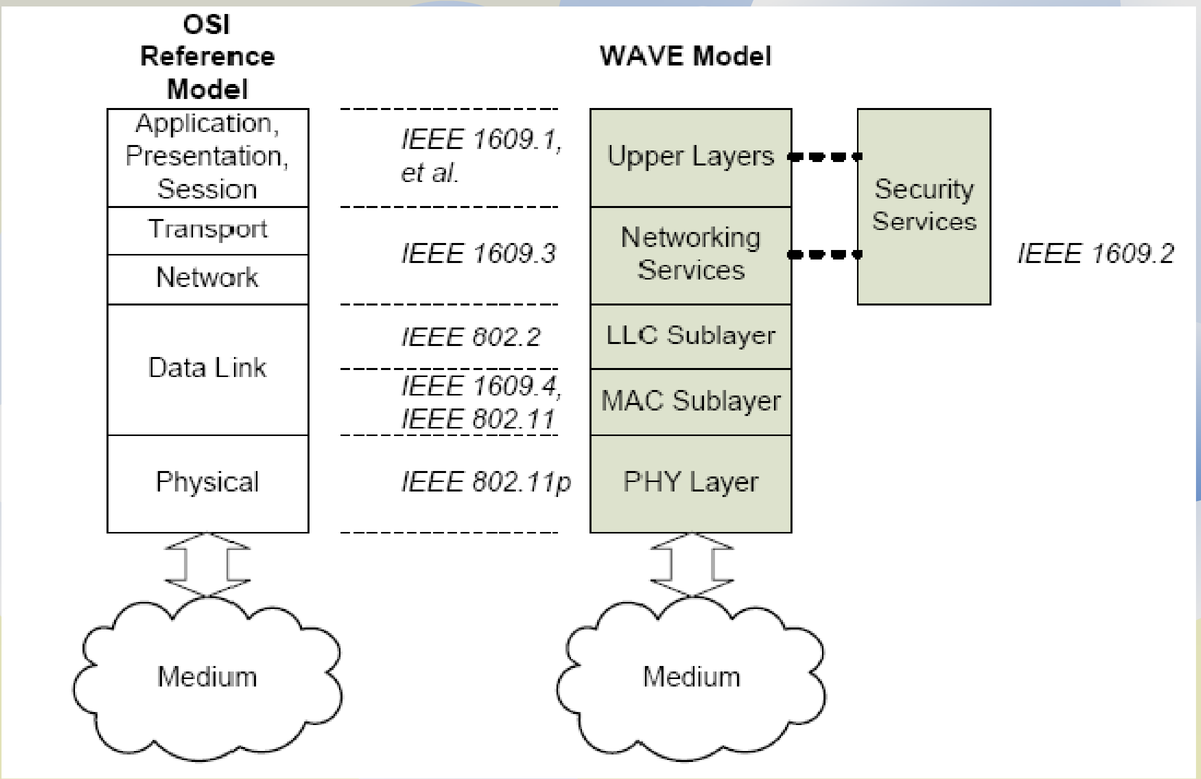
- **Vehicular Networks**
  - **Example WAVE stack (ITS,IEEE, ETSI, ..)**



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- **Current trends:**
  - **Vehicular Networks (VANET) → Internet of Vehicles (IoV)**
  - **Novel features, e.g.:**
    - ***Autonomous driving***
    - ***Cooperative working- there is a strong need for this***
  - **IoV can be seen as part of IoT "umbrella"**

  - **Cooperation with other IoT applications**
  - **Novel support technologies (resources)**
    - Enrich the V2X –based communications with additional features
    - Rich set of sensors and smart devices
    - Cloud computing/ Edge(Fog) computing
    - 5G - Hetnet
    - Software Defined Networking (SDN)
    - Network function Virtualization (NFV)
    - Information Centric Networking (ICN/CCN)

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- **IoV example : Vehicular Cloud Computing (VCC)** [4, 5]

- **Services:**
  - Network as a service (NaaS)
  - Storage as a service (STaaS)
  - Cooperation as a service (CaaS)
  - Computing as a service
  - Information as a service (INaaS)
  - Entertainment as a service (ENaaS)
  - Pictures on a wheel as a service

- **Formation of VC infrastructure**
  - Stationary VC formation
  - Linked with a fixed infrastructure
  - Dynamic formation

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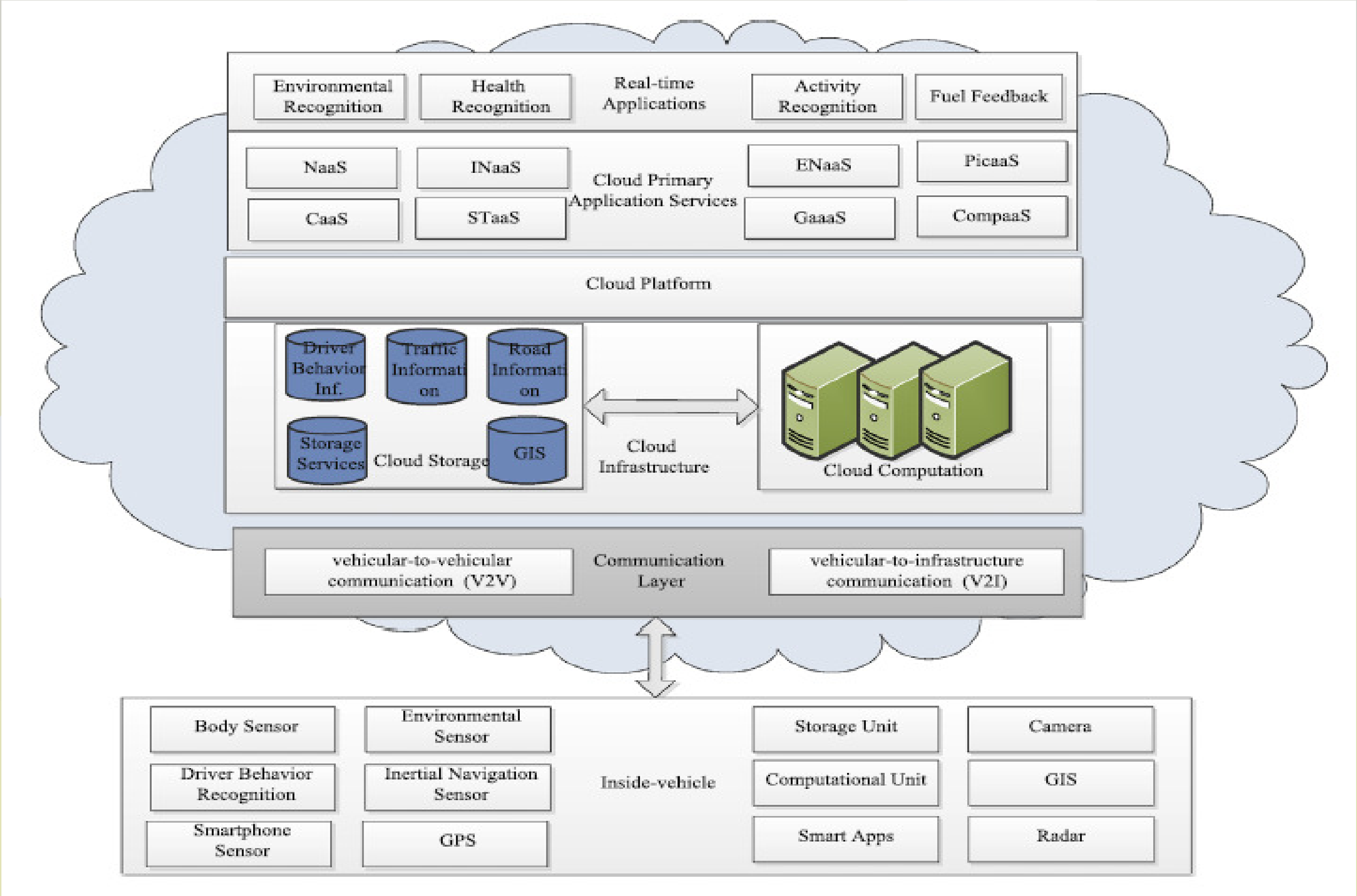
- **IoV example : Vehicular Cloud Computing (VCC) [5]**
  - **Architecture**



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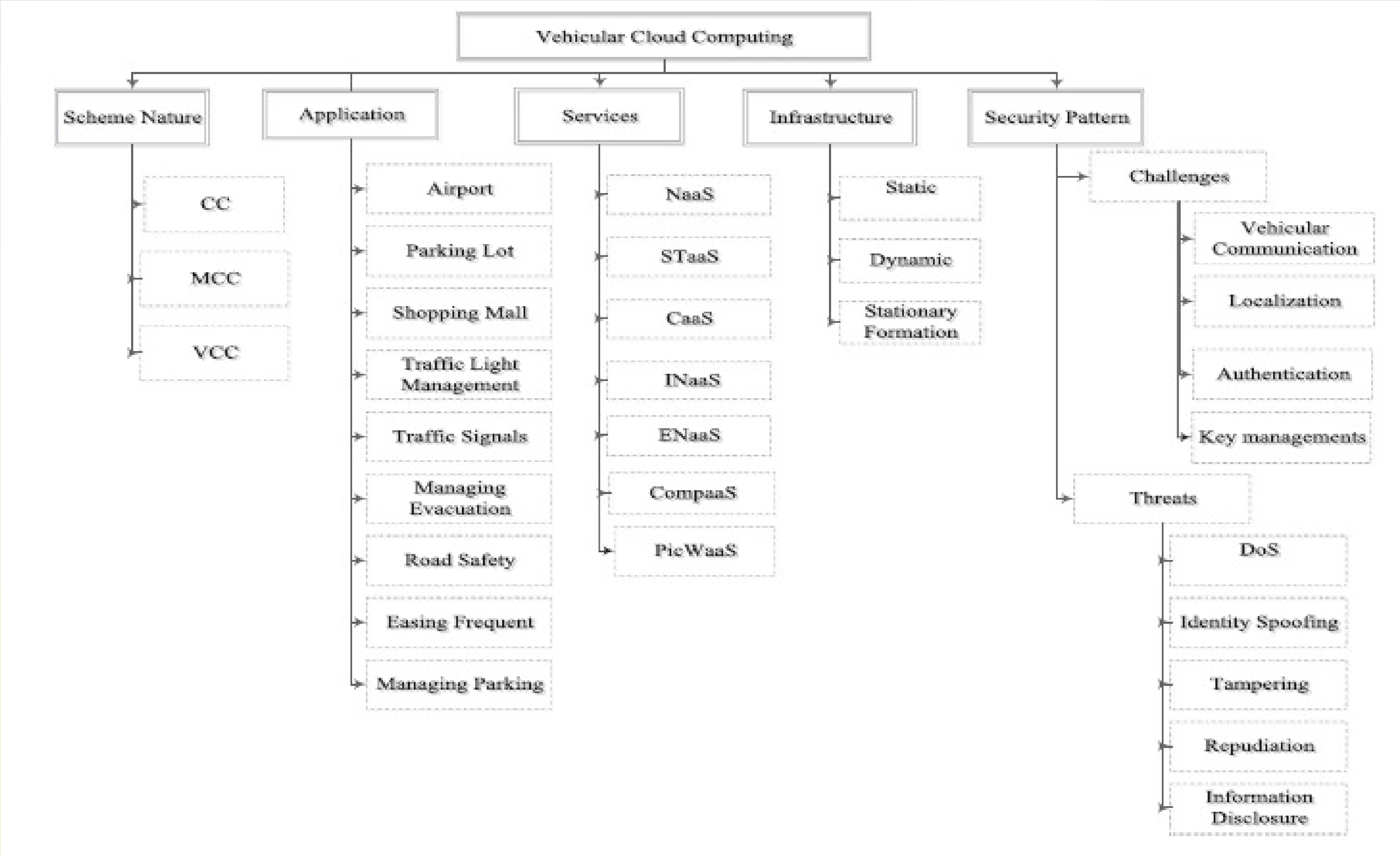
- **IoV example : Vehicular Cloud Computing (VCC) [5]**
  - **VCC Taxonomy**



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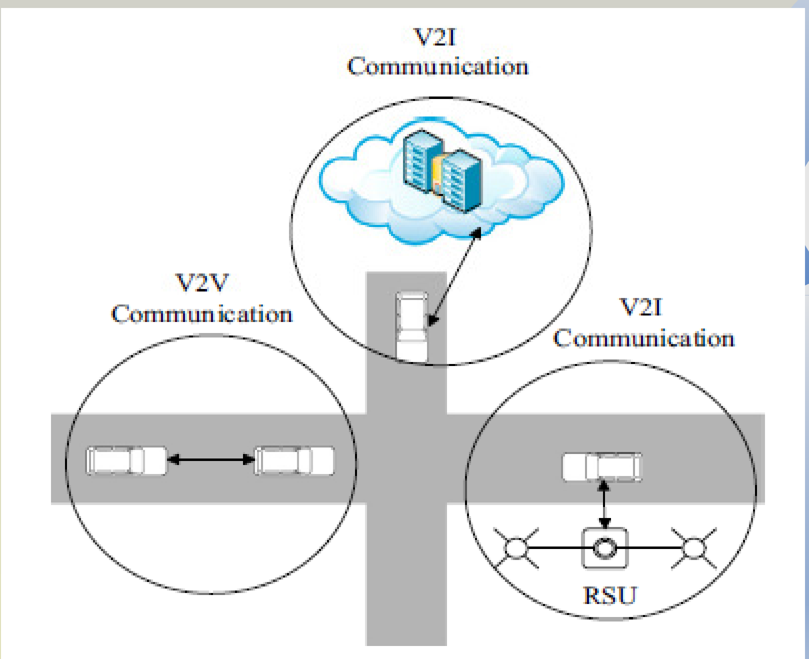
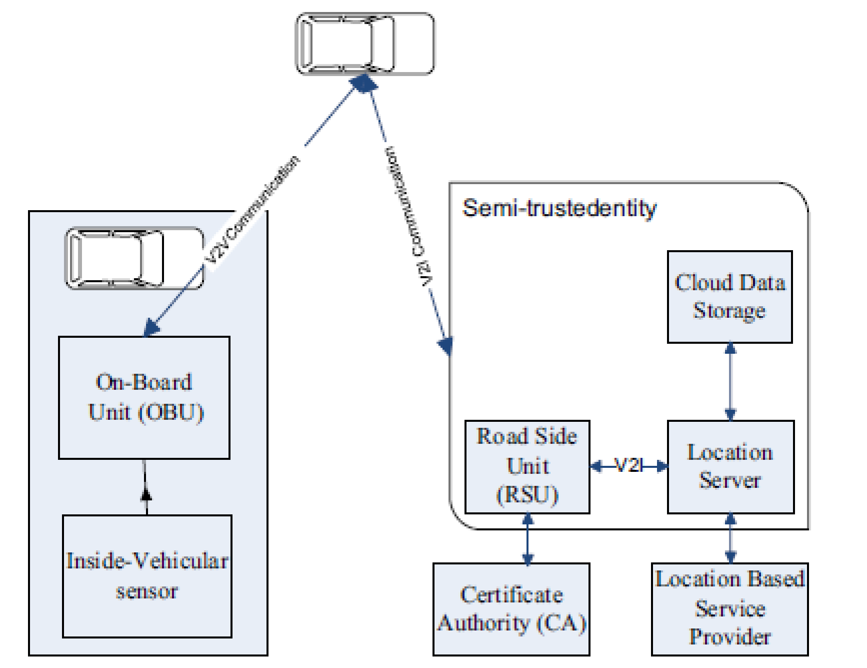
- **IoV example : Vehicular Cloud Computing (VCC) [5]**



VCC communications



VCC functional entities - example

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- Conclusions
  - IoV -emergent technology- extension of VANET
  - Still – many challenges to solve and open research issues
    - Scalability
    - Security
    - Real-time response
    - Reliability
    - Harmonization within the IoT general framework
    - Usage of support technologies: Cloud computing, edge computing, SDN, NFV, etc.

- Thank you !

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- **References**

1. “The Internet of Things: an overview “, https://www.internetsociety.org/sites/default/files/ISOC-IoT-Overview-201510
2. Ala Al-Fuqaha,Mohsen Guizani, Mehdi Mohammadi, Mohammed Aledhari, and Moussa Ayyash, "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications”, IEEE Communications Surveys &Tutorials Vol. 17, No. 4, 2015
3. Georgios Karagiannis, Onur Altintas, Eylem Ekici, Geert Heijenk, Boangoat Jarupan, Kenneth Lin, and Timothy Weil, "Vehicular Networking: A Survey and Tutorial on Requirements, Architectures, Challenges, Standards and Solutions“, IEEE Communications Surveys &Tutorials, Vol. 13, No. 4, 2011
4. M.Gerla and L.Kleinrock, "Vehicular networks and the future of the mobile internet", Computer Networks, 2011, www.elsevier.com/ locate/comnet, doi:10.1016/j.comnet.2010.10.015
5. Md Whaiduzzaman, Mehdi Sookhak, Abdullah Gani, Rajkumar Buyya "A survey on vehicular cloud computing ", Journal of Network and Computer Applications 40(2014) 325–344
6. A. Festag, “Cooperative Intelligent Transport Systems (C-ITS) Standards in Europe,” *IEEE Commun. Mag., vol.* 12, no. 52, Dec. 2014, pp. 166–72.
7. J. Kenney, “Dedicated Short-Range Communications (DSRC) Standards in the United States,” *Proc. IEEE, vol.* 99, no. 7, July 2011, pp. 1162–82.

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- **Acronym list**
  - ARIB — Association of Radio Industries and Businesses)
  - CALM — Continuous Air-interface Long and Medium range
  - DSRC — Dedicated Short-Range Communications)
  - D2D — Device to Device
  - EPC — Electronic Product Code
  - LTE — Long-Term Evolution
  - LTE-A — Long-Term Evolution Advanced
  - M2M — Machine-to-Machine
  - NFC — Near Field Communication
  - OBU — On Board Unit
  - RSU — Road Side Unit

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- **Acronym list**

  - **Semantic Web technologies**
    - RDF Resource Description Framework
    - OWL Web Ontology Language
    - W3C World Wide Web consortium
    - EXI Efficient XML Interchange format

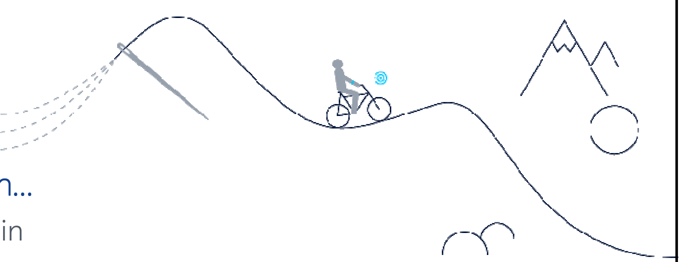
  - V2V Vehicle to Vehicle
  - V2R Vehicle to Road
  - V2I Vehicle to Infrastructure
  - V2X Vehicle to anything
  - VCC Vehicular Cloud Computing
  - UWB Ultra-Wide Bandwidth
  - WAVE Wireless Access in Vehicular Environments
  - WSNs Wireless Sensor Networks

Destination 5G

- Explosion of possibilities in the programmable world present huge opportunities
- Technological evolution that will bridge our physical, virtual and social worlds

A fundamental change to our business environment

- Create and deliver on-demand with a diverse service offering
- Tailor capabilities for new segments with different characteristics
- Multitude of ecosystems
- Multitude of business models
- Sharing economy
- Monetize new services
- Competitive Advantage - where to compete
- Co-opetition – where to partner



New opportunities mean new competition…

- Local operators, Verticals, Internet domain

and the way we do business

New customers

Tailored E2E solutions for

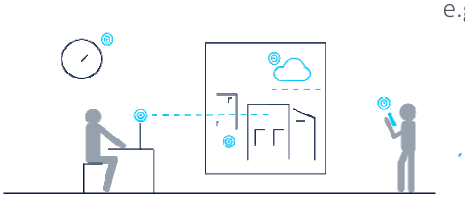
- Industry 4.0
- Enterprises
- Governments, cities and societies
- Verticals

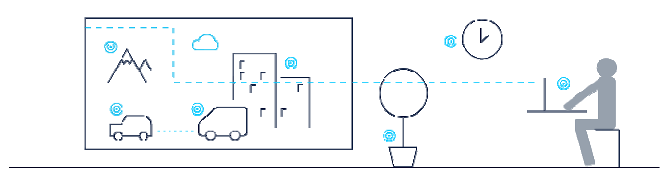
New use cases

- Extremely fast and secure, e.g., real-time medical imaging
- Low latency, critical availability e.g., healthcare, autonomous driving
- Machine communications with millions of sensors, e.g., factories, smart cities

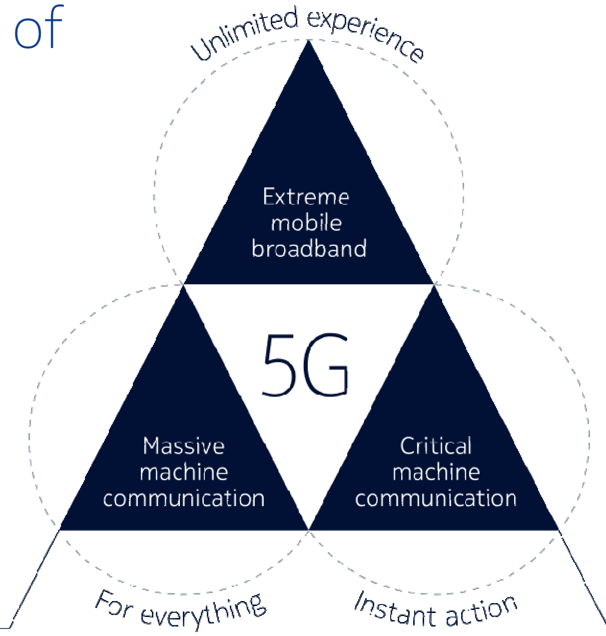
New business models

- Connectivity+
- Context
- Content
- Commerce
- X as-a-Service



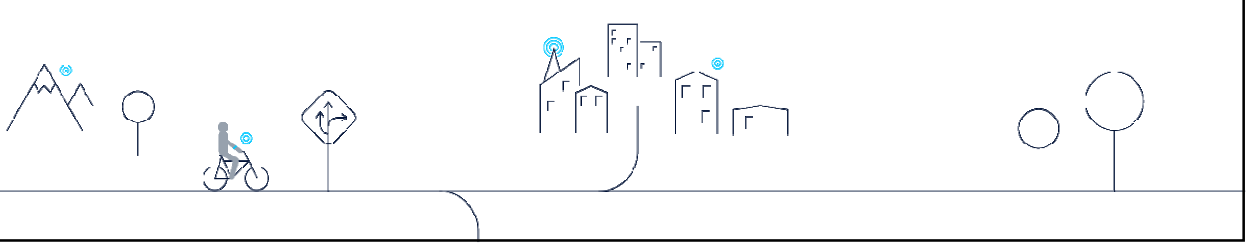


with extreme range of requirements and choices



Key questions to be asked

- How do we monetize our 5G network?
- How do we evolve to 5G?
- How do we deploy 5G on top of today's networks?
- How do we create and maintain network slices?

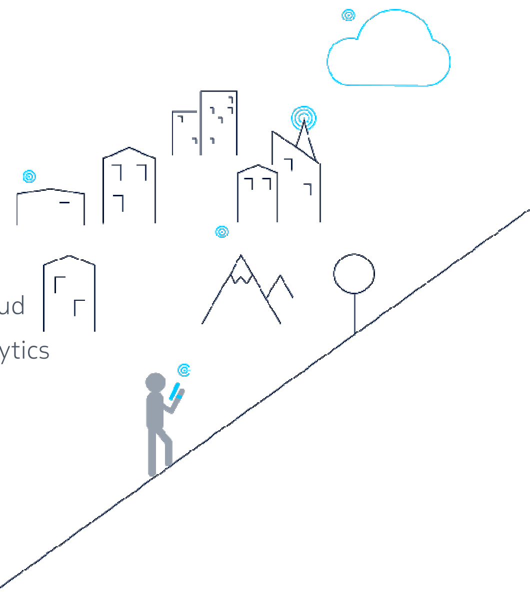


The new diversity challenge

Optimizing service delivery for heterogeneous use cases

Key considerations

- Traffic growth, densified networks
- Service availability
- Simplified network management
- Low latency, critical availability, use case scenarios
- Managing complexity: operating multiple networks and technologies
- Security and data
- Deployment cost
- Transport networks
- Migration to telco cloud
- Use big data and analytics



Huge market opportunity in the IoT ecosystem

>€100B or >50% 2015-25 CAGR; >€10B or >30% 2015-25 CAGR

2025 market projection in €	Mobility	Industries	Utilities	Digital Health	Smart Homes	Retail & Services	Public Safety	Smart City	IT	
Applications, Analytics and End-User Services	203B	110B	31B	23B	19B	18B	18B	6B	6B	434B (90%)
Application Enablement Platform	11B	3B	5B	2B	2B	0.6B	0.3B	3B	0.3B	28B (6%)
Connectivity Management Platform	2B	0.4B	0.8B	0.3B	0.2B	0.1B	0.04B	0.04B	0.002B	4B (1%)
Cellular Connectivity	6B	0.04B	0.02B	0.08B	0.01B	0.7B	0.7B	0.4B	0.01B	8B (2%)
IoT modules	2B	2B	1B	0.6B	2B	3B	0.1B	0.3B	0.4B	9B (2%)
	224B (46%)	117B (24%)	39B (8%)	26B (5%)	24B (5%)	19B (4%)	19B (4%)	10B (2%)	7B (1%)	484B

Source: Machina Research and Nokia

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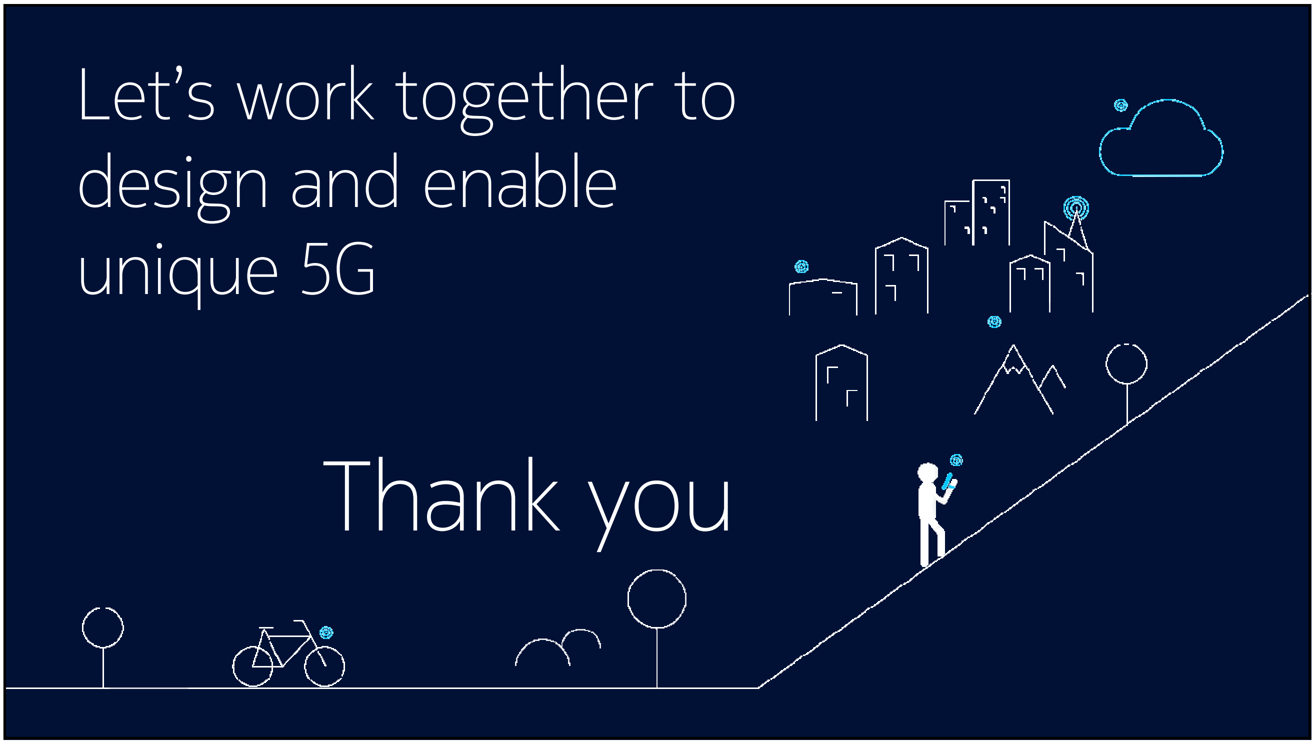
NOKIA


Let's work together to design and enable unique 5G
Thank you

UNIVERSITY OF TWENTE.

QUALITY AND GLOBAL RESOURCE UTILIZATION IN THE INTERNET OF THINGS ENVIRONMENTS

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LABORATORY OF DESIGN, PRODUCTION AND MANAGEMENT

February 2016, Lisbon

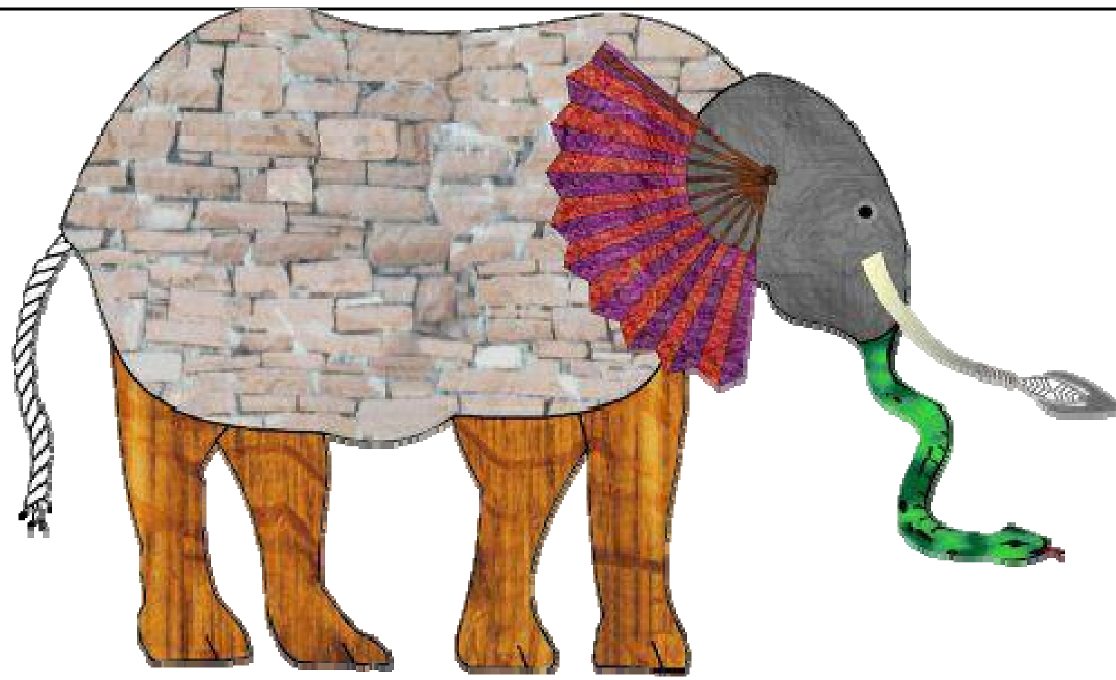
OVERVIEW

- Societal demands
- Design challenges
- Performance metrics
- A factual observation
- Considerations

HIGH-TECH WORLD

WHAT TO PAY ATTENTION TO?
IN COMPLEX PRODUCTS

- disciplines
- views
- requirements
- stakeholders
- functions
- structure
- behaviour
- etcetera



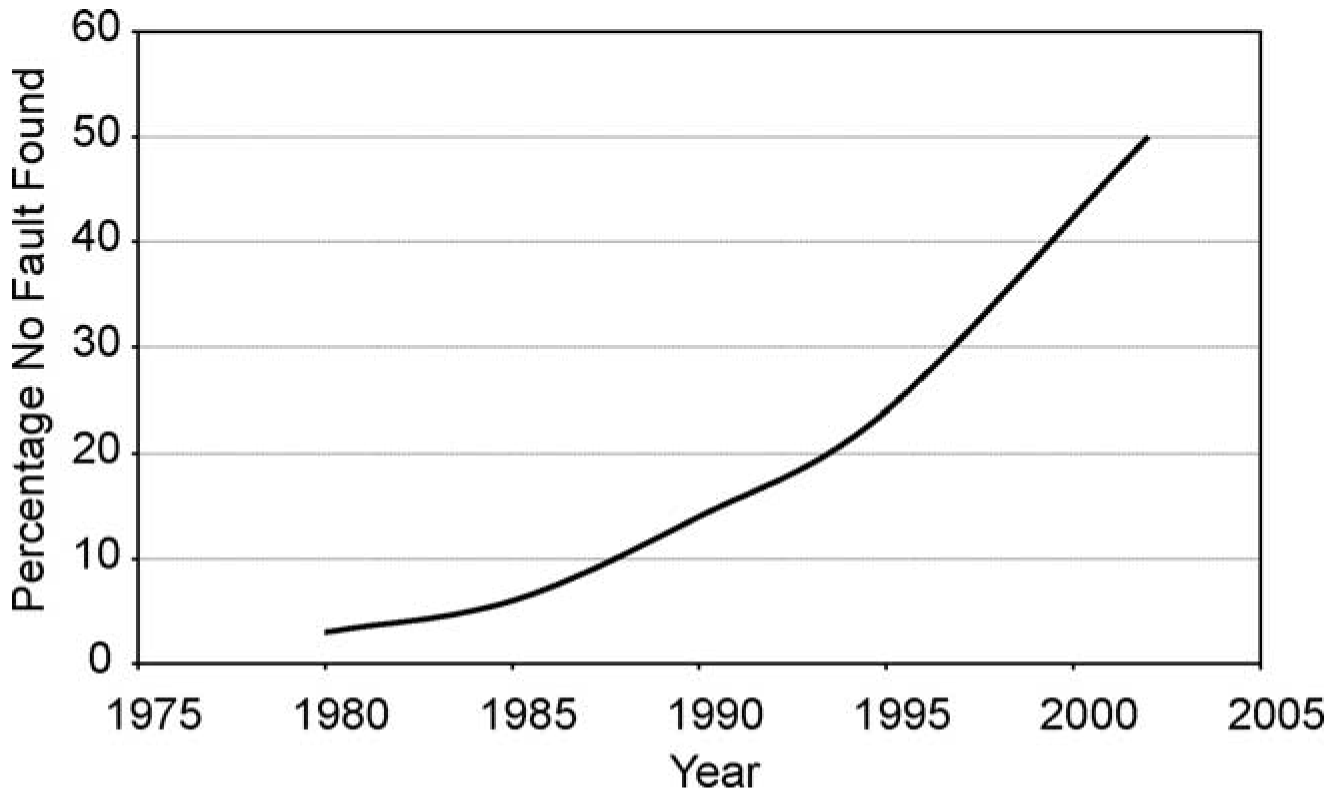
and still ensure

efficiency

PERFORMANCE METRICS

- Time to the market
- Quality
- Cost

CONSUMER SATISFACTION



Brombacher 2005, RESS, Trends in the reliability analysis of consumer electronics.

CONSIDERATIONS
DESIGN RELATED

- Fast feedback system
- New design processes
  - learn from strongly innovative products
- More efforts in upfront design
- Root cause analysis of
  - failures
  - quality problems
- Reviewing performance metrics

Performance Challenges of SDN Solutions

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Panel on

Quality and Global Resource Utilization in the Internet of Things Environments

The International Symposium on Advances in

Software Defined Networking and Network Functions Virtualization

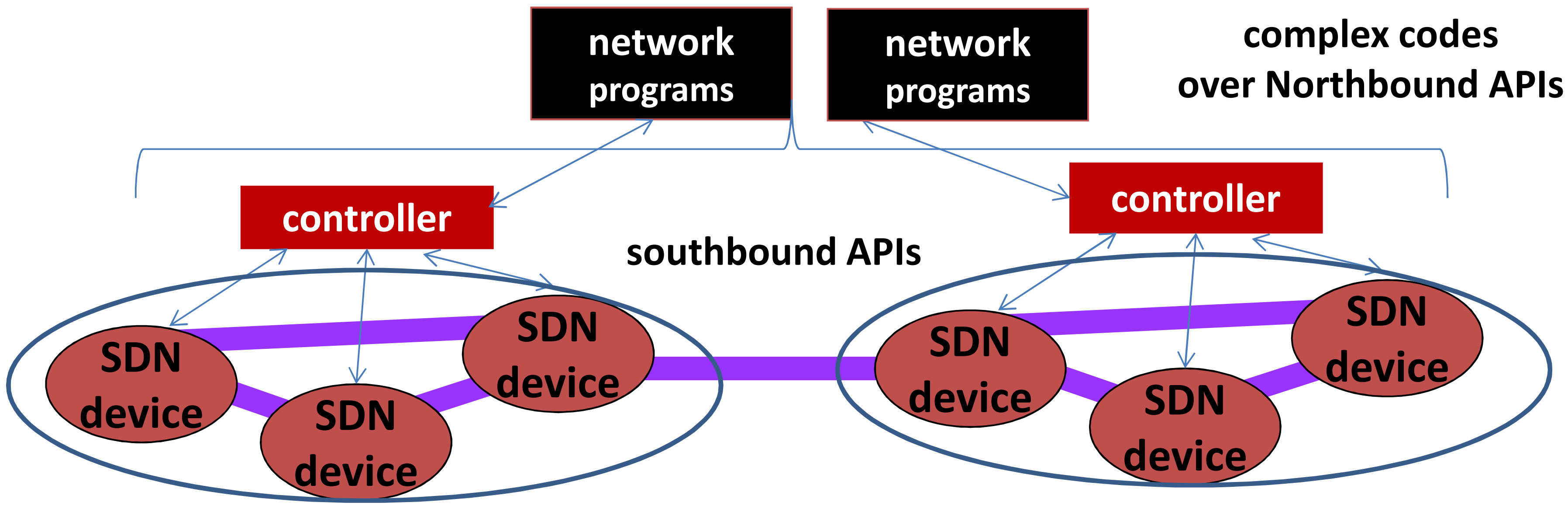
February 21 - 25, 2016

Lisbon, Portugal

Promise of Software Defined Networking

Unprecedented Promised Capabilities

- Networks “programmed” like computers using standard protocols and libraries
  - Speed: several “manual” operations are automated
  - Scale: thousands of network tasks executed in seconds to minutes
  - Ease of use: Northbound APIs – re-use of codes, e.g. python OF scripts
  - Increased sophistication network codes: optimization of paths, complex configuration, etc. , using libraries
- Standardization of protocols and APIs
  - Network devices offer uniform APIs
  - Controllers are swappable – e.g. OpenFlow
  - Users and network operators do not need to learn custom CLIs
  - Transportable northbound codes: sophisticated scripts developed once



Current SDN Technologies: Even if complex SDN codes are developed, performance information is missing
In short, we do not know how well controllers and switches perform for IOT

- **It is not just email – we control and monitor devices**

Rapid Technology Development

- **Too many controllers:**
    - **Open source**
        - **ODL (hydrogen, lithium, beryllium), Floodlight, ONOS, pox, nox, etc.**
        - **limited support and open documentation**
        - **very little performance characterization**
    - **Custom**
        - **Cisco, HP, Ciena, others**
- **Too much variability in device implementation**
    - **HP, Brocade, etc. – close to native OpenFlow**
    - **Cisco – onep layer**
    - **limited support and documentation**
    - **very little performance characterization**
- **Too many controller + switch combinations: not practical to test them all**

- **Vendor sales pitches are not generally helpful**
    - **very hard to extract technical information for specific scenarios**
    - **need technical support for implementation – not just salespersons**

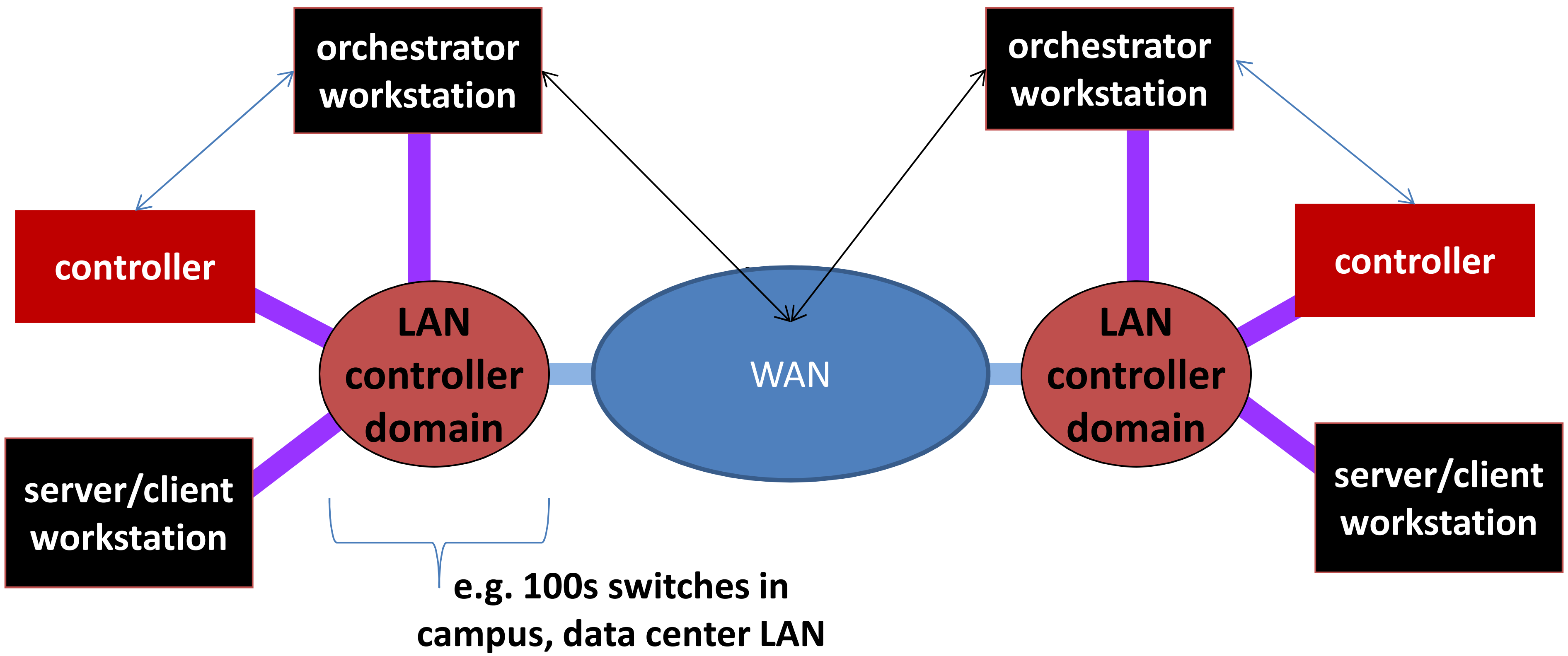
Choosing Controllers and Switches?

Typically, orchestrator codes are developed/composed by network engineers for a class of applications, e.g. network flow balancing in data center and long-haul

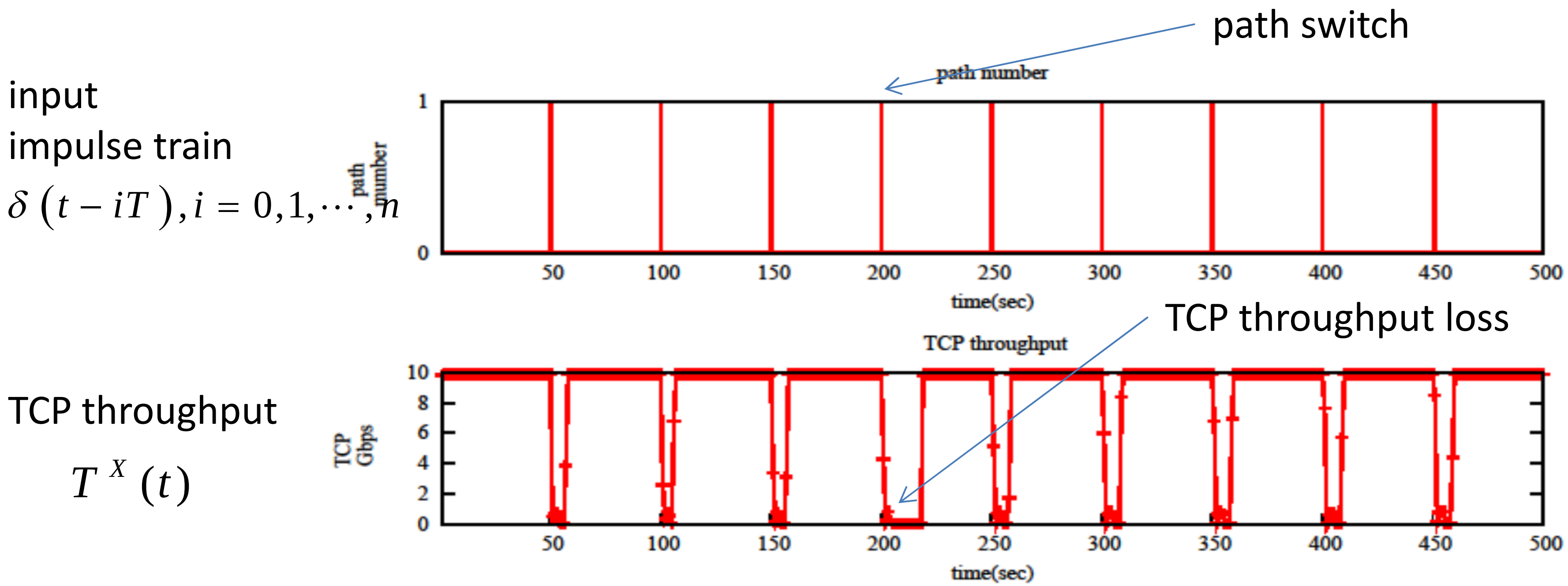
Application performance depends on switch, controller and orchestrator

- controllers in charge of switches in domain LAN – southbound API
- switches implement the flows – instructed by controllers
- orchestrators manage the networks through controllers

But, controllers and switches are to be selected – which ones?



Impulse Response Method: Path failover scenario
Orchestrators detect path degradation and activates controllers
Controllers install new flow entries on the switches



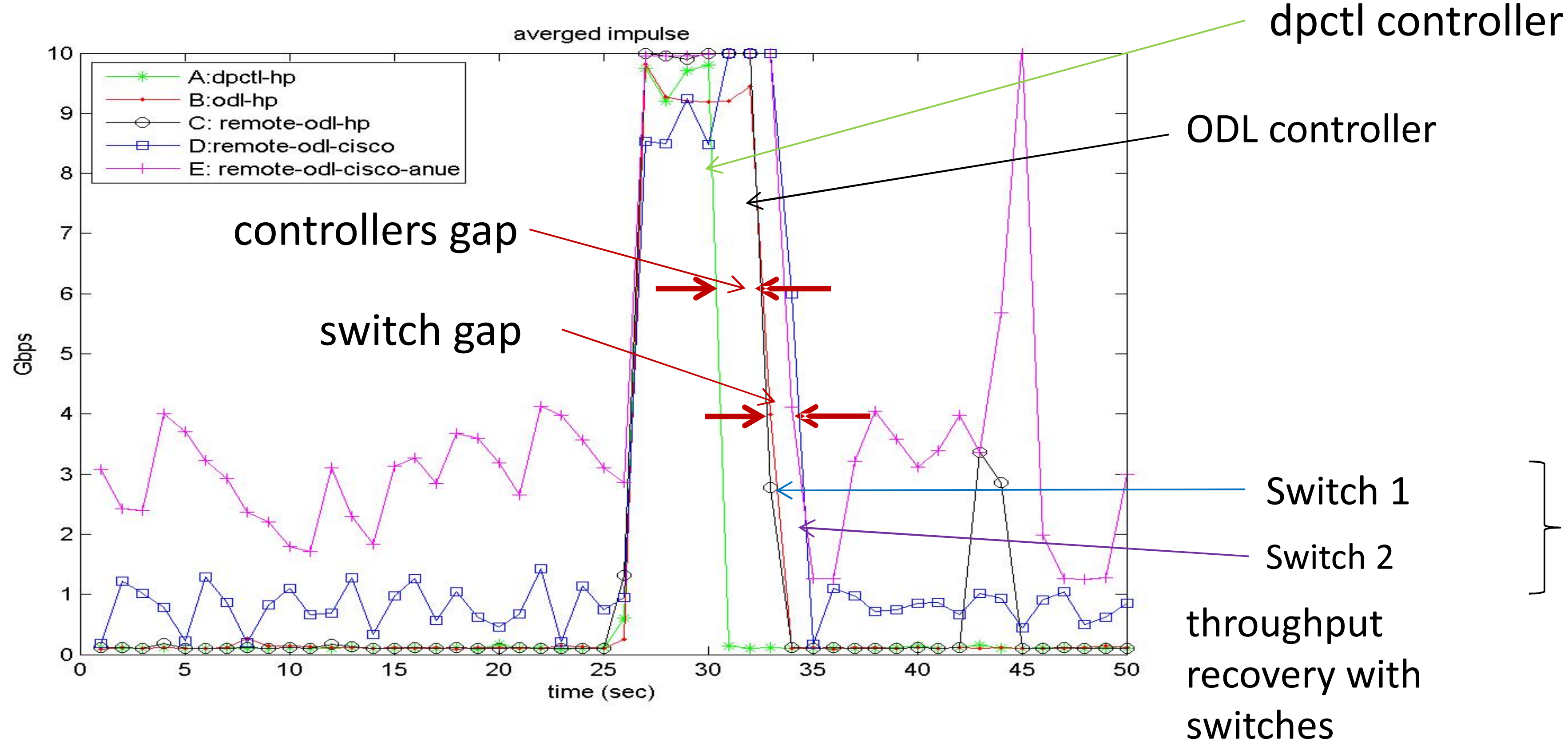
Impulse Response Methods:

- **Subject system to periodic forced path failovers:**
- **Keep track of TCP throughput at hosts**

Throughput recovery depends on:

1. **responsiveness of controller**
2. **responsiveness and flow implementation on switch**

Impulse Response: Estimated based on Measurements



Observations:

1. **dpctl controller is seconds faster**
2. **Switch 1 is faster than switch 2 by a few seconds**

Impulse Responses Provide Performance Information:

- **Sharp response implies fast recovery**
- **Width of response indicates how responsive recovery is**

Open Test Harness for Performance Testing

Concept:

General test harness for controllers and devices: normalized performance

- **plug in a new controller or device**
- **apply impulses and estimate response regression**
- **output: normalized performance**
- **public, open standard site/way to upload new controllers and devices**

Develop Canonical Test Scenarios: data center, LAN, WAN

- **Generic applications on hosts**
  - **data transfers**
  - **real-time monitoring and control**
  - **messaging, others**
- **Performance parameters: for controllers and switches**
  - **switching response times**
  - **number of flows handled per unit time**
  - **data throughput and jitter, others**

Develop Canonical Harnesses: Few neutral, open places house them

Desired Result: Vendors and open sources communities, publish performance results along with their product releases

NexComm 2016 Panel Discussion
ICN/COCORA/CTRQ/SOFTNETWORKING

Positioning Topic:

Identifier-Oriented Networking for IoT

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February 21 - 25, 2016
Lisbon, Portugal

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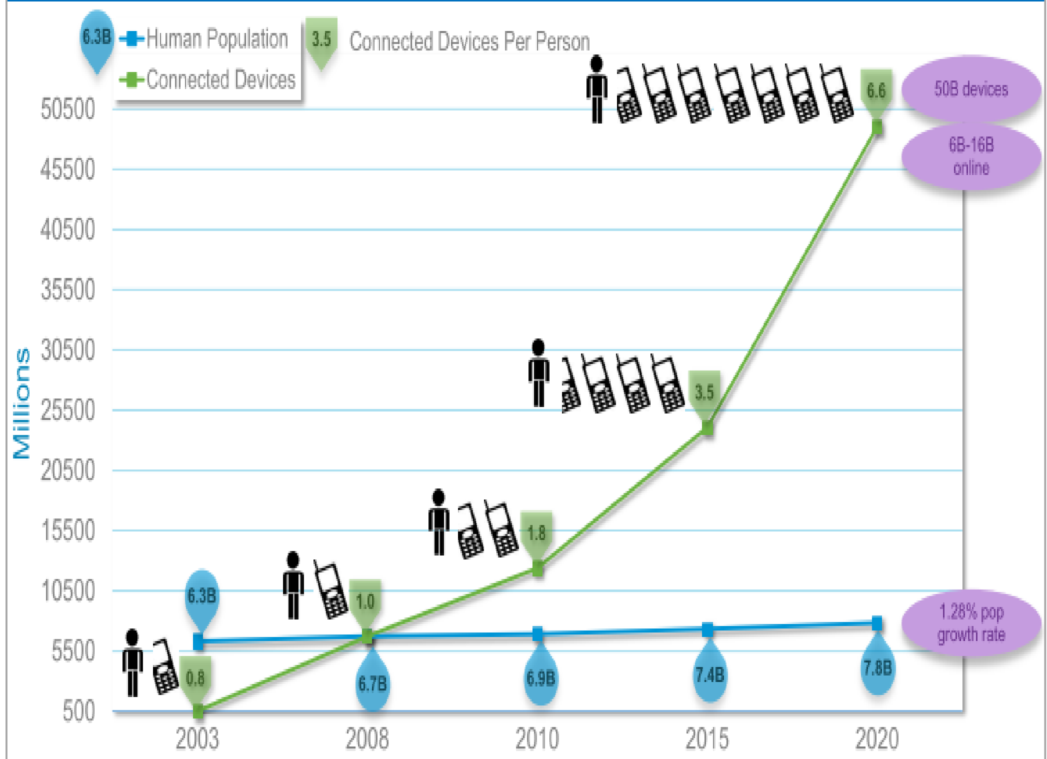
Do we need to Address Every IoT Device by IP?

Massive Connections and Traffic



- 50 billion things will be connected by 2020 (Cisco)

- More than 50% of internet bandwidth is used for M2M data traffic (IDC Predictions 2015)

Can not Address Billions of Things through traditional IP model

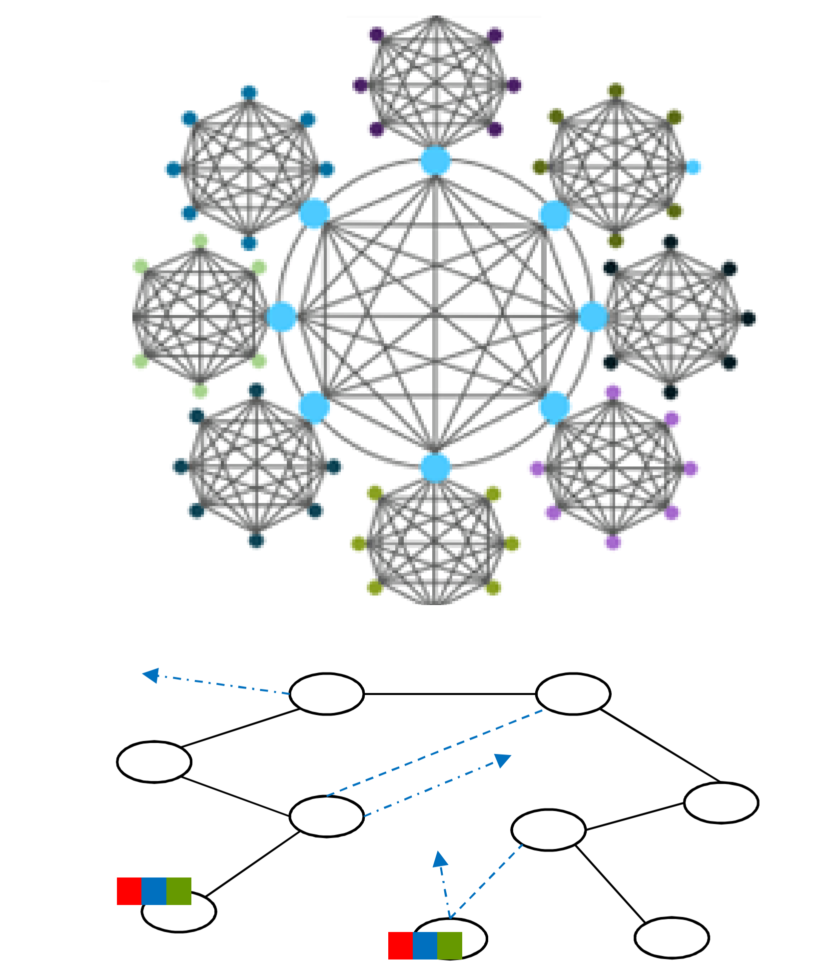
- Things are up and down due to low power
- Device Identity formats vary – sensor and application types
- Things may move more often than hosts/PCs

Can not scale connectivity with current IP Network Layer

- A device Identity is significant and needs its own plane in Internetwork layer model

IoT Device Characteristics

IOT vs. Traditional Internet

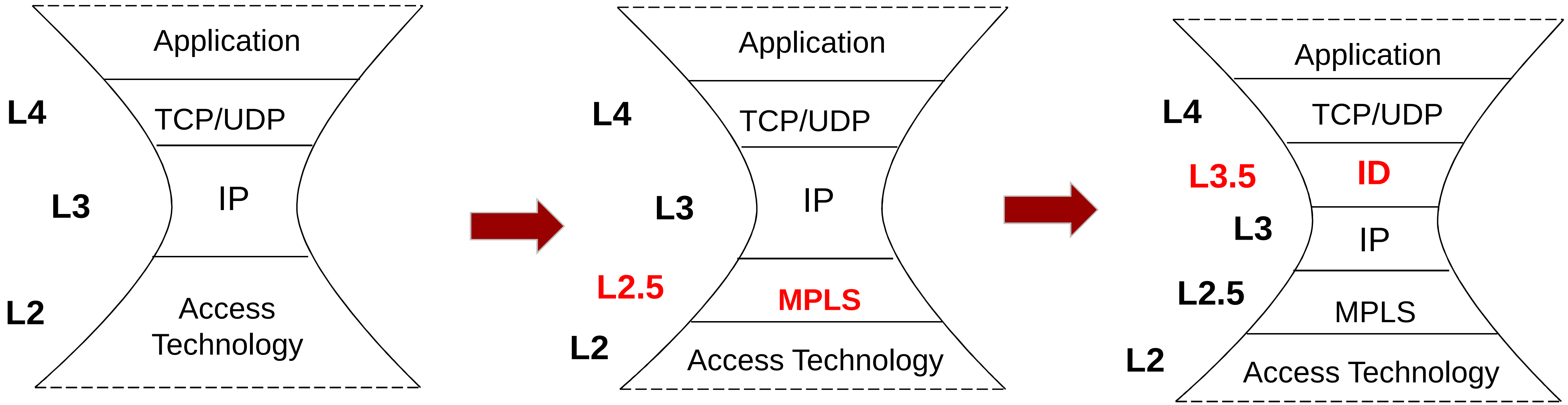


- Lightweight connectivity - low power, low throughput, low-performance CPU
- Things move, join or exit from a network dynamically
- Things have no stable adjacencies or gateways
- Things have varying degree of mobility - home-net (least), Industrial network, vehicle network (highest)

How to capture the above characteristics?

- Through Identity based intelligence

Identifier-Oriented Networking Protocol Stack



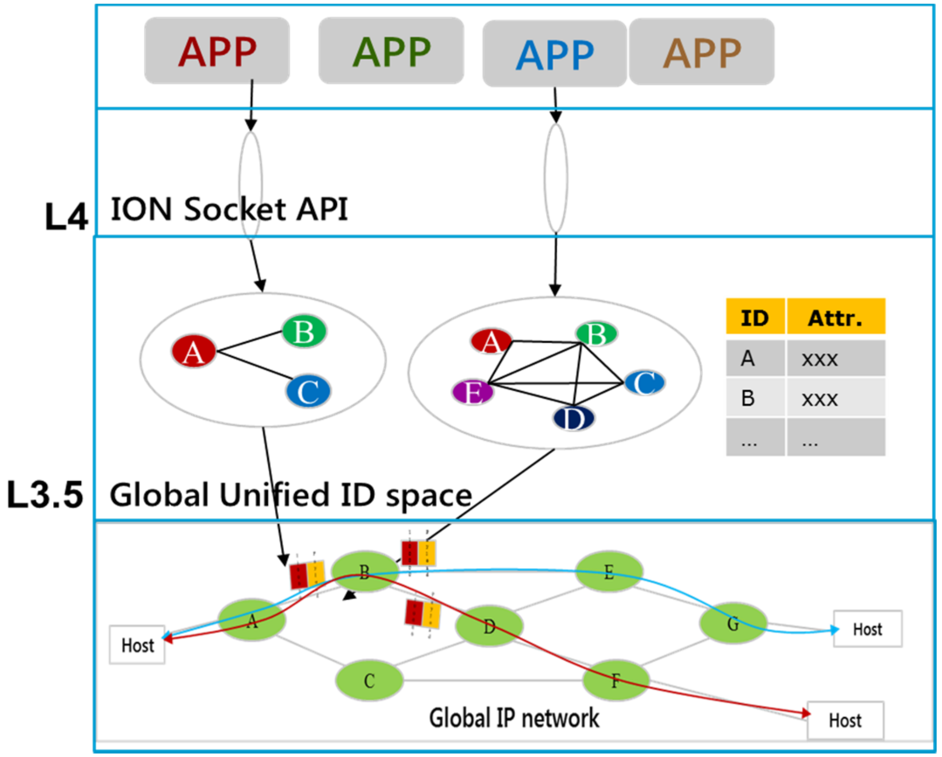
Current IP: Two Meanings of IP Addresses

1) Identity: What it is (Identity)
2) Location: Where it is (Location)

- ID for universal mobility and global reachability
- Locator for routing: address aggregation and longest prefix matching
- ID can represent user, host, content, and virtual network
- Locator varies from a place to another while ID keeps unchanged

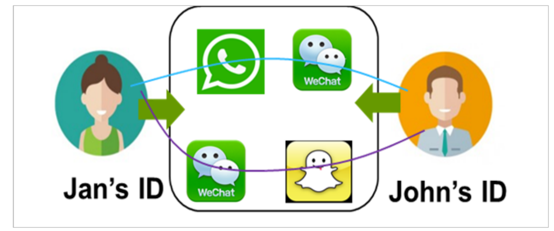
ION: Application Model

Enables Everything through an ID Aware Model

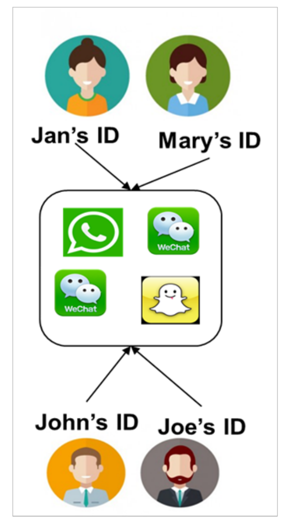


ION Sockets

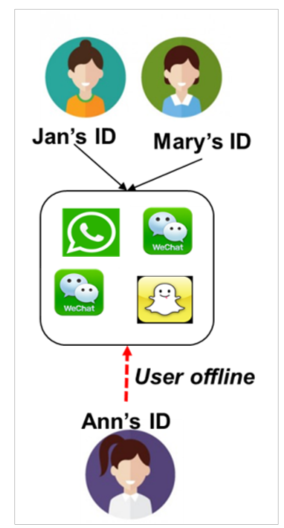
- Applications connect with ID based sockets
- IP layer locates source and destination ID accurately and sets up path



1. Point to Point



2. P2MP & MP2MP



3. Asynchronous

Easier To Manage Communication Relationships with IDs

1. **Point to Point**
   - Single ID For Multiple Applications
   - Cross-application Channels
2. **Group Communication with ID**
   - Both P2MP and MP2MP
   - Same as (1)
3. **Support Active/Passive Comm.**
   - Synchronous when ID is online
   - Asynchronous when offline.

Unified ID Space

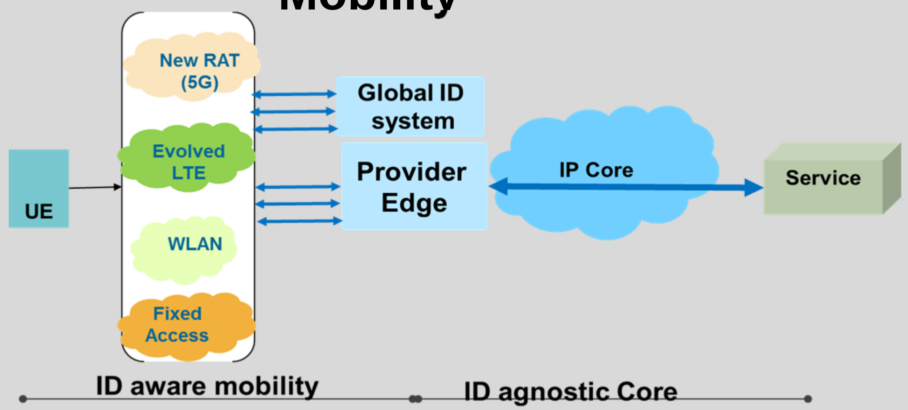
- All apps get same unique ID ('who is').
- ID Mapping system ensures ID is unique and globally accessible

ION: Examples

- **MobilityFirst**
  A project funded by USA NSF in Future Internet Architecture (FIA) program
- **LISP**
  Location Identifier Separation Protocol
- **SLIM**
  Separation for Location and Identifier for Mobility
- **HIP**
  Host Identity Protocol
- **HIMALIS**
  Heterogeneity Inclusion and Mobility Adaptation through Locator ID Separation
- **LINA**
  Location Independent Network Architecture
- **GSE**
  Global, Site, End system

ION Unlocks New Opportunities Beyond Mobility

Mobility

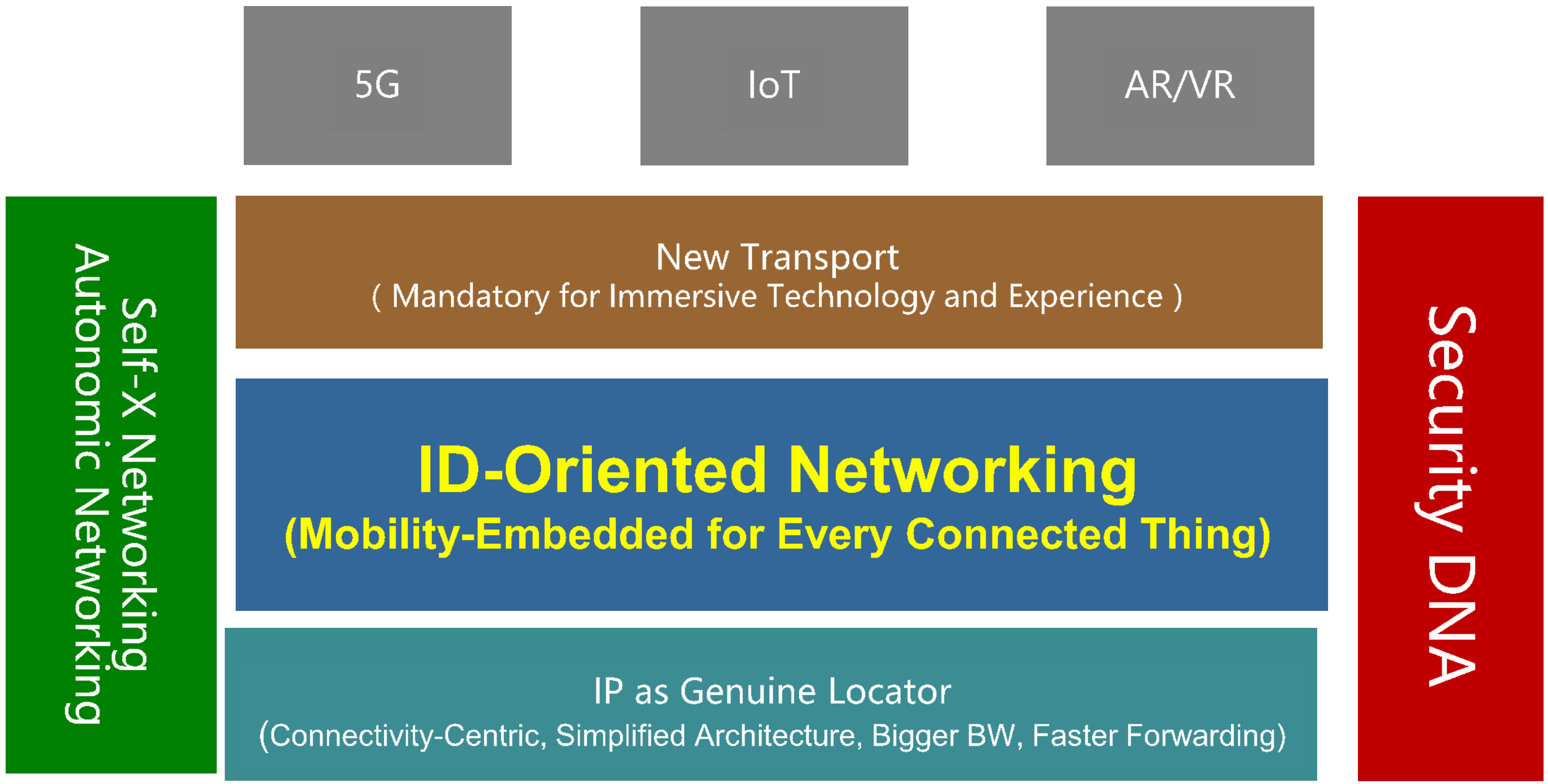


- ❑ **Delivers Better Service Experience**
  - **Optimal traffic path selection**
  - **No detours to mobility anchor point**
- ❑ **Simplified Network Operations**
  - **Unified ID plane for any fixed and mobile access**
- ❑ **ID Agnostic Stable Core**
  - **FIB remains locator based**
  - **As user moves, no route change triggers**

Benefits and Opportunities from Layer 3.5

- ❑ **L3.5 Communication**
  - **P2P Communications without servers**
  - **Cross-silo communication possible**
  - **ID based Group-communication (PIM free)**
- ❑ **Accelerated applications deployment over L3.5**
  - **Network/Topology change agnostic**
  - **Focus on business logic not network**
- ❑ **Refined L3.5 Edges**
  - **Fine grained ID aware TE, Policy, LBs**
  - **ID based End to End Security**

Huawei's IP2020



Thank you

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