leti
cea tech

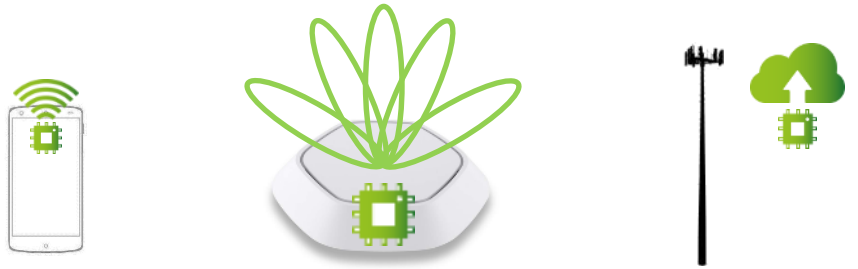
NEITHER IOT NOR 5G WITHOUT NEW TECHNOLOGY!

lionel.rudant@cea.fr | 13th International Conference and Exhibition on Device Packaging | Foutain Hills, USA | March 7th, 2017

OUTLINE OF THE DISCUSSION

Motivations

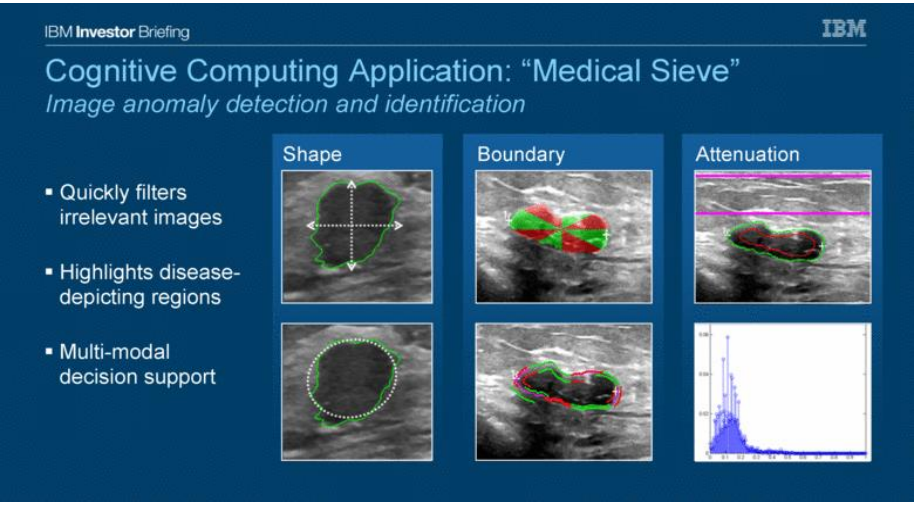
Technology



New motivations for new technology

INNOVATIONS OF THE HIPPEST

Artificial Intelligence



Machine Learning from annotated data on internet

Robotics

Cooperating social machines
M2M internet

New digital User eXperience

After gaming, social networking on internet, merge of cyber & physical

- **Technology strikes back in innovation!**
- **Concrete revolutions in lives and societies**

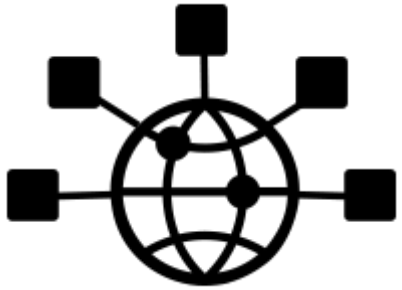
THE INTERNET

Internet
Key enabling technology of “digital” revolution

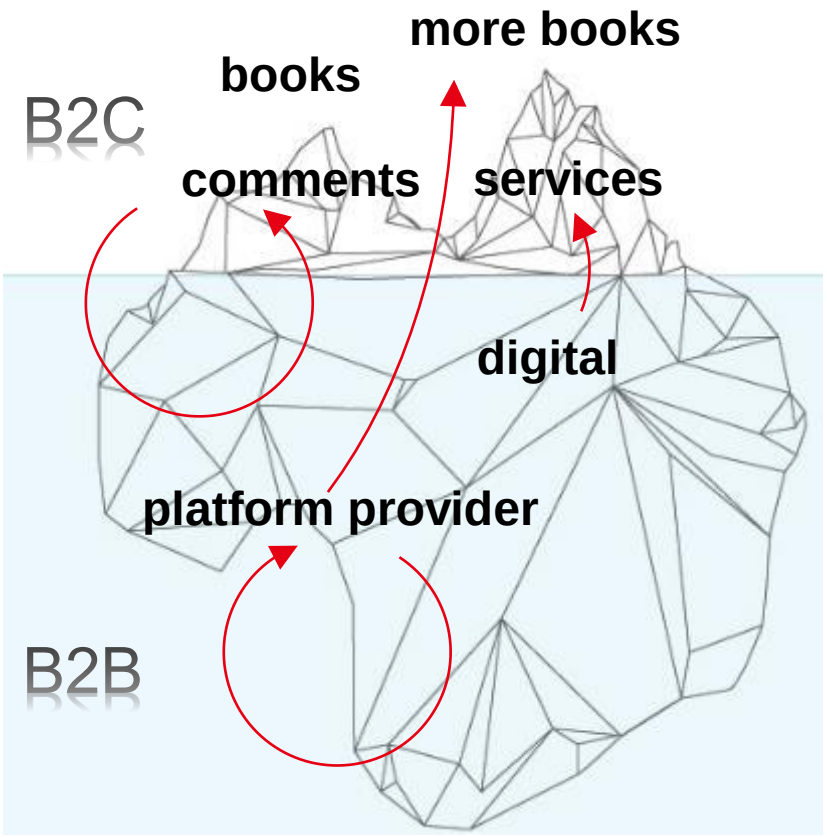
Global network

Personal services

Cyber-physical



DISRUPTION TO THE BUSINESS MODEL: PLATFORMS ON THE INTERNET



amazon.com

42,547
4.2 out of 5 stars
5 star 62%
4 star 17%
3 star 8%
2 star 5%
1 star 8%
See all 42,547 customer reviews

amazon Prime

amazon kindle

Google play

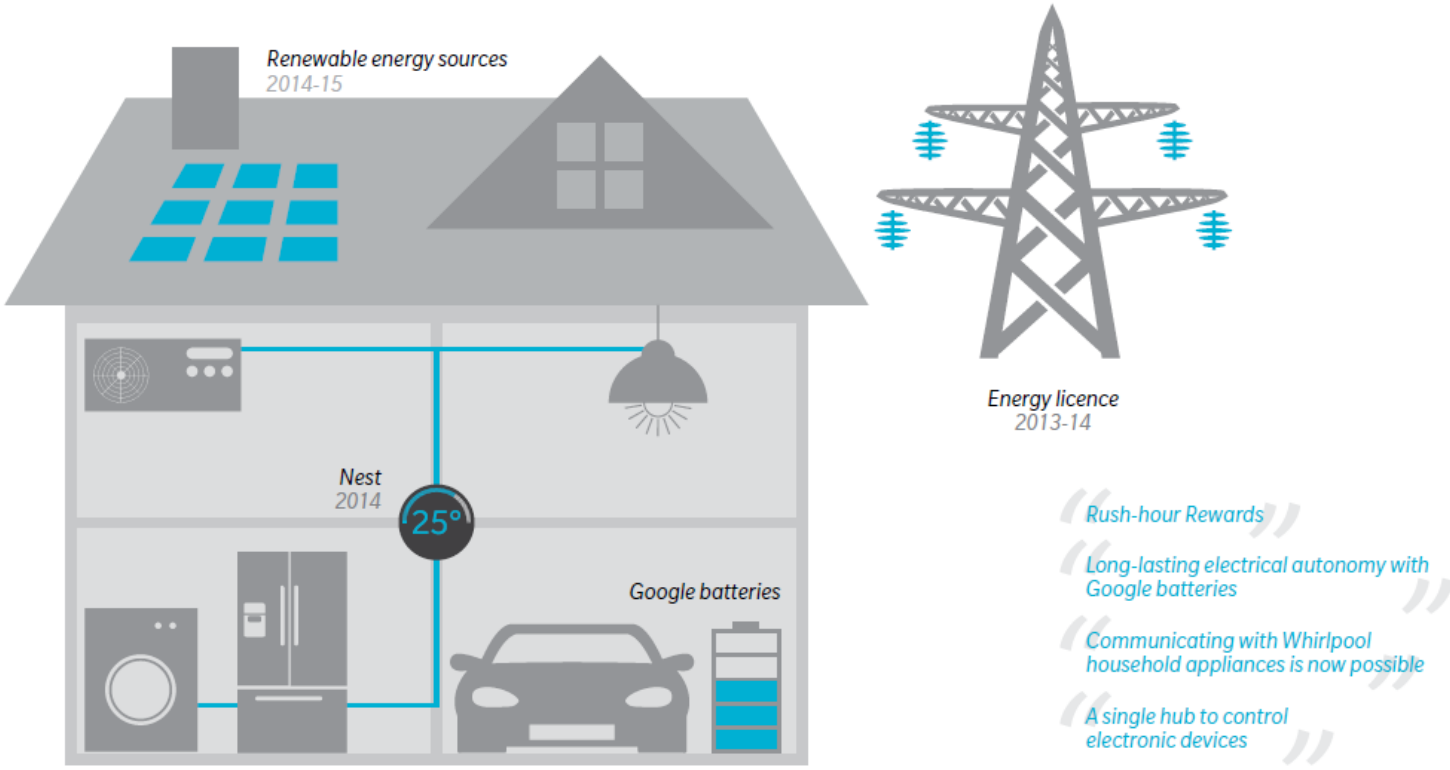
amazon.com marketplace

amazon Plate-forme Auteurs

amazon web services™

DISRUPTION TO THE BUSINESS MODEL: ENERGY

Exhibit 7: Could Google – or Orange – become your power service provider?

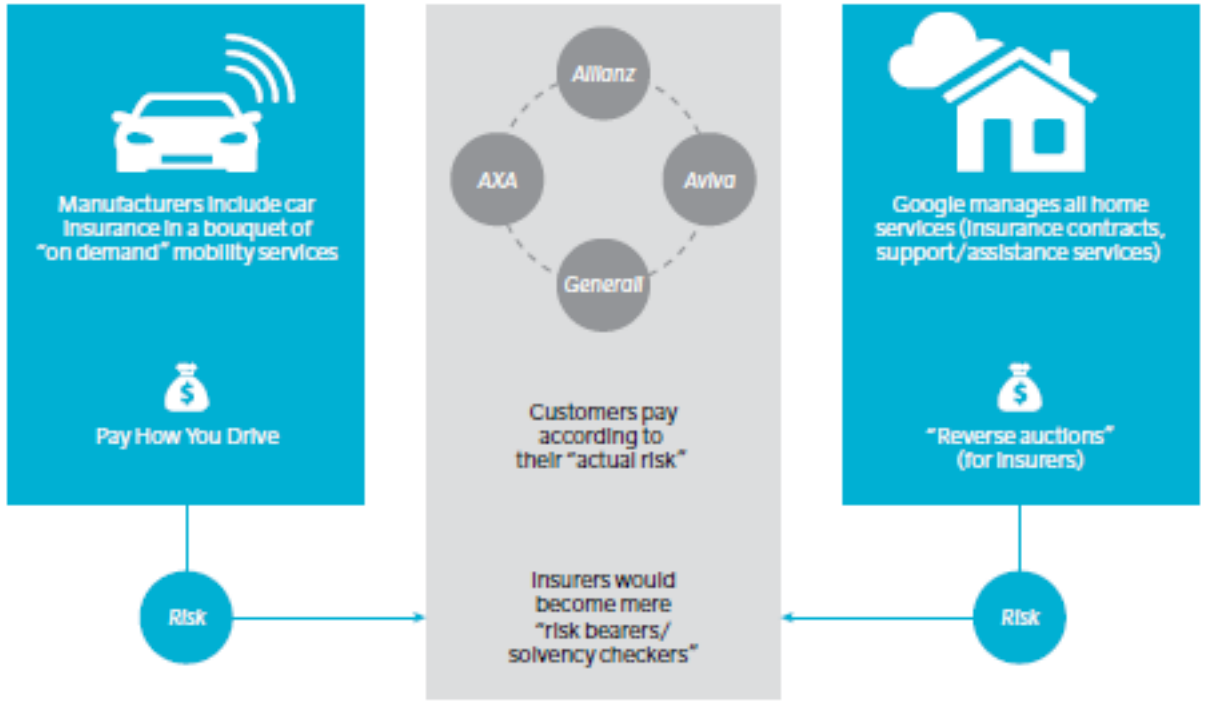


Source Oliver Wyman

Google has a license to purchase and distribute power.
Offerings which do not require any specific action by the customer

DISRUPTION TO THE BUSINESS MODEL: INSURANCE

Exhibit 4: Peugeot would become your car insurer, Google your home insurer



Source Oliver Wyman

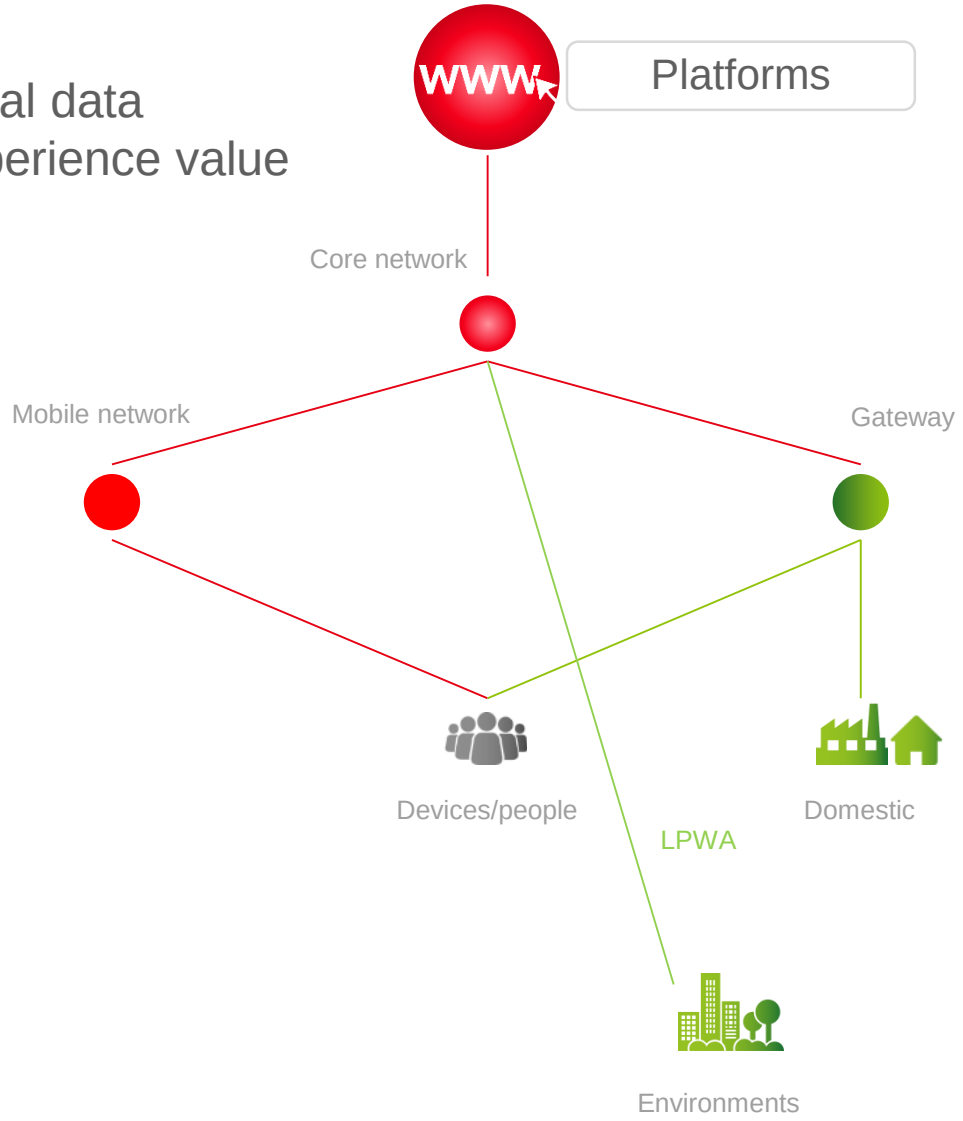
Other examples:

- Withings as heath insurer
- Trimble as vineyard insurer

FROM TODAY'S IOT…
KEY BARRIERS TO ADOPTION

Centralized platforms
- Zero marginal value of additional data
- Limited functional and user experience value

Vertical network
- High connectivity costs
- Privacy and security concerns



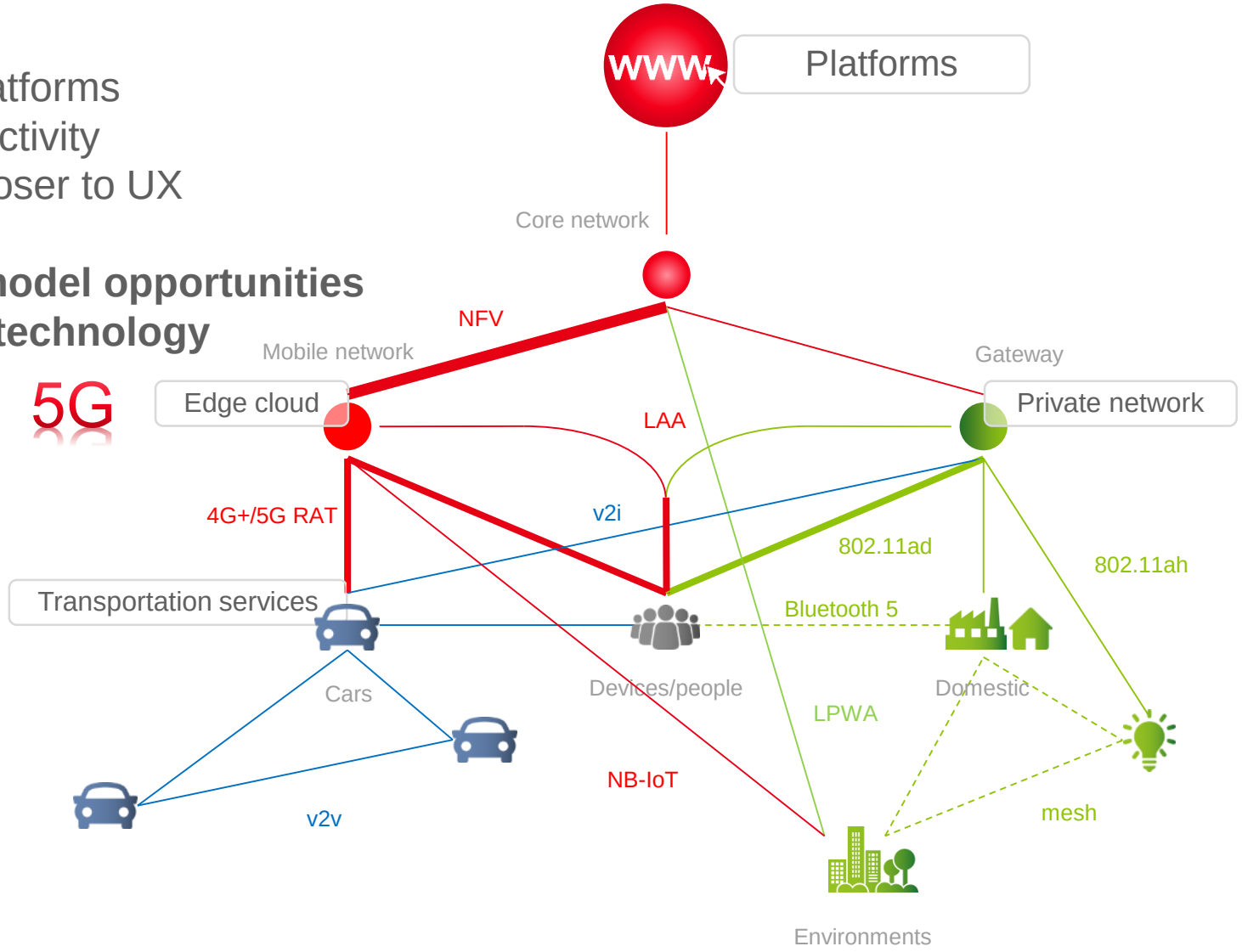
… TOWARDS INTERNET OF EVERYTHING
ONGOING ICT ROADMAPS

Innovations

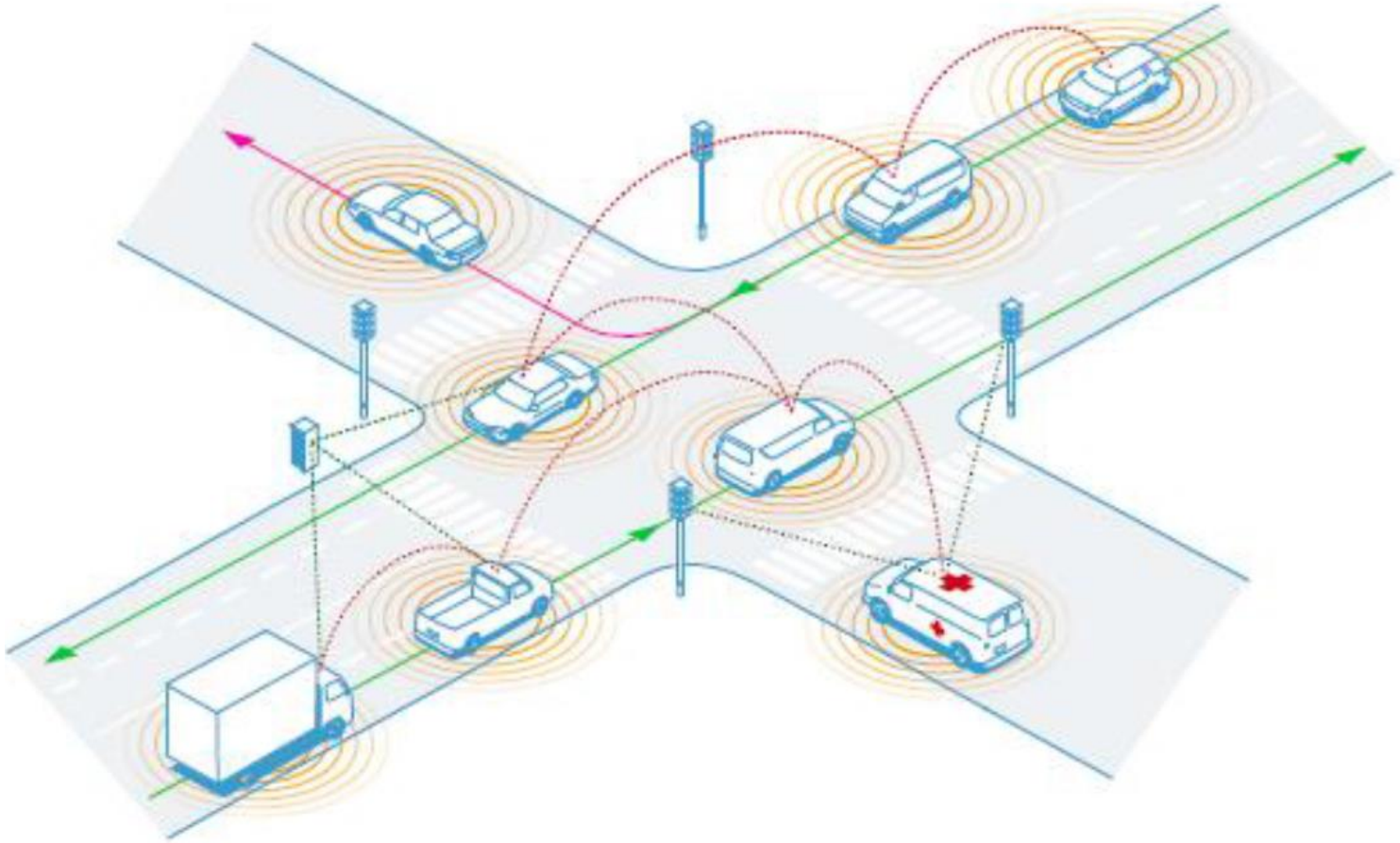
- Decentralized platforms
- Horizontal connectivity
- Value creation closer to UX

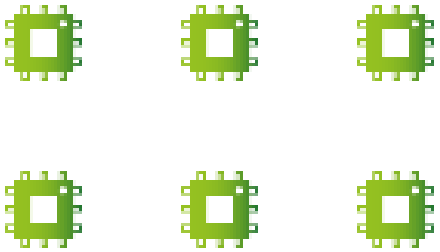
⇨ **New business model opportunities**

⇨ **Motivations for technology**



E.G. COOPERATIVE INTELLIGENT TRANSPORT SYSTEM C-ITS

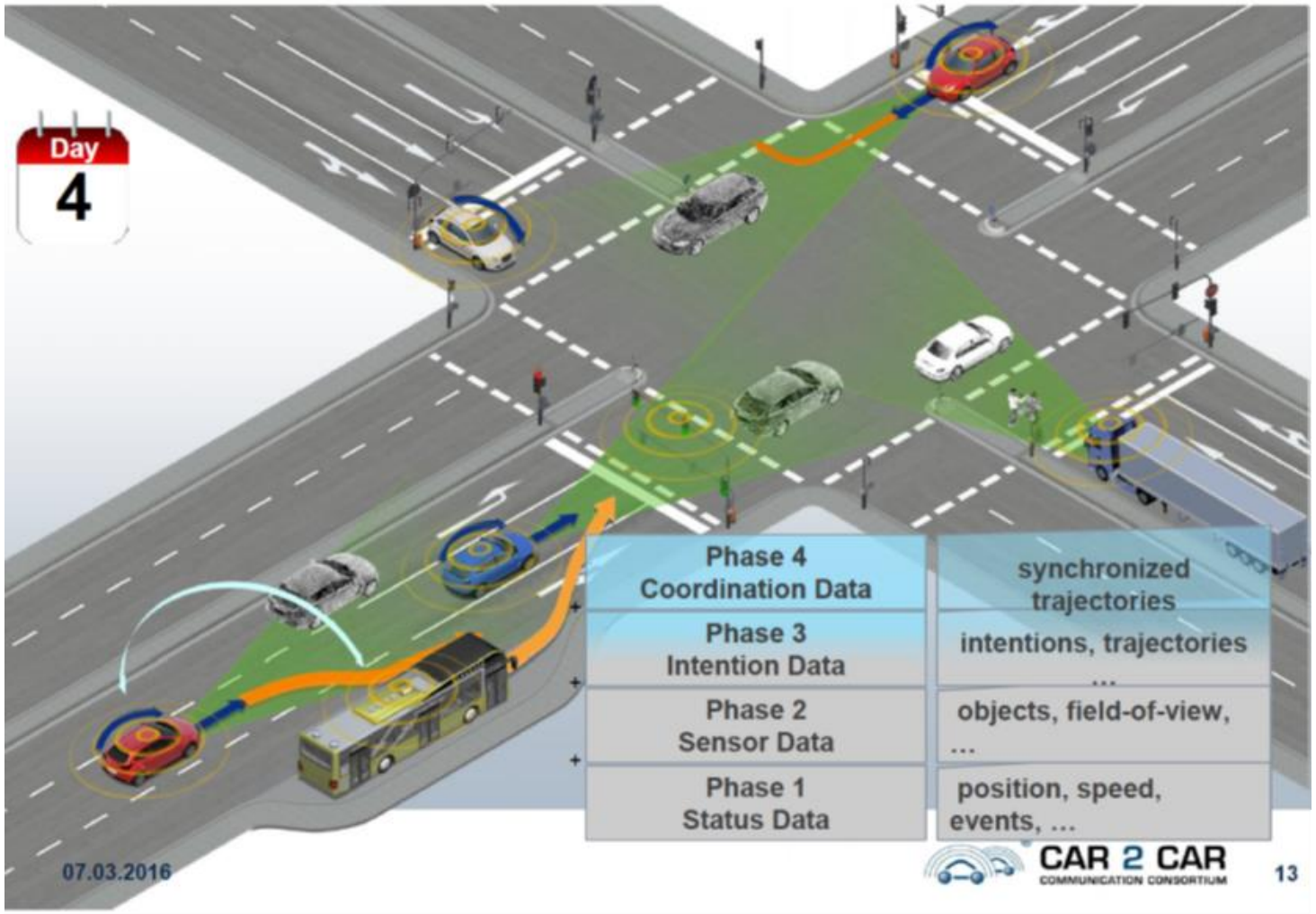




C-ITS electronic components

- Sensors
- ADAS
- GNSS
- …

AUTOMOTIVE CONNECTIVITY ROADMAP
V2X - STANDARDIZATION OF PROTOCOL AND APPLICATION LAYERS



V2X-BASED COOPERATING POSITIONING

GNSS information
Cooperative Awareness Message (CAM)
RSSI information

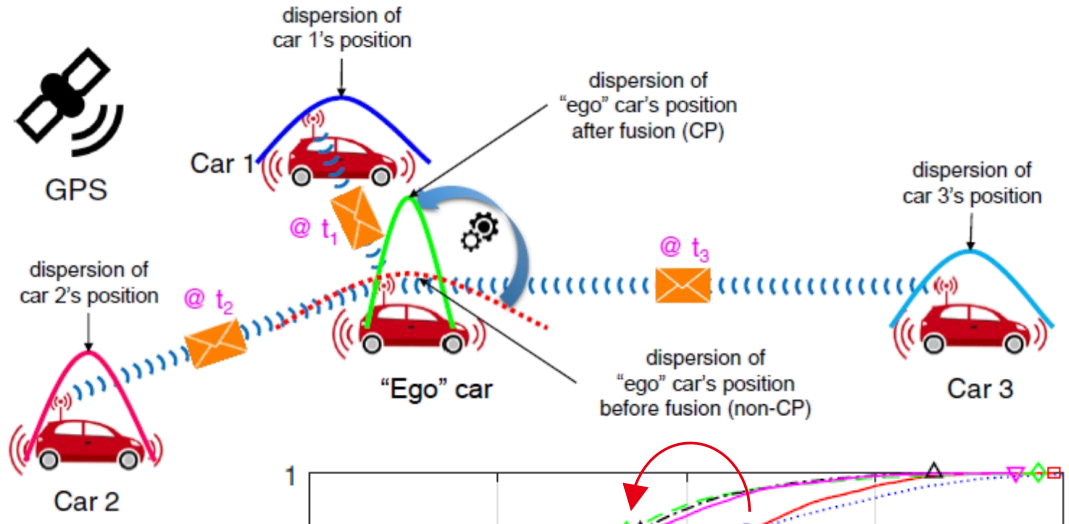
Non-linear hybrid data fusion, particle filter

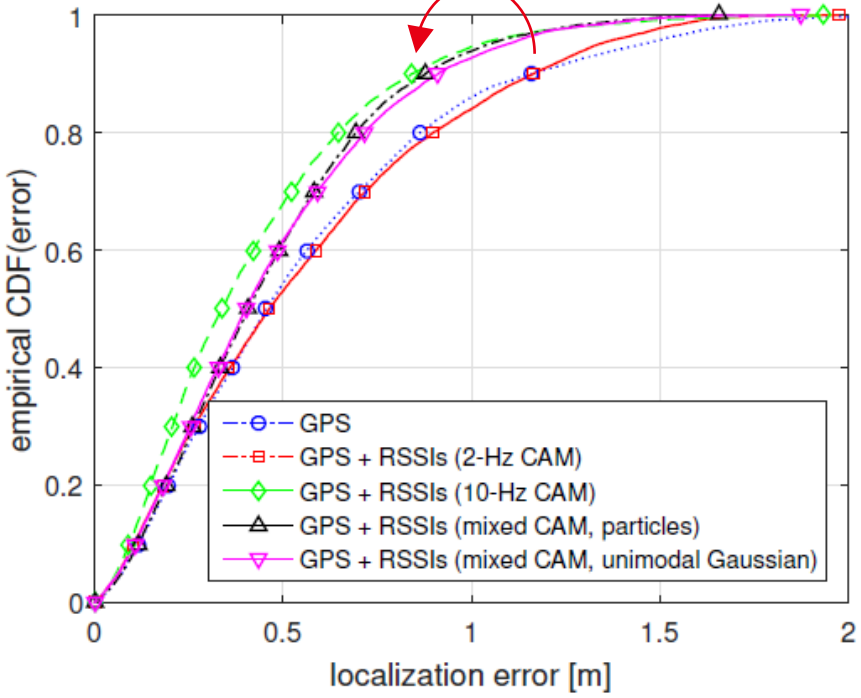
Performance and v2v channel overload?
Parametric density approximation
Adaptive transmission payload, power and rate

Results for 3-line highway, 110km/h, 3km
Decimetric-accurate geo-localization

Requirements for GNSS integrated systems?

Source: Leti, HIGHTS Eu project





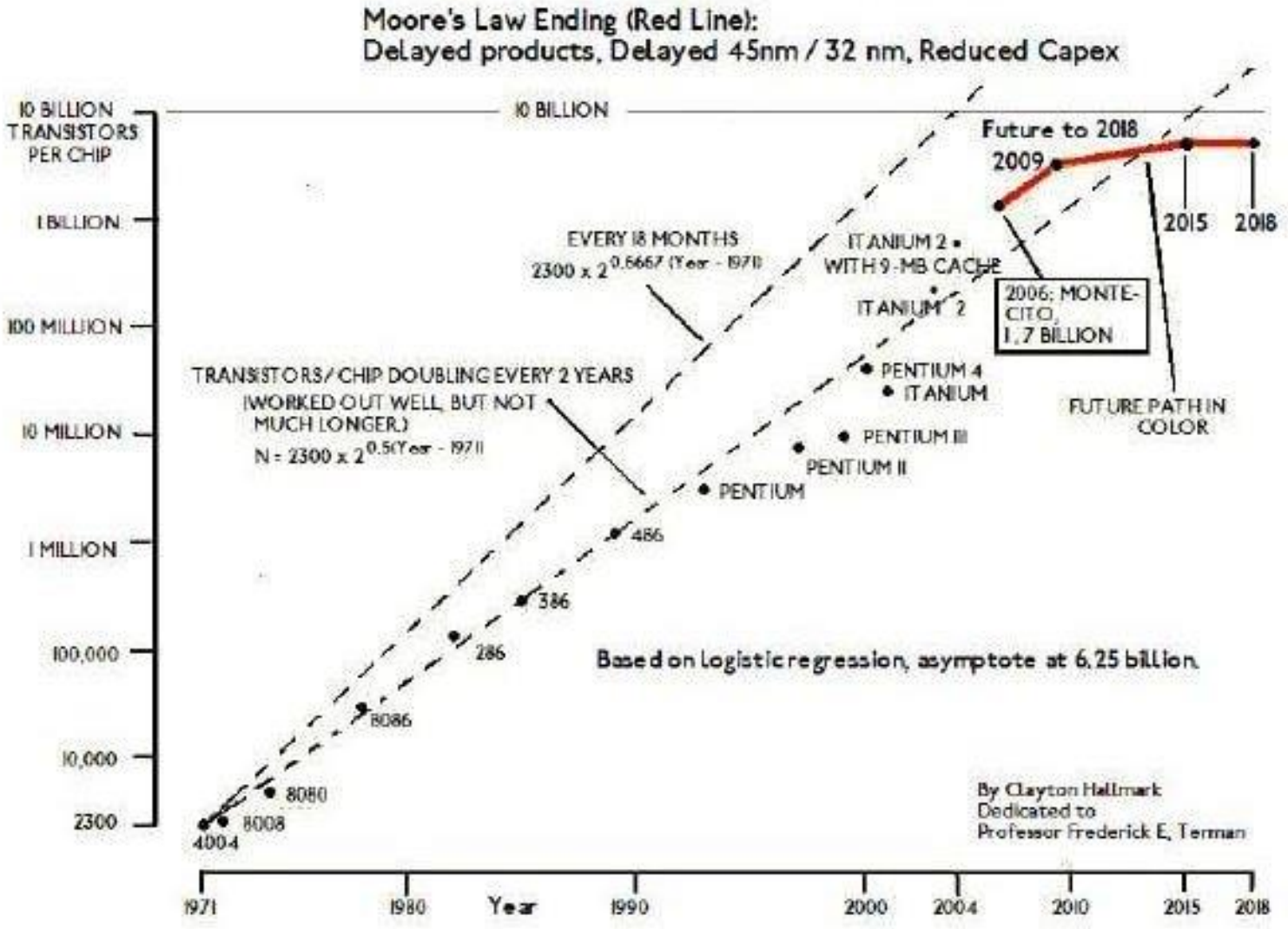
HIGHTS

NEW MOTIVATIONS FOR NEW TECHNOLOGY

- The internet continues disrupting to business models.
- ICT roadmaps will unleash IoT market growth.
- Electronics will be defined in a network perspective.

Technology/system roadmap

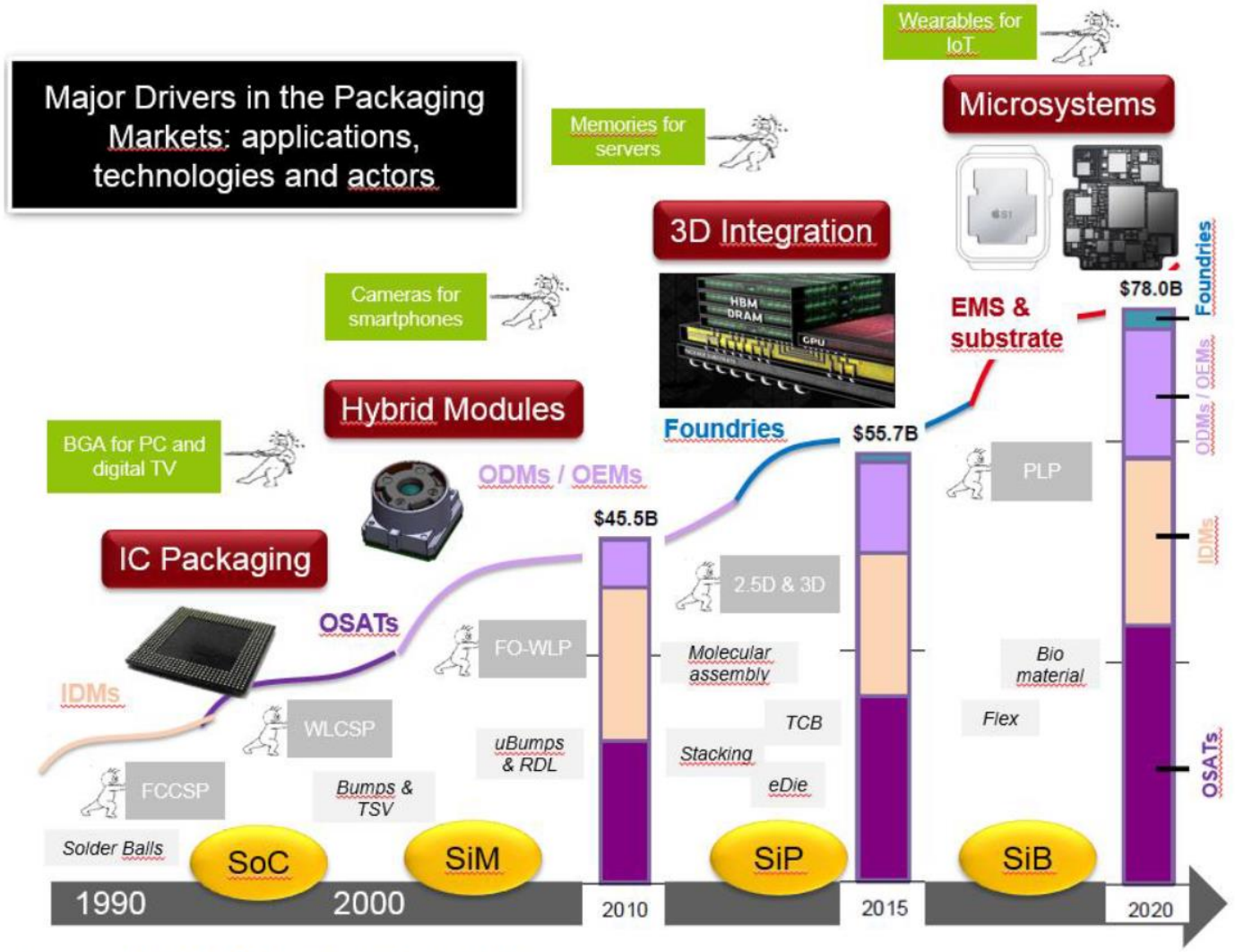
NEW ROADMAPS OF MICRO NANO TECHNOLOGIES
MOORE'S LAW ENDING



NEW ROADMAPS OF MICRO NANO TECHNOLOGIES
TECHNO-PUSH & SYSTEM-DRIVEN

Packaging roadmap for heterogeneous integration

- System-In-Board (SiB)
- Fan Out Wafer Level Packaging (FO-WLP)

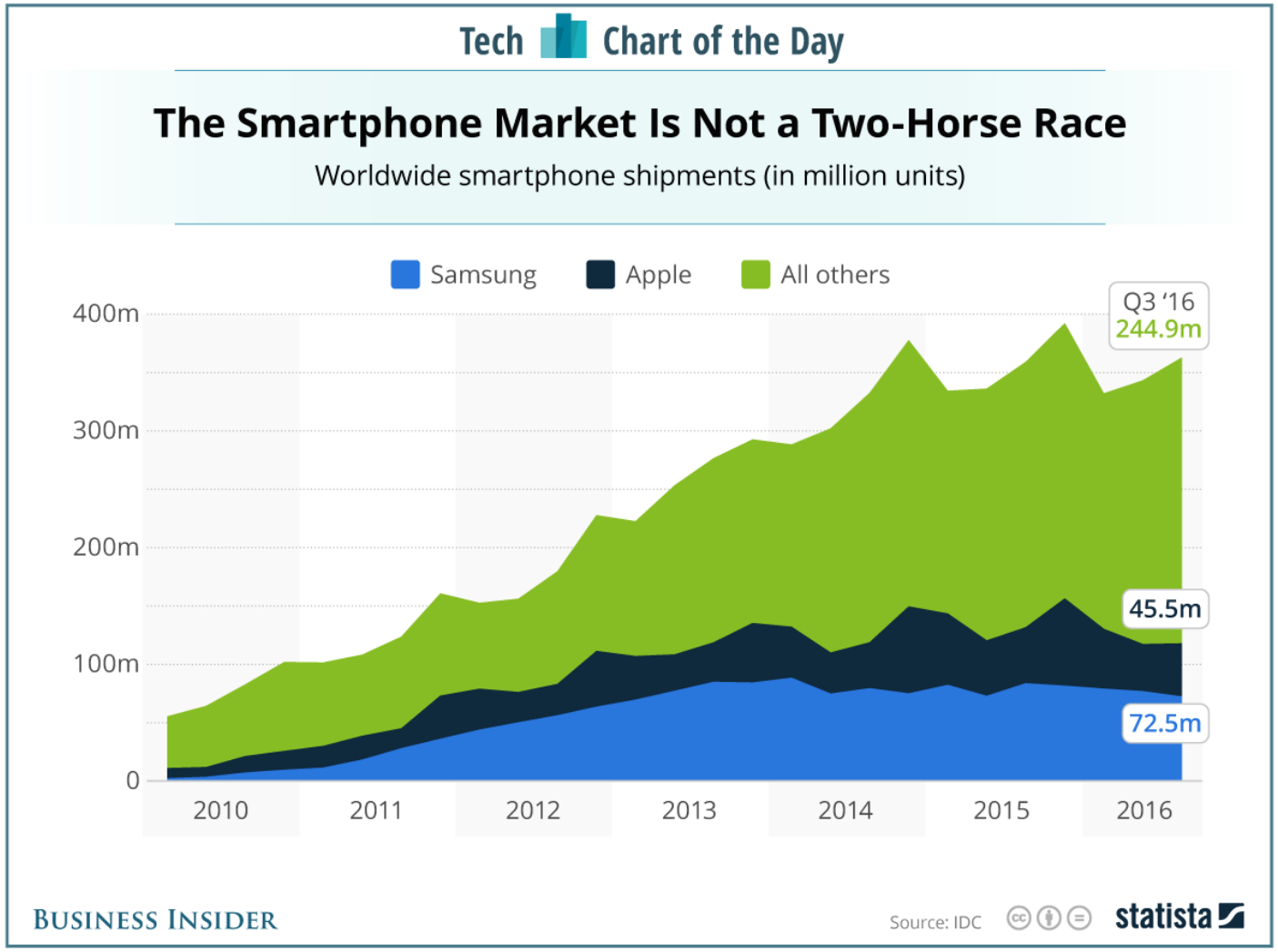


Sources : IBS 2016, ASE MepTec 2015, IEEE 2016

NEW ROADMAPS OF MICRO NANO TECHNOLOGIES SMARTPHONE DRIVER

10th anniversary of IPhone
Golden age: volume, revenue, value, renewal

Smartphone is becoming commodity.
Limited growth and hype…

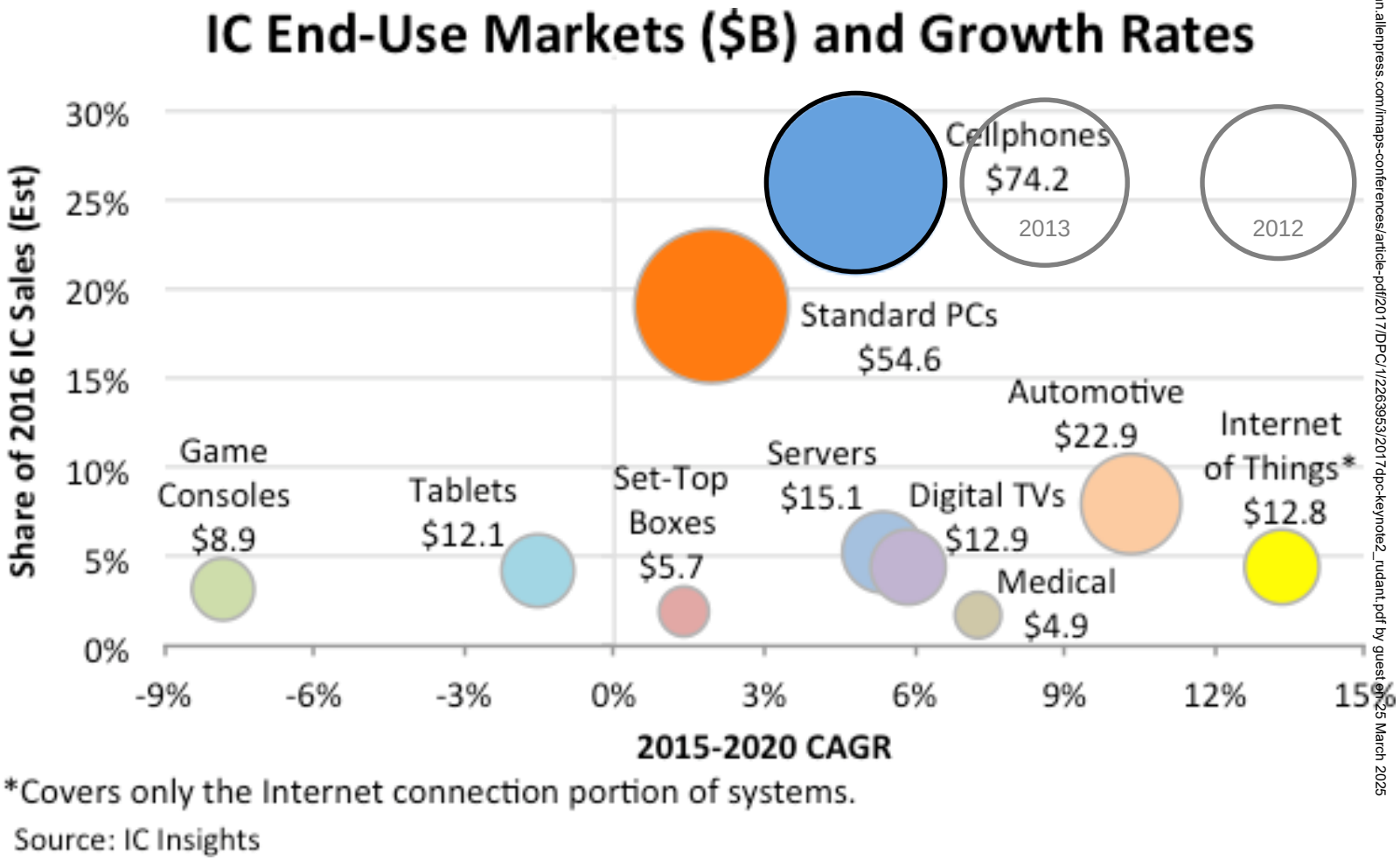


NEW ROADMAPS OF MICRO NANO TECHNOLOGIES
NEW DRIVERS

New market drivers

Automotive
Electronics' part in car's value
Needs change in car's ownership

IoT
Diverging services
Industrial applications should drive.



4G+/5G TIMELINE
#MWC2017

New 5G logo from 3GPP

3GPP timeline	Rel-12	Rel-13	Rel-14	**Rel-15**	**Rel-16**

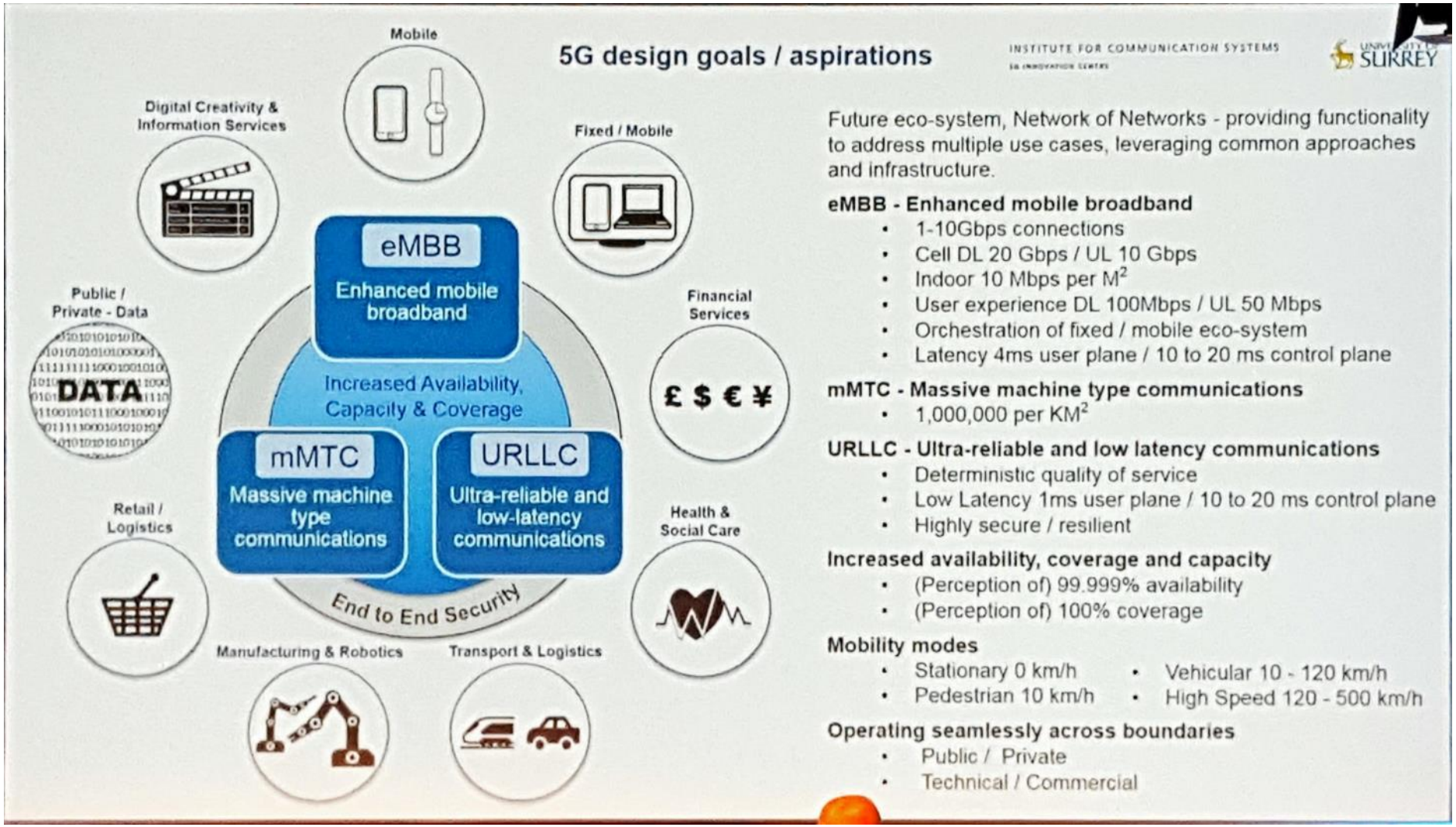
2014	2016	2018	2019	2020	2022
		Olympics Korean	ITU WRC	Olympics Japan	FIFA Quatar

5G-like NB-IoT and Gigabit Lte

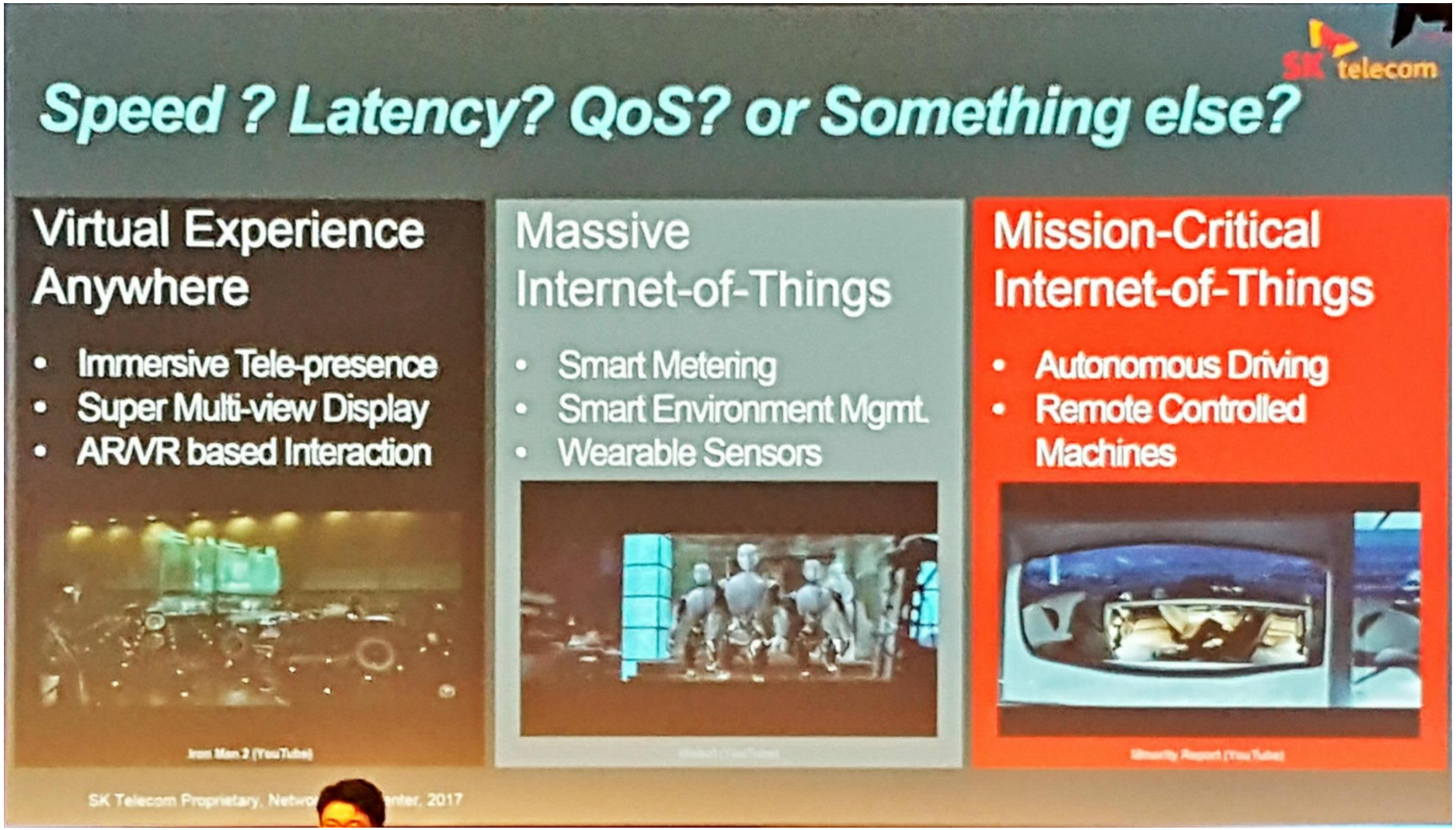
First pre-commercial trials in Pyeonchang

First commercial 5G (KT/SK)

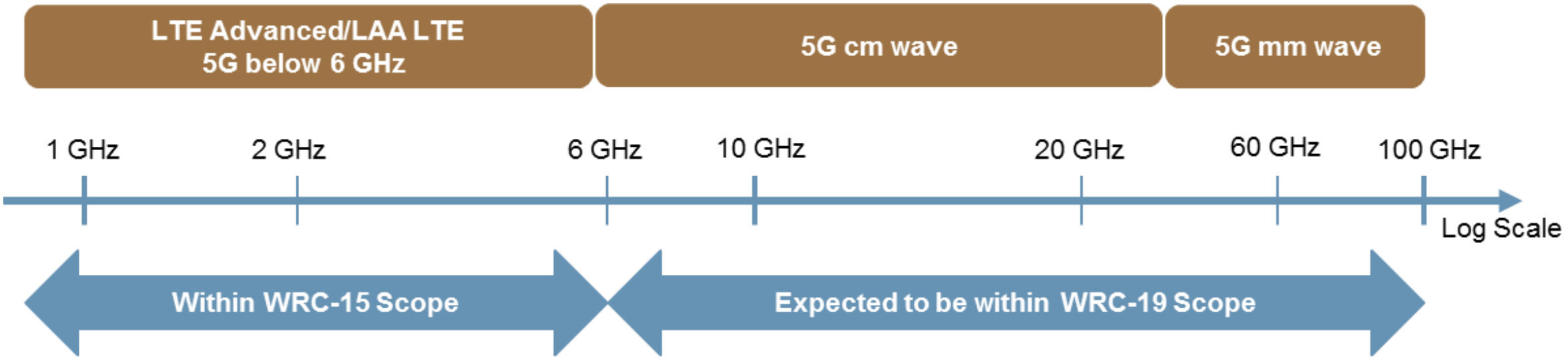
5G REQUIREMENTS, ITU 2017
#MWC2017



5G APPLICATIONS, 5G VERTICAL INDUSTRIES #MWC2017

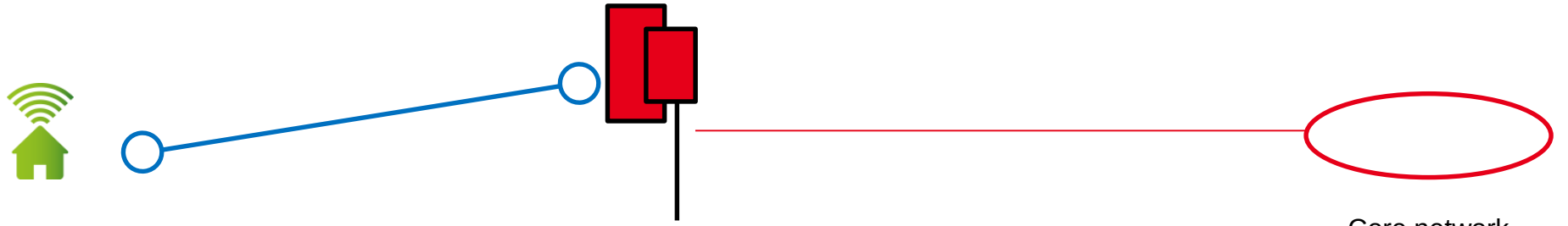


EXTRA SPECTRUM RESOURCES



Source: Nokia

MMWAVES IN 5G-LIKE APPLICATIONS & 5G NETWORK ARCHITECTURES

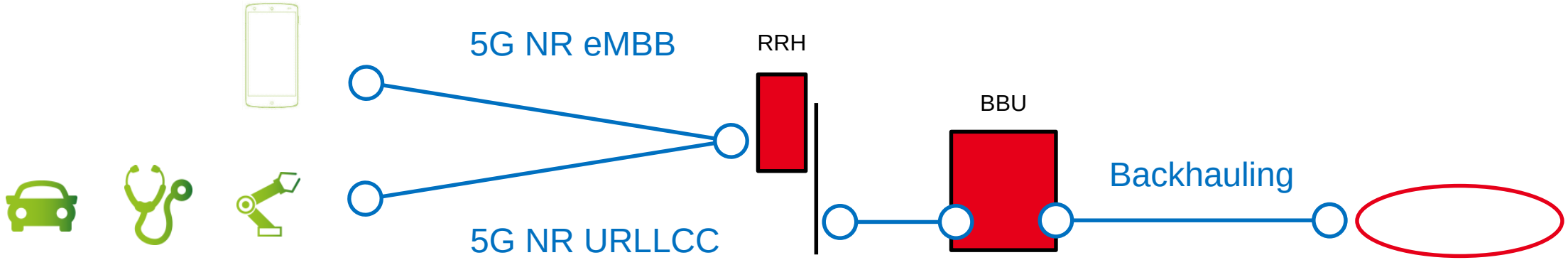


Fixed Wireless Access (FWA) to high-speed internet

Core network

5G-like Gigabit Lte
NB-IoT

Backhauling



5G NR eMBB

5G NR URLLCC

RRH

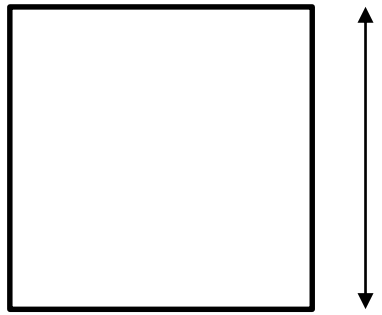
BBU

Backhauling

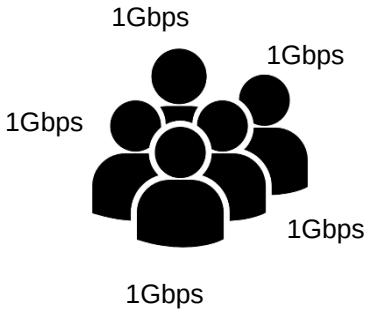
Fronthauling

C-RAN architecture

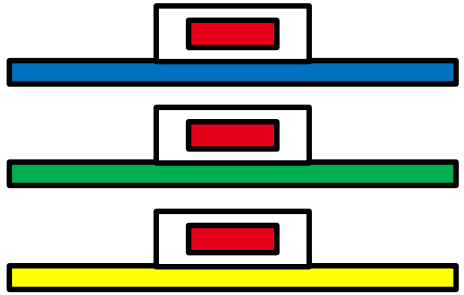
CHALLENGES OF THE MM-WAVE AIR INTERFACE



Large antenna array for long range
with tracking capability



Multi User Multi Input Multi Ouput (MIMO)



Cost-effective 5G solution, generic IC & per-application module

FWA

Backhauling

Fronthauling

5G NR eMBB

5G NR URLLCC

MM-WAVE AIR INTERFACE CHALLENGE
FUNDAMENTAL APPROACHES

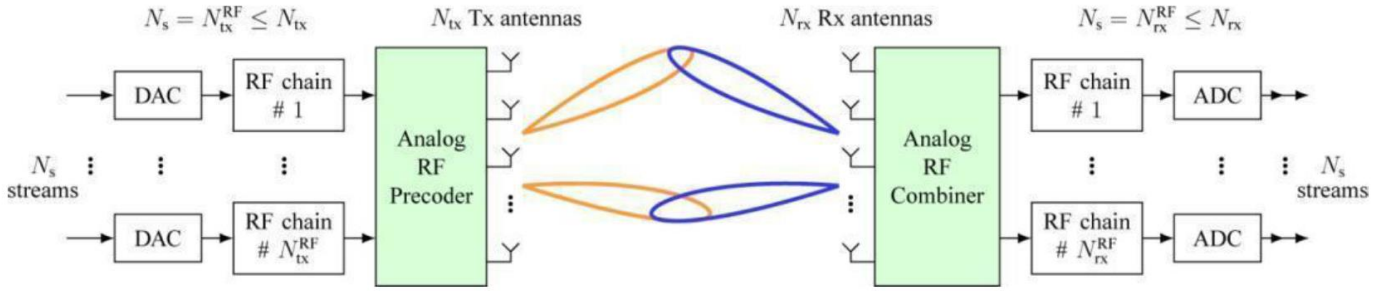


Figure 3-3: Analogue RF Beamforming Architecture

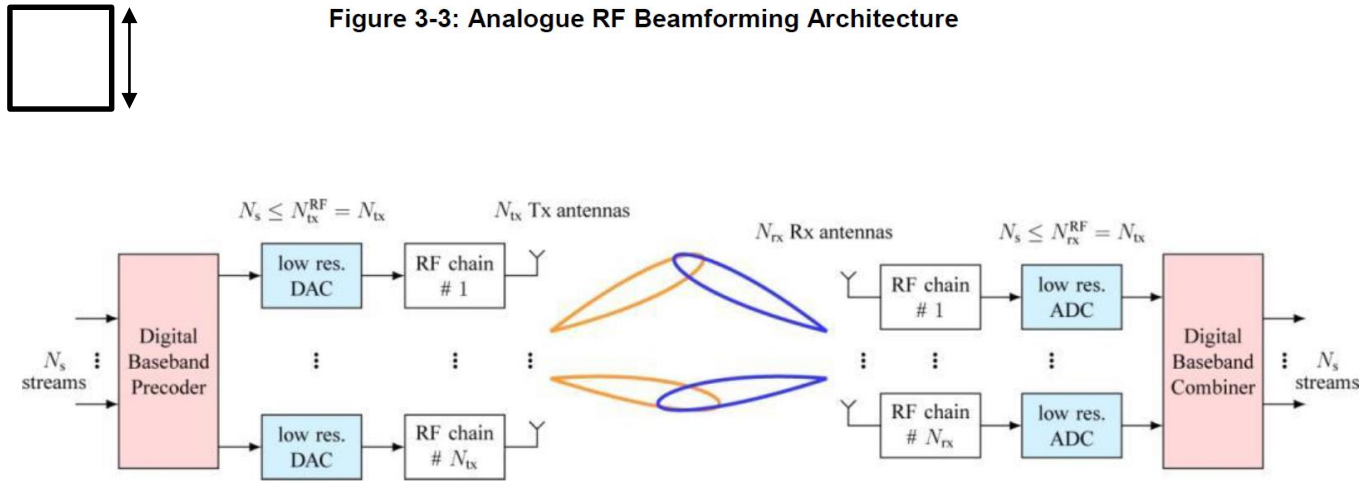
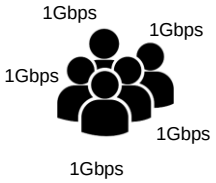


Figure 3-4: Digital Beamforming with Low Resolution Converters



- RF or IF
- Today: high-end radars, 60GHz indoor 802.11ad
- Phase/amplitude or Delay lines

☺ Best for coverage, antenna gain

☹ Frequency flat

☺ Frequency selective, best for flexibility, multi-user access

☹ Large amount of high resolution converters, if low resolution MIMO channel estimation and data detection are difficult.

MM-WAVE AIR INTERFACE CHALLENGE
HYBRID BEAMFORMING ARCHITECTURES

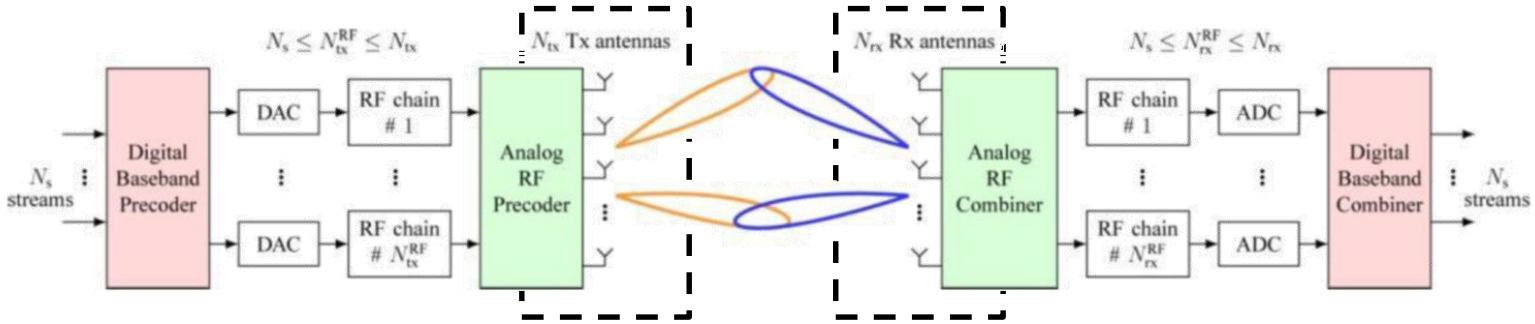
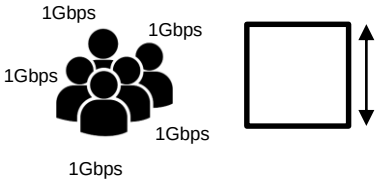
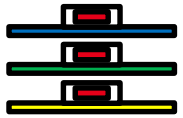


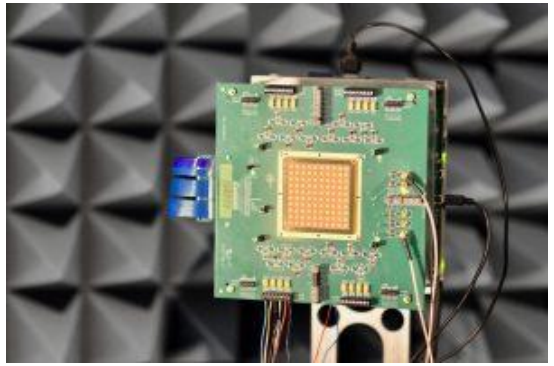
Figure 3-5: Hybrid Beamforming with Analogue RF Beamforming

- ☺ Coverage and flexibility according to applications' requirements
- ☹ Getting Channel State Information is difficult because of the analog precoder.
- ☹ RF/Digital Base Band co-design



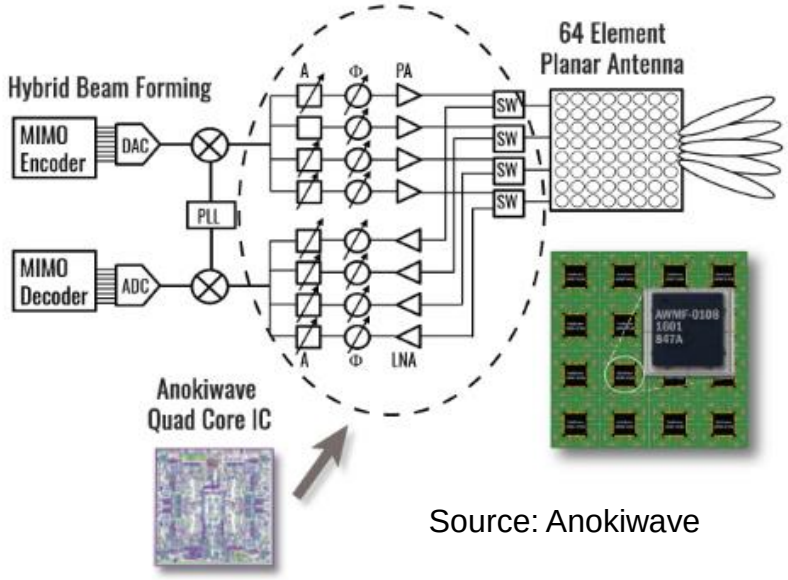
In-package integration





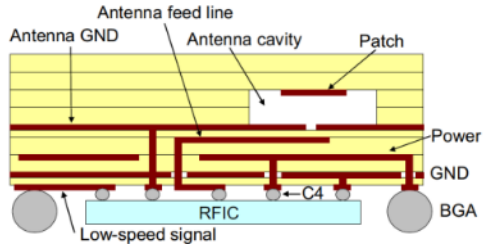
Source: IBM, Ericsson

Source: IMEC



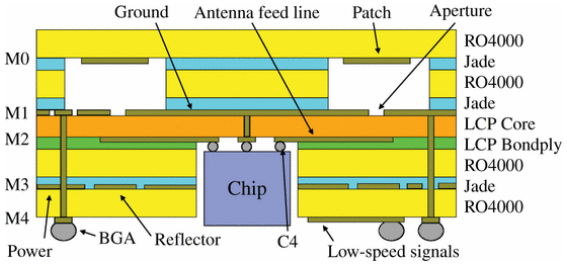
Source: Anokiwave

ANTENNA IN PACKAGING TECHNOLOGIES



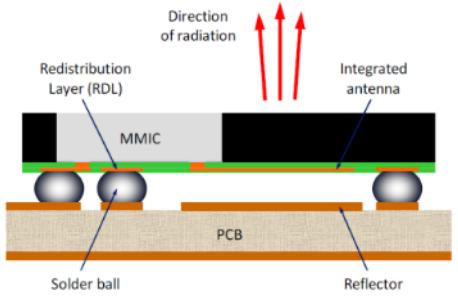
Ceramics (LTCC/HTCC)

IBM, Kyocera,…



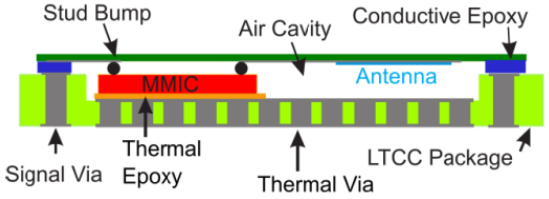
Multi-Layer Organics

IBM, STMicro, Intel,…



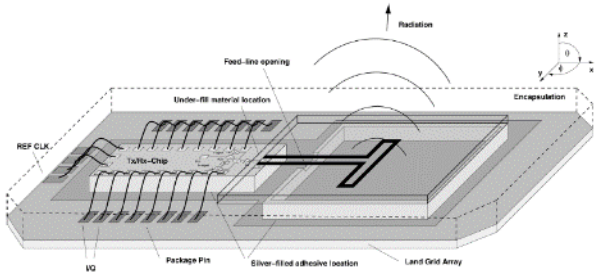
eWLB/Fan-Out

Infineon/DICE, Linz Univ.,TSMC,…



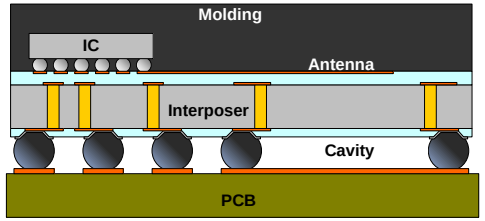
Hybrid LTCC/Thin-film

IHP, Bosch, Silicon Radar, KIT…



Hybrid LGA or DCA + Glass

IBM



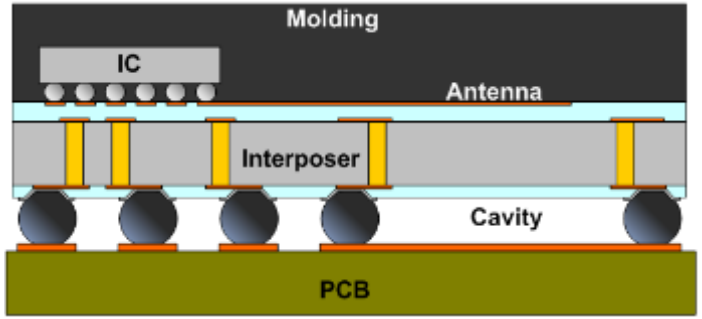
Interposer (Si / Glass)

LETI, IMEC, Georgia-Tech

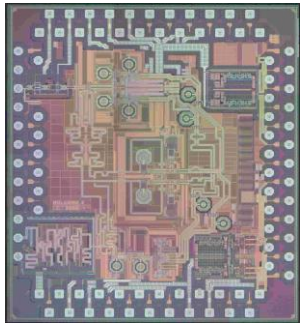
60GHZ TRANSCEIVER MODULE @LETI
SYSTEM ARCHITECTURE

Smallest 60-GHz T/R module with integrated antennas

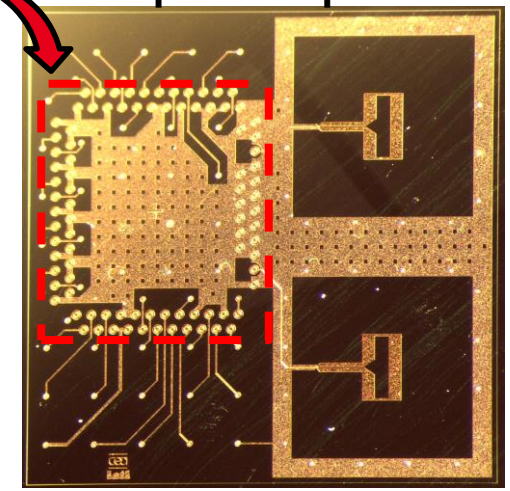
- Size: 6.5×6.5×0.5 mm^3
- 60-GHz CMOS transceiver
- 2 antennas : cavity-backed folded dipoles



RFIC

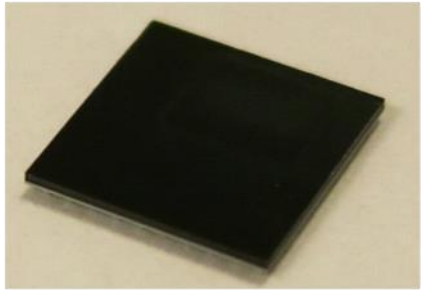


Interposer top view

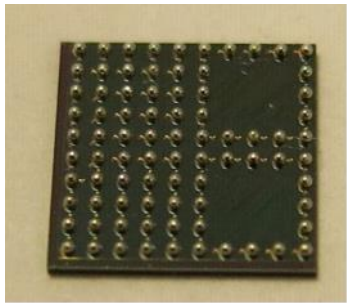


Balled molded interposer

Top



Bottom

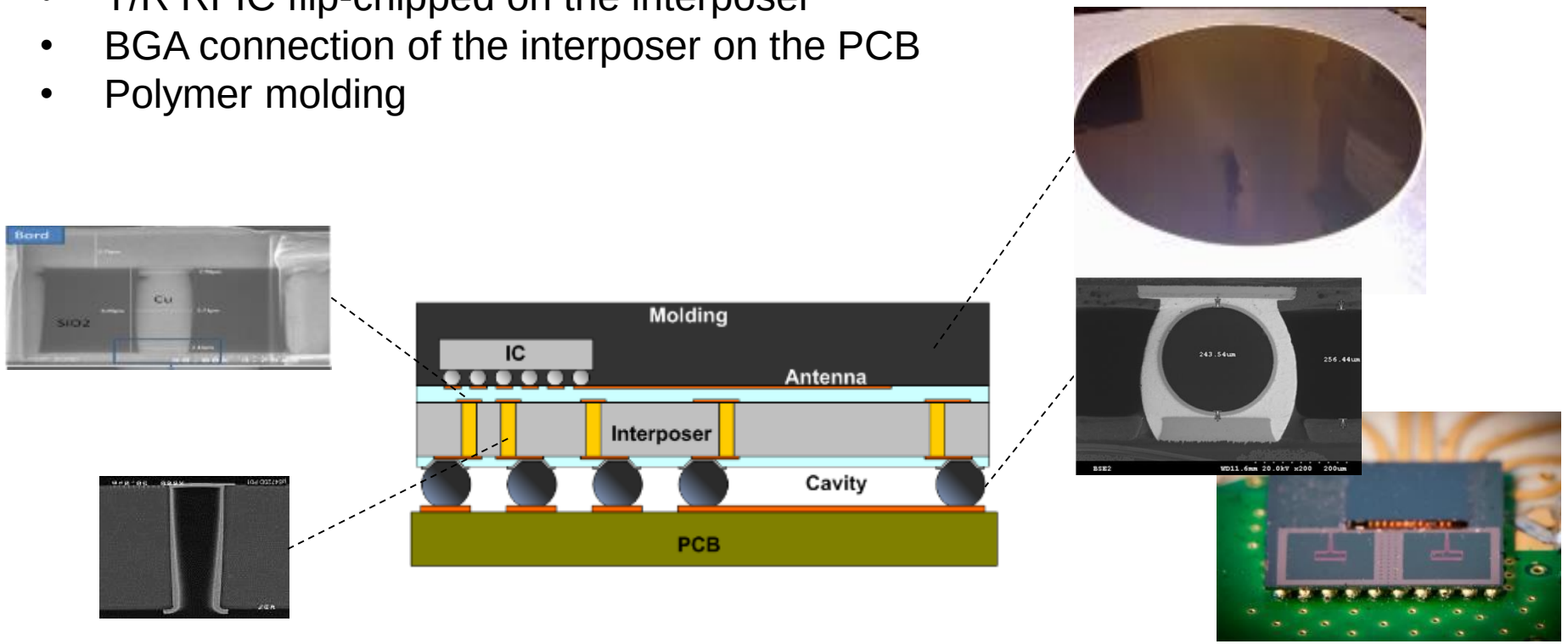


Source: Leti

60GHZ TRANSCEIVER MODULE @LETI TECHNOLOGIES

Smallest 60-GHz T/R module with integrated antennas

- High-Resistivity Si
- 2-metal layer back-end
- TSV for vertical interconnects and substrate mode mitigation
- T/R RFIC flip-chipped on the interposer
- BGA connection of the interposer on the PCB
- Polymer molding

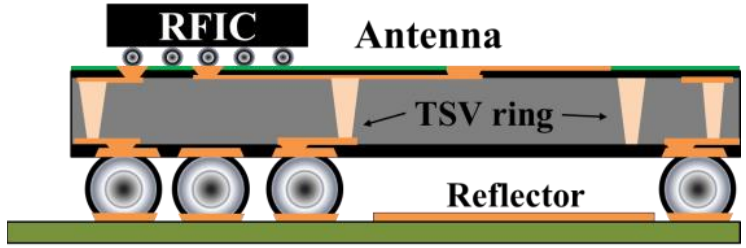


Source: Leti

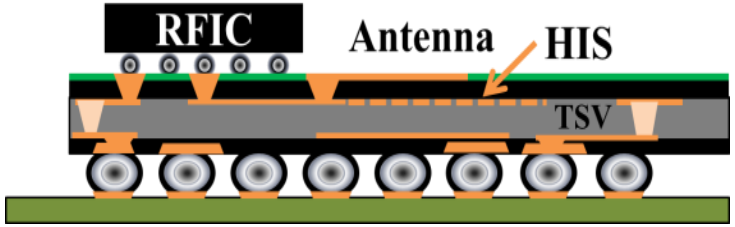
LIMITATIONS IN RADIATING ELEMENT'S INTEGRATION

Perspectives for higher integration

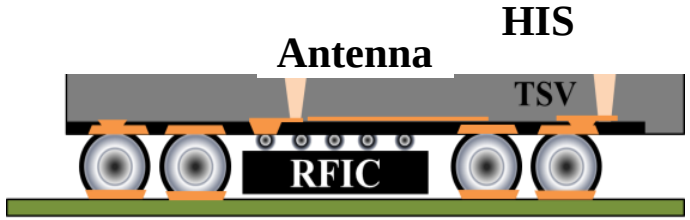
Previous design:
++ Antenna perf.
+ Reliability
- Footprint



2 options using **High-Impedance Surfaces (HIS)**



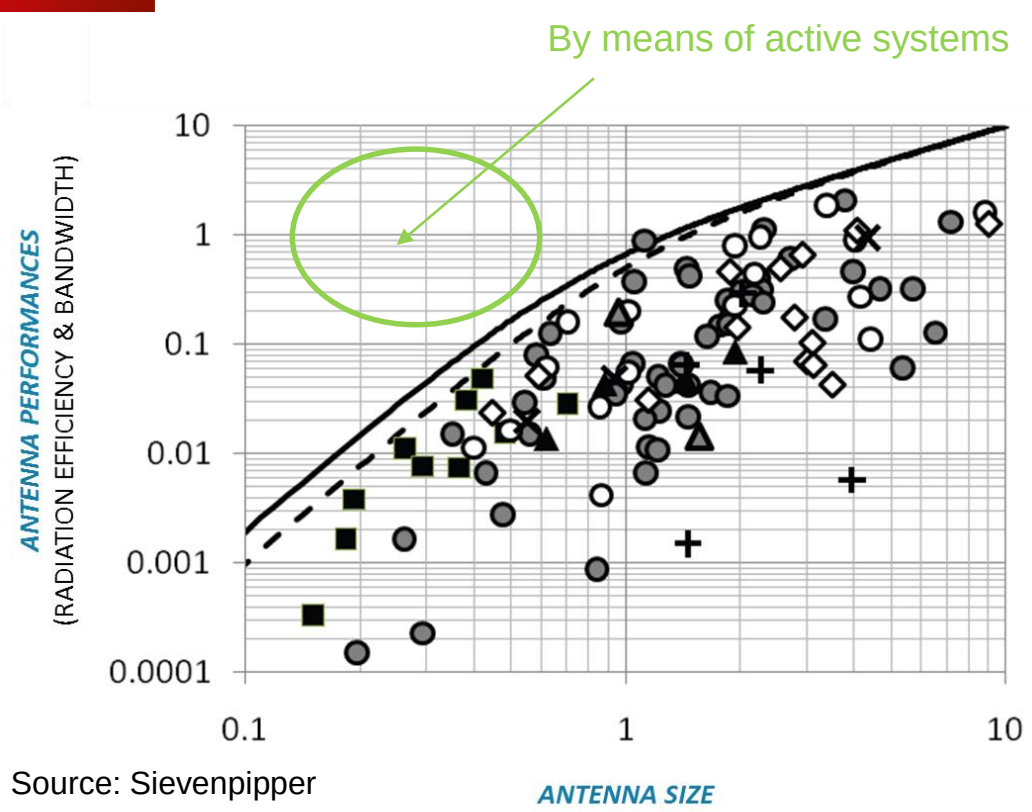
Horizontal integration:
+ Antenna perf.
++ Reliability
- Footprint



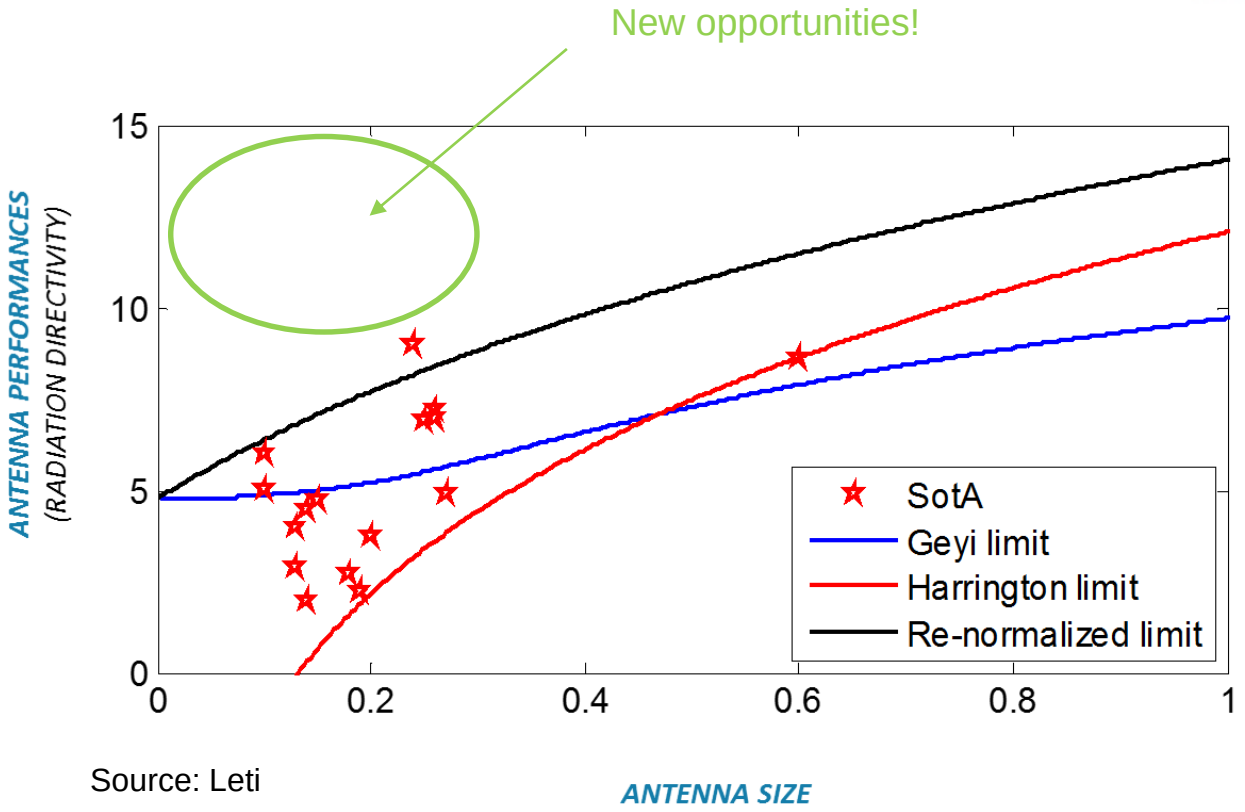
Vertical integration:
- Antenna perf.
+ Reliability
++ Footprint

Sources: Leti

LIMITATIONS IN RADIATING ELEMENT'S PERFORMANCES



Source: Sievenpipper



Source: Leti

How to reach best efficiency?

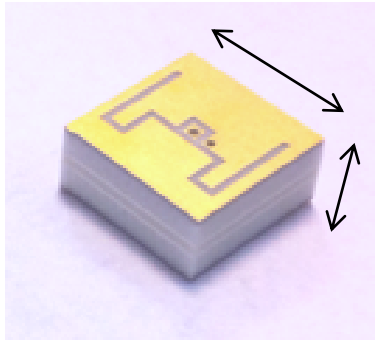
- Material and passive in antenna geometry
- Impedance/frequency tuning
- Non-Foster impedance matching

How to reach best directivity?

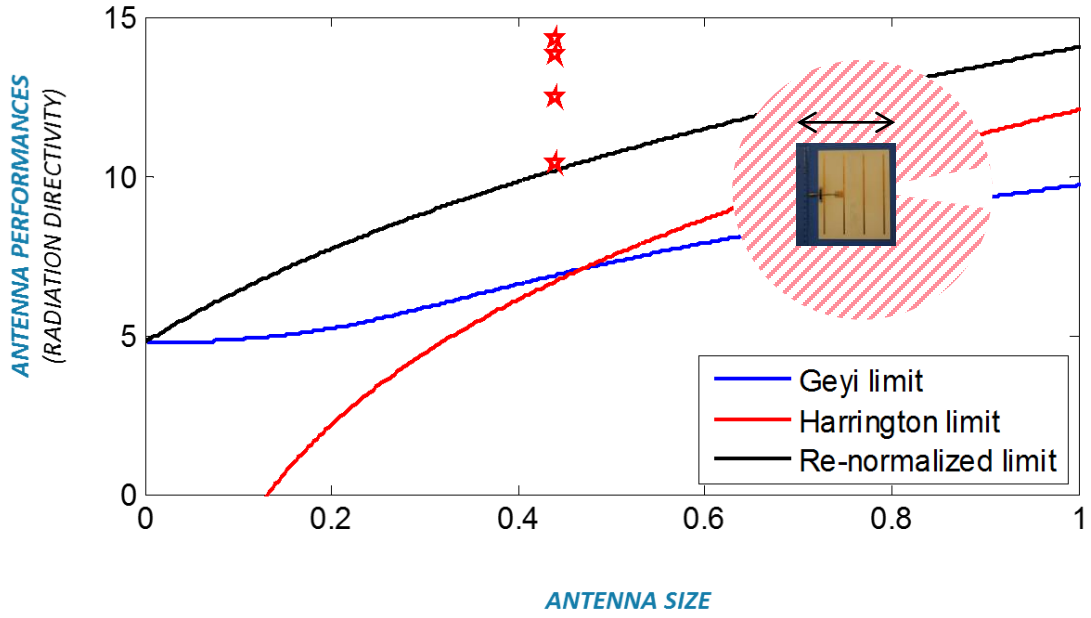
- Huygen's source, superdirectivity
- Passives in antenna geometry, superdirectivity

DISRUPTING COMPACT ANTENNA CONCEPTS

Electrically small radiating sources
Frequency tuning
Application: in-vivo integration



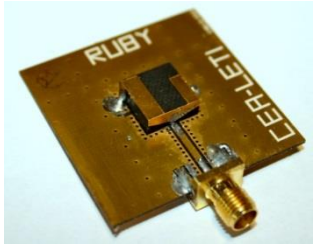
Superdirectivity with compact antenna
Yagi-Uda type antenna
Application: handheld RFID readers

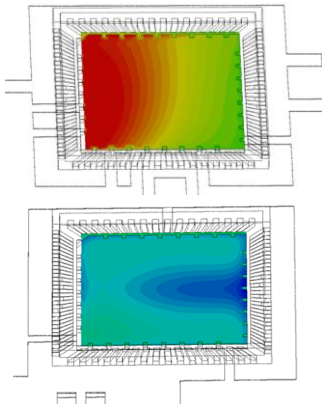


40% relative bandwidth
λ/60 per λ/25

12dBi (directivity)
λ/2

Balanced excitation
Integration in QFN 64 package
Application: wearables





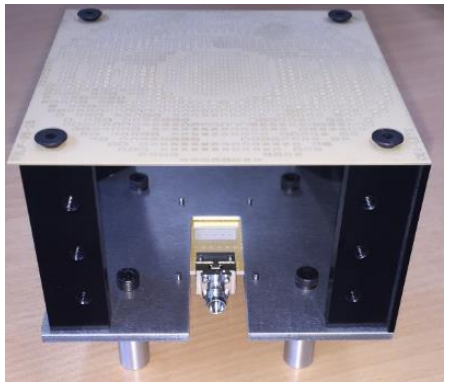
60% of initial near-field in the packaging

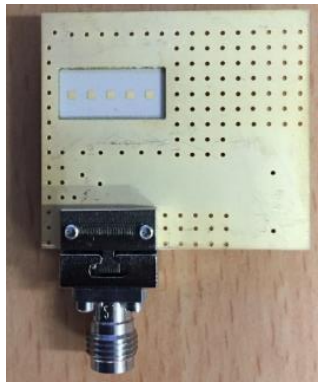
Sources: Leti

IMPLEMENTATION IN PER-APPLICATION MODULE TRANSMIT ARRAY ARCHITECTURES

Sources: Leti

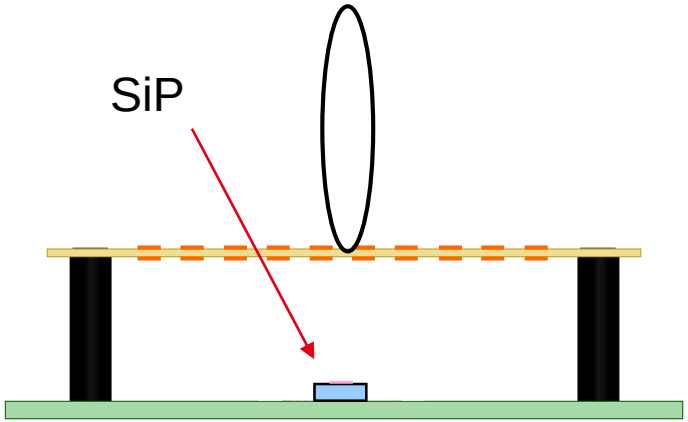
Very high gain compact antenna

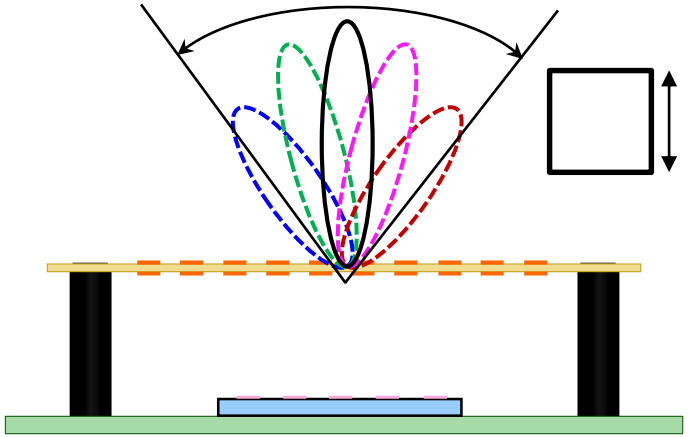


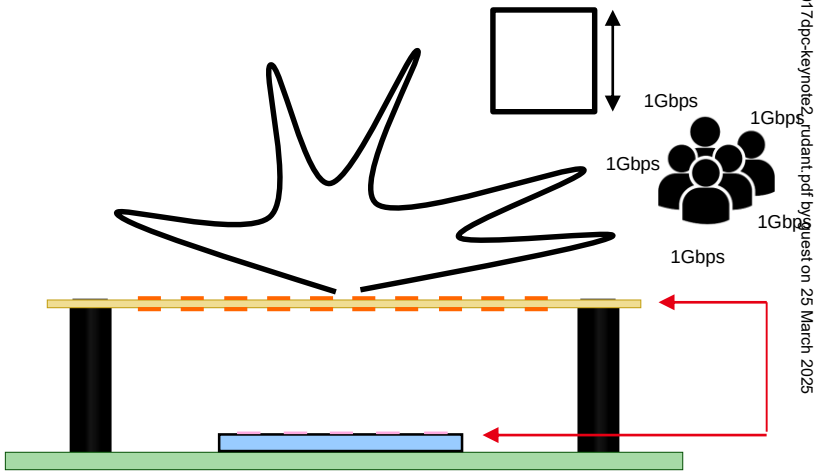


Auto-aligning / beam steering

Hybrid beamforming, long range



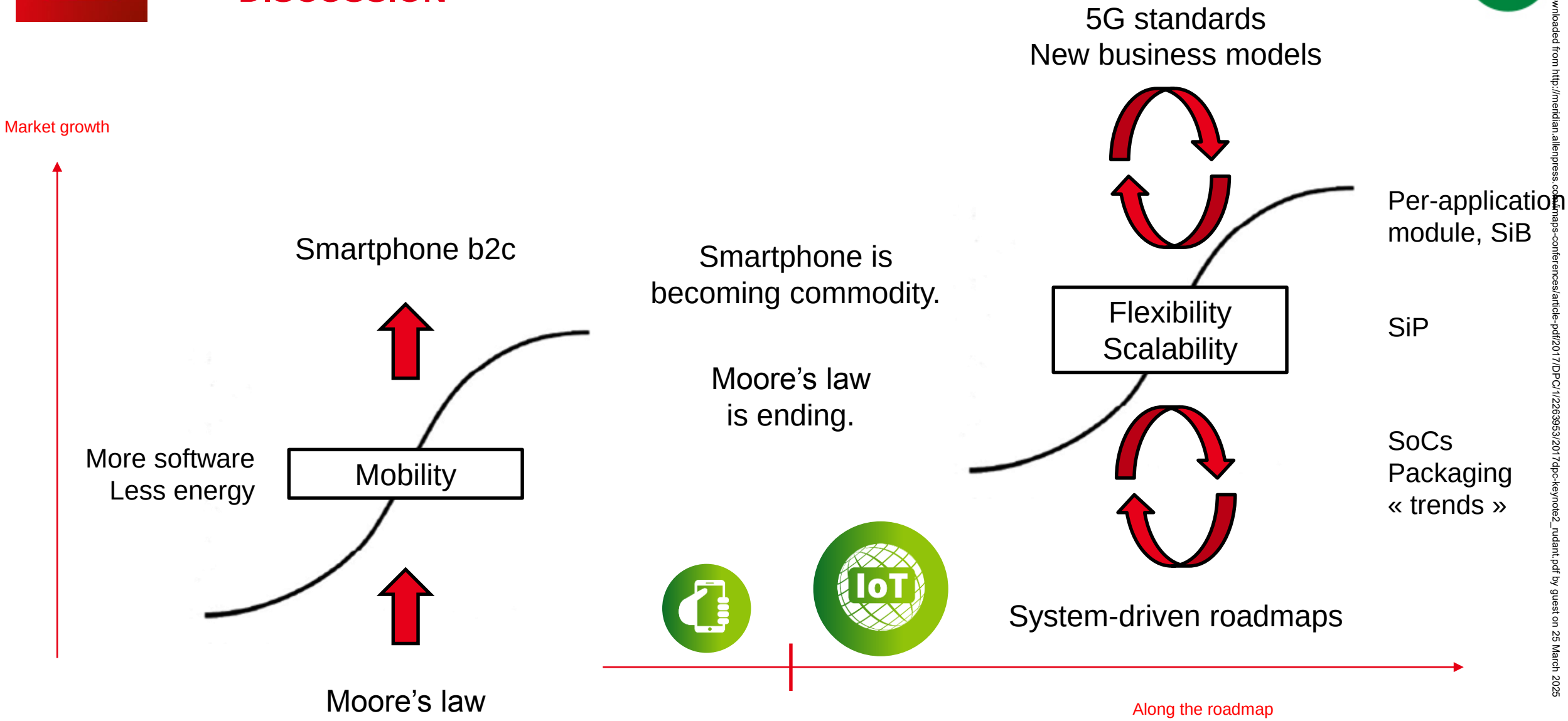




TECHNOLOGY/SYTEM ROADMAP
5G MMWAVE WIRELESS SYSTEMS

- Hybrid beamforming architectures are under evaluation.
- In-package antennas enable per-application design.
- Innovative antenna concepts should be investigated.

NEITHER IOT NOR 5G WITHOUT NEW TECHNOLOGY! DISCUSSION



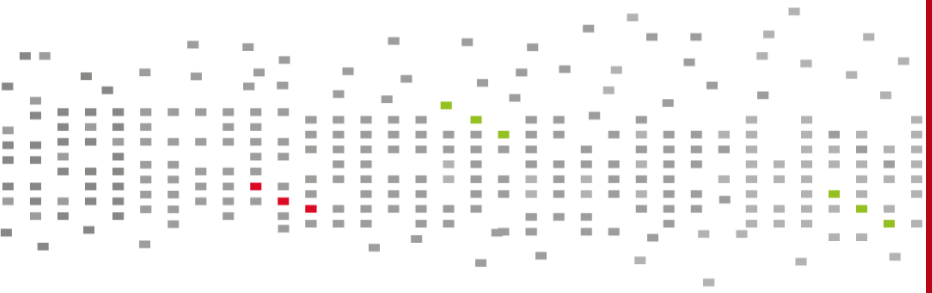
Meet me:

Physical

Fountain Hills USA
Grenoble France, Leti Innovation Days, June 28-29

Cyber

http://www.leti-cea.fr
https://www.linkedin.com/in/lrudant



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