Moscow wireless Week, October 2018

5G: is the business in the radio?

A critical view on the next generation

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creating and sharing knowledge for telecommunications

Outline

- Short Introduction to IT
- A view from History
- What do we aim for?
- What do we need?
- And the tools are..
- Conclusions

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Not for profit association of:

Universidade de Aveiro
Universidade de Coimbra
Universidade de Lisboa
Altice Labs
Nokia
Universidade de Porto
Universidade da Beira Interior
Instituto Ciências e Tecnologias Empresariais

IT Sites

Aveiro | Coimbra| Lisboa



Main partnerships

Instituto Politécnico de Leiria	(IPL-STG)
Instituto Politécnico de Coimbra	(ISEC)
Instituto Politécnico de Lisboa	(ISEL)
Instituto Politécnico de Setúbal	(EST)
Instituto Politécnico de Tomar	(ESTT)
Universidade do Algarve	(UAlg)
Universidade de Évora	(UEv)
Universidade da Madeira	(UMad)

3

ATNOG – Advanced Telecommunications and Networking group

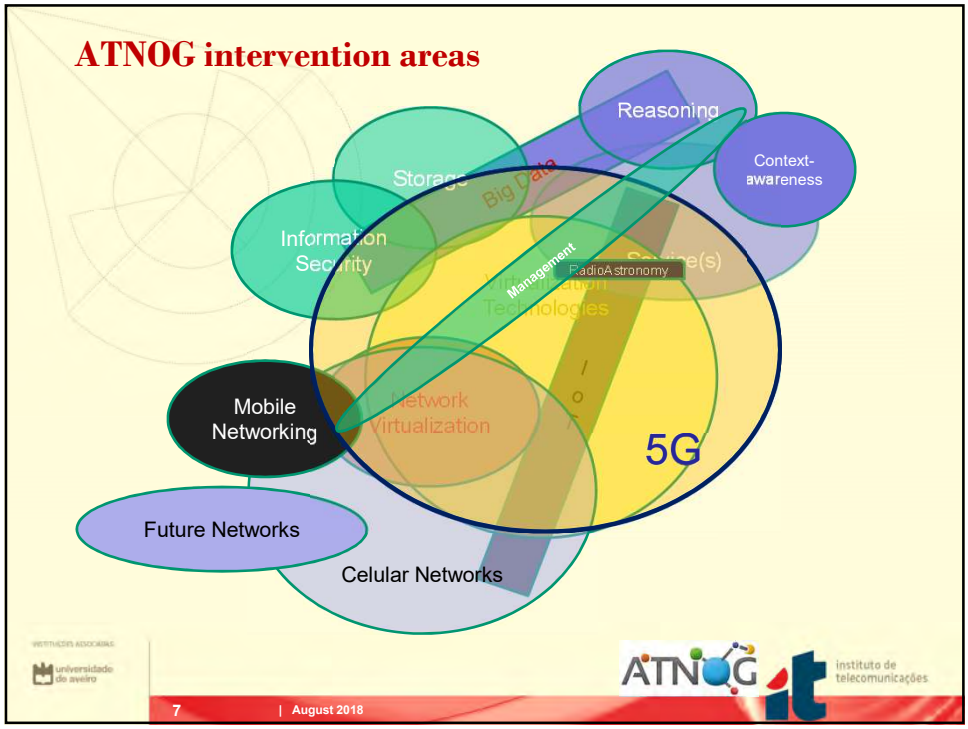
- 12 PhD, ~50 members
- Multiple lines of work
  - Research
  - Industry cooperation
  - Standardization
- High practical component
  - Testbeds, implementations, tools...
- Open Source contributions
  - https://github.com/ATNoG
  - Test infrastructures

Rui L. Aguiar

Head of Networks and Multimedia, IT

Networld!2020 SB Chair
IEEE Distinguished Lecturer

6


ATNOG intervention areas
Reasoning
Context-awareness
Storage
Big Data
Information Security
Management
RadioAstronomy
Service(s)
Virtualization Technologies
Mobile Networking
Network Virtualization
IoT
5G
Future Networks
Celular Networks
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7
August 2018


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When did this "5G" started?

Several initiatives across the world now, even in market deployment.

Europe was piooneer, discussing this from 2011.

- **Objective**: trying to catch up lost leadership in mobile communications
- Early drive from EU:
  - Setting a workprogramme inside H2020
  - Last calls of FP7 already pushing in this direction
  - Setting up the ETP (Networld2020) and the PPP (5G IA)

So, 5G?

- Long term discussion on the future of cellular systems
- Being pursued across the whole world



Horizon 2020 & 5G PPP

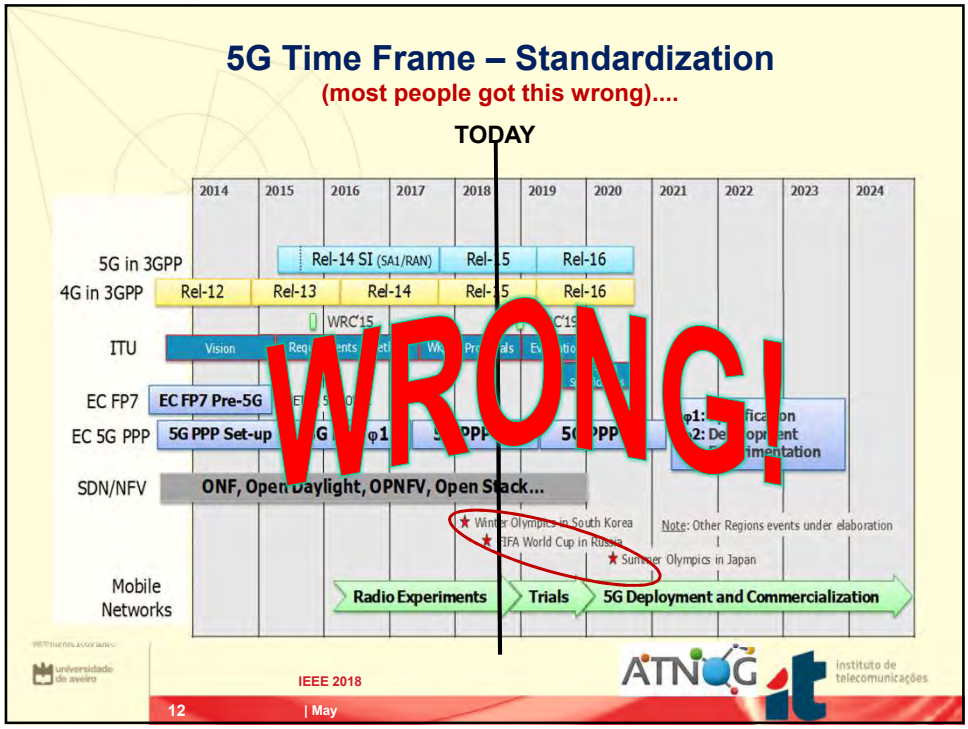
BRASIL May 2017

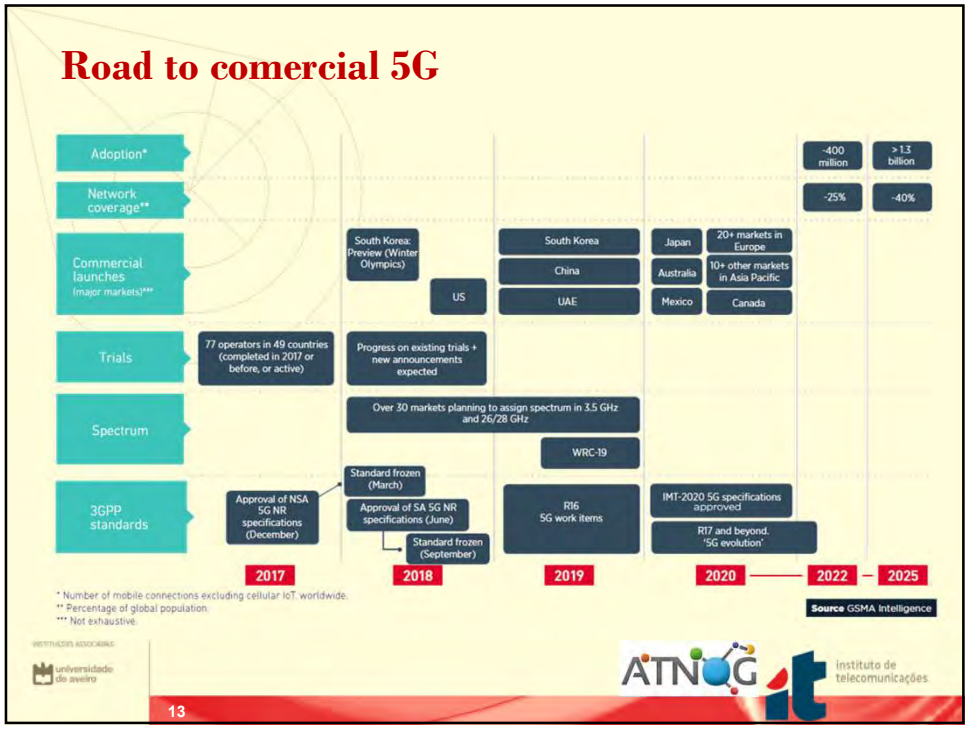
5G Americas

IMT 2020 Promotion Group
MOST 5G Research program

5G Forum
5GIGA

ARIB AdHoc
"2020 and Beyond"
5G Mobile Communications
Promotion Forum (5GMF)

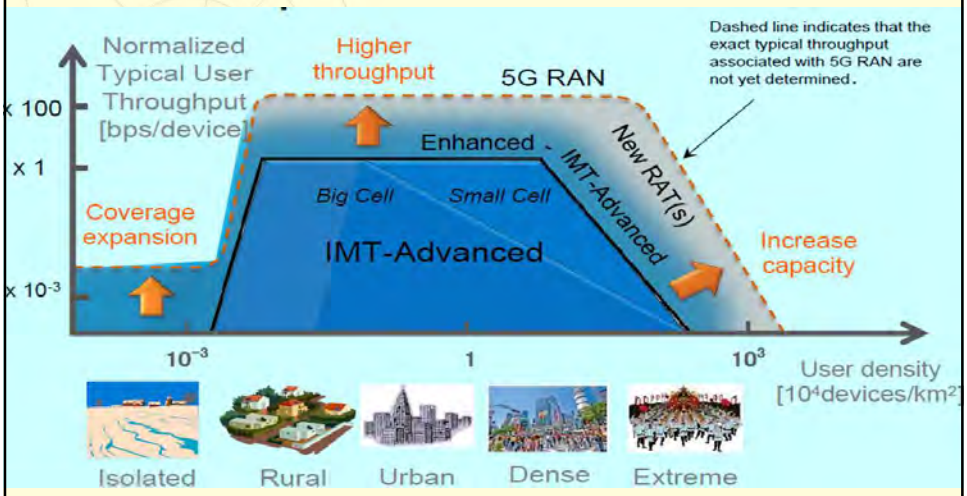

5G Time Frame – Standardization
(most people got this wrong)....
TODAY
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
5G in 3GPP
Rel-14 SI (SA1/RAN)
Rel-15
Rel-16
4G in 3GPP
Rel-12
Rel-13
Rel-14
Rel-15
Rel-16
WRC'15
ITU
Vision
EC FP7
EC FP7 Pre-5G
EC 5G PPP
5G PPP Set-up
SDN/NFV
ONF, Open Daylight, OPNFV, Open Stack...
WRONG!
Winter Olympics in South Korea
FIFA World Cup in Russia
Summer Olympics in Japan
Note: Other Regions events under elaboration
Mobile Networks
Radio Experiments
Trials
5G Deployment and Commercialization
IEEE 2018
12
| May


Road to comercial 5G
Adoption*
Network coverage**
Commercial launches (major markets)***
Trials
Spectrum
3GPP standards
-400 million
>1.3 billion
-25%
-40%
South Korea: Preview (Winter Olympics)
US
South Korea
China
UAE
Japan
Australia
Mexico
20+ markets in Europe
10+ other markets in Asia Pacific
Canada
77 operators in 49 countries (completed in 2017 or before, or active)
Progress on existing trials + new announcements expected
Over 30 markets planning to assign spectrum in 3.5 GHz and 26/28 GHz
WRC-19
Standard frozen (March)
Approval of NSA 5G NR specifications (December)
Approval of SA 5G NR specifications (June)
Standard frozen (September)
R16 5G work items
IMT-2020 5G specifications approved
R17 and beyond. '5G evolution'
2017
2018
2019
2020
2022
2025
* Number of mobile connections excluding cellular IoT worldwide.
** Percentage of global population.
*** Not exhaustive.
Source GSMA Intelligence
13

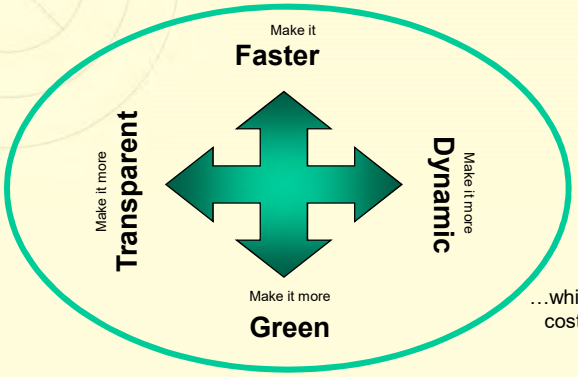
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Example of ambition (framework) for cellular

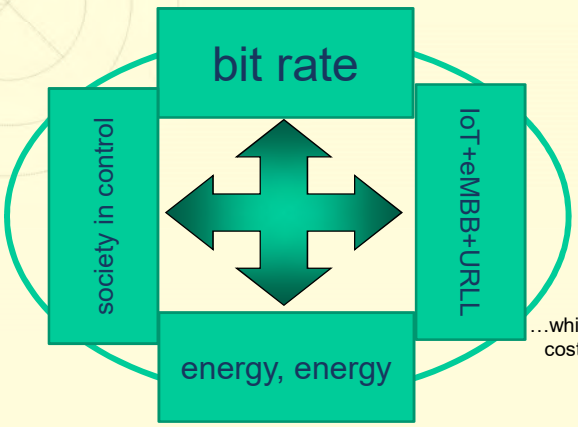


Cellular technology trends



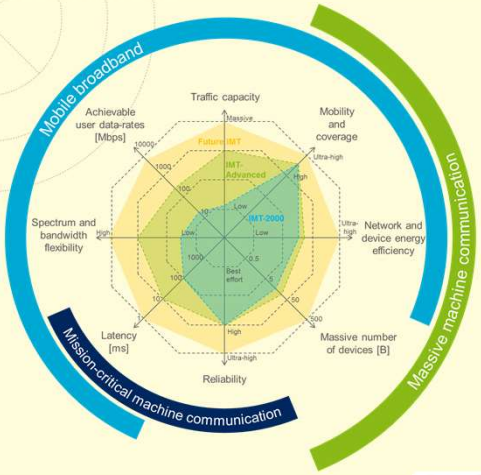
…while driving down the cost per managed bit

Cellular technology trends

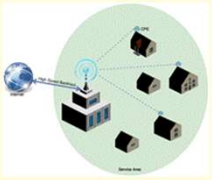


…while driving down the cost per managed bit

Europe 5G PPP IA vision of 5G



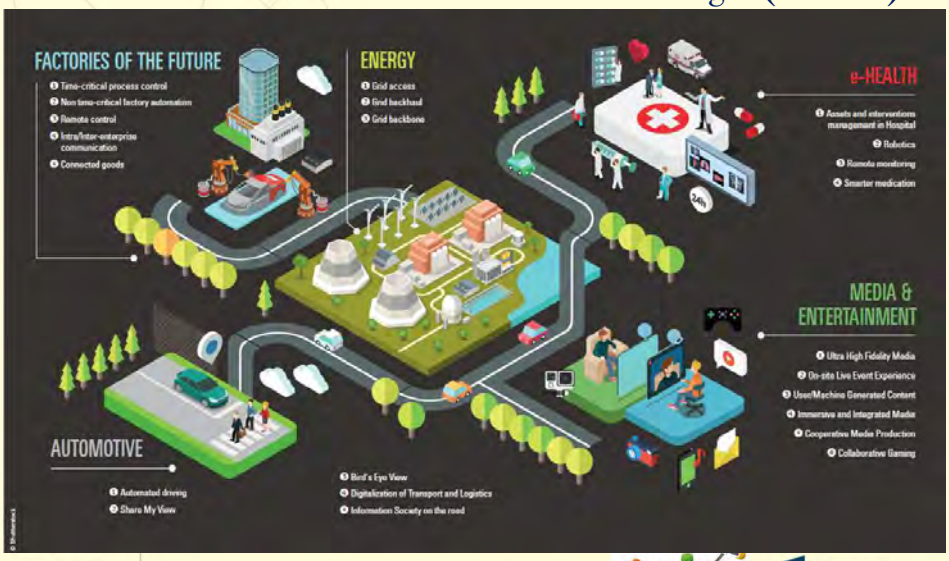
No FWA considered!



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5G – A driver for industrial and societal changes (5G PPP)



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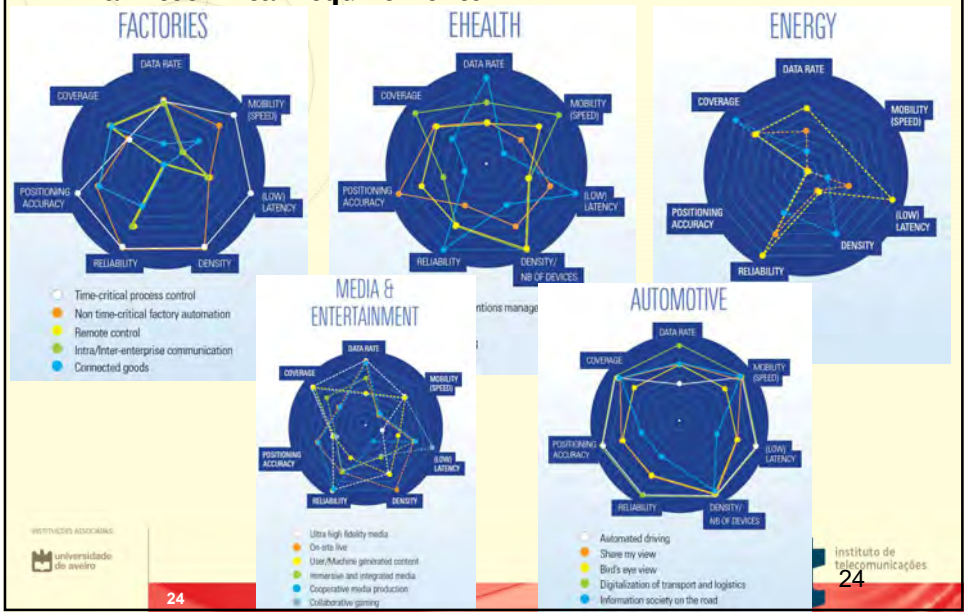
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Vertical sectors
Main technical requirements



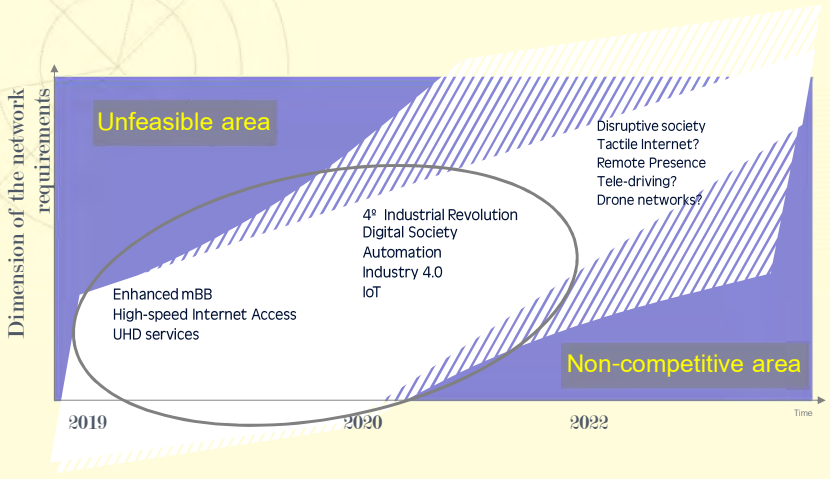
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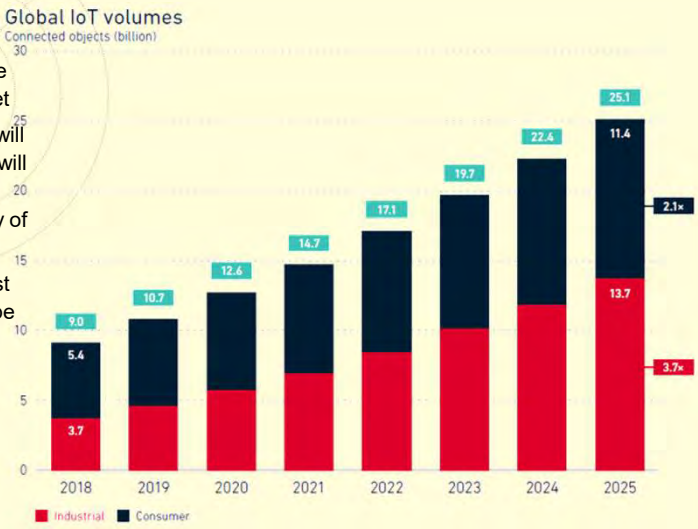
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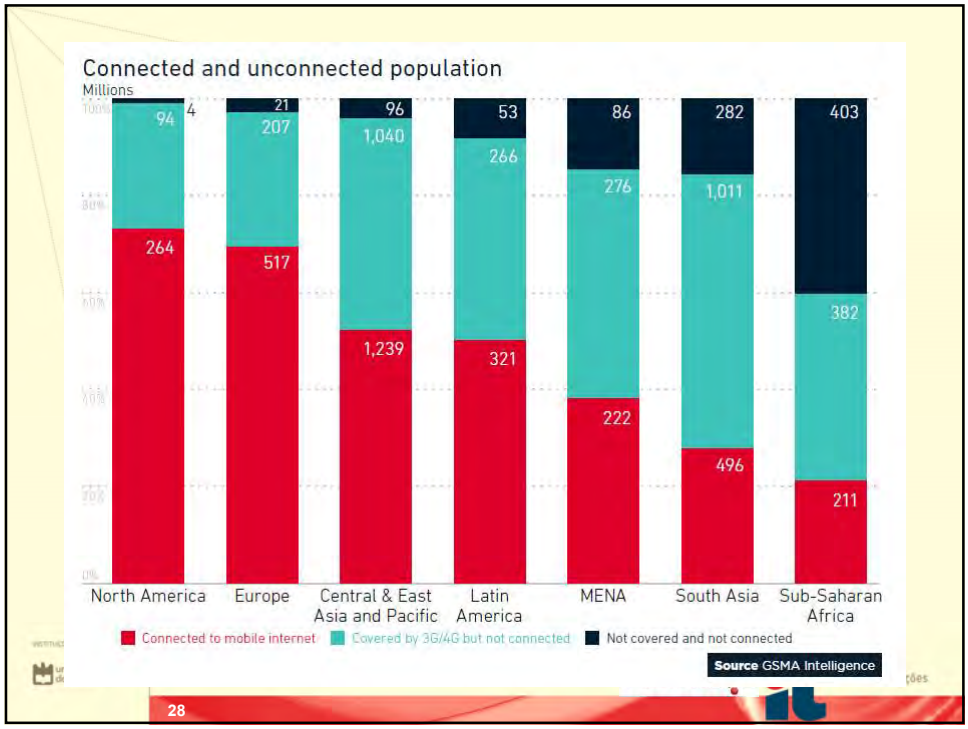
How do we build the future?

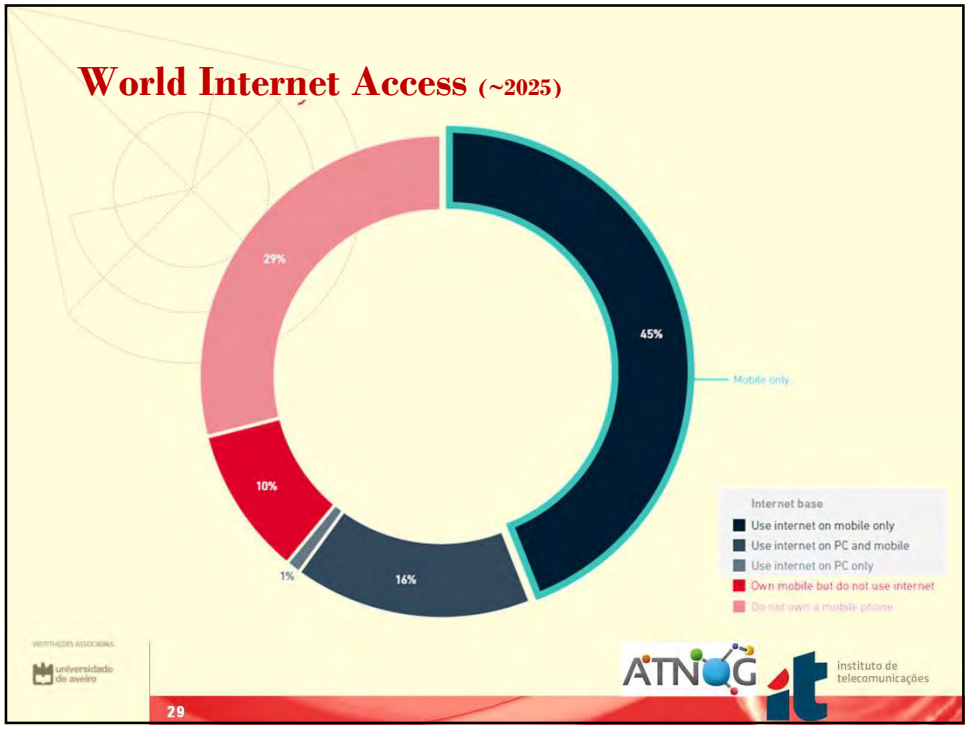


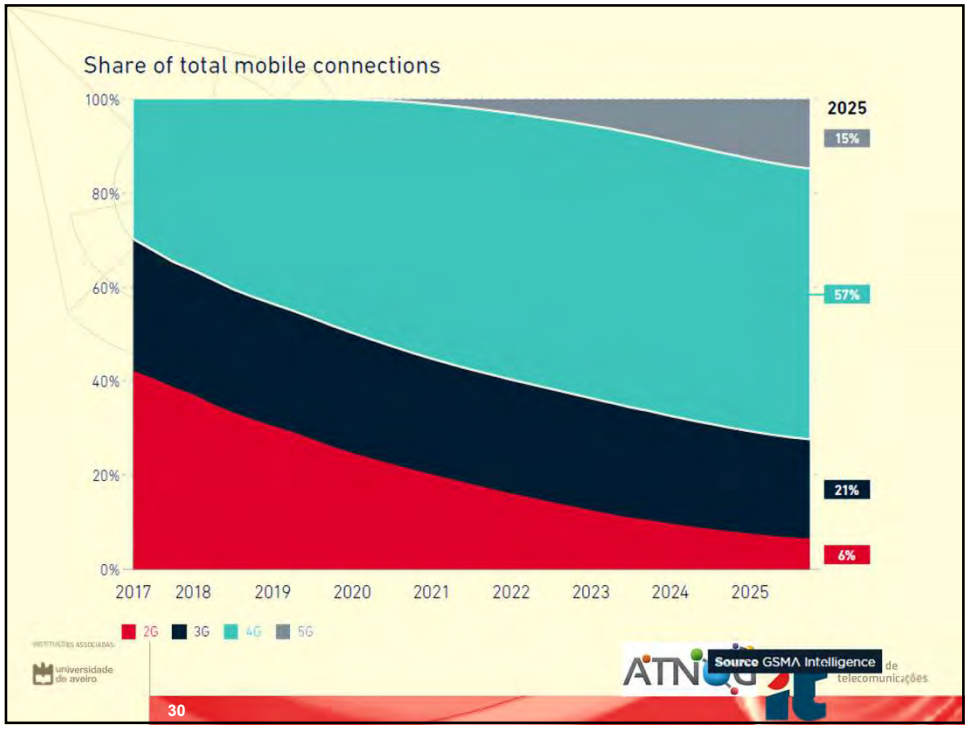
IoT and verticals

1. Enterprise will be the main revenue market
2. Home environment will be mainstream, but will saturate rapidly (~economic capacity of populations)
3. Most devices (almost all for indoors!) will be connected with unlicensed technologies




Connected and unconnected population
Millions
94
4
264
21
207
517
96
1,040
1,239
53
266
321
86
276
222
282
1,011
496
403
382
211
North America
Europe
Central & East Asia and Pacific
Latin America
MENA
South Asia
Sub-Saharan Africa
Connected to mobile internet
Covered by 3G/4G but not connected
Not covered and not connected
Source GSMA Intelligence
28


World Internet Access (~2025)
45%
29%
10%
1%
16%
Mobile only
Internet base
Use internet on mobile only
Use internet on PC and mobile
Use internet on PC only
Own mobile but do not use internet
Do not own a mobile phone
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29



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3GPP standardization efforts

Project Co-ordination Group (PCG)		
TSG RAN Radio Access Network	**TSG SA** Service & Systems Aspects	**TSG CT** Core Network & Terminals
RAN WG1 Radio Layer 1 spec	SA WG1 Services	CT WG1 MM/CC/SM (Iu)
RAN WG2 Radio Layer 2 spec Radio Layer 3 RR spec	SA WG2 Architecture	CT WG3 Interworking with external networks
RAN WG3 Iub spec, Iur spec, Iu spec UTRAN O&M requirements	SA WG3 Security	CT WG4 MAP/GTP/BCH/SS
RAN WG4 Radio Performance Protocol aspects	SA WG4 Codec	CT WG6 Smart Card Application Aspects
RAN WG5 Mobile Terminal Conformance Testing	SA WG5 Telecom Management	
RAN WG6 Legacy RAN radio and protocol	SA WG6 Mission-critical applications	

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Bands Identified for IMT

- Rec. M-1036-5 (10/2015)

Band (MHz)	RR Footnote
450-470	5.286AA
698-960	5.313A, 5.317A
1 710-2 025	5.384A, 5.388
2 110-2 200	5.388
2 300-2 400	5.384A
2 500-2 690	5.384A
3 400-3 600	5.430A, 5.432A, 5.432B, 5.433A

- WRC-15: 470 – 698 MHz; 1427 – 1518 MHz; **3300 – 3400 MHz;** 3600 – 3700 MHz; 4800 – 4990 MHz

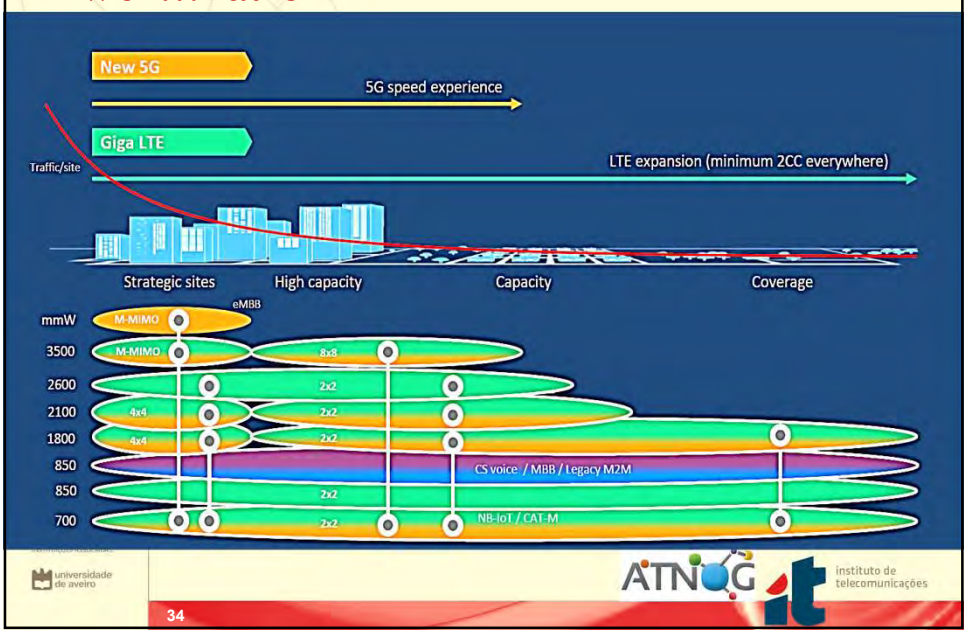
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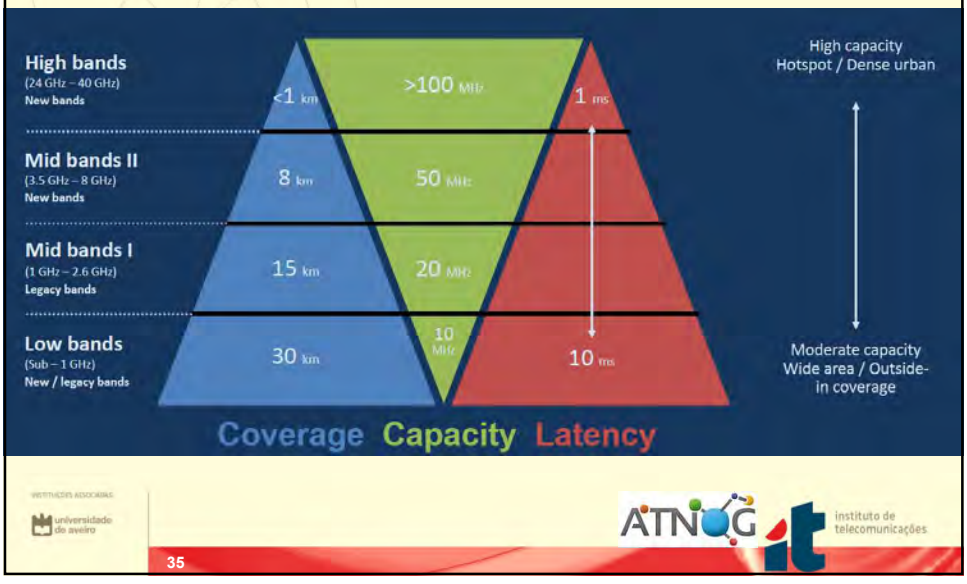
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33

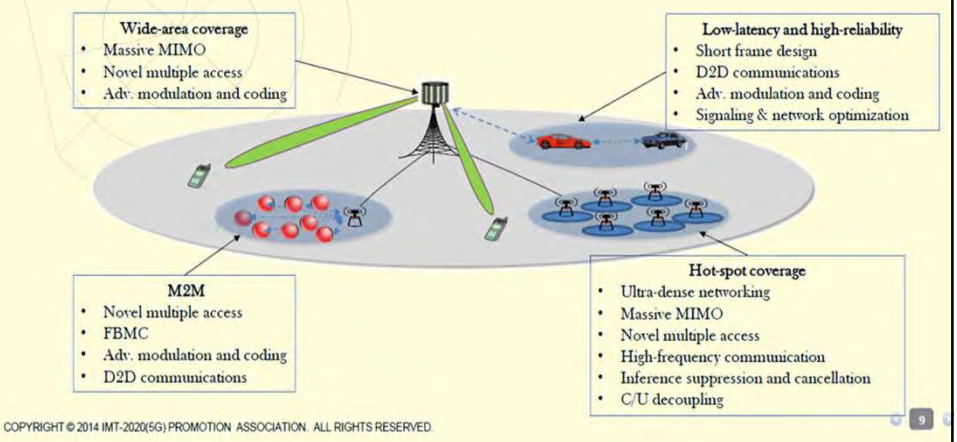
Well… radio



How to use these bands?



5G RAN Scenarios and Key Technologies



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36

In summary

Yes, New Radio layer with new features (speed, latency, reliability…), but also:

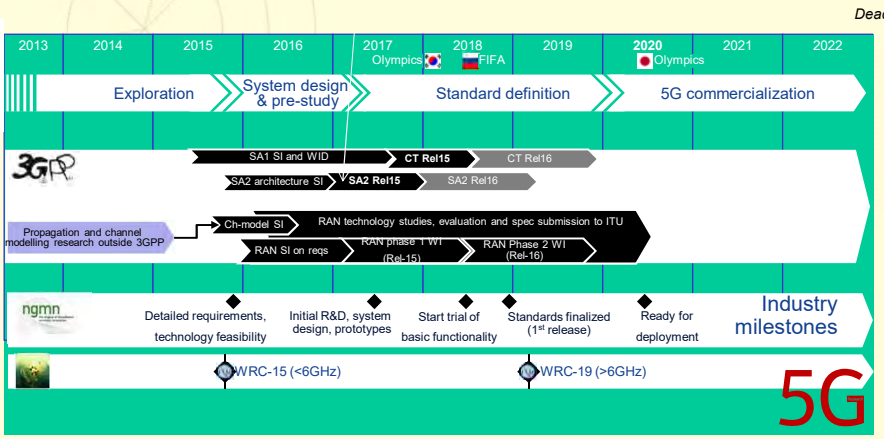
- More radio flexibility
- More diverse modes of communication
- Increased Radio Link Aggregation
- Seamless Support for more Technologies

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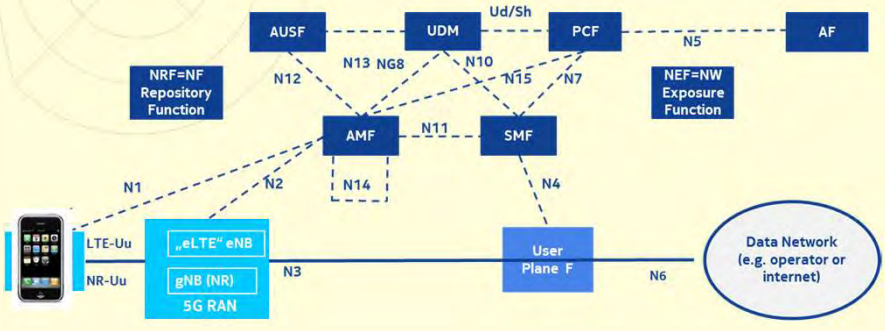
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3GPP Status on Core standardization



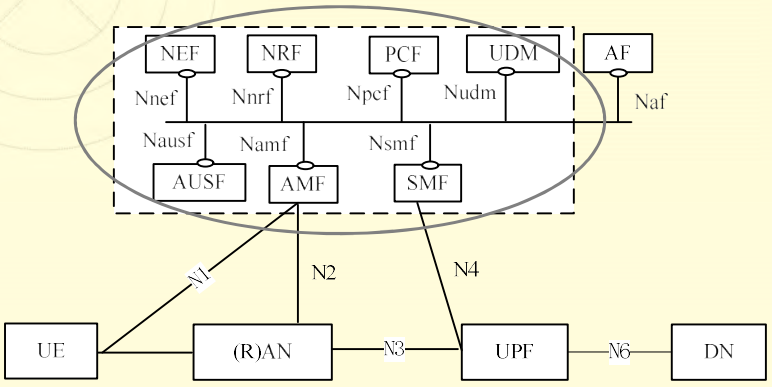
"5G Architecture"

References points….



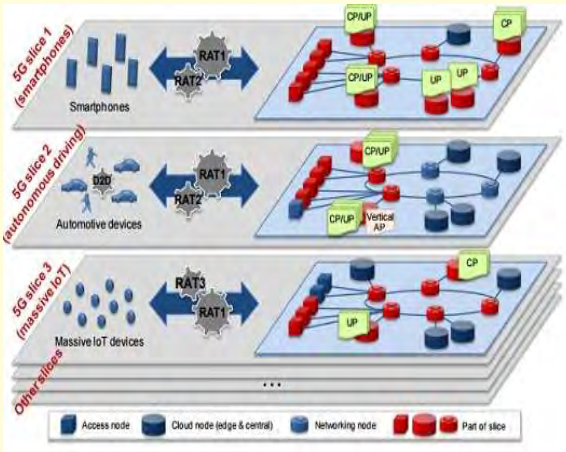
"5G Architecture"

But also a set of network functions….

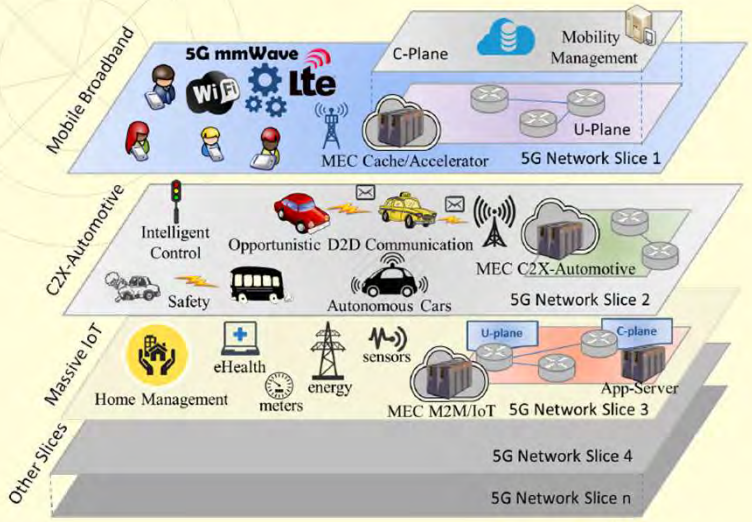


NFV/SDN and Slicing; infrastructure for 5G

- Virtual Networks creation
  - Slices: end-2-end networks
  - Network isolation
  - Vertical-oriented (business)
  - For different entities (MVNOs)
- Using shared resources
  - Connectivity (links)
  - Data center (VMs, VNFs, NSs)
- Includes management
  - Internal management
  - Orchestration
  - Control



Technology: MEC+slicing for verticals



Outline

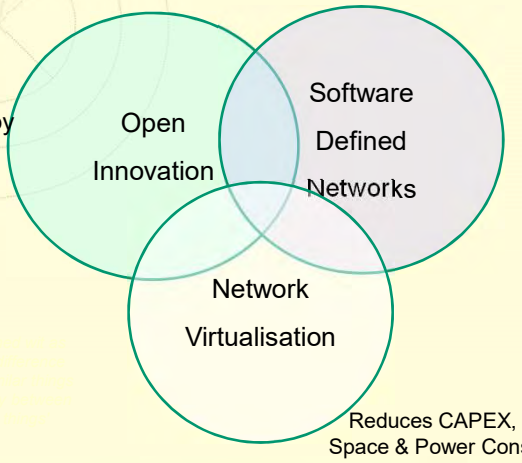
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What makes 5G interesting?



What are we witnessing…

Creates competitive supply of innovative applications by third parties (verticals)

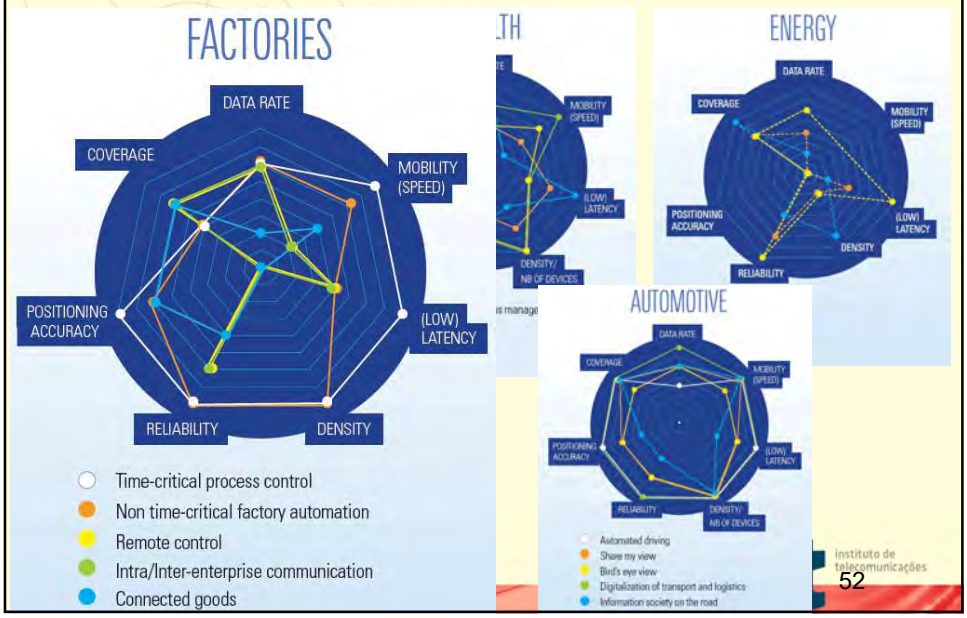


Separate control plane from data plane, centralised and programmable control, APIs towards applications

Create abstractions to enable faster innovation.

Reduces CAPEX, OPEX, Space & Power Consumption.

Going Back to Requirements



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52

In summary…

Radio is essential to provide new services and usage for mobile communications.

"Radio", does not necessarily need 3GPP "New Radio".

Lots of use cases require Flexible Networks, with intelligent management of resources

We will have a situation where deployments will need to cater for current and novel technologies….

So… Is the near term business on new radio solutions?

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53


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Moscow wireless Week, October 2018
5G: is the business in the radio?
Graduate and Postgraduate opportunities available
Questions?
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