Wydział Elektroniki
i Technik Informacyjnych

POLITECHNIKA WARSZAWSKA

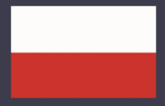
Techniki Sieci Mobilnych Następnej Generacji (TESM)

Wykład 1-2

Dr hab. inż. Jordi Mongay Batalla

Materiał w ramach Projektu „NERW 2 PW. Nauka–Edukacja–Rozwój–Współpraca”, współfinansowanego przez UE w ramach Europejskiego Funduszu Społecznego

Fundusze Europejskie
Wiedza Edukacja Rozwój



Rzeczpospolita Polska

Politechnika Warszawska

Unia Europejska
Europejski Fundusz Społeczny

Informacja organizacyjna przedmiotu

Dr hab. inż. Jordi Mongay Batalla
jordi.mongay.batalla@pw.edu.pl
Pokój 334A, śr. 12-16 (lepiej umówić się mailowo)

Przedmiot: Techniki sieci mobilnych następnej generacji (TESM)

Kod przedmiotu: 103A-TLTIC-MSP-TESM

ECTS: 4

Godziny: Wykład: 30; Projekt: 30

Wykład: Środa 16:00 – 18:00, Sala 117

Projekt: -

Informacja organizacyjna przedmiotu

Bibliografia:

- 5G Mobile Core Network: Design, Deployment, Automation, and Testing Strategies, R. Sudhakar Shetty, 2021. ISBN 978-1484264720
- **5G Core Networks. Powering digitalization. S. Rommer et al., Elsevier Academic Press, 2020. ISBN 978-0-08-103009-7**
- TS 23.501 – System Architecture for the 5G System (5GS), 3GPP
- TS 23.502 – Procedures for the 5G System, 3GPP
- TS 33.501 Security architecture and procedures for 5G System, 3GPP
- **5G New Radio. Fundamentals, procedures, testing aspects. M. Kottkamp et al., Rohde&Schwarz, 2019. ISBN 978-3-939837-15-2**
- 5G Technology: 3GPP New Radio, A. Toskala et al., John Wiley & Sons, 2020. ISBN: 978-1119236313
- TS 38.300 NR; NR and NG-RAN Overall Description, Release 16, 3GPP
- TS 38.401 NG-RAN Architecture description, Release 16, 3GPP

Informacja organizacyjna przedmiotu

Zaliczenie przedmiotu:

Egzamin: 60%; Projekt: 40%, Wymagana ocena egzaminu: 3.0

2 sposoby zdania egzaminu:

- Egzamin ustny pod koniec semestru
- Krótkie kolokwia co trzy-cztery wykłady (podczas wykładu). Żeby zdać kolokwia, student musi pisać wszystkie kolokwia (maks. 1 raz może to oddać w innych godzinach niż wykład) i średnia ocen wszystkich kolokwiów musi być >=3.0 – ten sposób zdania egzaminu jest nieobowiązkowy

Kto zdaje kolokwia (średnia wszystkich kolokwiów >=3.0) nie musi (ale może) zdać egzaminu. Jeśli student pisze i zdaje kolokwia i zdaje także egzamin, ocena ostateczna będzie najwyższa (średnia kolokwiów lub egzamin)

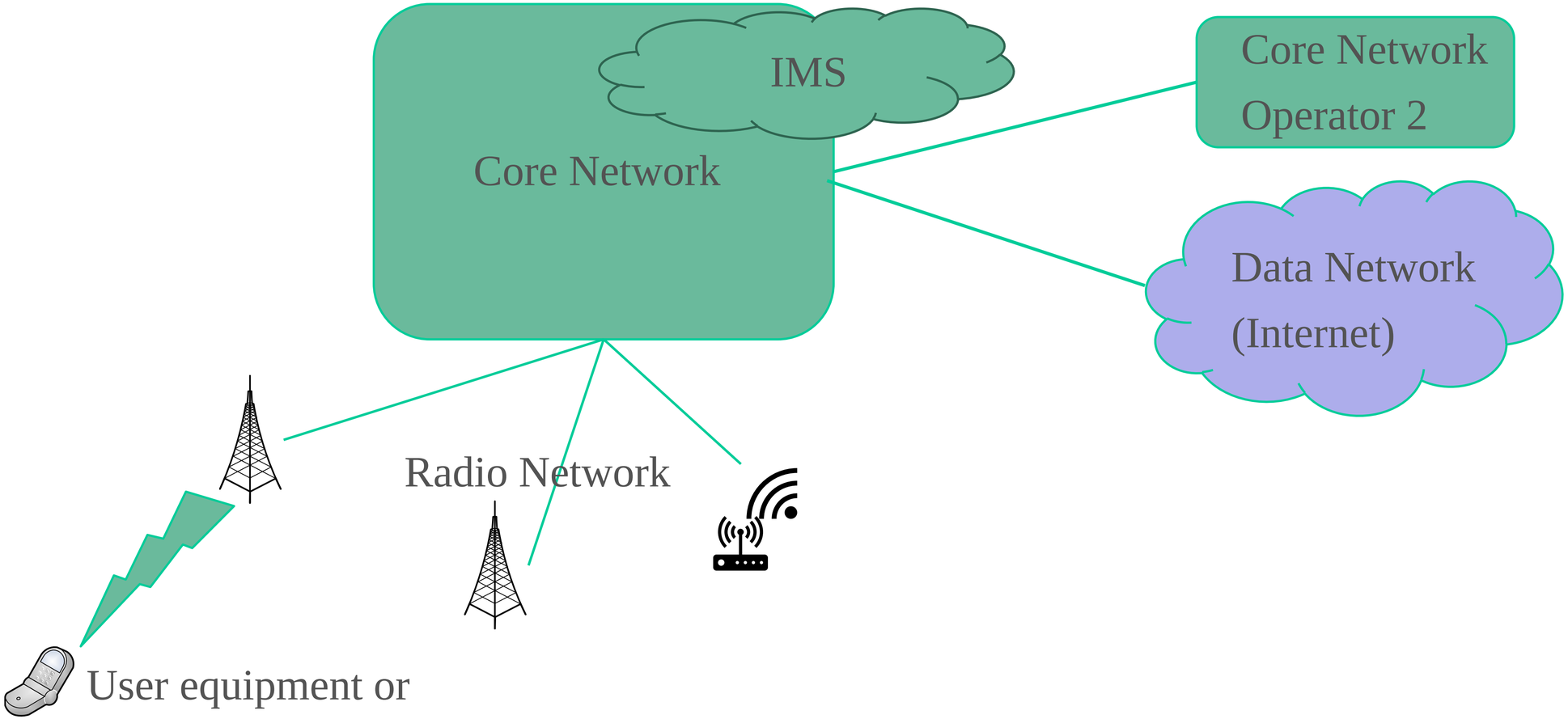
Informacja organizacyjna przedmiotu

Kalendarz semestru: 22Z

Poprzedni semester | Semestr 22Z | Następny semester

2022/2023	Październik						Listopad				Grudzień				Styczeń					Luty	
Poniedziałek		3	10	17	24	31	7	14	21	28	5	12	19	26	2	9	16	23	30	6	13
Wtorek		4	11	18	25	1	8	15	22	29	6	13	20	27	3	10	17	24	31	7	14
Środa		5	12	19	26	2	9Pi	16	23	30	7	14	21	28	4	11	18	25	1	8	15
Czwartek		6	13	20	27	3	10	17	24	1	8	15	22	29	5Pi	12	19	26	2	9	16
Piątek		7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17
Sobota	1	8	15	22	29	5	12	19	26	3	10	17	24	31	7	14	21	28	4	11	18
Niedziela	2	9	16	23	30	6	13	20	27	4	11	18	25	1	8	15	22	29	5	12	19
		N/P	P	N	P	N	N/P	P	N	P	N	P	N		P	N	P	N			

5G – Recall


IMS
Core Network
Core Network
Operator 2
Data Network
(Internet)
Radio Network
User equipment or
mobile device

5G – Recall

SPECTRUM:

Significant new widely harmonised mobile spectrum is needed 5G needs spectrum within three key frequency ranges to deliver widespread coverage and support all use cases: Sub-1 GHz, 1-6 GHz and above 6 GHz The highest range (above 6GHz) should be agreed among governments to avoid extra-costs in user's devices

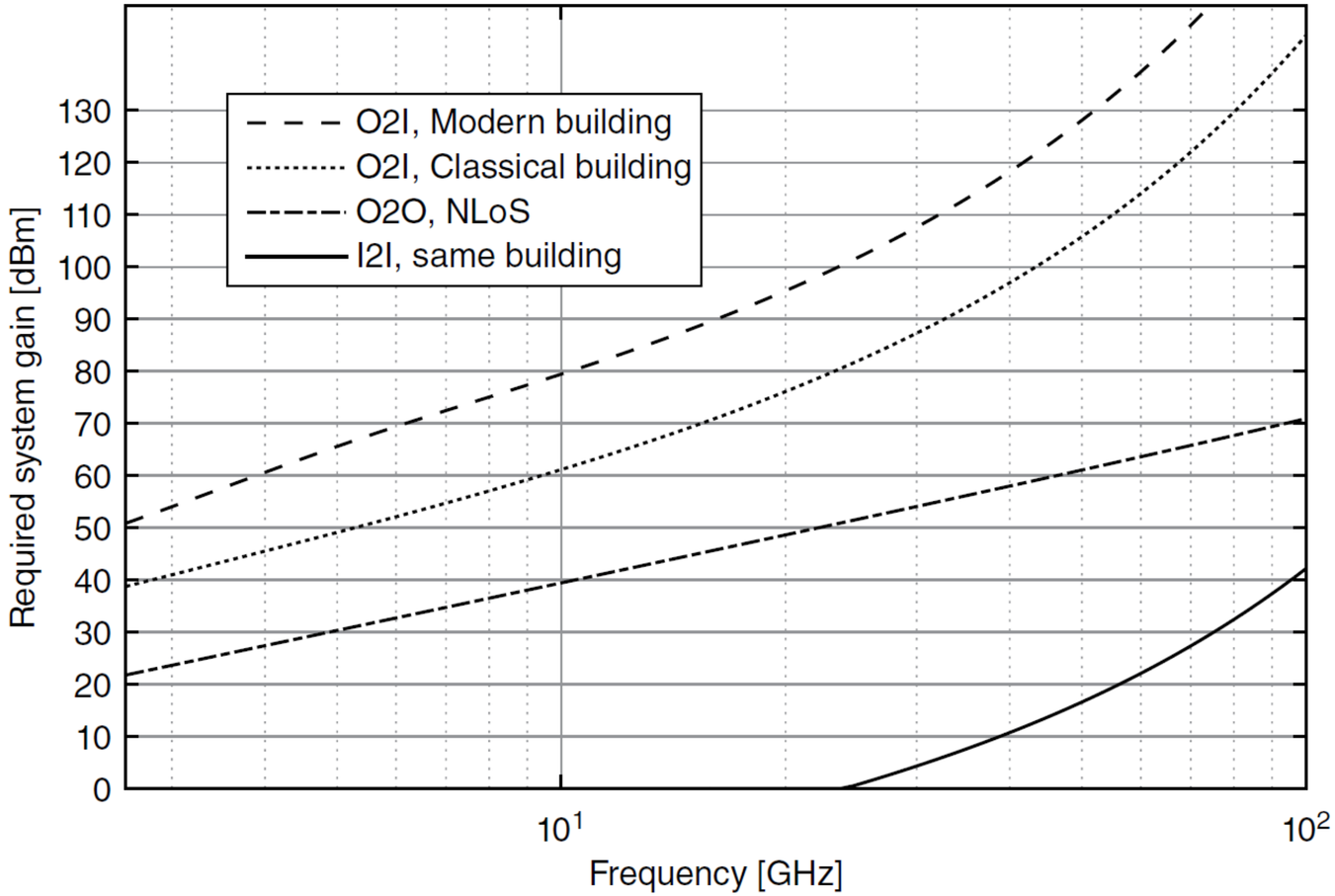
Licensed spectrum should be the core 5G spectrum management model.

Unlicensed spectrum can play a complementary role.

There is significant potential for the coexistence of 5G and other wireless services (e.g. satellite and fixed links) in higher frequency bands (e.g. above 24 GHz).

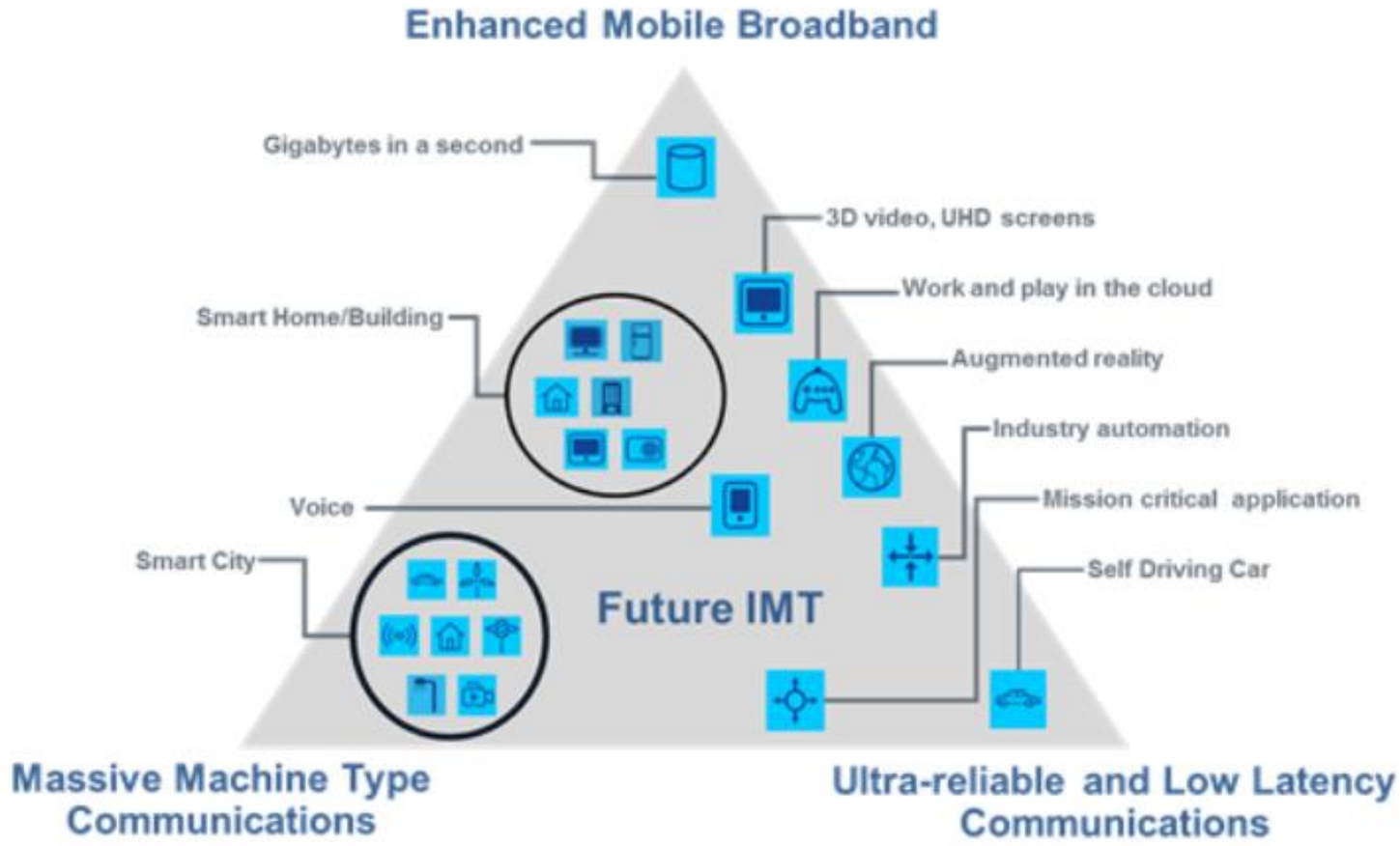
Technology neutral spectrum licences are essential. They allow existing bands which are used for existing mobile technologies to be easily refarmed for 5G thus ensuring spectrum is used most efficiently.

5G – Recall: Signal penetration of High Frequencies



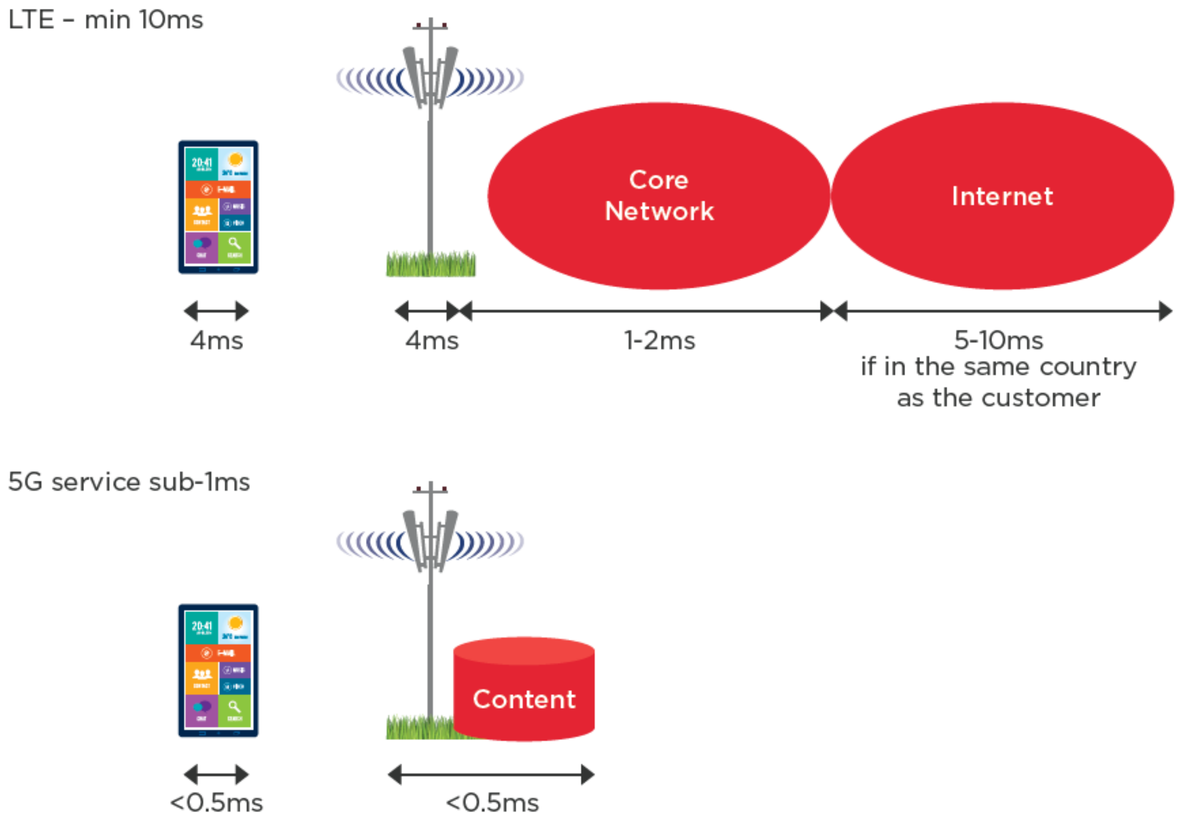
Source: 5G Technology: 3GPP New Radio, A. Toskala et al., John Wiley & Sons

5G – Recall: Scenarios

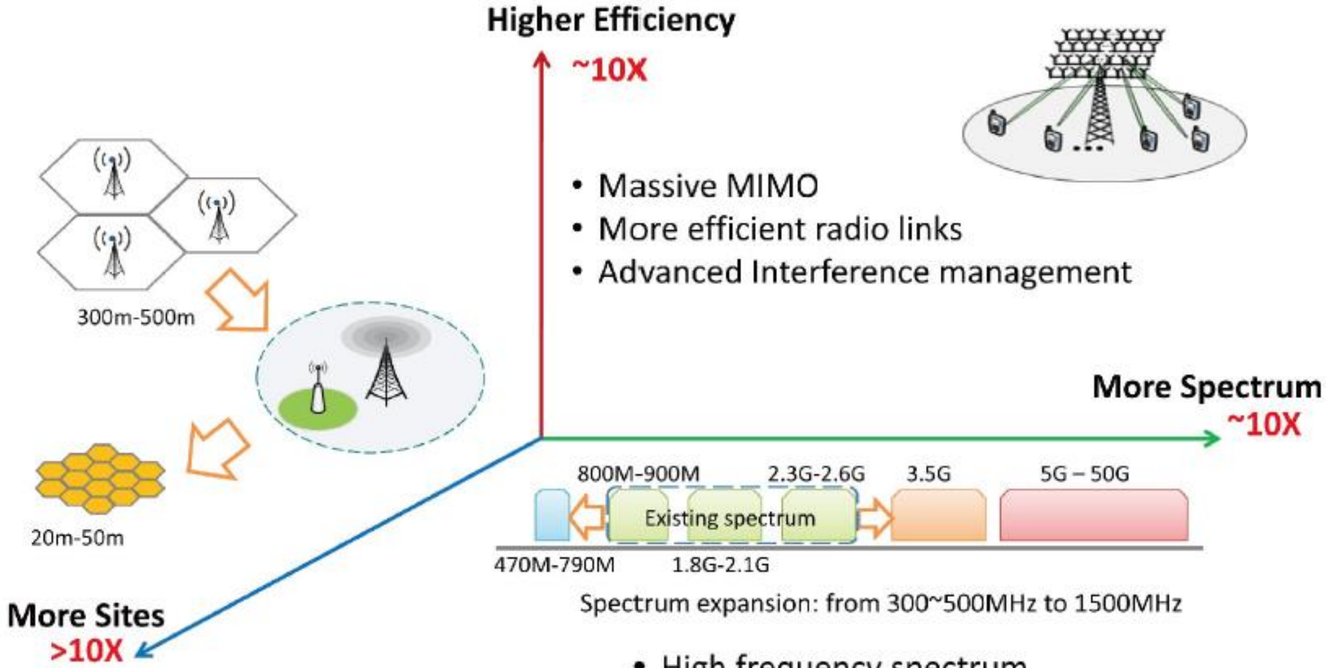


Source: ITU-T

5G – Recall: Scenarios



5G – Recall: Scenarios

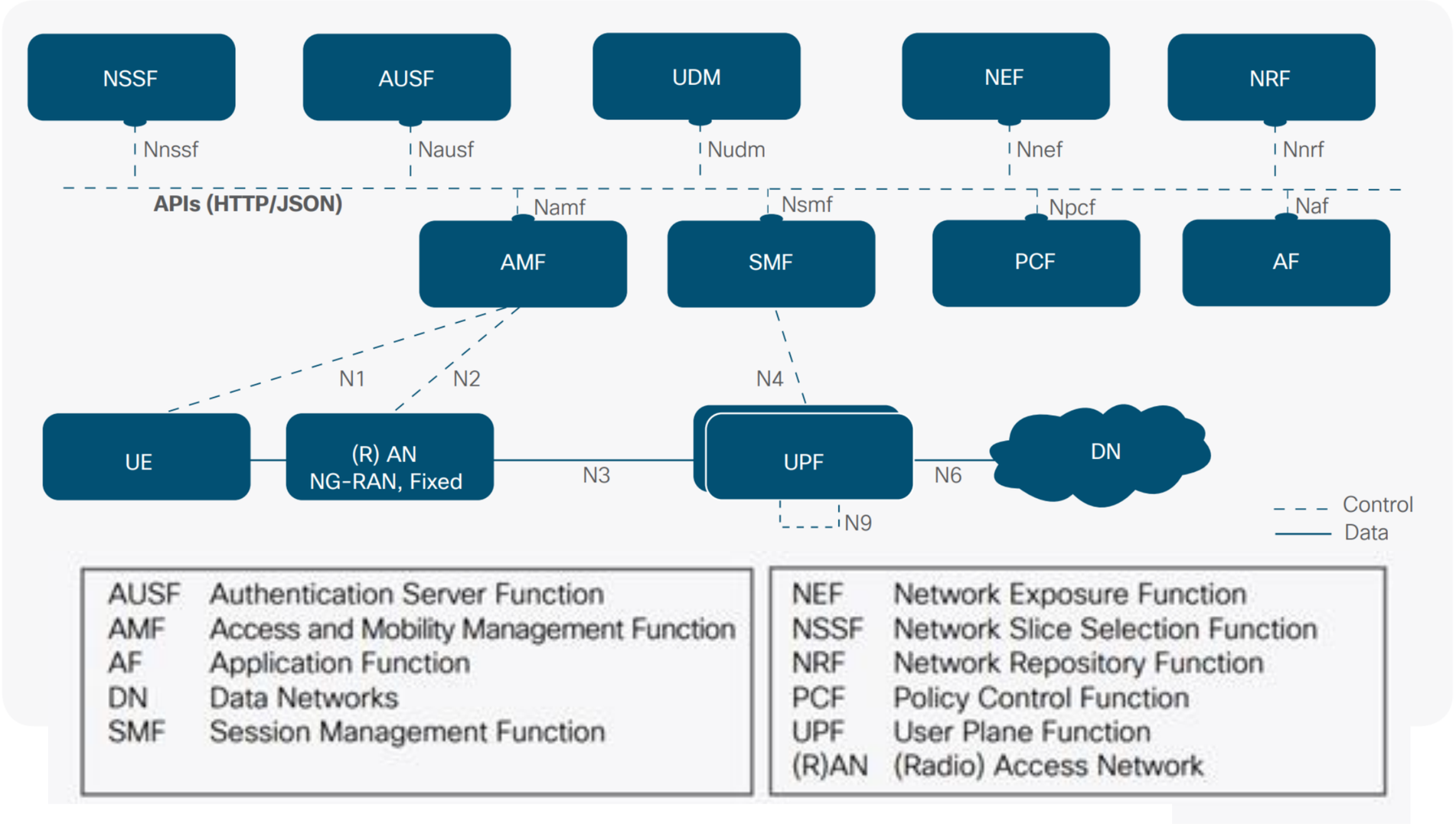


5G – Recall: Scenarios

Massive Machine Type Communication (mMTC):

- Low bandwidth
- High numer of devices
- High requirements of computing resources (long-time connections)
- Requirements of energy saving

5G – Recall: 5G architecture

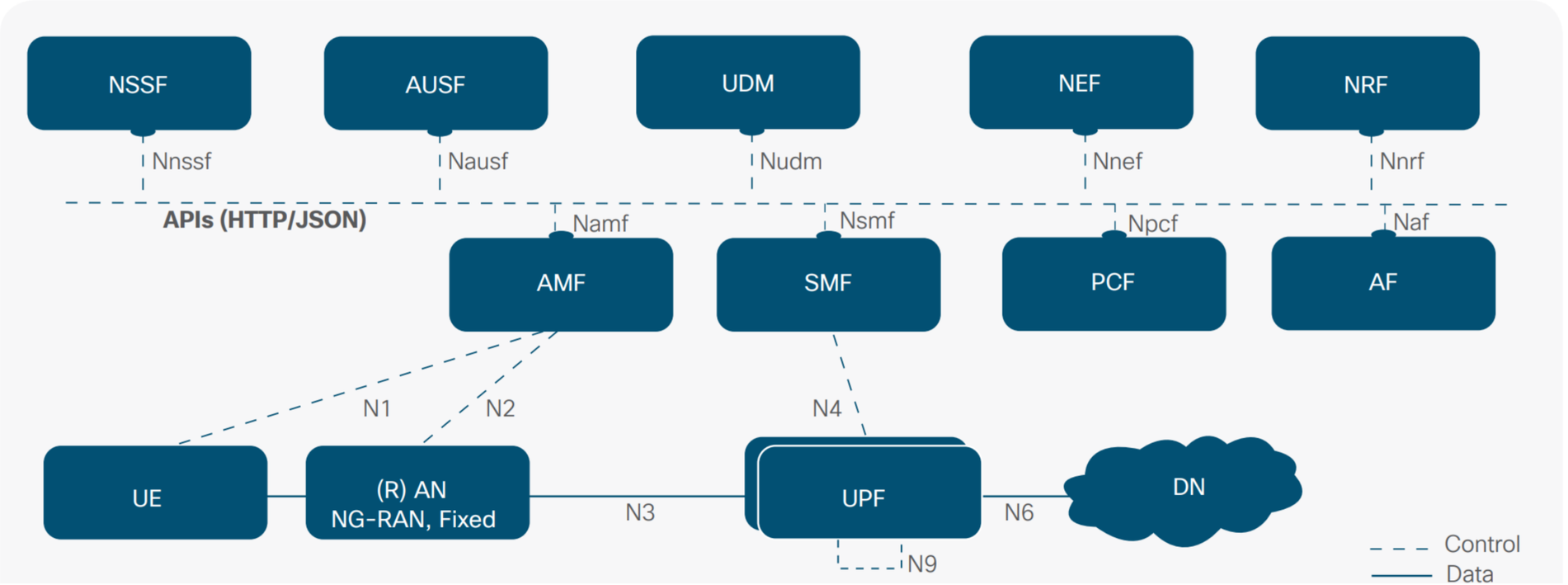


AUSF	Authentication Server Function
AMF	Access and Mobility Management Function
AF	Application Function
DN	Data Networks
SMF	Session Management Function

NEF	Network Exposure Function
NSSF	Network Slice Selection Function
NRF	Network Repository Function
PCF	Policy Control Function
UPF	User Plane Function
(R)AN	(Radio) Access Network

Source: 3GPP

5G – Recall: 5G architecture



Core vs. Radio

Control Plane vs. User Plane

Physical infrastructure (DU+CU + Transport + Local site + Transport +Regional site + Transport +National site)

Source: 3GPP

5G – Recall

Technological Innovations -> 5G NR:

- Massive MIMO (beamforming) - Increase of spectral efficiency (min. 2x, max. 5x)
- Multi-technology including 10 GHz or higher bands . High rates
- New multi-carrier radio transmission: Filter-Bank Multi-Carrier (FBMC), Universal Filtered Multi-Carrier (UFMC), and Generalized Frequency-Division Multiplexing (GFDM) -> lower latency on uplink (fewer synchronization)
- Non-Orthogonal Multiple Access (NOMA) and Sparse Coded Multiple Access (SCMA) for avoiding extensive signaling -> lower delay (URLLC). Non-Orthogonal complements orthogonal access. Non-orthogonal has higher interference but interference is reduced thanks to power differences (beamforming).
- Shared Spectrum Access. Systems for serving primary (incumbent, e.g., government), secondary (licensed, e.g., cellular), and tertiary (unlicensed) users

5G – Recall

Technological Innovations -> 5G NR:

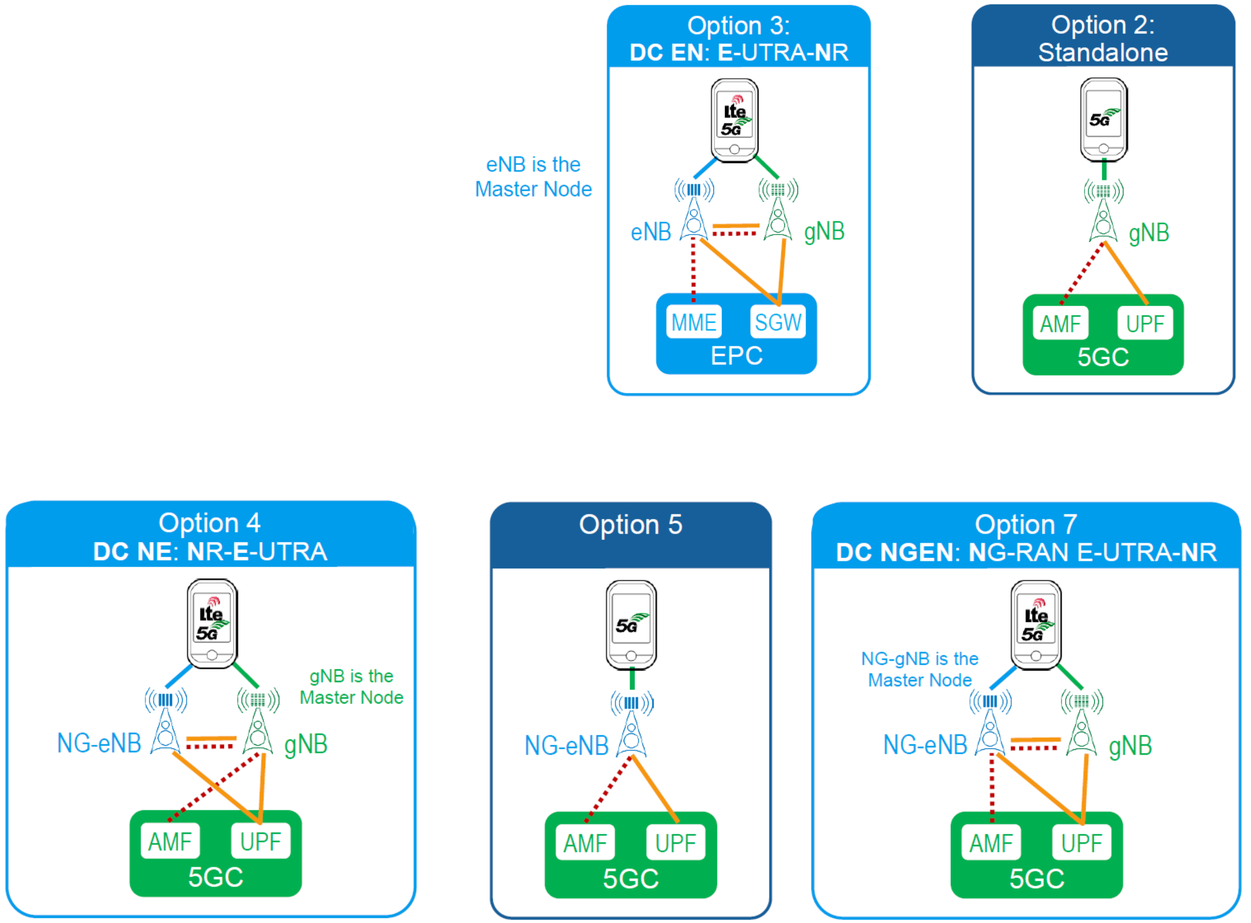
- Advanced Inter-Node Coordination thanks to cloud RAN. One user may be served by different nodes -> much higher bandwidth
- Simultaneous Transmission Reception in low-power transmission (small cells)
- Device-to-Device Communication for arriving to multiple users. It is network-controlled specially for licensed BW
- Multi-Radio-Access-Technologies (Wi-Fi, 4G, 3G, D2D) -> better policies
- Flexible Networks. 5G will be fully virtualized based on NFV and software-defined networking -> flexibility and reduction of time-to-deployment
- Backhaul/Fronthaul and integration of backhaul/radio access (backhaul wireless mm-bands)
- Flexible duplex. FDD for normal duplex communication. TDD in the case of high bandwidth

5G – Recall

Technological Innovations -> 5G Core (5GC)

- Complex networks incorporating multiple services, standards, and site types
- Coordination of multi-connectivity technologies
- On-demand deployment of service anchors
- Flexible orchestration of network functions
- Shorter period of service deployment

5G – Recall: 5G connection scenarios



Source: M. Kottkamp et al., 5G New Radio: Fundamentals, procedures, testing aspects. Rohde&Schwarz

5G – Recall: Standardisation

Telecommunications Technology Association, Korea

The Association of Radio Industries and Businesses, Japan

Telecommunication Technology Committee, Japan

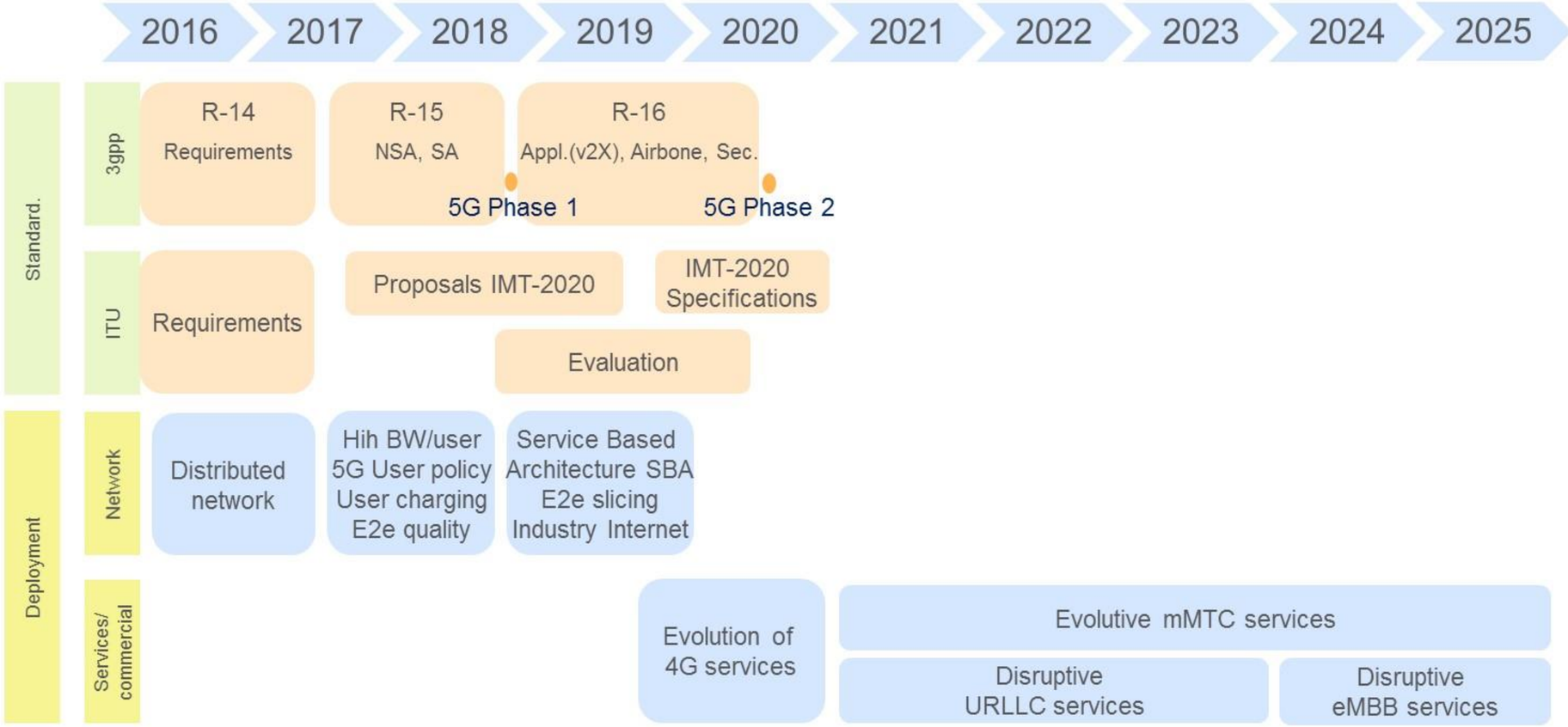
China Communications Standards Association

Telecommunications Standards Development Society, India

The Alliance for Telecommunications Industry Solutions

The European Telecommunications Standards Institute

5G – Recall: Standardisation



5G – Recall

Q&A