RIMEDO LABS

6G Requirements and Potential Enabling Technologies from the Perspective of Mobile Operators

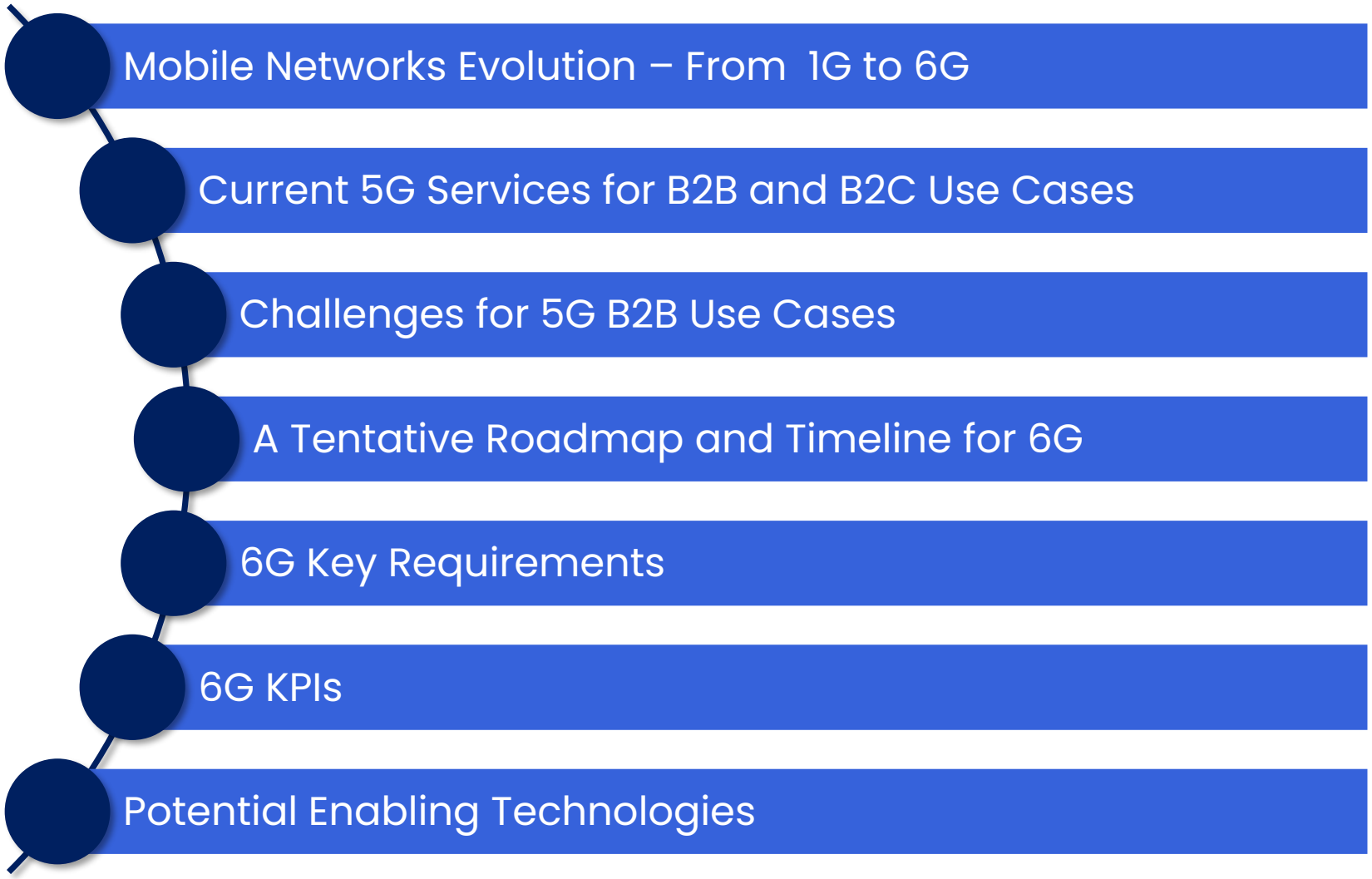
Dr. Youssouf Ould Cheikh Mouhamedou

Member of Rimedo Labs Business & Technical Advisory Board

All things wireless

September 2022

Agenda


Mobile Networks Evolution – From 1G to 6G
Current 5G Services for B2B and B2C Use Cases
Challenges for 5G B2B Use Cases
A Tentative Roadmap and Timeline for 6G
6G Key Requirements
6G KPIs
Potential Enabling Technologies

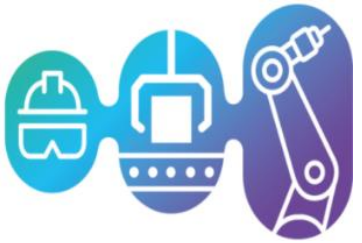
5G Status

RIMEDO LABS

rimedolabs.com

Mobile Networks Evolution – From 1G to 6G

1G	2G	3G	4G	5G	6G
	9.6 Kbps	2 Mbps	1 Gbps	10 Gbps	1 Tbps
Analog	Digital	WCDMA	OFDM + All-IP PS Network	Virtualized Core	AI, Open RAN, RIS, ..etc
Voice call	SMS & Roaming	Mobile Internet	Mobile Broadband Internet	Massive Broadband + IoT + Industry Verticals	Full Digital and Connected World
1980	1990	2000	2010	2020	2030

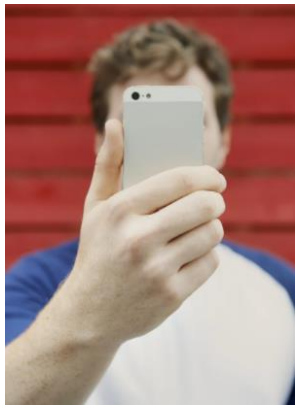


Current 5G Services for B2B and B2C Use Cases

5G Vision

5G Reality

Making voice calls



Watching and sharing videos and selfies

B2C

Worldwide, there are no (or just few) 5G services for B2B industry verticals

B2B

Challenges for 5G B2B Use Cases

5G is a game-changer for many B2B industry verticals, but not yet a game-winner. Why?

Businesses Challenges:

- Lack of business cases
- Delay in ecosystem readiness (devices and network)

Mobile Operators Challenges:

- Not willing to upgrade to meet business demand unless there is clear demand
- It takes time to develop different SLA levels based on unique business requirements
- Not straightforward to develop Business model for charging

Towards 6G

RIMEDO LABS

rimedolabs.com

G+ Happens Every 10 Years and 6G Won't Be an Exception

Marketing machinery is in full gear

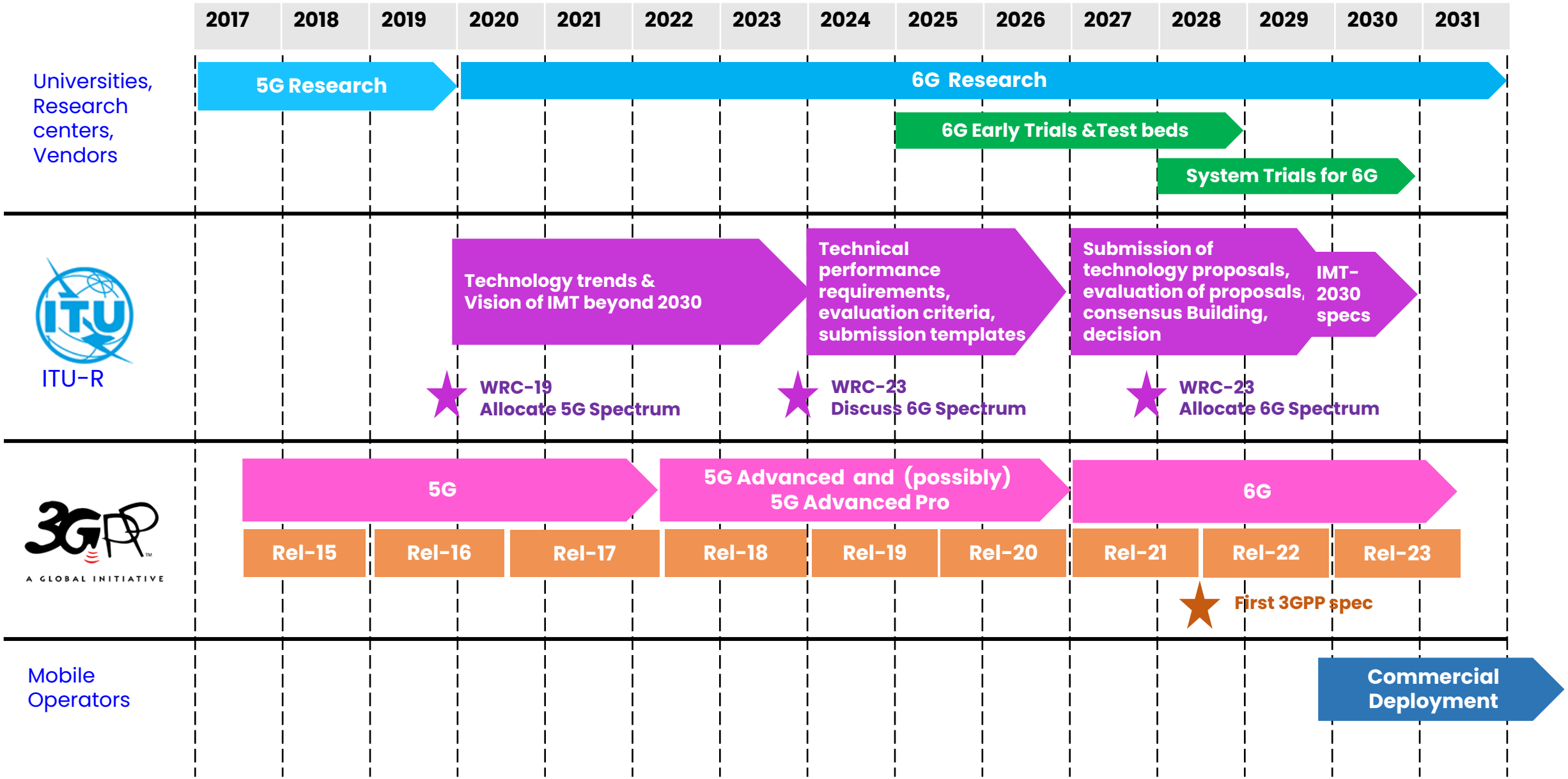
		Benefits
Vendors	G+ will be cash cow because of the many great verticals it can serves	Selling more equipment
Regulatory body	G+ will accelerate the digitalization of economies and society	Selling more Spectrum
Univ. Researchers	G+ will eliminates drawbacks of G and introduce technological advances	Getting research funds
Mobile Operators	G+ is the answer to all emerging needs of consumers, businesses, and society	New revenue streams

Beneficiaries' hopes

Consumers	Improved user experience at competitive pricing
Businesses	Cost-efficient ways to enhance existing businesses and explore new ones
Society	Privacy and health (e.g., limited Electromagnetic Field (EMF) emissions)

In conclusion, 6G will happen in 2030 and 7G in 2040 (if not earlier)

A Tentative Roadmap and Timeline for 6G



6G Key Requirements

Perception of Infinite Capacity

- Higher data rates for Immersive virtual environments such as Metaverse & extended reality (xR)
- Higher connection density to support the ever increasing demands of connected devices

Resilience and security

- Resilience = high robustness + fast recovery over failure
- Secure, reliable, and available under all circumstances

Sustainability

- Significant reduction in energy consumption per bit
- Green energy for RAN (e.g. energy produced by nearby solar panel and stored in battery bank)
- Fully recyclable components

Ubiquitous 3D coverage

- Elimination of dead spots
- High-speed wireless connectivity throughout land, sea, sky, space

6G KPIs

KPI	5G	6G
Peak data rate	**20 Gbps**	**1 Tbps**
User experienced data rate	100 Mbps	1 Gbps
Peak spectral efficiency	30 b/s/Hz	60 b/s/Hz
User experienced spectral efficiency	0.3 b/s/Hz	3 b/s/Hz
End-to-End latency	**10 ms**	**1 ms**
Radio-only latency	1 ms	100 microseconds
Block Error Rate (BLER)	**10^{-5}**	**10^{-9}**
Connection density	10^6 devices/Km^2	10^7 devices/Km^2
Network energy efficiency	**Not Specified**	**1 pJ/b**
Position accuracy	1 m	0.1 m
Mobility	**500 Km/h**	**1000 Km/h**
Maximum frequency	100 GHz	10 THz
Maximum bandwidth	1 GHz	100 GHz
Satellite integration	**Partial**	**Fully**

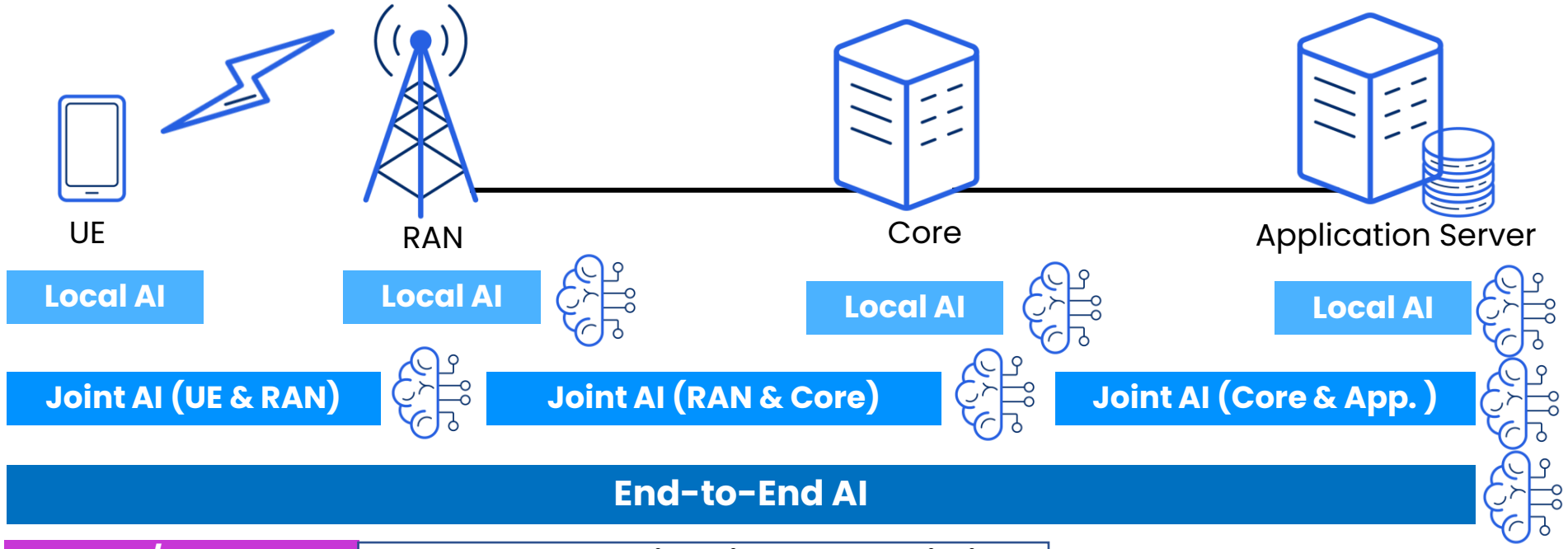
Potential 6G Enabling Technologies

Potential Enabling Technologies

There are many interesting technologies that have potential to enable 6G.

The focus here is on some 6G enabling technologies that have potential to noticeably contribute to Mobile operators businesses in term of creation of revenue and growth.

AI-Native Design for Better Teaming

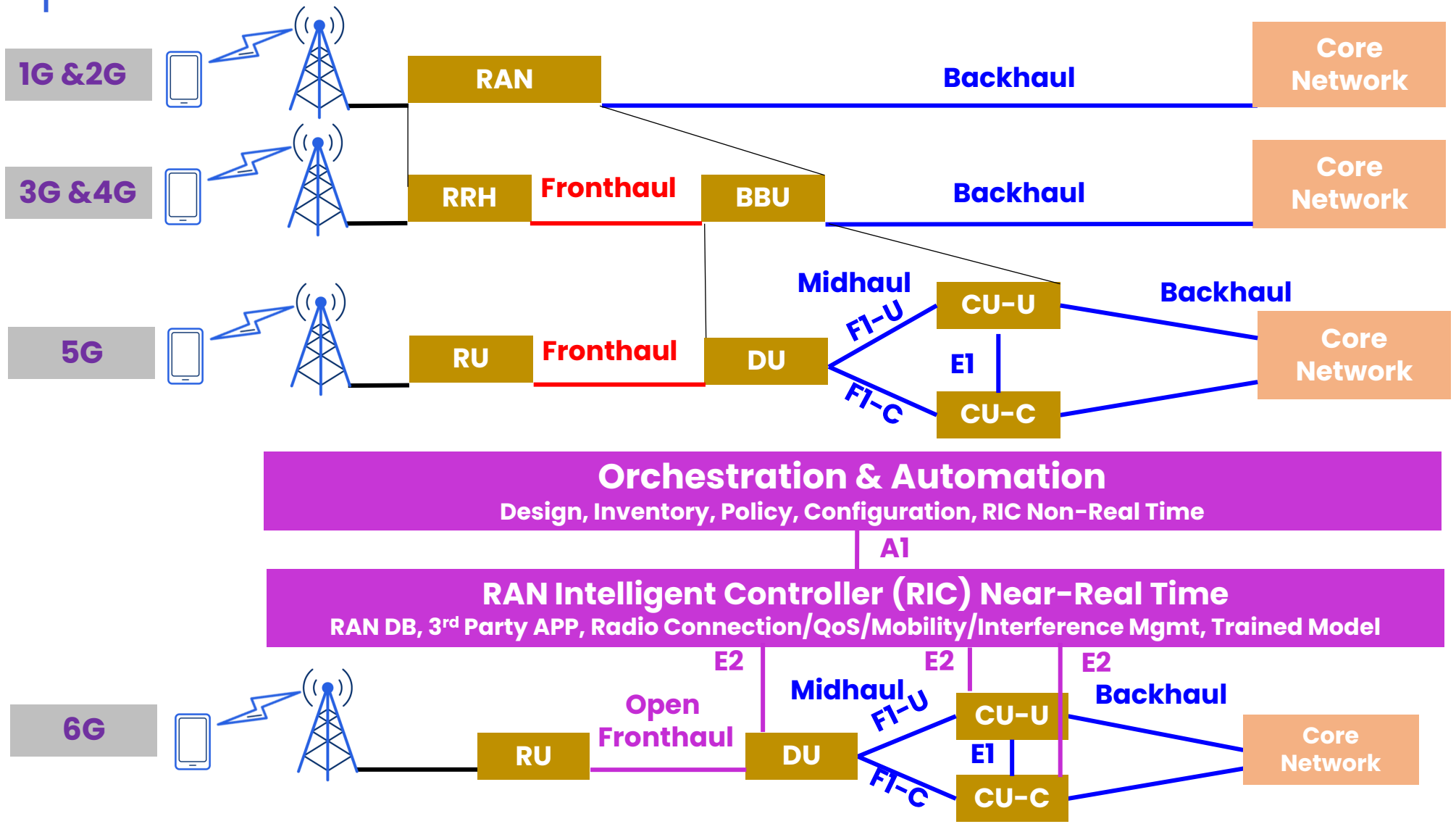


Local UE/RAN	**• e.g., Channel estimation and prediction**
Joint RAN<--> Core	**• e.g., Handover optimization - predict future users' location/speed to trigger handover on time**
Core	**• e.g., How to manage signaling storms when Network falls down and recovers**

E2E AI benefits:

- Predict anomalies in network operation → take corrective action on time → enhance network reliability and achieve OPEX reduction
- Optimized network slicing → Can accommodate new Network slices for additional industry vertical → enhance network efficiency and reduce CAPEX

Open RAN



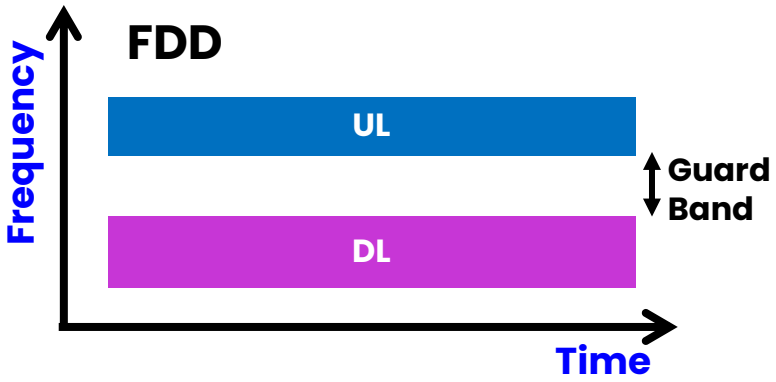
Not 3GPP

Open RAN benefits:

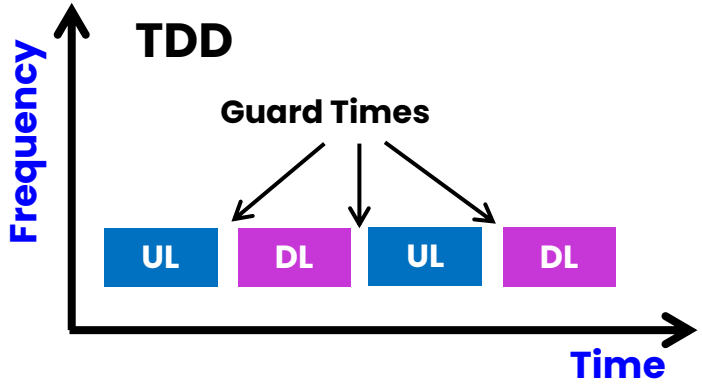
- Open interfaces for Interoperability
- Open Ecosystem (no vendor lock-in),
- Innovation,
- Quick Time-to-Market,
- Intelligent Management

→ Significant reduction in OPEX & CAPEX

In-band Full-Duplex Communication



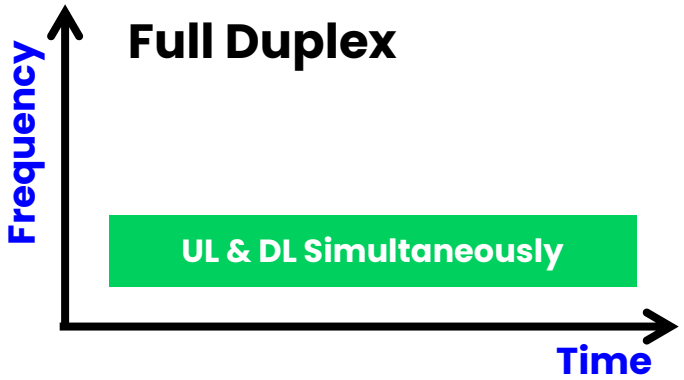
Tx & Rx at the same time, but each has dedicated block of spectrum



Tx & Rx in alternating time slots, using a single block of spectrum, but feels like simultaneous Tr &Rx

1G, 2G, & 3G: FDD

4G & 5G: FDD & TDD



Tx & Rx at the same time, using a single block of spectrum

6G: Full-Duplex, FDD, and TDD

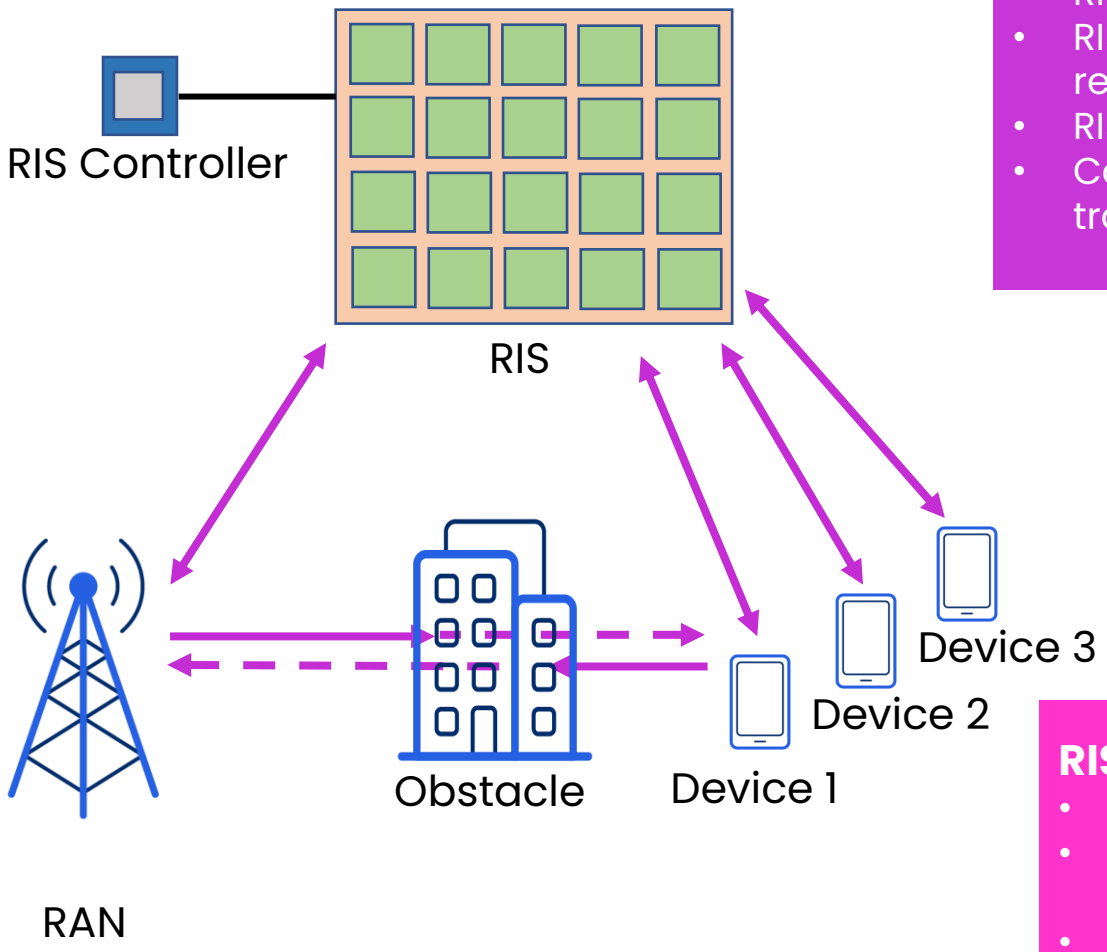
Need self-interference technology that allows a radio to completely cancel out its own transmission, such that it can receive in the same block of spectrum .

Full-Duplex Benefits:

- Doubling spectral efficiency → Can get the job done using ½ of the available block of spectrum → Next spectrum auction purchase only ½ of otherwise needed spectrum → Cost saving
- Use of Relays to extend coverage of mmWave

Reconfigurable Intelligent Surfaces (RISs)

Goal: to partially control the channel for better coverage and data rate gains



- RIS is a two-dimensional grid of antennas/reflectors, whose properties are reconfigurable rather than static
- RIS Controller controls the RIS antennas/reflectors
- RIS system is almost passive (i.e., signal is not amplified or regenerated), the only power consumed is the one by RIS controller
- RIS system increases coverage
- Can be placed on building facades, billboards, underground ceilings, train stations, airports

When compared to rely, RIS system has:

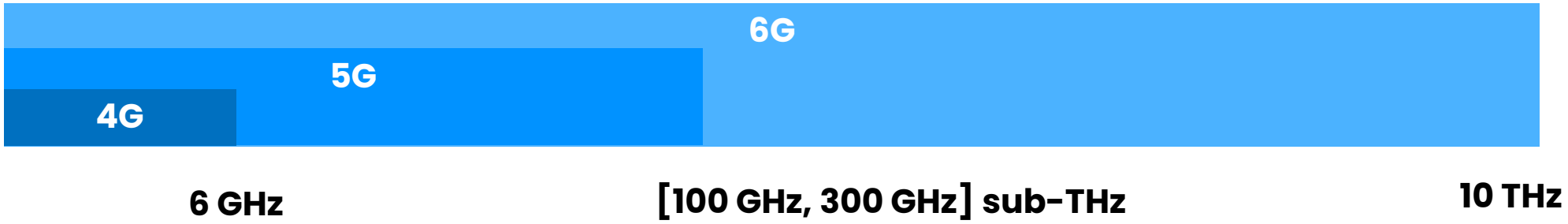
- Simplified hardware,
- Much lower energy consumption,
- Lower cost

RISs benefits:

- **Better Planning:** When placing a new RAN is difficult or costly
- **Deployment cost:** Accelerating the use of mmWave in cost effective manner
- **Sustainability:** Lowering energy consumption
- **Society:** Reducing exposure to to electromagnetic fields (EMF)

Terahertz Communication

Don’t Give Up on Terahertz (THz) bands (0.1-10 THz) . Likely, it will be adopted in 6G standard.



BUT, unless practical & profitable breakthrough happens in enabling technologies such as Reconfigurable Intelligent Surfaces (RIS) and the like, THz bands will have harder time than 5G mmWave bands.

- Even if THz bands are adapted in 6G standard, they won’t be used in early deployment of 6G because of the lack of profitable use cases
- Maybe profitable use cases and cost-efficient devices will evolve around 7G era (~2040)

Your trusted partner in: O-RAN, 5G & Beyond, Private Mobile Networks.

Let's keep in touch!

RIMEDO Labs
ul. Polanka 3
61-131 Poznan, Poland

info@rimedolabs.com
rimedolabs.com