Magma for 5G
Understanding ongoing (existing) feature development and testing

LFN Developer and Testing Forum

10 January 2022

https://www.magmacore.org/
https://github.com/magma/magma

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AI-First Technology Company for the
Digital, Cognitive & Industry 4.0 Era

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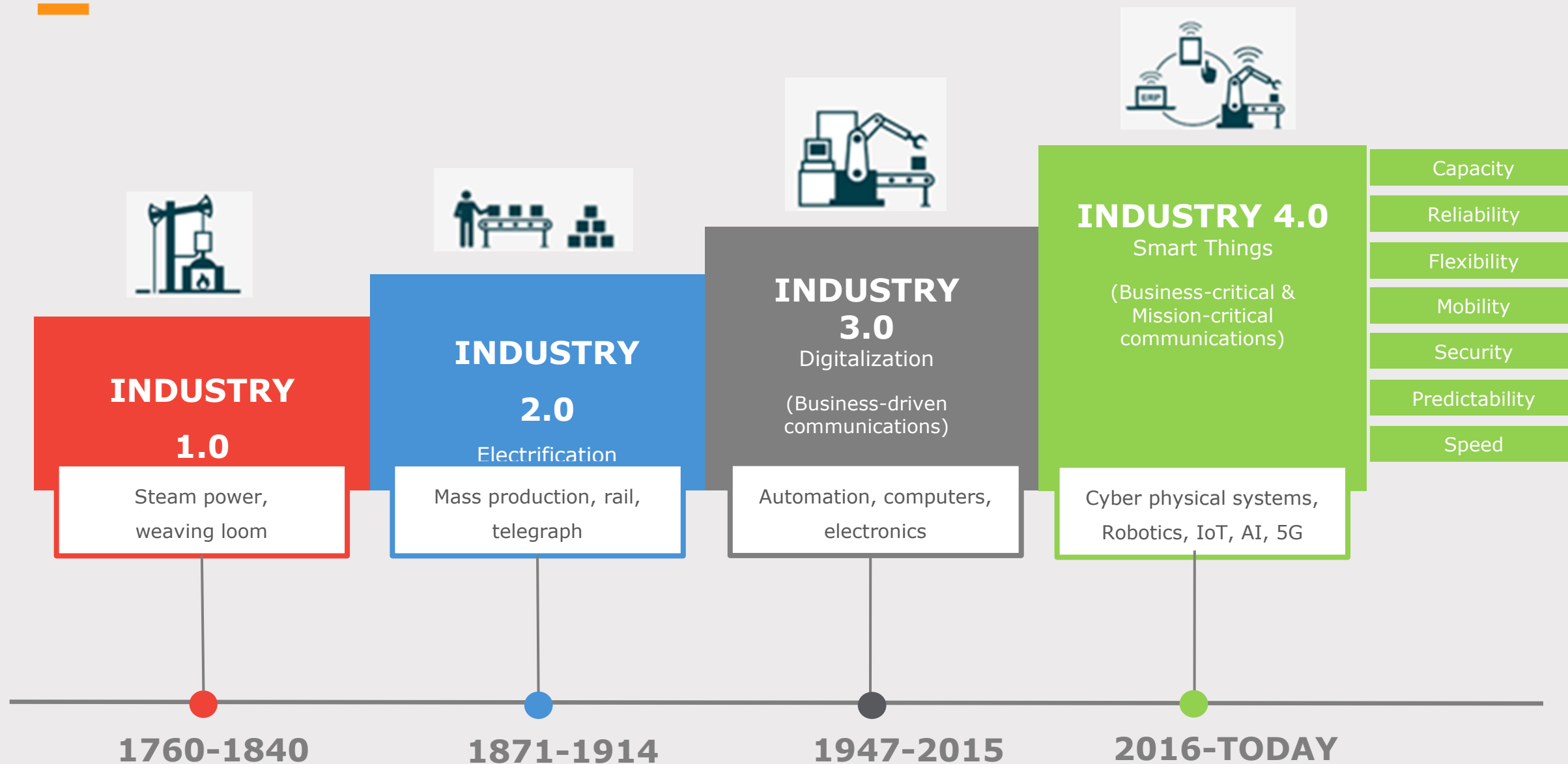
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Agenda

January 10, 2022

- 5G, the Major Opportunity Today and Tomorrow

- Magma Mission and Overview

- Magma Architecture

- Magma 5G SA supported features

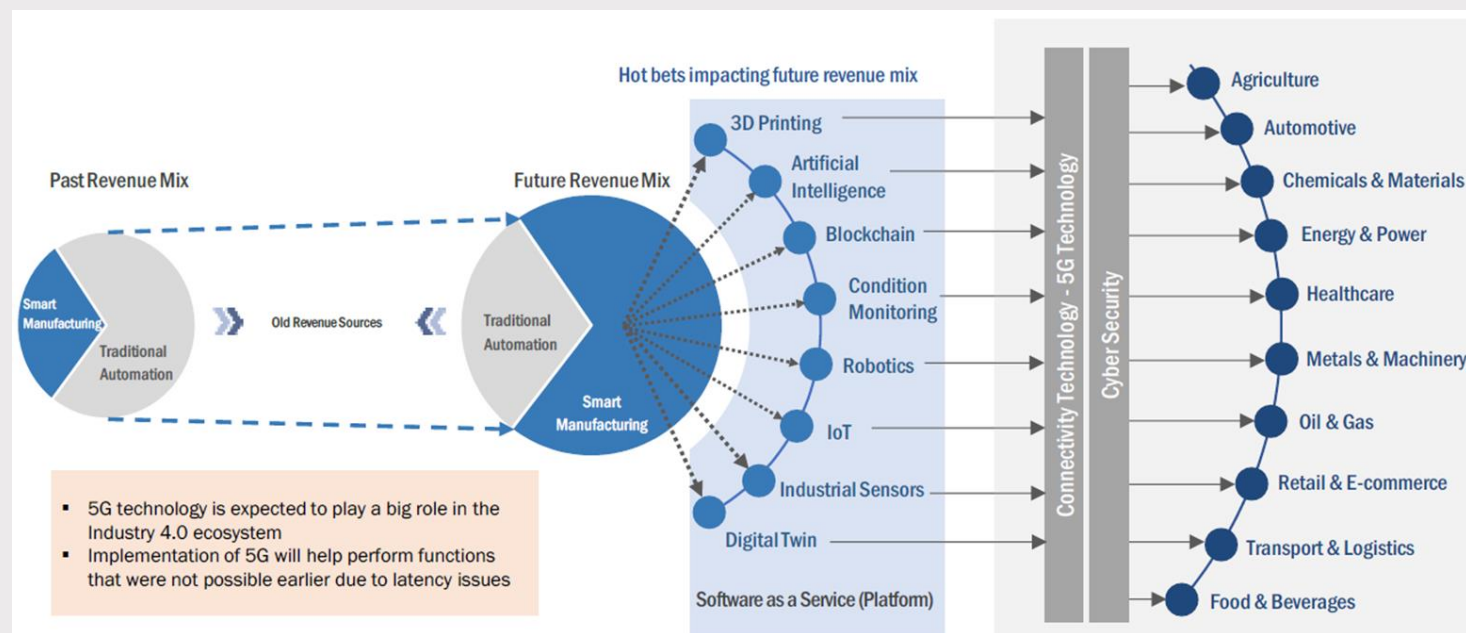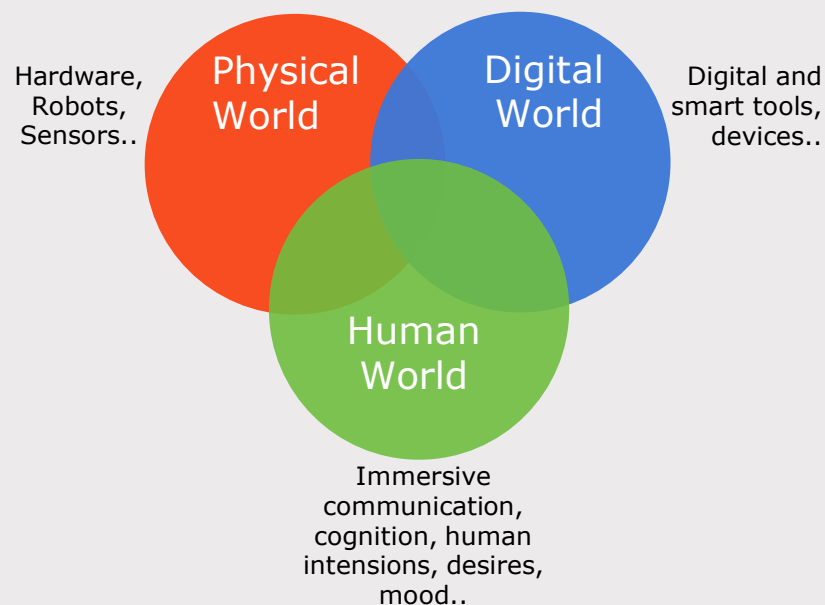- How we test Magma 5G SA & Demo

- Q&A

The Evolution of Industry 1.0 to 4.0

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INDUSTRY 1.0

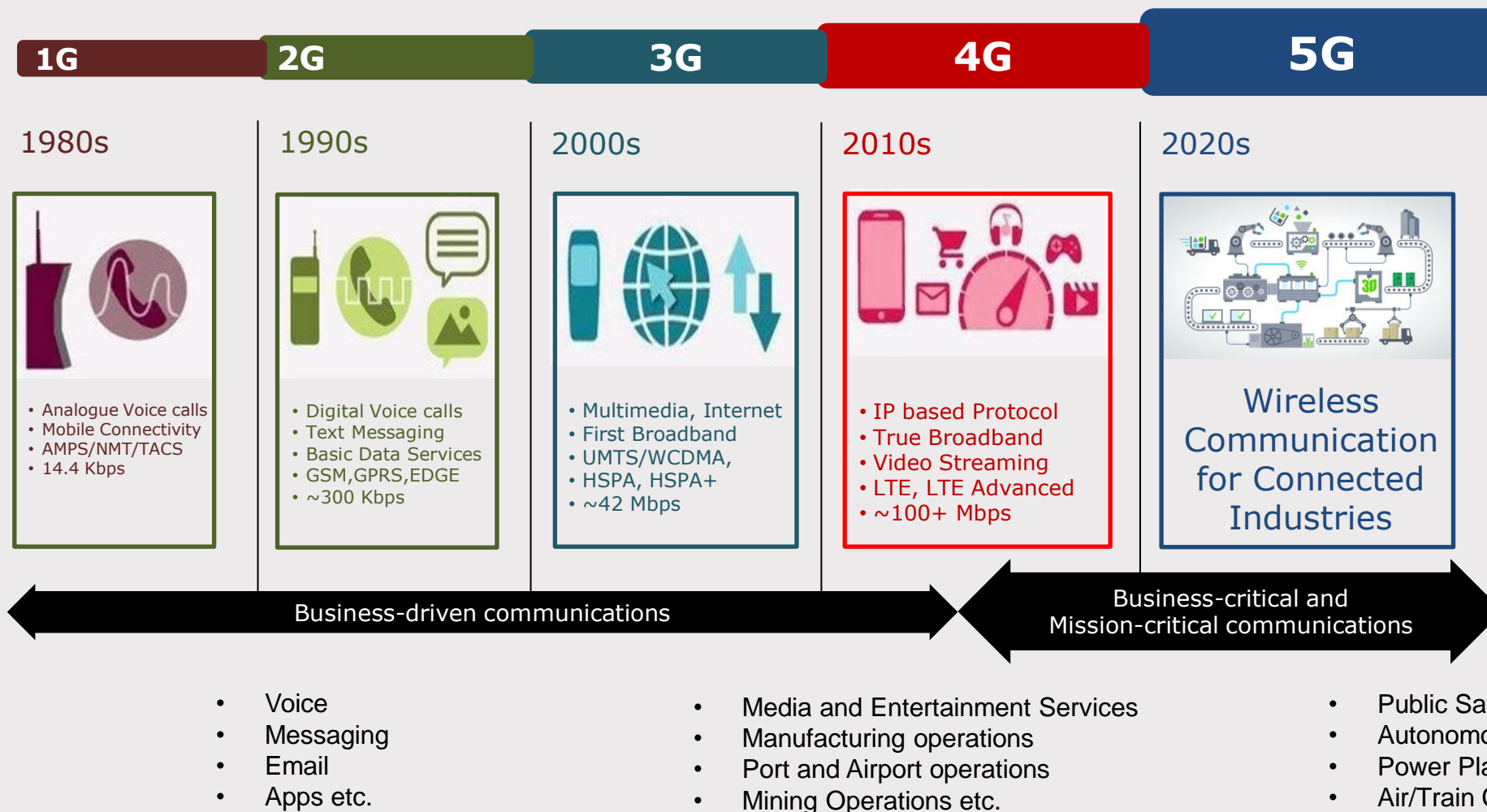Steam power, weaving loom

INDUSTRY 2.0

Electrification

Mass production, rail, telegraph

INDUSTRY 3.0

Digitalization

(Business-driven communications)

Automation, computers, electronics

INDUSTRY 4.0

Smart Things

(Business-critical & Mission-critical communications)

Cyber physical systems, Robotics, IoT, AI, 5G

Capacity

Reliability

Flexibility

Mobility

Security

Predictability

Speed

1760-1840

1871-1914

1947-2015

2016-TODAY

5G technology role in Industry 4.0 ecosystem

| Fully Connected Intelligence | 5G will play a big role in the Industry 4.0 ecosystem |

Hardware, Robots, Sensors..

Physical World

Digital World

Digital and smart tools, devices..

Human World

Immersive communication, cognition, human intensions, desires, mood..

Hot bets impacting future revenue mix

Past Revenue Mix

Smart Manufacturing

Traditional Automation

Old Revenue Sources

Traditional Automation

Future Revenue Mix

Smart Manufacturing

- 3D Printing
- Artificial Intelligence
- Blockchain
- Condition Monitoring
- Robotics
- IoT
- Industrial Sensors
- Digital Twin
- Software as a Service (Platform)

Connectivity Technology - 5G Technology

Cyber Security

- Agriculture
- Automotive
- Chemicals & Materials
- Energy & Power
- Healthcare
- Metals & Machinery
- Oil & Gas
- Retail & E-commerce
- Transport & Logistics
- Food & Beverages

- 5G technology is expected to play a big role in the Industry 4.0 ecosystem
- Implementation of 5G will help perform functions that were not possible earlier due to latency issues
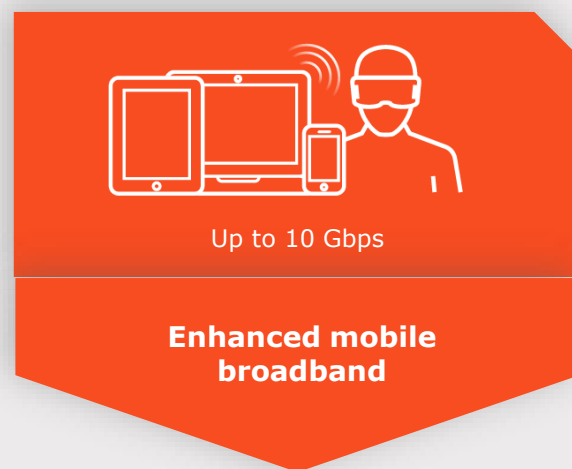
Source: Secondary Research, Industry Journals, Expert Interviews, and MarketsandMarkets Analysis

The Evolution of Mobile technology 1G to 5G
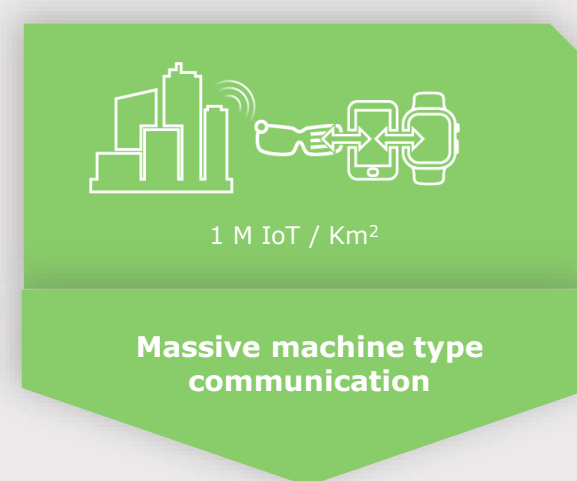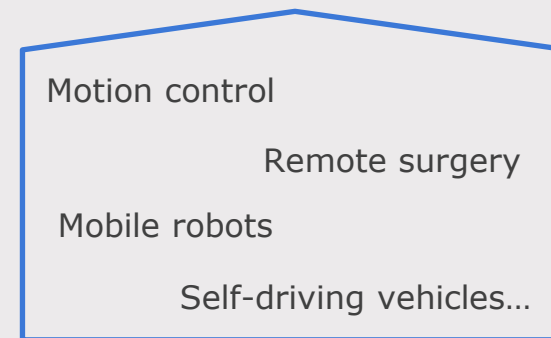
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1G	2G	3G	4G	5G

1980s

• Analogue Voice calls
• Mobile Connectivity
• AMPS/NMT/TACS
• 14.4 Kbps

1990s

• Digital Voice calls
• Text Messaging
• Basic Data Services
• GSM,GPRS,EDGE
• ~300 Kbps

2000s

• Multimedia, Internet
• First Broadband
• UMTS/WCDMA,
• HSPA, HSPA+
• ~42 Mbps

2010s

• IP based Protocol
• True Broadband
• Video Streaming
• LTE, LTE Advanced
• ~100+ Mbps

2020s

Wireless
Communication
for Connected
Industries

Business-driven communications

Business-critical and
Mission-critical communications

- Voice
- Messaging
- Email
- Apps etc.

- Media and Entertainment Services
- Manufacturing operations
- Port and Airport operations
- Mining Operations etc.

- Public Safety Services
- Autonomous Robotics
- Power Plant & Grid Control
- Air/Train Control etc.

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5G designed ground up for several Industry 4.0 use cases

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Up to 10 Gbps

Enhanced mobile broadband

2017 → **From 3GPP R15** →

CCTV offload / transfer

Augmented reality

Remote maintenance

Asset management...

1 ms / 6X9's / TSN

Ultra-reliable and low latency communication

2018 → **From 3GPP R16 + R17** →

Motion control

Remote surgery

Mobile robots

Self-driving vehicles...

1 M IoT / Km^2

Massive machine type communication

2021 → **From 3GPP R18** → **2023**

Street lightning

Security / Surveillance

In-car operations

Other massive sensors...

Private 5G Networks - The Major Opportunity Today and Tomorrow

magma

Private 5G Network Market Size Is Projected to Reach $13.92 Billion By 2028 | CAGR: 40.9%: Polaris Market Research

POLARIS MARKET RESEARCH

Private 5G Network Market Size (2021-2026)

Market Data Forecast

The global Private 5G Network market was worth **USD 1357.3 million in 2020** and is estimated that it will reach **USD 14248.96 million by 2026**, registering a **CAGR of about 40.9%** between 2021 and 2026.

Private 5G Network Market Size And Forecast

VMR VERIFIED MARKET RESEARCH

Private 5G Network Market size was valued at USD 1.2 Billion in 2020 and is projected to reach **USD 16.05 Billion by 2028**, growing at a **CAGR of 38.8% from 2021 to 2028.**

Private 5G Network Market Size Worth $13.92 Billion By 2028 | CAGR: 40.9%

POLARIS MARKET RESEARCH

5G PRIVATE NETWORK PROJECTS HAVE DOUBLED IN THE PAST YEAR
(e.g.) US$ 75 billion by 2020 from ABIresearch

ABIresearch THE TECH INTELLIGENCE EXPERTS

Integration Services for Private 5G Networks reach US$5.8 billion by 2026

SYSTEMS INTEGRATION WILL SOON COST MORE THAN ACTUAL PRIVATE CELLULAR INFRASTRUCTURE

New York, New York - October 26, 2021

Connect the world to a faster network by enabling service providers to build cost-effective, extensible, and carrier-grade networks.
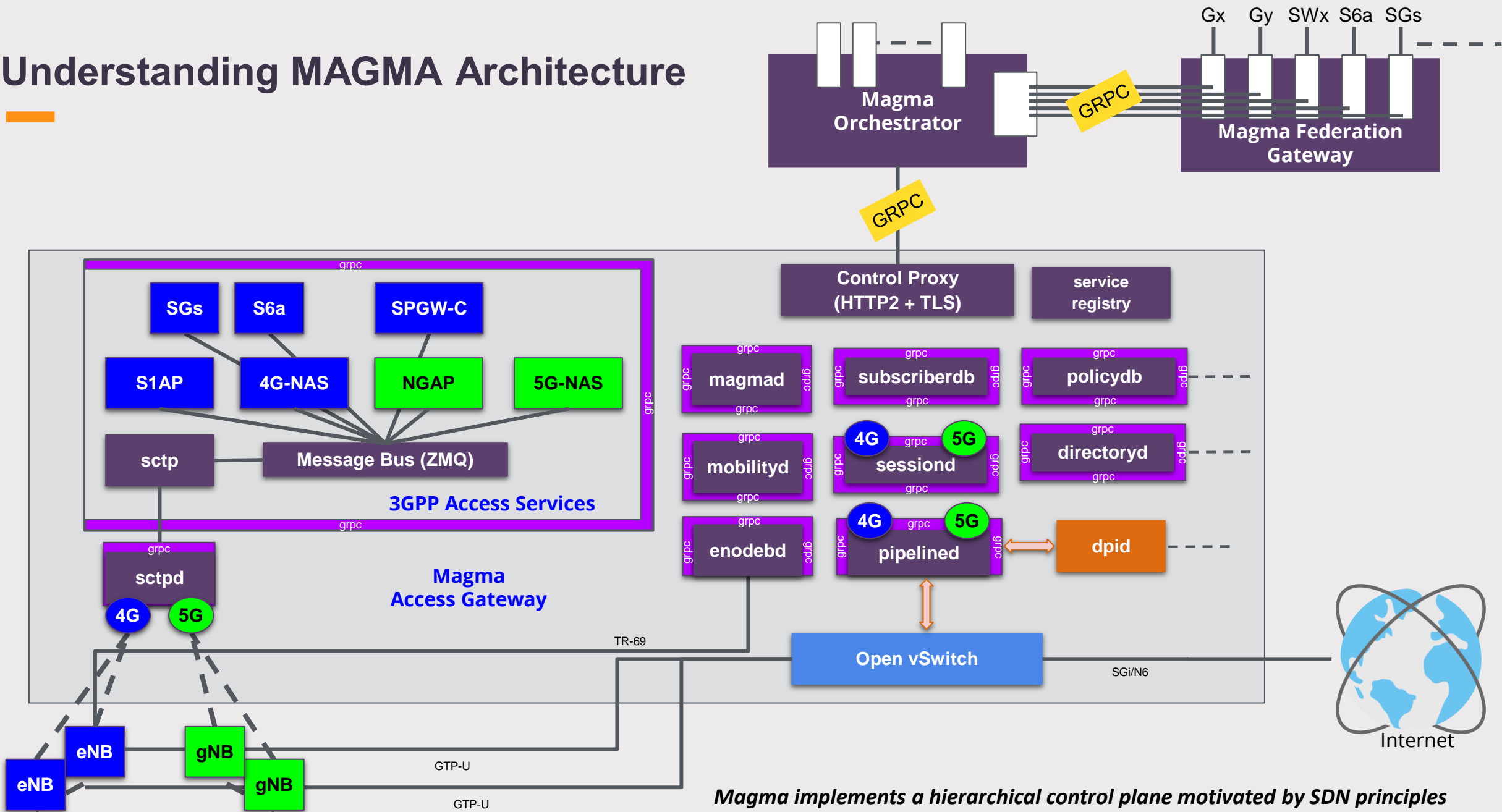
Magma Overview

Magma enables network operators to offer an open, flexible and scalable FWA and Private Wireless Network solution

Highlights

- **Open source** packet core and **free** to use
- 3GPP generation (4G or 5G) & access **network agnostic** (cellular or Wi-Fi)
- Distributed and EDGE ready, local breakout for internet traffic
- **Cloud Managed** - Orchestrator can be deployed on a public/private cloud
- **Vendor agnostic** - works with standardized RAN H/W
- **Scales horizontally**
- Exposes REST APIs to **integrate** with 3rd-party OSS/BSS

ACCESS NETWORK

MAGMA CONVERGED CORE

MNO CORE

REST APIs

Orchestrator & NMS

Federation Gateway

MNO Core

PCRF   HSS

OCS   Wi-Fi

S6a, Gx, Gy

Radio

S1a,, N1, N2, N3

4G LTE / 5G / Wi-Fi / CBRS

Magma Access Gateway

LTE	Wi-Fi	5G
SGW PGW	AAA	UPF AMF SMF
MME HSS	AGW	AUSF PCF UDM

CPE

SGi, N6

Internet

Cell Site (OTS H/W)

Private Cloud

Public Cloud
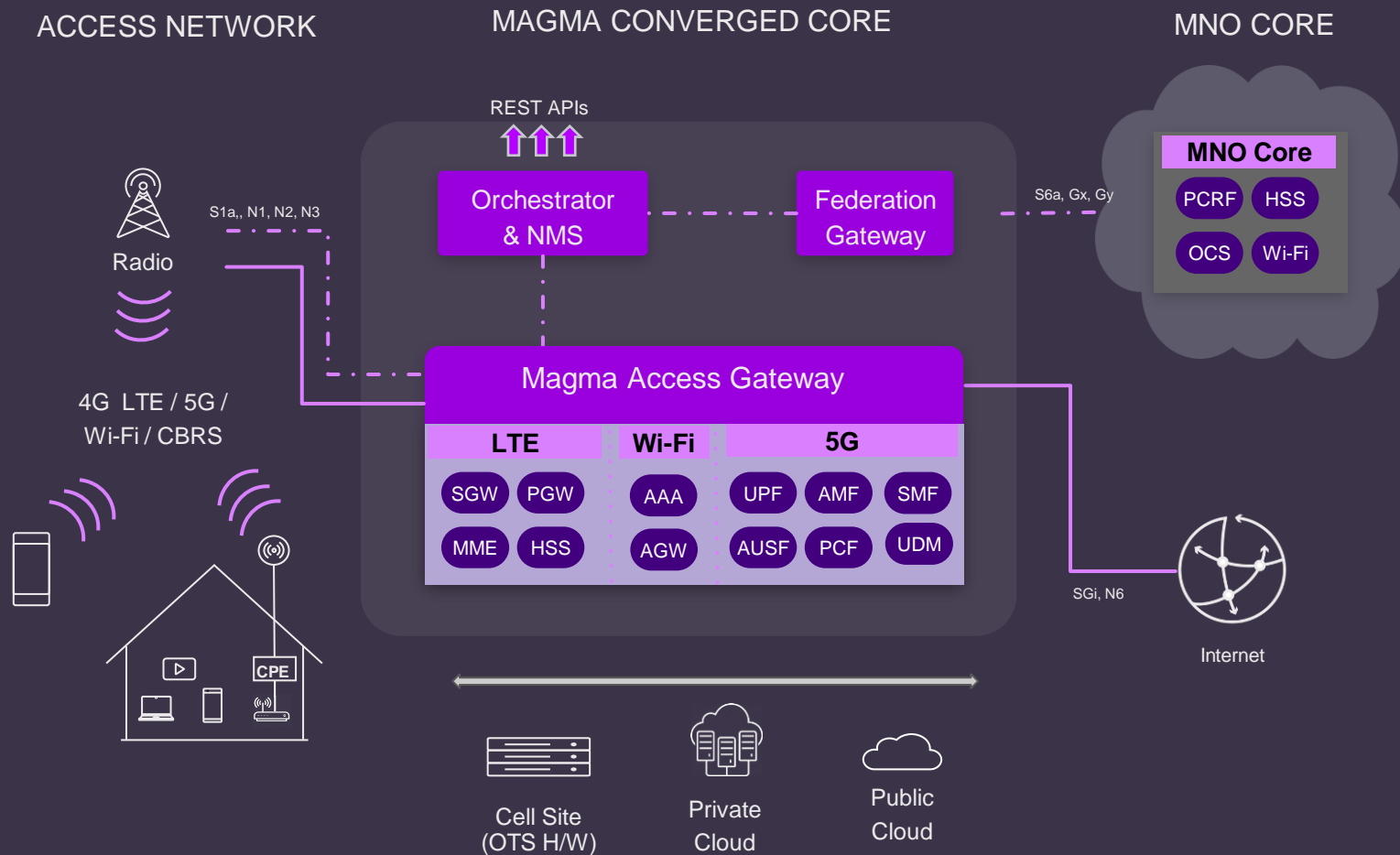
Understanding MAGMA Architecture

Magma implements a hierarchical control plane motivated by SDN principles

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Magma Architecture Principles

1. Allow for failure

Node failing should have limited overall impact
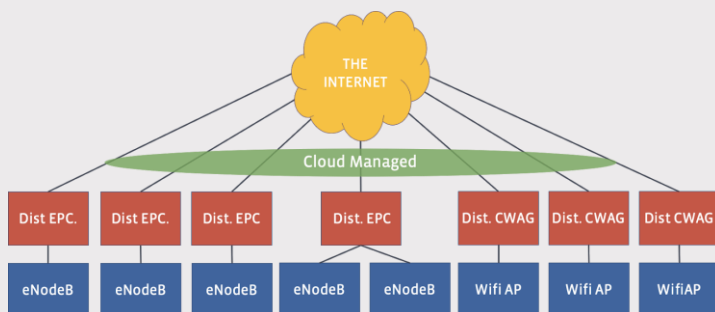
2. Simplify failure semantics

Failure domain maps to clean state boundaries
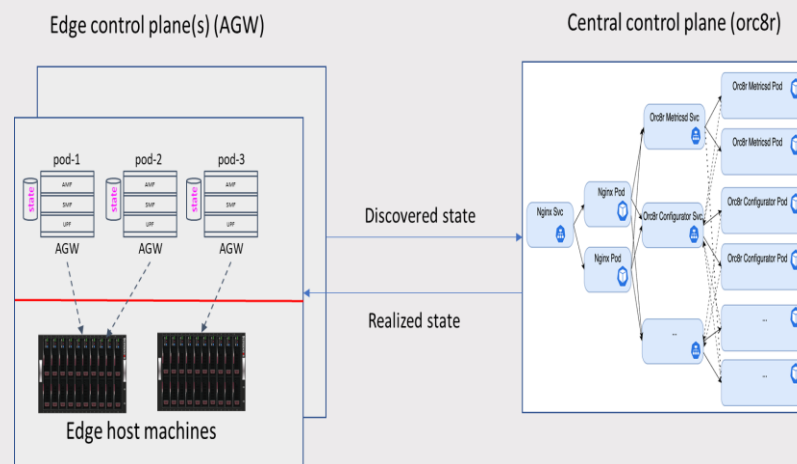
3. Simplify recovery

Well defined state propagation for recovery
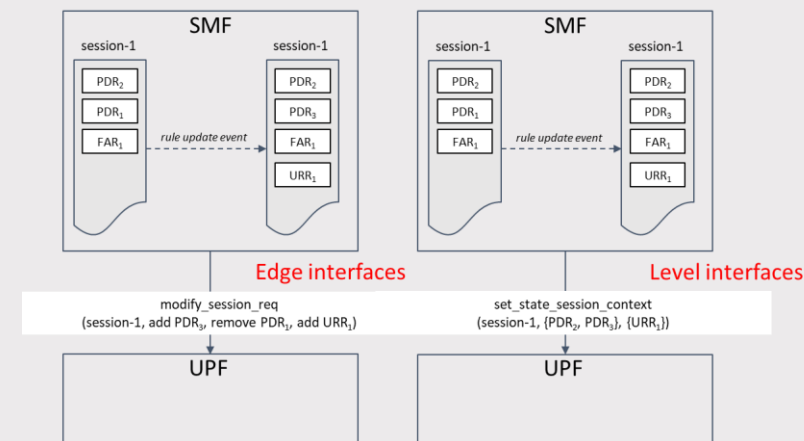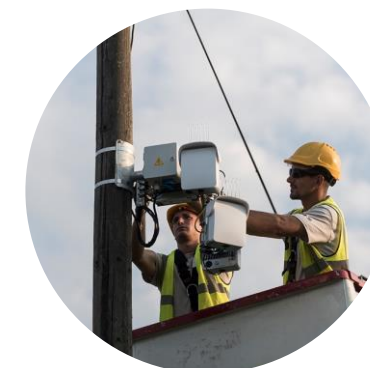
- Model only service state
- Use level trigger

Magma 5G SA Supported Features

Procedures / Features Available today

(1) Registration

(2) 5g specific Authentication

(3) PDU Session Establishment

(4) Idle mode and Paging

(5) Service Request

(6) UE initiated Session Release

(7) UE initiated De-registration

(8) Dynamic Policy support & 5G QOS

(9) Usage reporting & Charging

FWA

Private Wireless

(1) Registration

SUCI as mobile Identity

- 1. Registration Request
- 2. Registration Request
- 3. Authentication/Security
- 4. Calculated XRES
- 5. Authentication Request
- 6. Authentication Response
- 7. Security Mode Command
- 8. Security Mode Complete
- 9. Initial Context Request + Registration Accept
- 10. Initial Context Response
- 11. Registration Complete

GUTI as mobile Identity

- 1. Registration Request
- 2. Registration Request
- 3. Identity Request
- 4. Identity Response
- 5. Authentication
- 6. Authentication Request/Response
- 7. Securtiy Mode Command and Response
- 9. Initial Context Request + Registration Accept
- 10. Initial Context Response
- 11. Registration Complete

(2) 5G Specific Authentication

Subscription Identification de-concealing function (SIDF) decrypts SUCI using Home Network Private Key

gNB → NGAP → AMF → AUSF/Subscriberdb

SCTP_DATA_IND
ngap_amf_handle_initial_ue_message
callback

NGAP_INITIAL_UE_MESSAGE
amf_handle_registration_request
callback

If type_of_identity is SUCI and protect_schm_id is Profile A or Profile B

M5GSUCIRegistration
ue_pubkey_identifier, bytes
ue_ciphertext,
ue_encrypted_mac

Returns concealed ue_msin

Initiate Registration procedures-Authentication, SMC

(3) PDU session establishment

Efficient level trigger operations, state management on Access side
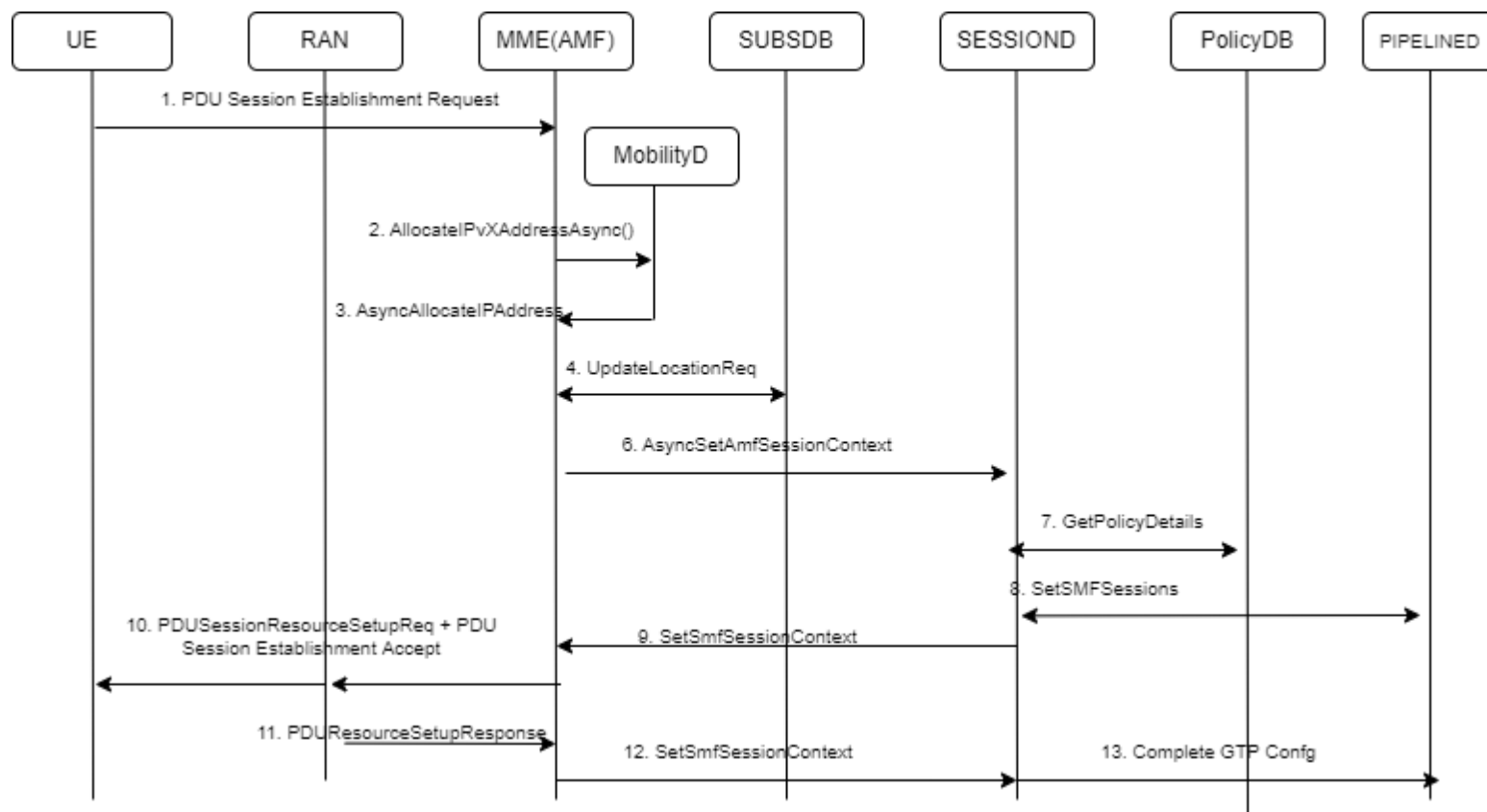
(4) Idle Mode and Paging
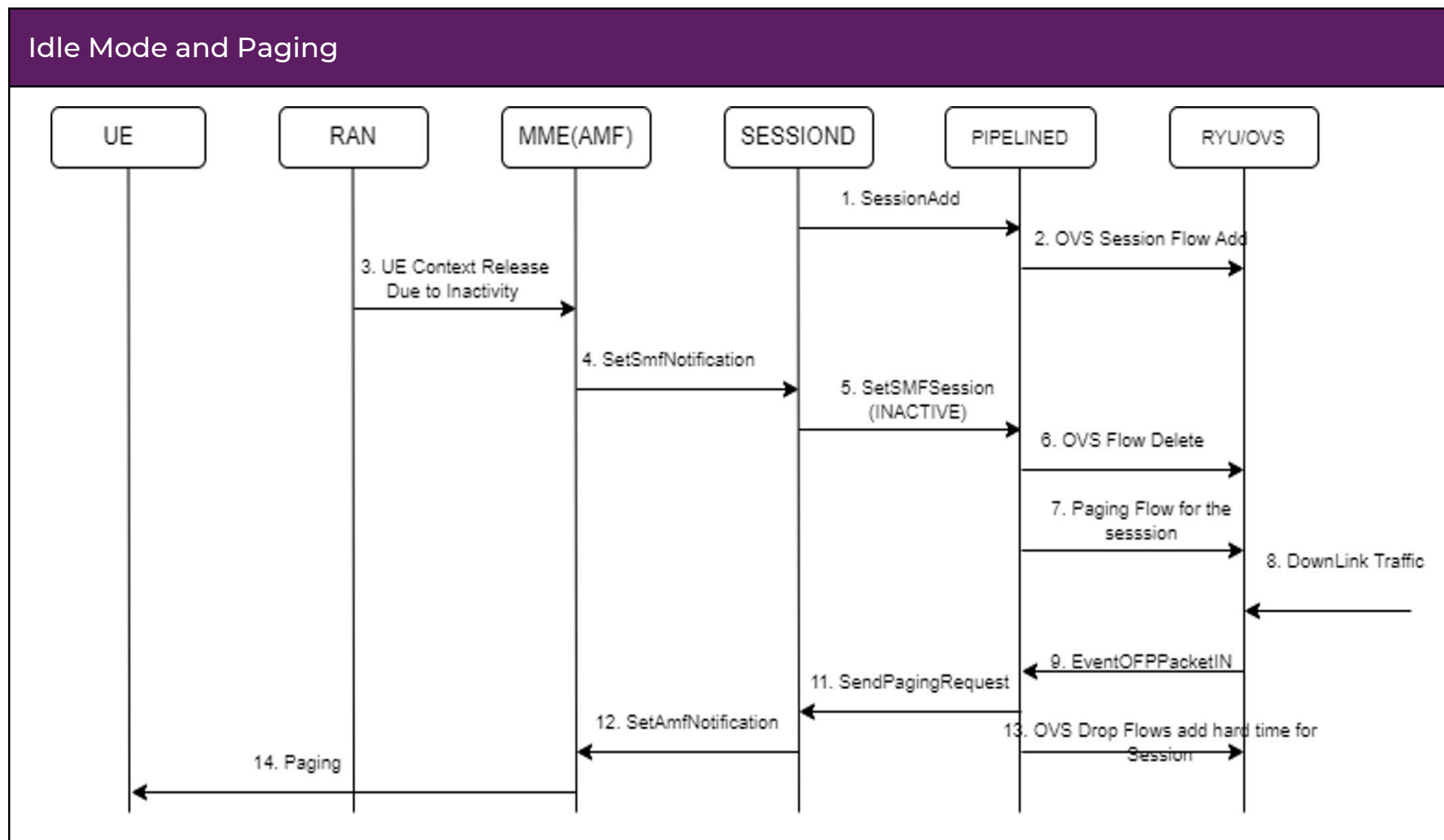
(5) Service Request
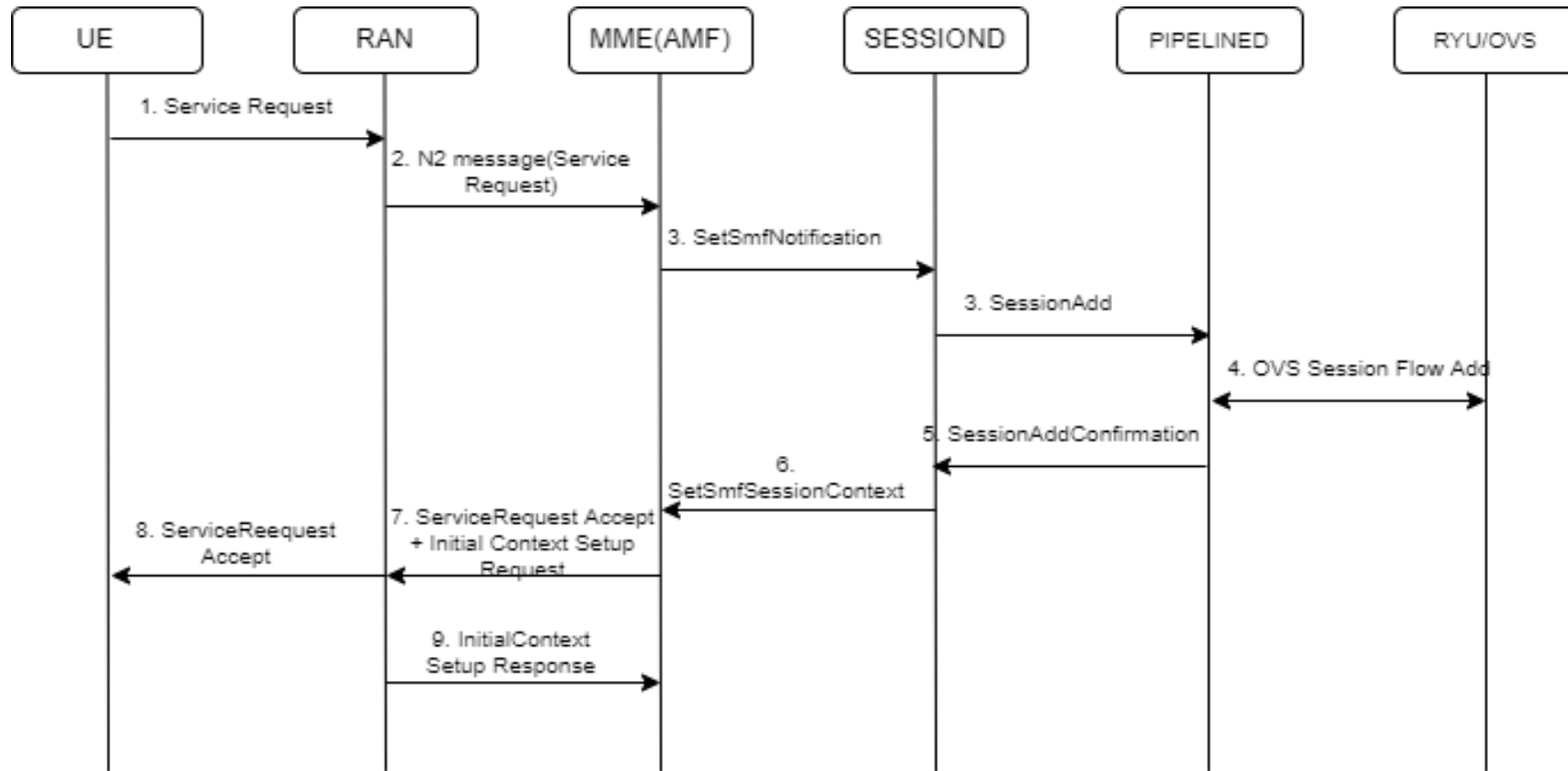
(6) UE initiated PDU session Release

UE initiated PDU session Release
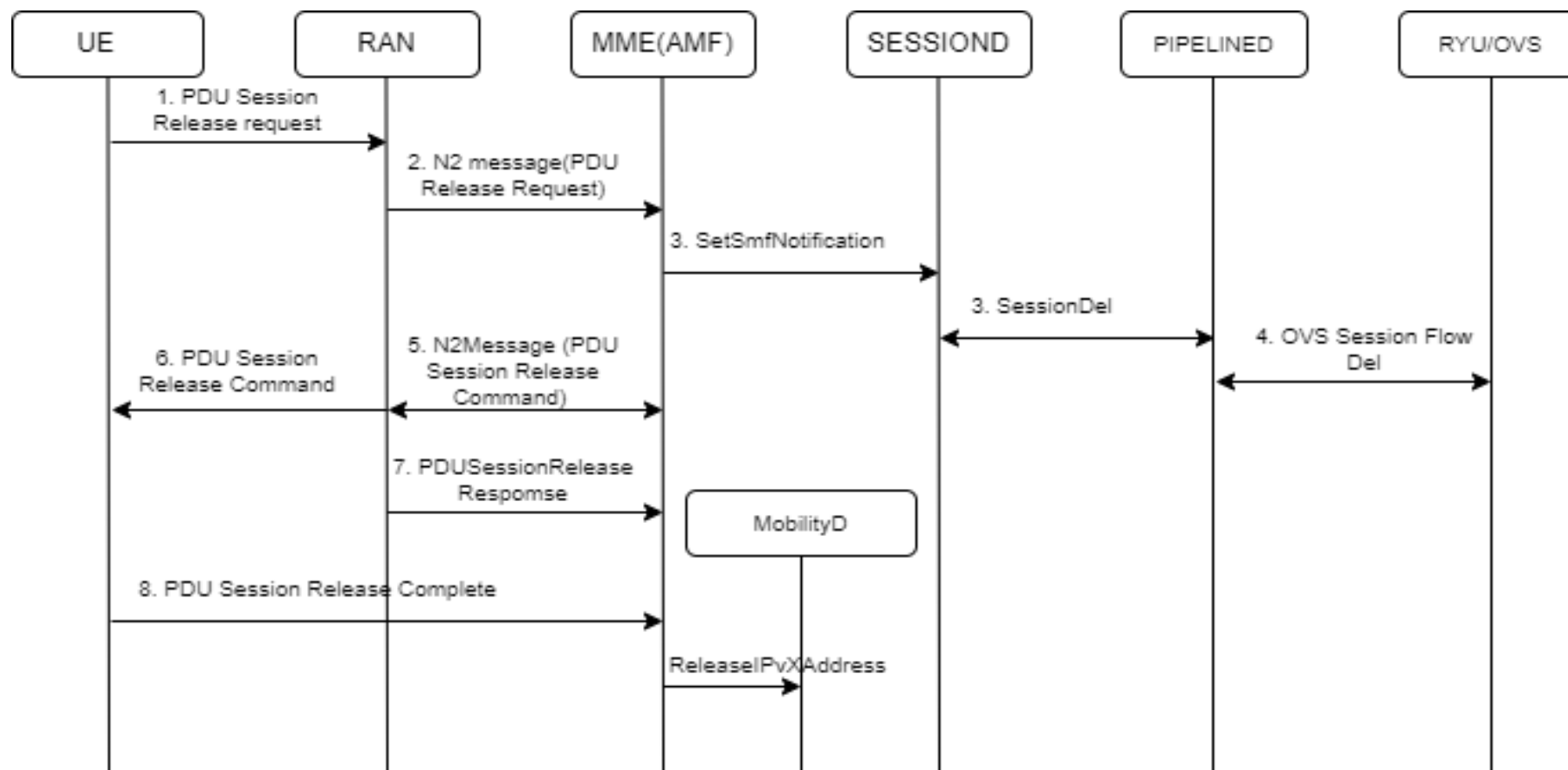
(7) UE initiated De-Registration
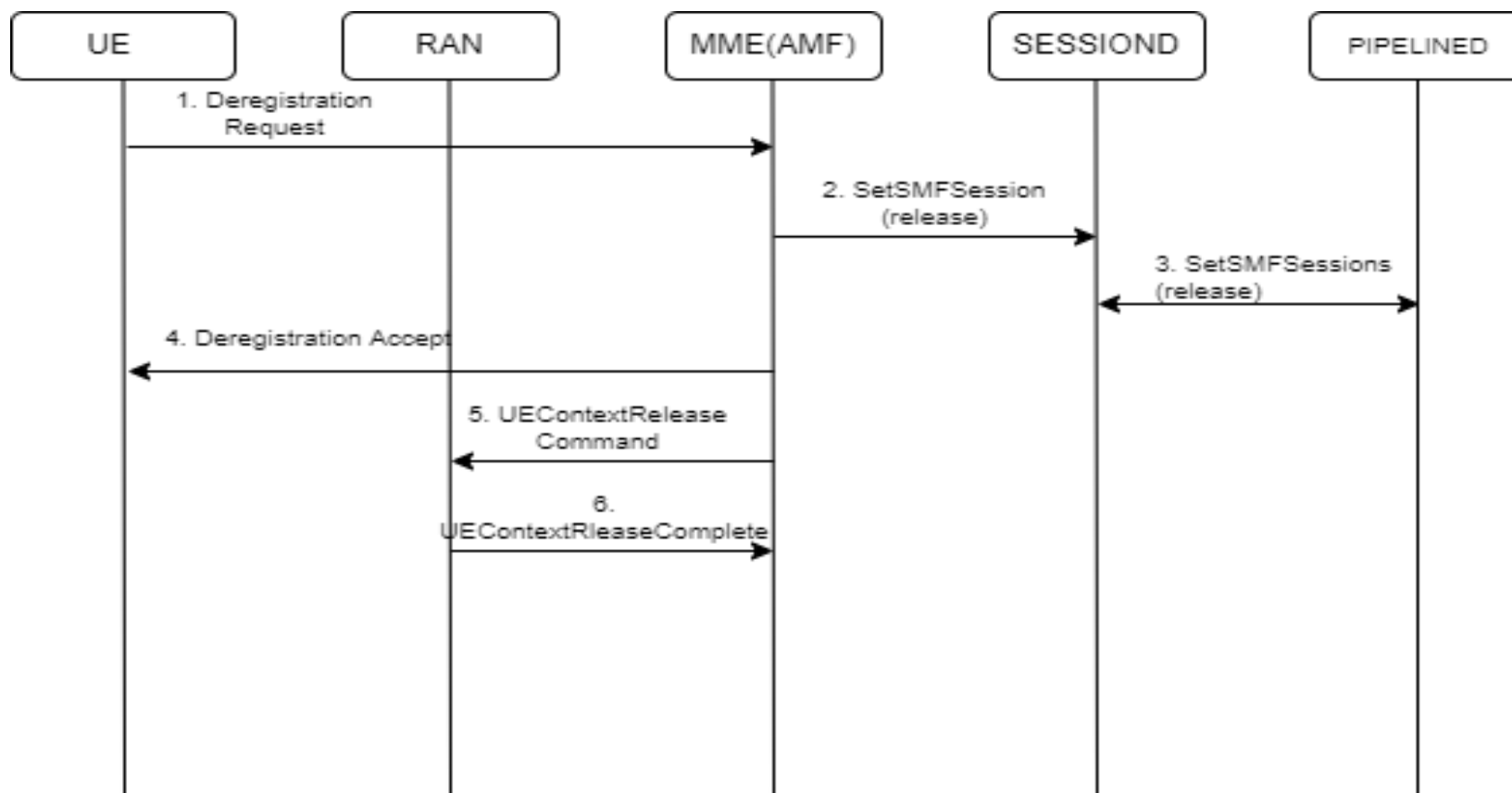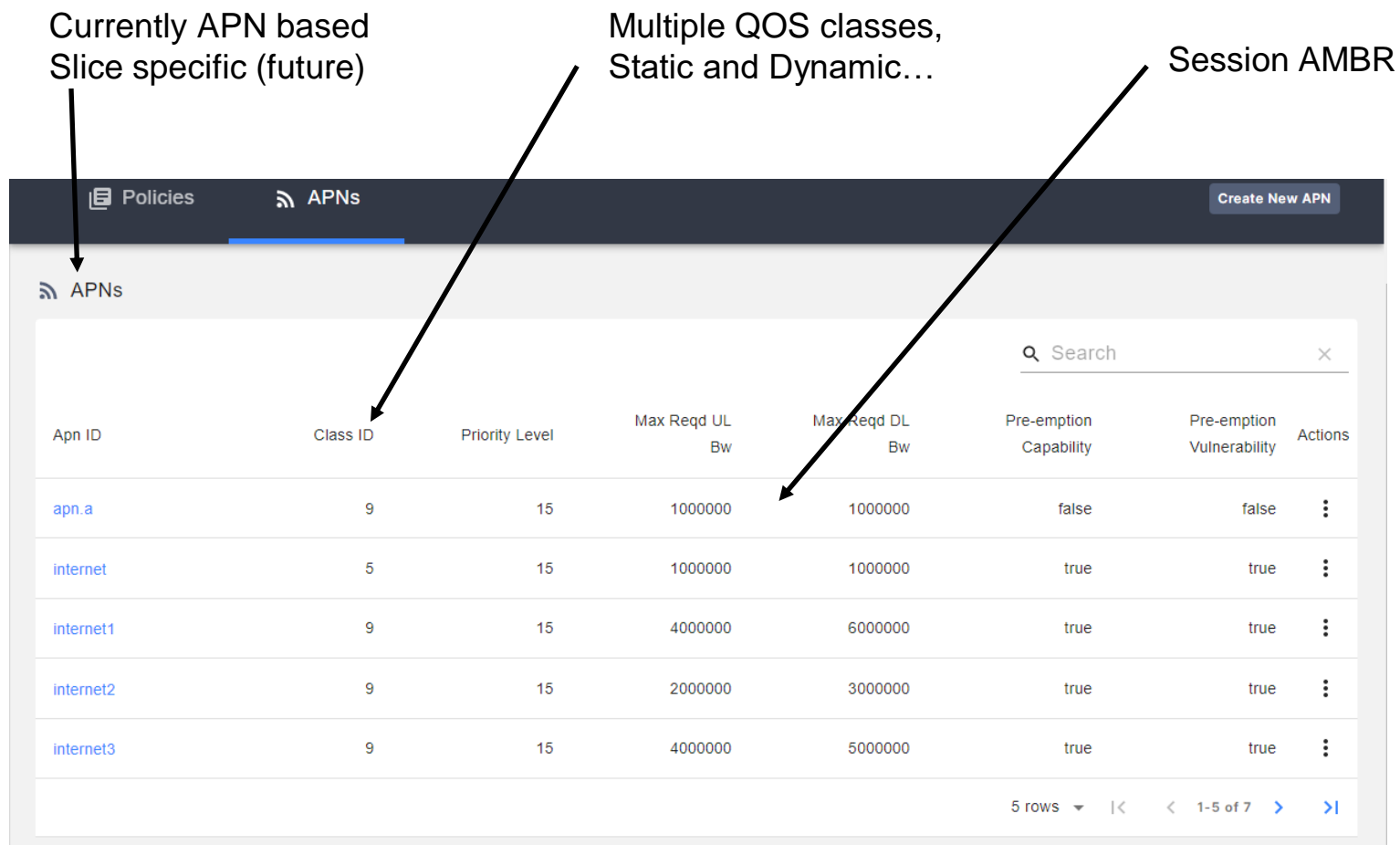
(8) Dynamic Policy support & 5G QOS (1 of 2)

Architecture
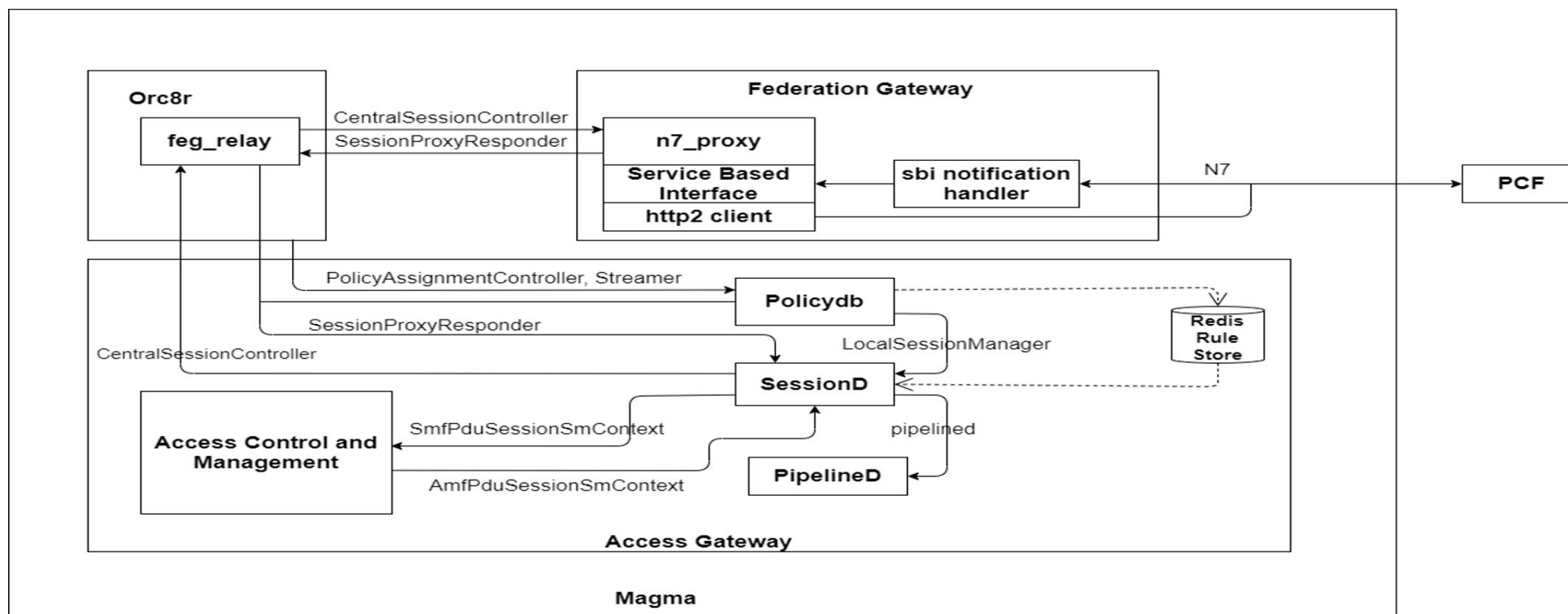
(8) Dynamic Policy support & 5G QOS (2 of 2)

Currently APN based
Slice specific (future)

Multiple QOS classes,
Static and Dynamic…

Session AMBR

| | Policies | | APNs | | | | | Create New APN |

APNs

Apn ID	Class ID	Priority Level	Max Reqd UL Bw	Max Reqd DL Bw	Pre-emption Capability	Pre-emption Vulnerability	Actions
apn.a	9	15	1000000	1000000	false	false	⋮
internet	5	15	1000000	1000000	true	true	⋮
internet1	9	15	4000000	6000000	true	true	⋮
internet2	9	15	2000000	3000000	true	true	⋮
internet3	9	15	4000000	5000000	true	true	⋮

5 rows ⯆ |< ‹ 1-5 of 7 › >|

QoS flow

- QoS Identifier (**5QI**)

- An Allocation and Retention Priority (**ARP**)

- **GBR** QoS Flow
  - Guaranteed Flow Bit Rate (**GFBR**) for both uplink and downlink
  - Maximum Flow Bit Rate (**MFBR**) for both uplink and downlink

- **Non-GBR** QoS Flow
  - Session-**AMBR**

(9) Usage reporting & Charging
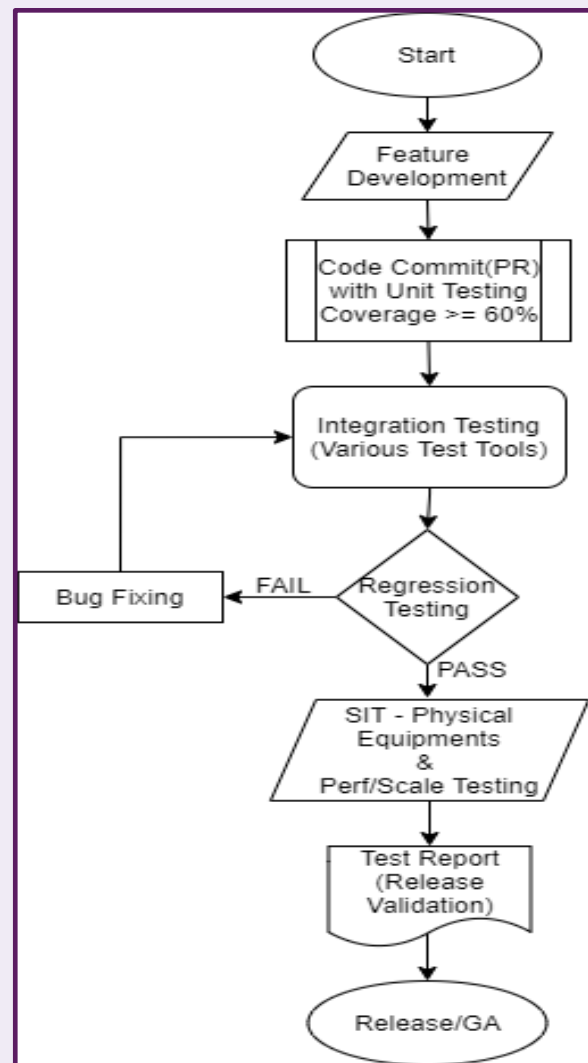
Understanding Magma 5G in the GitHub

magma

How we test Magma 5G SA

Magma Orchestrator in AWS

Automated CI Testing and Reporting

magma-ci.web.app

Apps | New Tab | Build a Custom A... | nagiosgraph / Dis... | Getting Started | Imported From Fir... | Gmail | YouTube | Maps | Magma | DevOps | Reading List

« ‹ 1 2 3 4 … › » Rows per page 20

	Metadata				Builds					Workers				
Build ID	Time	Run	Branch	Actor	AGW	FEG	ORC8R	NMS	CWAG	FB Spirent	FB TVM	WL 5G	LTE INTEG	CWF INTEG
			filter	filter										
c1638c09	1/7/22, 10:02	1665872514	master	ardzoht	✓	✓	✓	✓	✓	○	!	✓	○	○

Report

about:blank

Wavelabs 5G SA test result report.

Magma build : 1.7.0-1641529342-c1638c09

| Test Case Name	Test Run Result	Scenario			Steps			
		Failed	Passed	Total	Failed	Passed	Skipped	Total
5G_Registration_PDU_Session_Establishment.feature	passed	0	1	1	0	27	0	27
NG_Setup_Failure_Unknown_PLMN.feature	passed	0	1	1	0	12	0	12
NG_Setup_Request_Magma.feature	passed	0	1	1	0	12	0	12
5G_Registration_PDU_Session_Establishment_with_ping_data.feature	passed	0	1	1	0	28	0	28
5G_Initial_Registration.feature	passed	0	1	1	0	24	0	24

Demo – Let us see it running

Procedures / Features Available today
(1) Registration
(2) 5g specific Authentication
(3) PDU Session Establishment
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MAGMA 5G SA SUPPORT

Dedicated Channel for demo, integration support for 5G
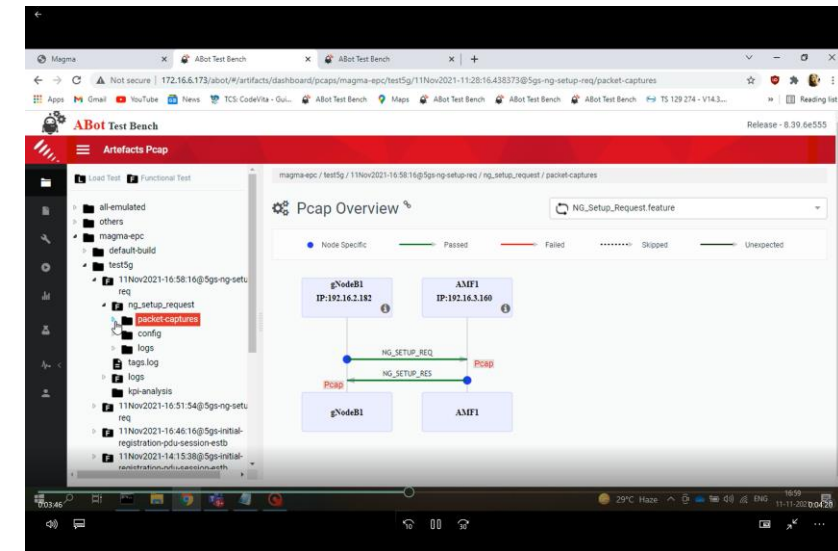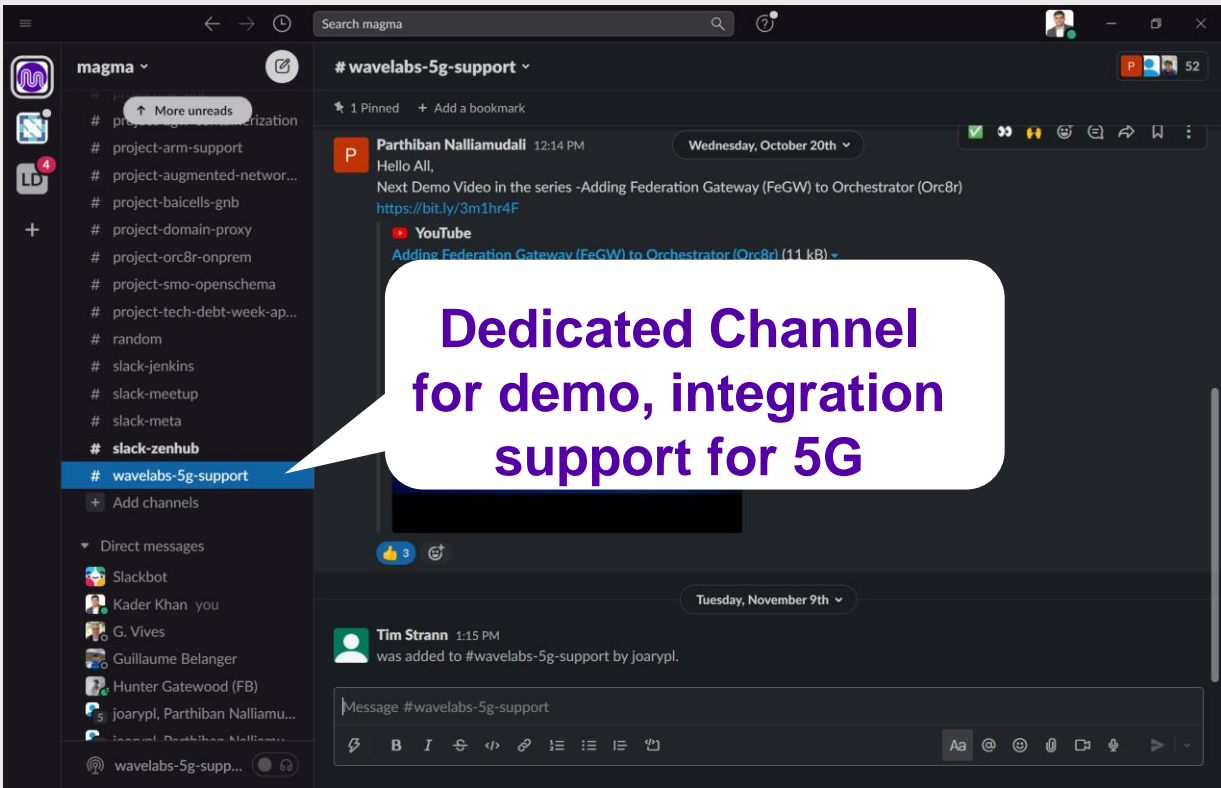
Try it ! We are Ready to Support it !

Magma Orchestrator in AWS

Magma AGW in any of your Hardware
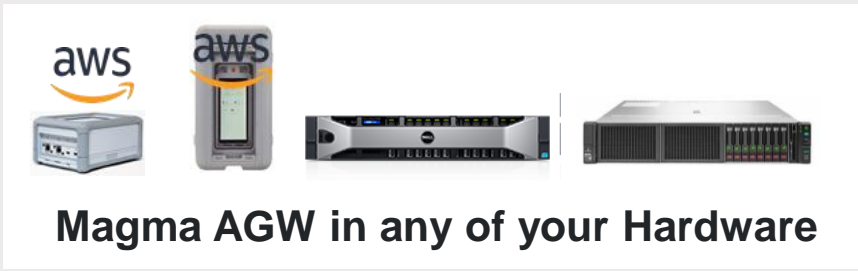
Wavelabs Commitment to Magma 5G SA Open Source

EMBRACE 'OPEN X' NETWORK VISION WITH WAVELABS
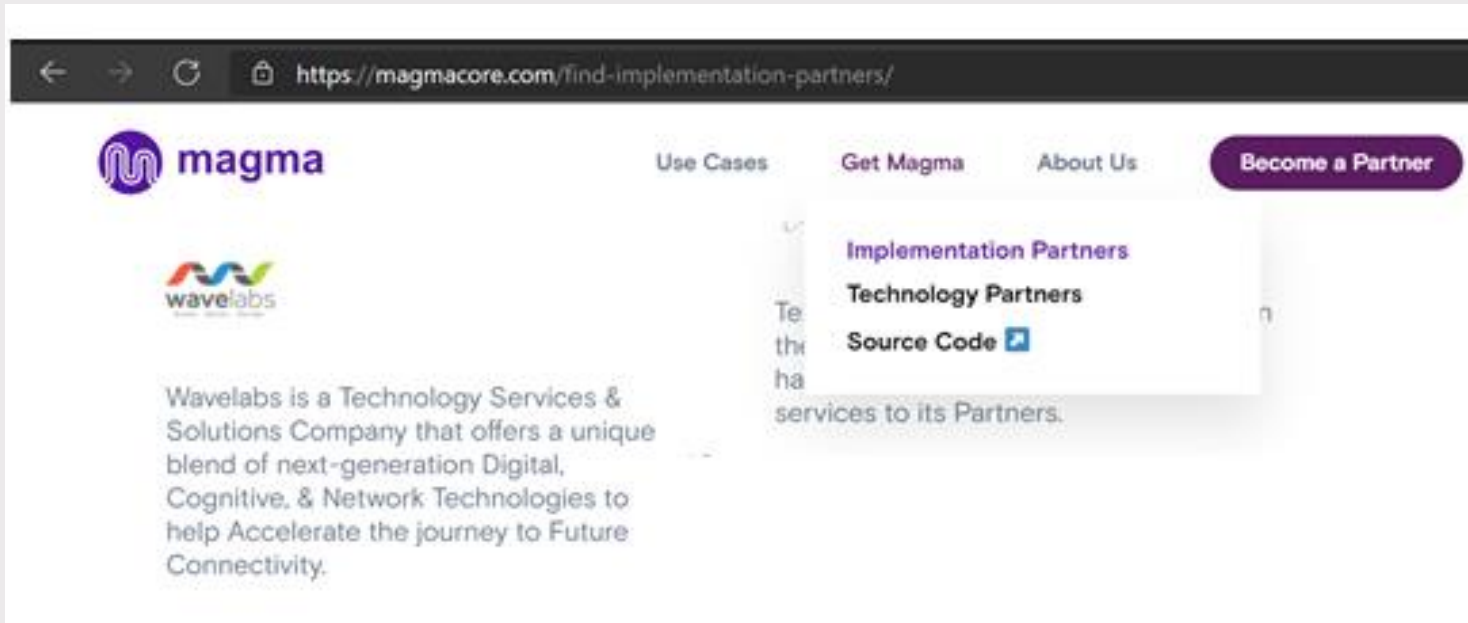
Wavelabs is an ardent proponent of 'OPEN X' network vision that enables unprecedented innovation, agility, choice, cost efficiency, and speed to market.
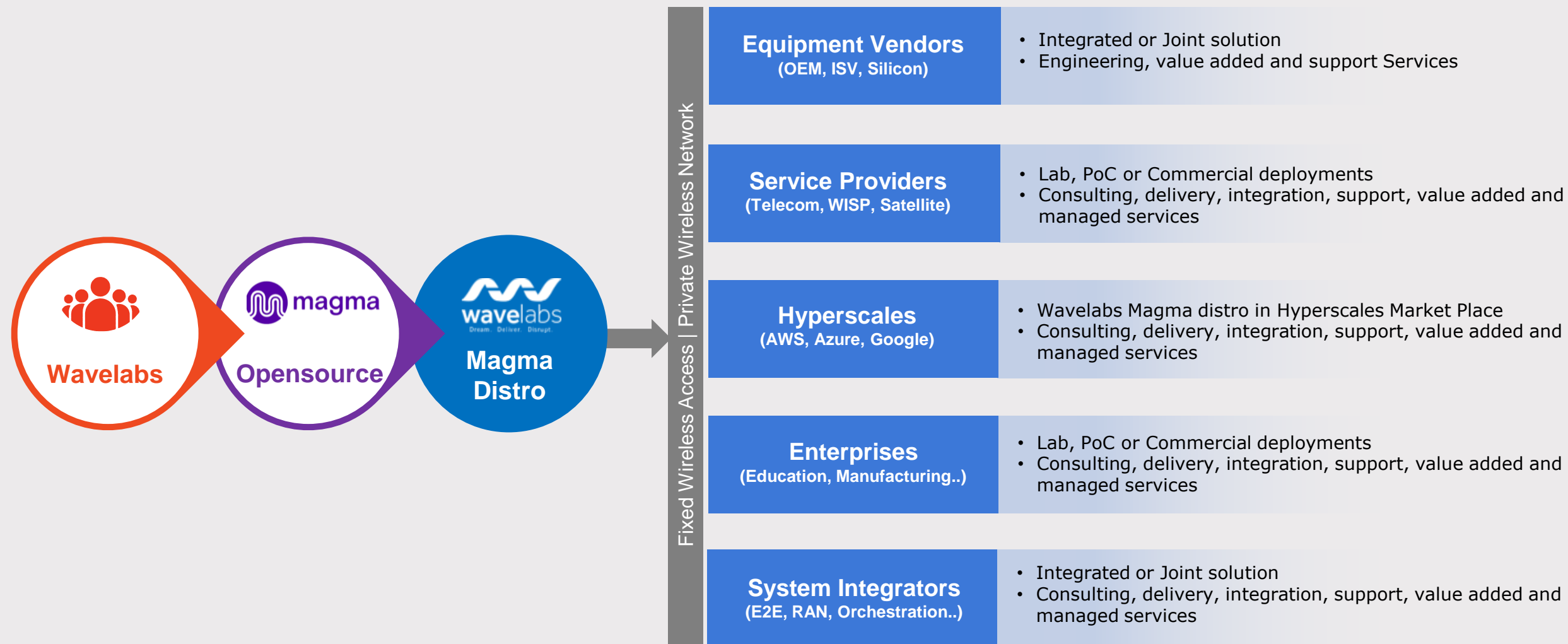
We help our clients to overcome challenges and realize the vision of the open and disaggregated 'White Box' connectivity products and solutions a reality.

Enabling engagement, collaboration, and adoption of Magma for 5G

Wavelabs → **Opensource** → **Magma Distro** →

Fixed Wireless Access | Private Wireless Network

Equipment Vendors (OEM, ISV, Silicon)	• Integrated or Joint solution • Engineering, value added and support Services
Service Providers (Telecom, WISP, Satellite)	• Lab, PoC or Commercial deployments • Consulting, delivery, integration, support, value added and managed services
Hyperscales (AWS, Azure, Google)	• Wavelabs Magma distro in Hyperscales Market Place • Consulting, delivery, integration, support, value added and managed services
Enterprises (Education, Manufacturing..)	• Lab, PoC or Commercial deployments • Consulting, delivery, integration, support, value added and managed services
System Integrators (E2E, RAN, Orchestration..)	• Integrated or Joint solution • Consulting, delivery, integration, support, value added and managed services

Q & A

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Thank You!

https://www.magmacore.org/
https://github.com/magma/magma