Smart Cities Communications

Presented by:

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NDI Communications
Design, Analyse, Learn

"Be nice to nerds. You may end up working for them. We all could."

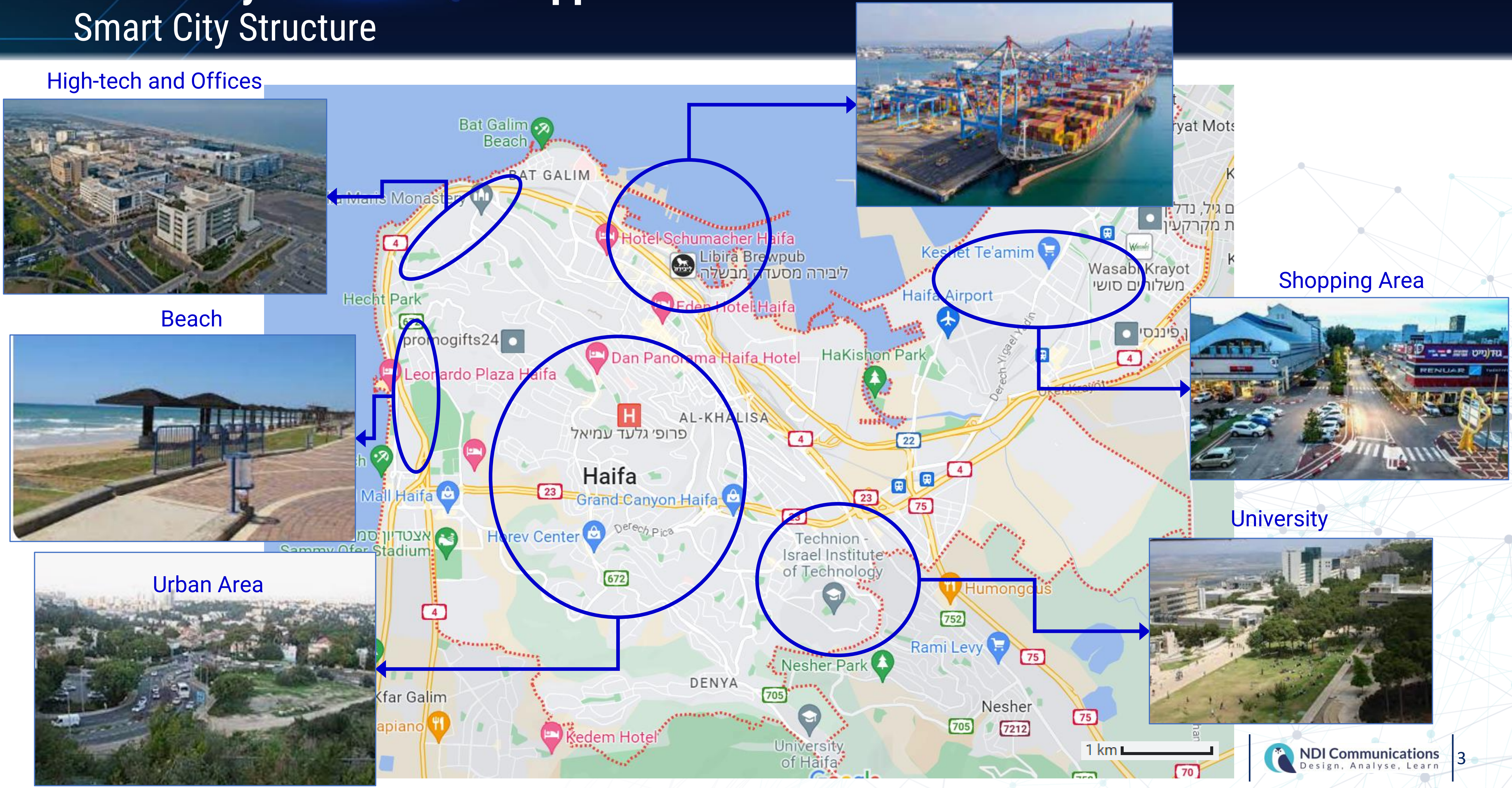
Charles J. Sykes

Lecture Contents

- Smart City Structure and applications requirements
- Smart City network structure
- Communications technologies for the smart city networks
- Survivability and security

Smart City Structure and Applications

Smart City Structure



High-tech and Offices

Beach

Urban Area

Sea port

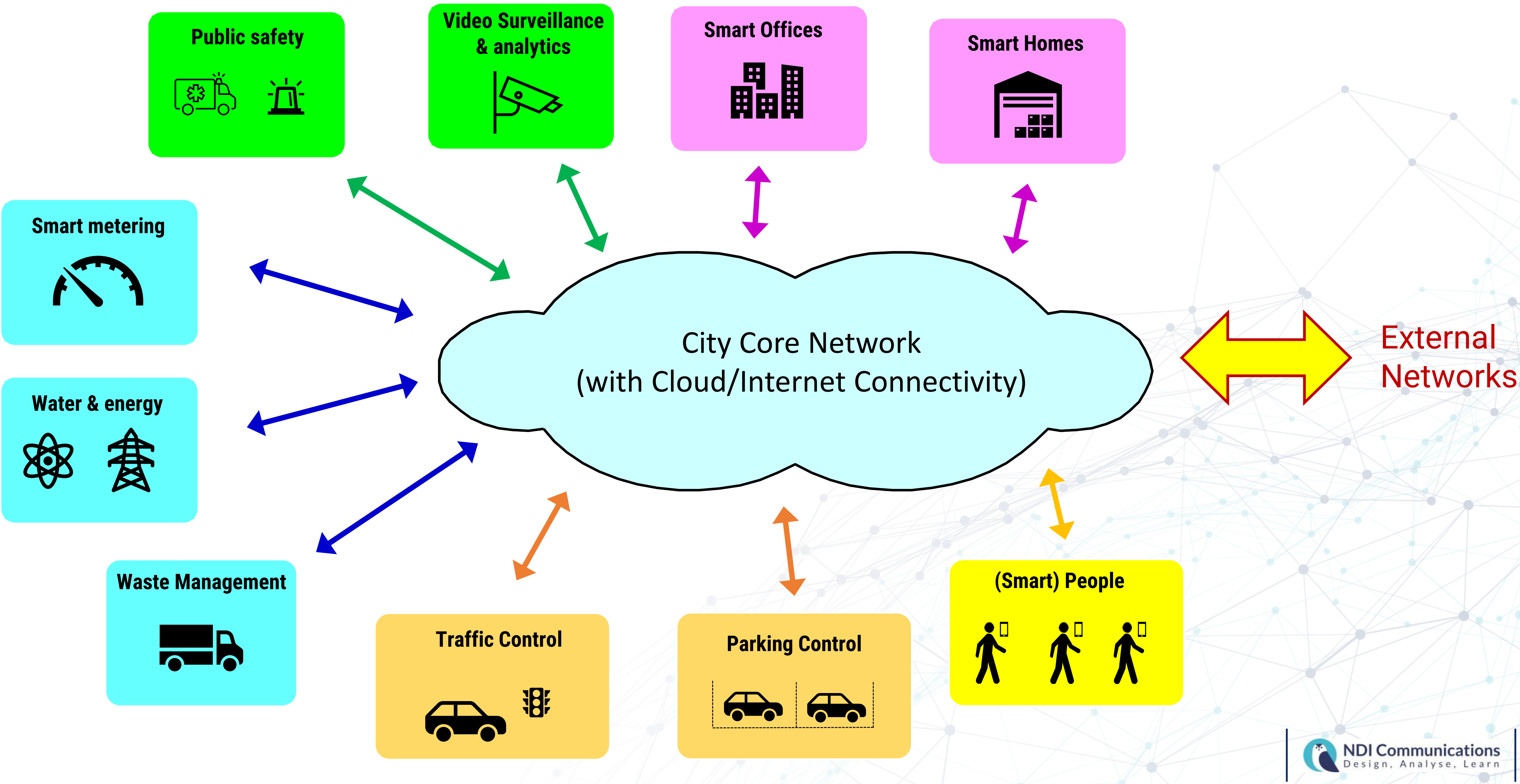
Shopping Area

University

Bat Galim Beach
BAT GALIM
Monastery
Hotel Schumacher Haifa
Libira Brewpub
ליבירה מסעדה מבשלה
Eden Hotel Haifa
Hecht Park
promogifts24
Dan Panorama Haifa Hotel
Leonardo Plaza Haifa
AL-KHALISA
פרופ׳ גלעד עמיאל
Haifa
Mall Haifa
Grand Canyon Haifa
Horev Center
Derech Pica
Sammy Ofer Stadium
Keshet Te'amim
Haifa Airport
HaKishon Park
Wasabi Krayot
Derech Yigael Yadin
Technion - Israel Institute of Technology
Humongous
Rami Levy
Nesher Park
DENYA
Nesher
Kfar Galim
Kedem Hotel
University of Haifa
1 km

Smart City Structure and Applications

Application Types



Public safety

Video Surveillance & analytics

Smart Offices

Smart Homes

Smart metering

Water & energy

Waste Management

Traffic Control

Parking Control

(Smart) People

City Core Network
(with Cloud/Internet Connectivity)

External Networks

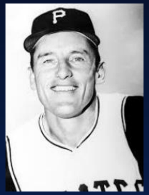
Smart City Structure and Applications

Application Requirements

	Public safety	Video Surveillance & analytics	Water & energy	Smart metering	Waste Management	Smart Offices	Smart Homes	(Smart) People	Parking Control	Traffic Control
High Bandwidth (Symm/Asymm)	V	V				V	V	V	V	V
Low Delay/Jitter	V					V	V			V
High density			V	V		V				V
High Reliability	V	V								V

“Experience is a hard teacher because she gives the test first, the lesson afterwards“

Vernon Sanders Law



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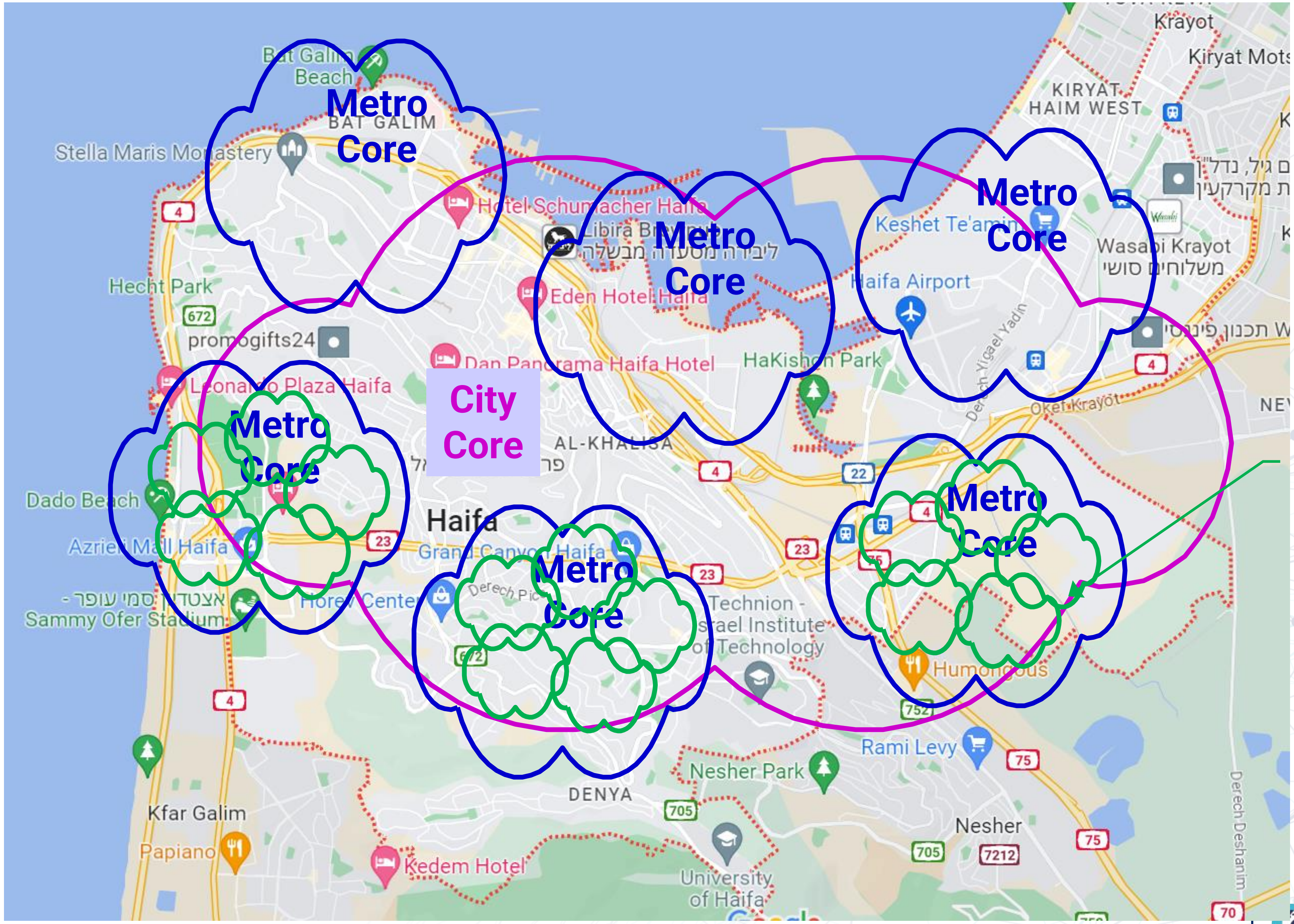
Smart City Network Structure

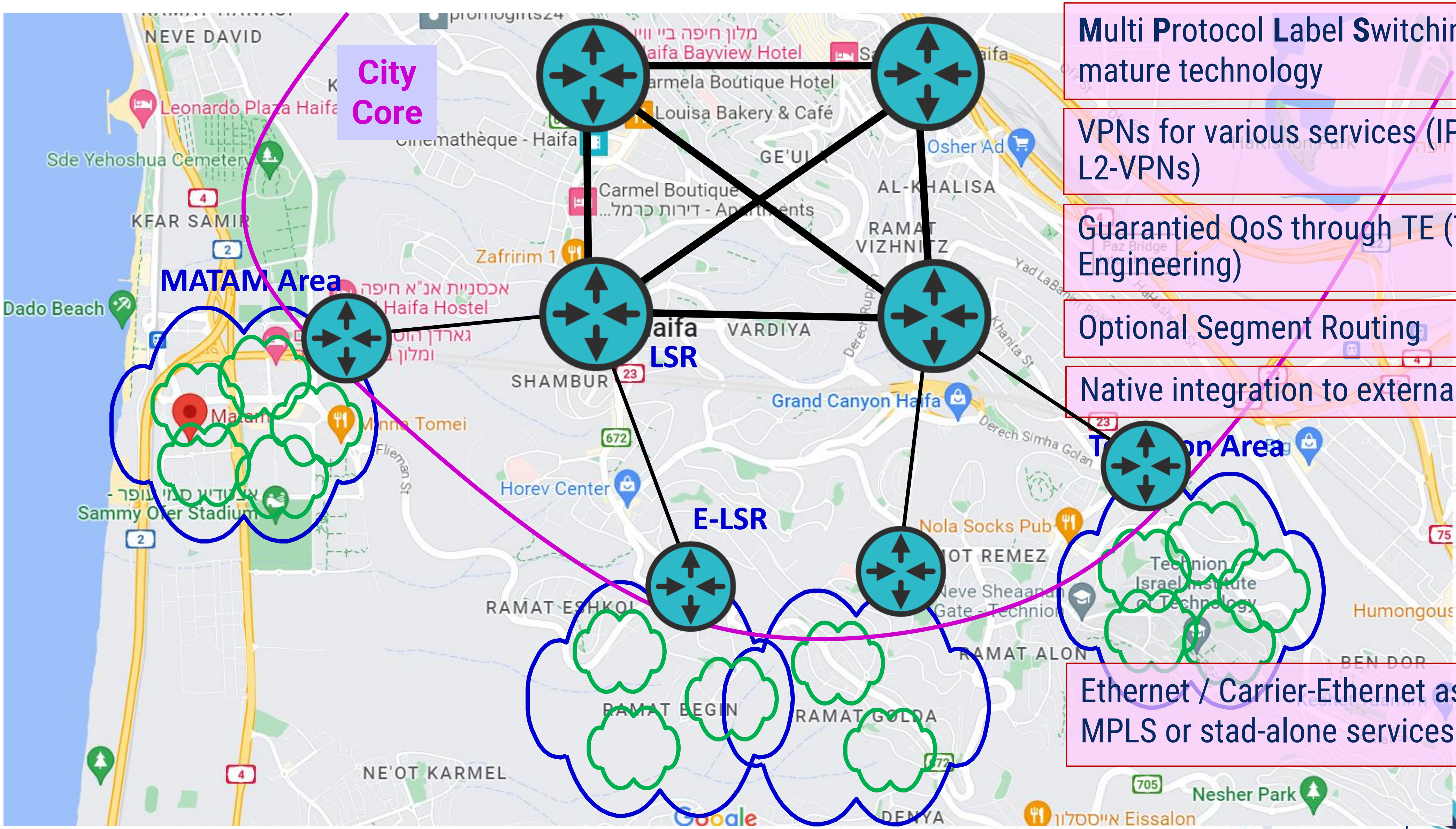
The Network Structure – Overall Architecture


Metro Core
Metro Core
Metro Core
City Core
Metro Core
Metro Core
Metro Core
Haifa
Technion - Israel Institute of Technology
University of Haifa
Haifa Airport
Nesher
Kfar Galim
DENYA
BAT GALIM
AL-KHALISA
KIRYAT HAIM WEST

Metro Access

Smart City Network Structure

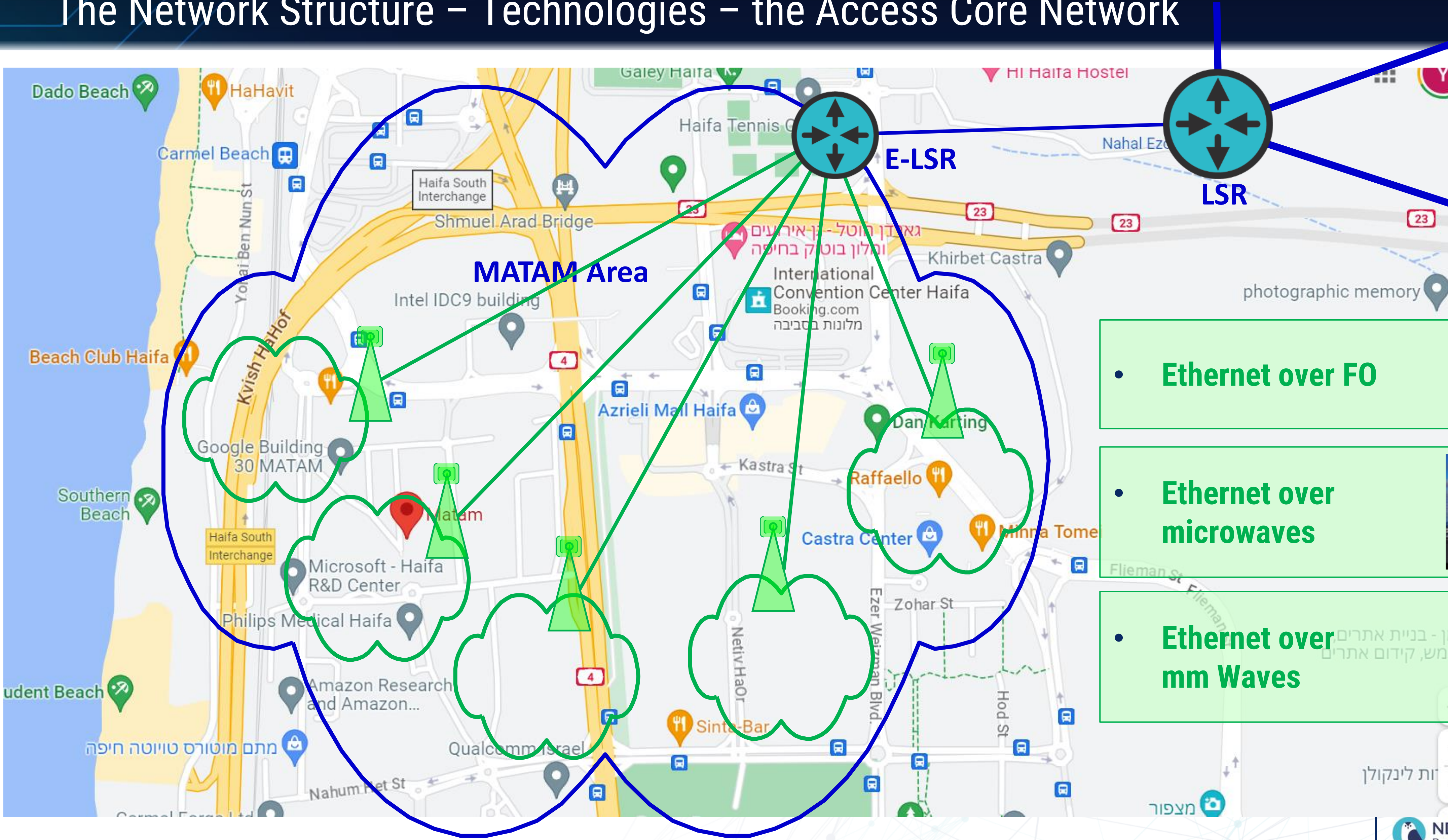
The Network Structure – Technologies – the Core Network



- **M**ulti **P**rotocol **L**abel **S**witching - Early 2000's mature technology
- VPNs for various services (IP/BGP-VPNs or L2-VPNs)
- Guarantied QoS through TE (Traffic Engineering)
- Optional Segment Routing
- Native integration to external networks
- Ethernet / Carrier-Ethernet as underlay for the MPLS or stad-alone services

Smart City Network Structure

The Network Structure – Technologies – the Access Core Network


E-LSR
LSR
MATAM Area
Dado Beach
HaHavit
Galey Haifa
Hi Haifa Hostel
Carmel Beach
Haifa Tennis C
Haifa South Interchange
Shmuel Arad Bridge
Nahal Ezo
23
4
גאֶרדן הוטל - גן אירועים ומלון בוטיק בחיפה
Khirbet Castra
International Convention Center Haifa
Booking.com
מלונות בסביבה
photographic memory
Intel IDC9 building
Yoval Ben Nun St
Kvish HaHof
Beach Club Haifa
Azrieli Mall Haifa
Dan Karting
Google Building 30 MATAM
Kastra St
Raffaello
Southern Beach
Matam
Castra Center
Minna Tome
Haifa South Interchange
Microsoft - Haifa R&D Center
Flieman St
Philips Medical Haifa
Zohar St
Ezer Weizman Blvd
Netiv HaOr
Hod St
udent Beach
Amazon Research and Amazon...
מתחם מוטוסים טיוטה חיפה
Sinta Bar
Qualcomm Israel
Nahum Het St
Carmel Forge Ltd
מצפור
תחנת לינקולן

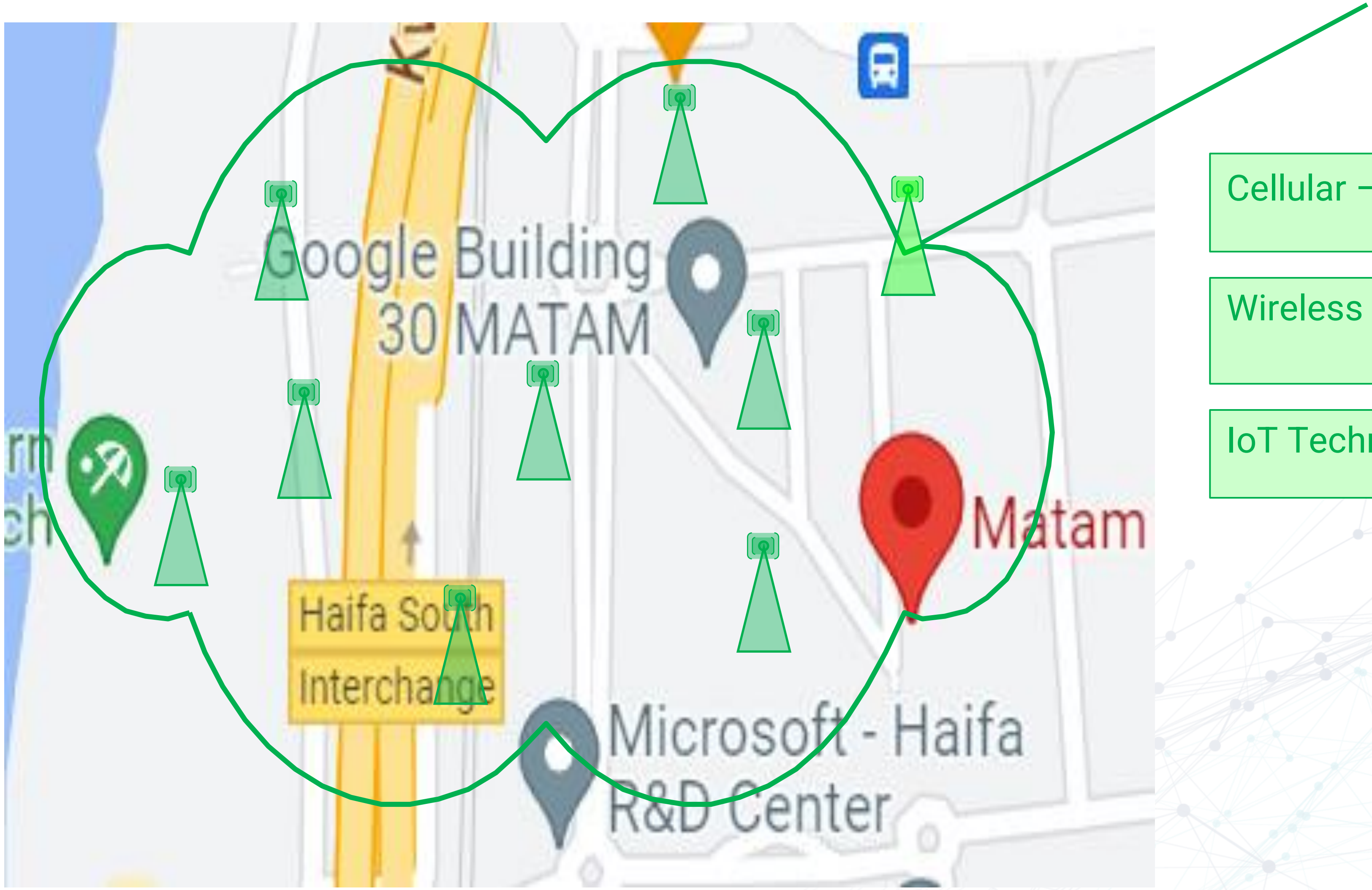
- **Ethernet over FO**

- **Ethernet over microwaves**

- **Ethernet over mm Waves**

Smart City Network Structure

The Network Structure – Technologies – the Access Network


Google Building
30 MATAM
Matam
Haifa South
Interchange
Microsoft - Haifa
R&D Center

Cellular – 4G/5G, 6G

Wireless – Wi-Fi -4/5/6, 7 (2024)

IoT Technologies (802.15.4, BLE….)

“Success consists of going from failure to failure without loss of enthusiasm.”

Winston S. Churchill

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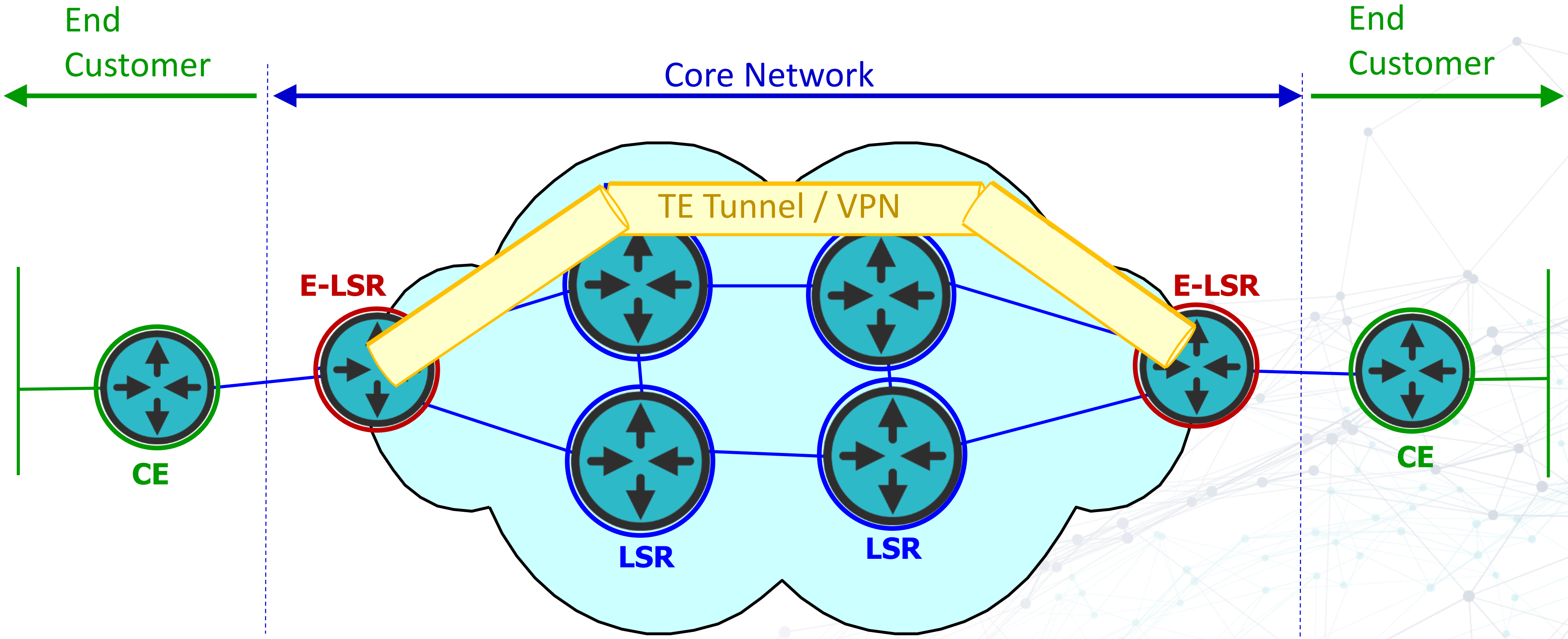
Smart City Network Structure

The Network Structure – Technologies – Core and Metro Core


End Customer
Core Network
End Customer
TE Tunnel / VPN
E-LSR
E-LSR
CE
LSR
LSR
CE

Smart City Network Structure

The Network Structure – Technologies – the Access Networks – Radio Technologies

Technology	Protocol	Frequency	Throughput	Range
4G/LTE	3GPP R8 to R14	850/900/1800/1900/ 2100…MHz	10's of Mbps and higher	10's of meters up to 10's of Km's
5G/6G	3GPP R15 to R18 (5G) R19 (Early 6G)	Sub-1G up to 60GHz+	100's of Mbps to 100's of Gbps	10's of meters up to 10's of Km's
WiFi-4/5/6/7	Wifi / 802.11	2.4G/5G/6GHz	10Gbps+ per AP	PtP – Km's PtMP – 100's meters
LoRa/LoRaWAN	ITU-T Y.4480 / LoRa Alliance	433, 868, 900 MHz	0.3 kbps to 50 kbps	20Km's
Bluethooth Low Energy (BLE)	Bluethooth	2.4GHz	1Mbps	10's meters
ZibBee	802.15.4	2.4GHz	Mbps's	10's ot 100's meters
PtP / PtMP Microwaves	Proprietaries	5-6GHz to 60GHz+	Gbps to 10's of Gbps's	10's of Km's, 100's meters (mm Waves)

Wireless and Cellular history

How it started and where we are today

1980-1989
The early years

1G Cellular and proprietary Wireless technologies

Early technologies – WLL, Proprietaries
Cellular analog communications

1990-1999
Standards and connectivity

2G Cellular
Early 802.11b/g

Voice calls, low bandwidth connectivity, first packet-based communications

2000-2009
Bandwidth and early Multimedia

3G Cellular
802.11n

10’s to 100’s Mbps
FDMA
SU-MIMO

2010-2020
Public safety, HD multimedia

4G Cellular
802.11ac/ax

MU-MINO
OFDMA
Beamforming

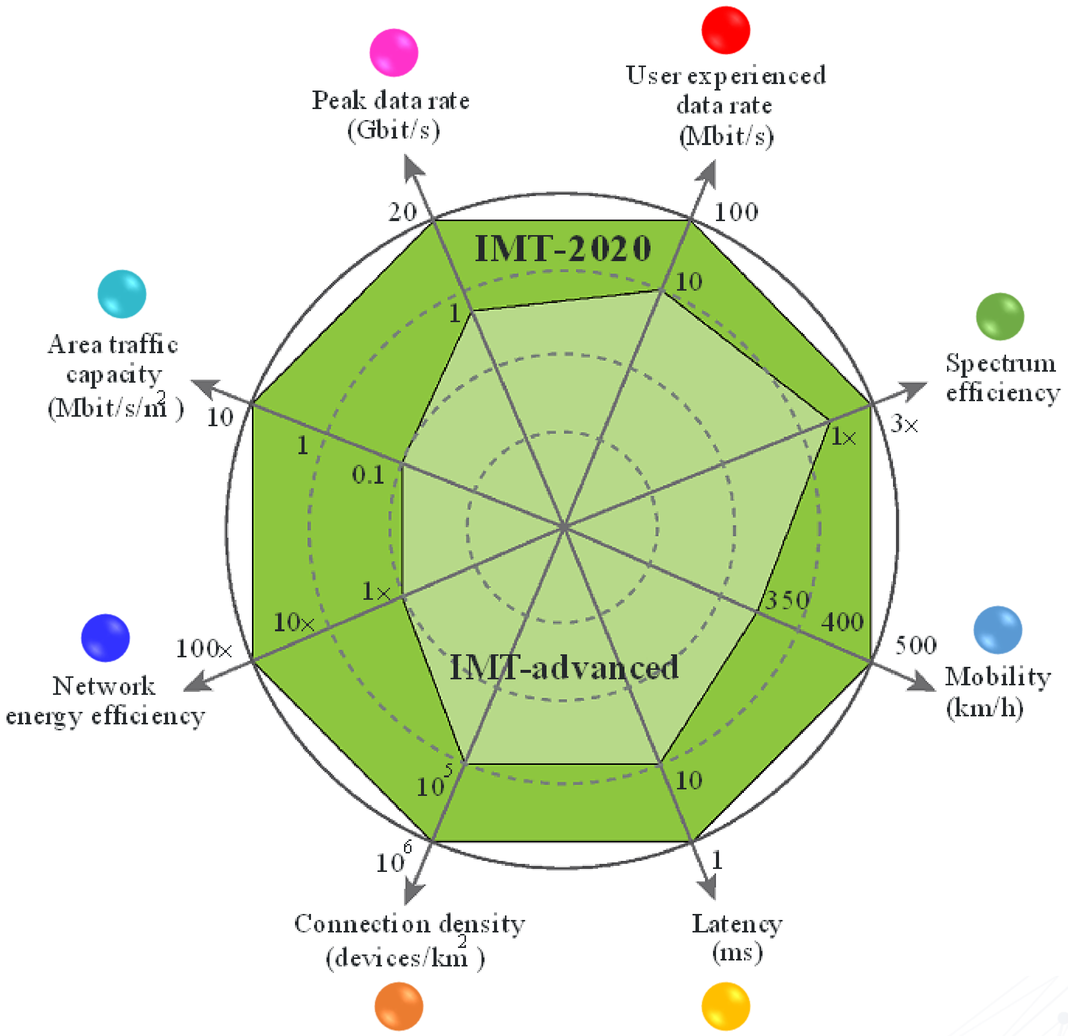
2020-2029
IoT, Autonomous cars, high BW

5G/6G Cellular
802.11ax/be
IoT protocols
THz frequencies

Sensor networks
Hi-fidelity 3D

5G Objectives

5G objectives by ITU-R



Source: ITU-R, M.2083-0 (09/2015)

USER EXPERIANCE

From 10Mbps to 100/50Mbps (Downlink/Uplink)

PEAK DATA RATE

From 1Gbps to 20Gbps/10Gbps (Downlink/Uplink)

AREA TRAFFIC CAPACITY

From 0.1Mbits/Sec/m^2 to 10Mbits/Sec/m^2

ENERGY EFFICIENCY

X100 improvement from 4G

CONNECTION DENSITY

From 10^3 to 10^6 Devices/Km^2

LATENCY

User/data plane - from 10mS in 4G to 1mS in 5G (3GPP target is 0.5mS)

Control plane – 20mS (3GPP target 10mS)

MOBILITY

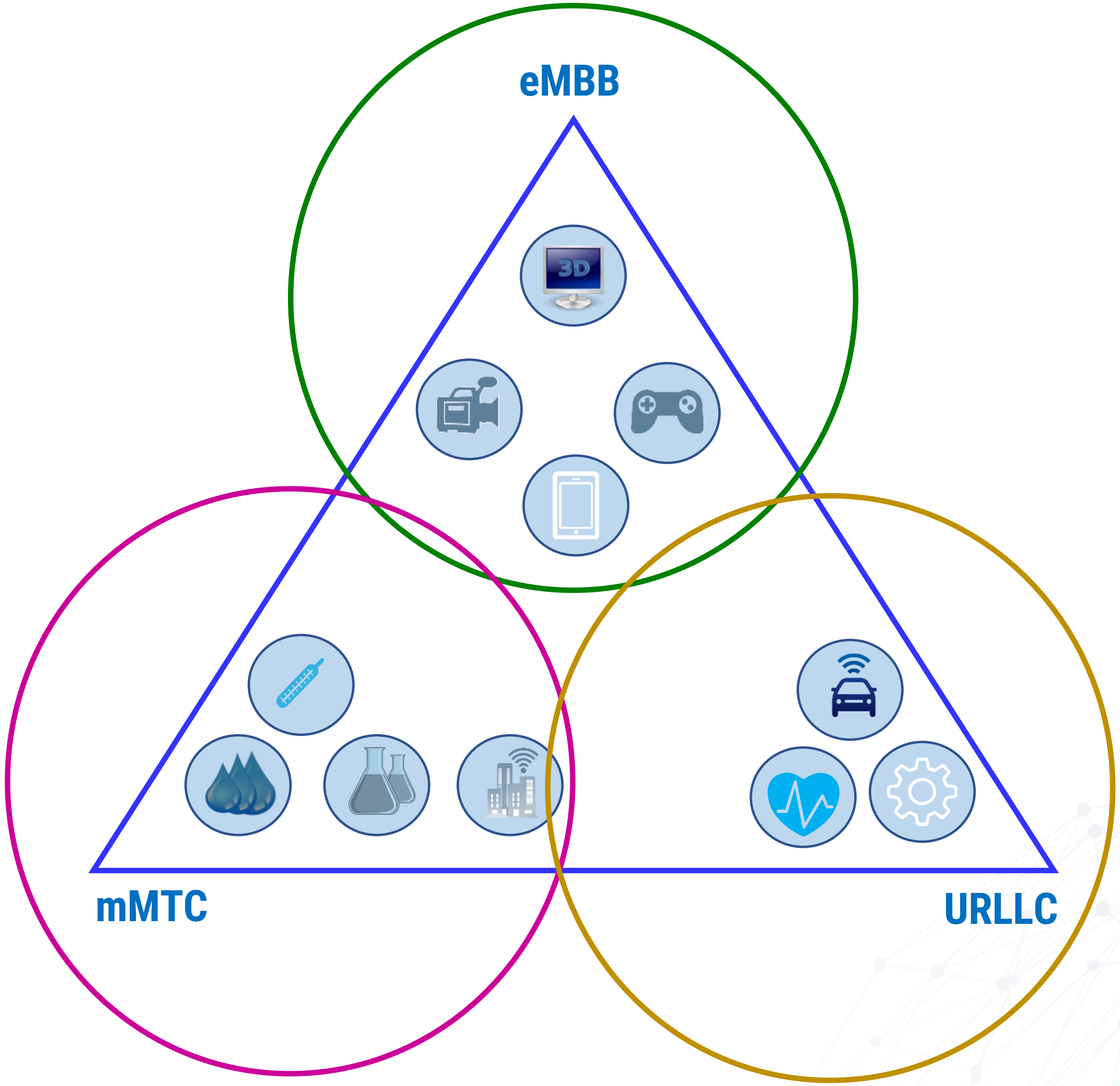
From 350Km/hour to 500Km/hour connectivity in motion

SPECTRAL EFFICIENY

3 times more then 4G – 30/15 bits/sec/Hz (Downlink/Uplink)

5G Applications Requirements

Requirements to be supported by the 5G network



eMBB (enhanced Mobile Broadband)

- Fixed Wireless Access (FWA)
- High Speed Home / SOHO Broadband

➡ High bandwidth
Average and peak

mMTC (massive Machine Type Communications)

- Massive connectivity
- IoT and Sensor networks

➡ High density
Low energy
High reliability

URLLC (Ultra-reliable and Low-latency communications)

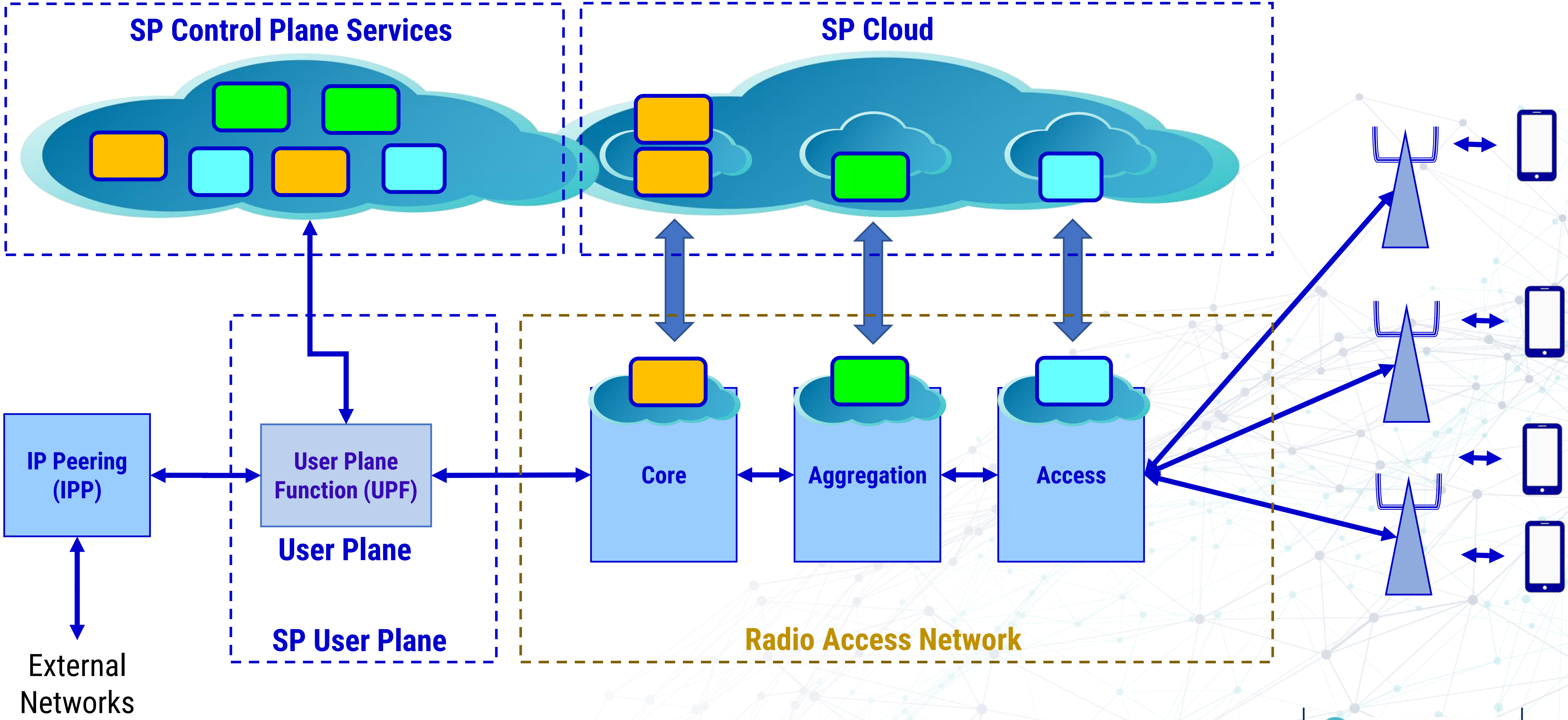
- Public safety
- Medical devices
- Industrial automation

➡ Low delay
Ultra-high reliability

Source:
ITU recommendation ITU-R M.2083-0

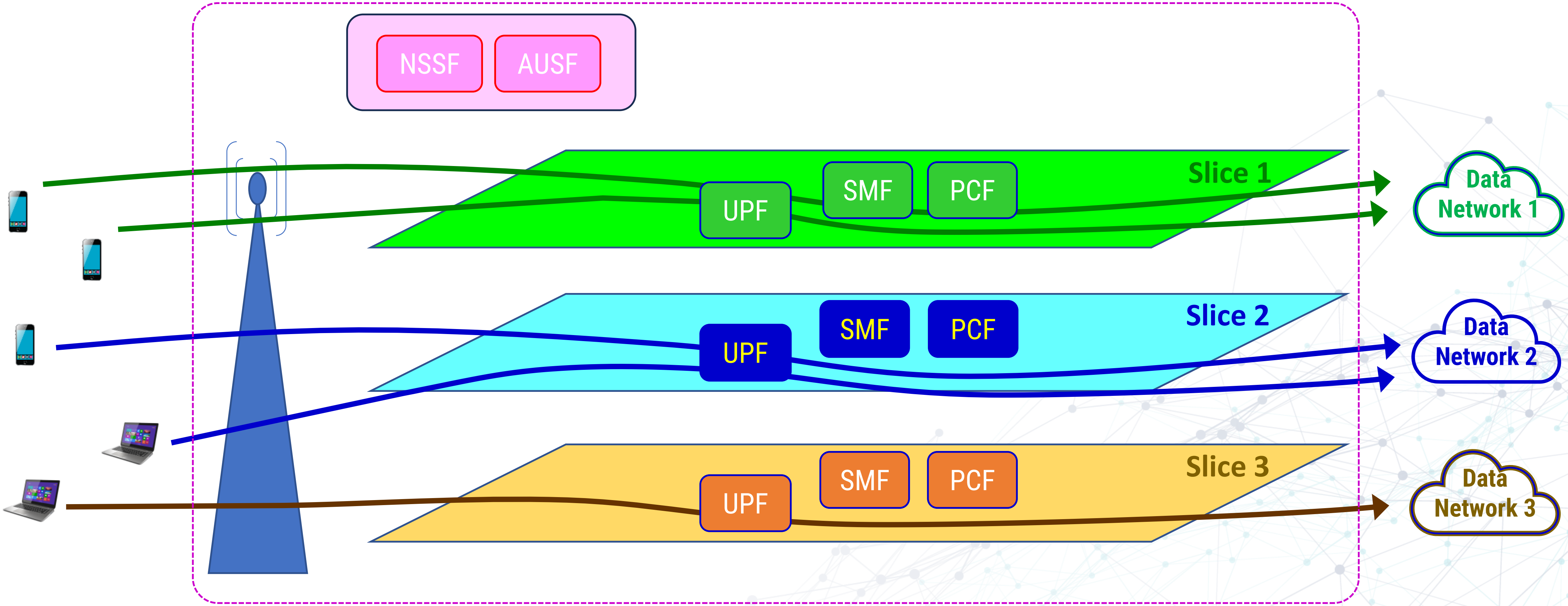
The Overall Picture

5G networks - the overall architecture


SP Control Plane Services
SP Cloud
IP Peering (IPP)
User Plane Function (UPF)
User Plane
SP User Plane
Core
Aggregation
Access
Radio Access Network
External Networks

Enabling Technologies – Network Slicing

Different networks for different purposes, user mapping to each


NSSF
AUSF
Slice 1
UPF
SMF
PCF
Data Network 1
Slice 2
UPF
SMF
PCF
Data Network 2
Slice 3
UPF
SMF
PCF
Data Network 3

NSSF – Network Slice Selection Function
AUSF – Authentication Server Function
UPF – User Plane Function
SMF – Session Management Function
PCF – Policy Control Function

> *“Three things cannot be long hidden: the sun, the moon, and the truth. “*
>
> *Buddha*

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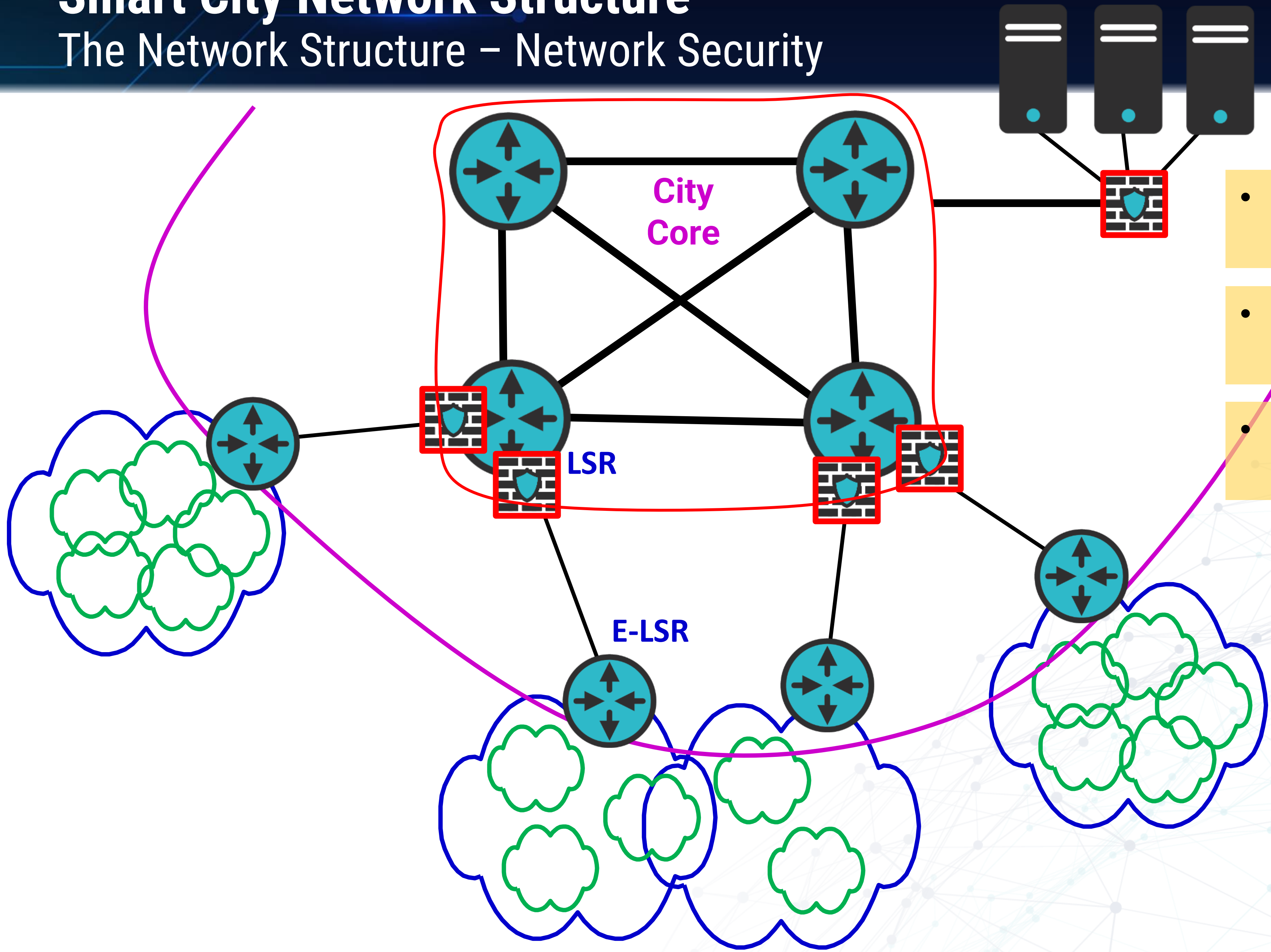
Smart City Network Structure

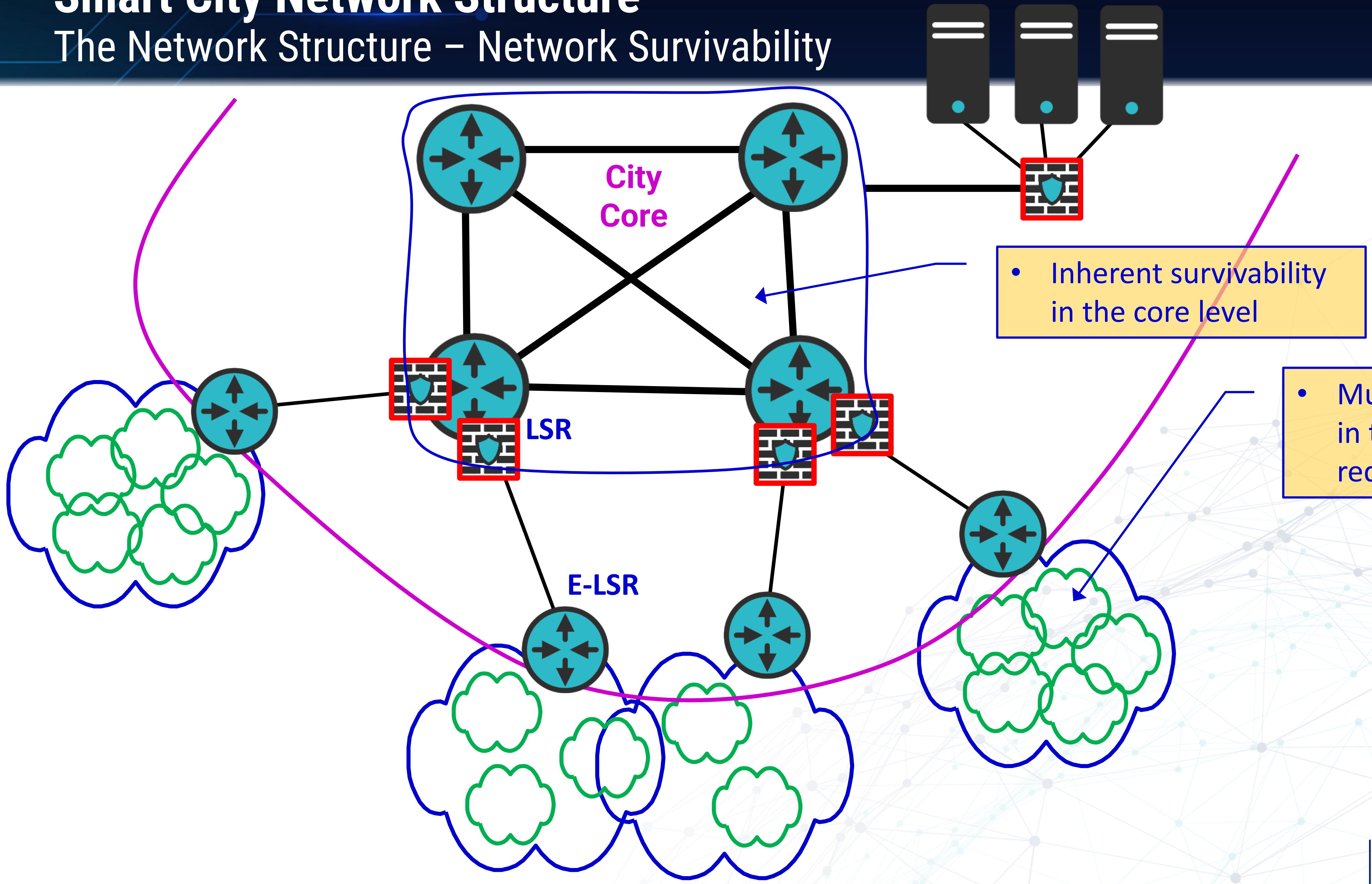
The Network Structure – Network Security



- FW features protection on multiple levels
- Packet analysis and application FWs protection on Data Centers
- Behavior analysis on multiple points in the network

Smart City Network Structure

The Network Structure – Network Survivability



- Inherent survivability in the core level

- Multiple connections in the access-core (if required)

Summary

Various applications with various performance and availability requirements

MPLS and Carrier-Ethernet at the core network, Cellular, Wi-Fi ant IoT technologies at the access network

Security achieved by standard protection mechanisms and behavior analysis

Thanks
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