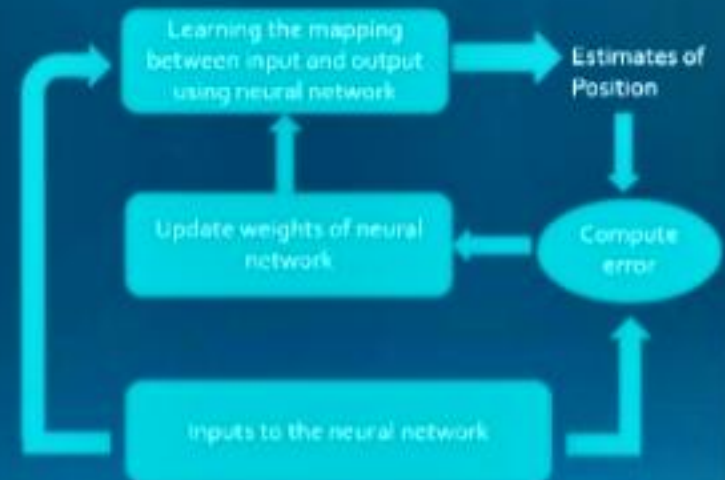


Beam Management

Positioning

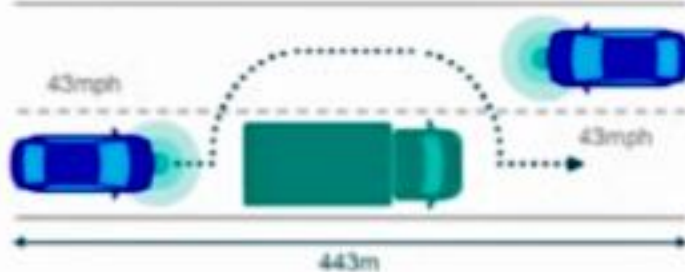
Channel state feedback
enhancement



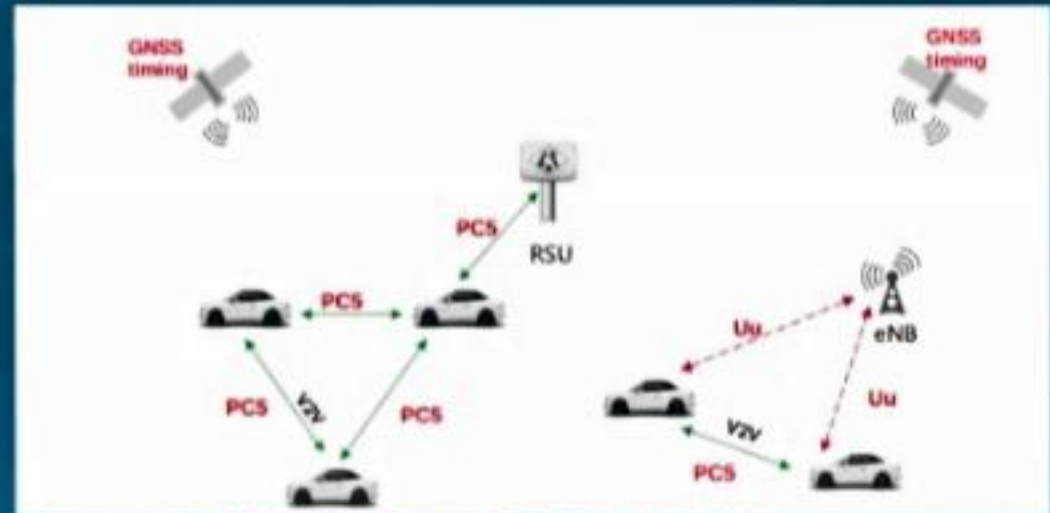
An example of training a
neural network for
positioning

AI/ML for air interface

C-V2X



Source: 5G Americas White Paper, Cellular V2X Communications Towards 5G



Source: V2X White Paper by NGMN Alliance

V2X services



Source: What is IIoT, TIBCO

Industrial IoT

Network Energy Savings

Approximately 23% of operational expenses (OPEX) comes from the network/gNB operations

Adapting the transmission/reception procedures at gNB to reduce energy consumption

- ◇ Motivation: To reduce operational cost and environmental impacts.
- ◇ Adaptation based on traffic condition, channel, UE feedback/assistance information etc.
- ◇ Constraint: Minimum impact on performance, legacy UEs and specification.

NES

Adaptations of gNB operations in time, frequency, spatial and frequency domain

Examples:

Spatial:



a) 32
Ports/64
antenna
elements



b) 16
Ports/32
antenna
elements

NES

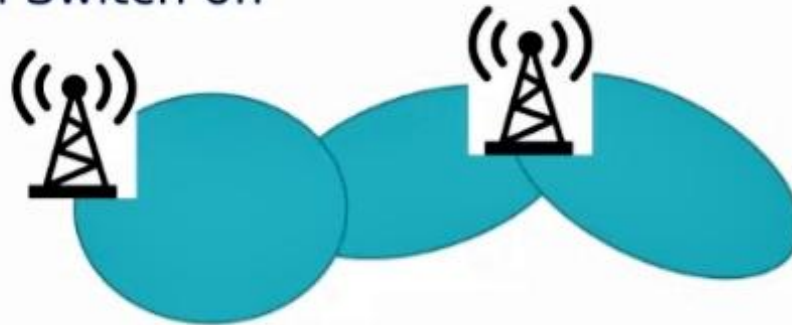
Time:

1. Sleep

2. DTX/DRX



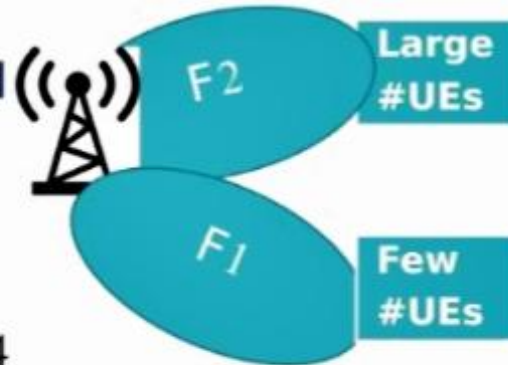
3. Cell Switch off



NES

Power doamin:

1. Multiple possible powers
2. select one based on channel quality report



E.g., P_1

$\Delta_1 < \Delta_2 < \Delta_3 < \Delta_4$

data	Power	Report from UE	Channel Quality Indicator
	P_1	1st report	Good SINR
	$P_2 = P_1 - \Delta_1$ $= 46 - 3 = 43\text{dBm}$	2nd report	Good SINR
	$P_3 = P_1 - \Delta_2$	3rd report	Good SINR
	$P_4 = P_1 - \Delta_3$	4th report	Good SINR
	$P_5 = P_1 - \Delta_4$	5th report	Bad channel

Areas to work on

Standardisation

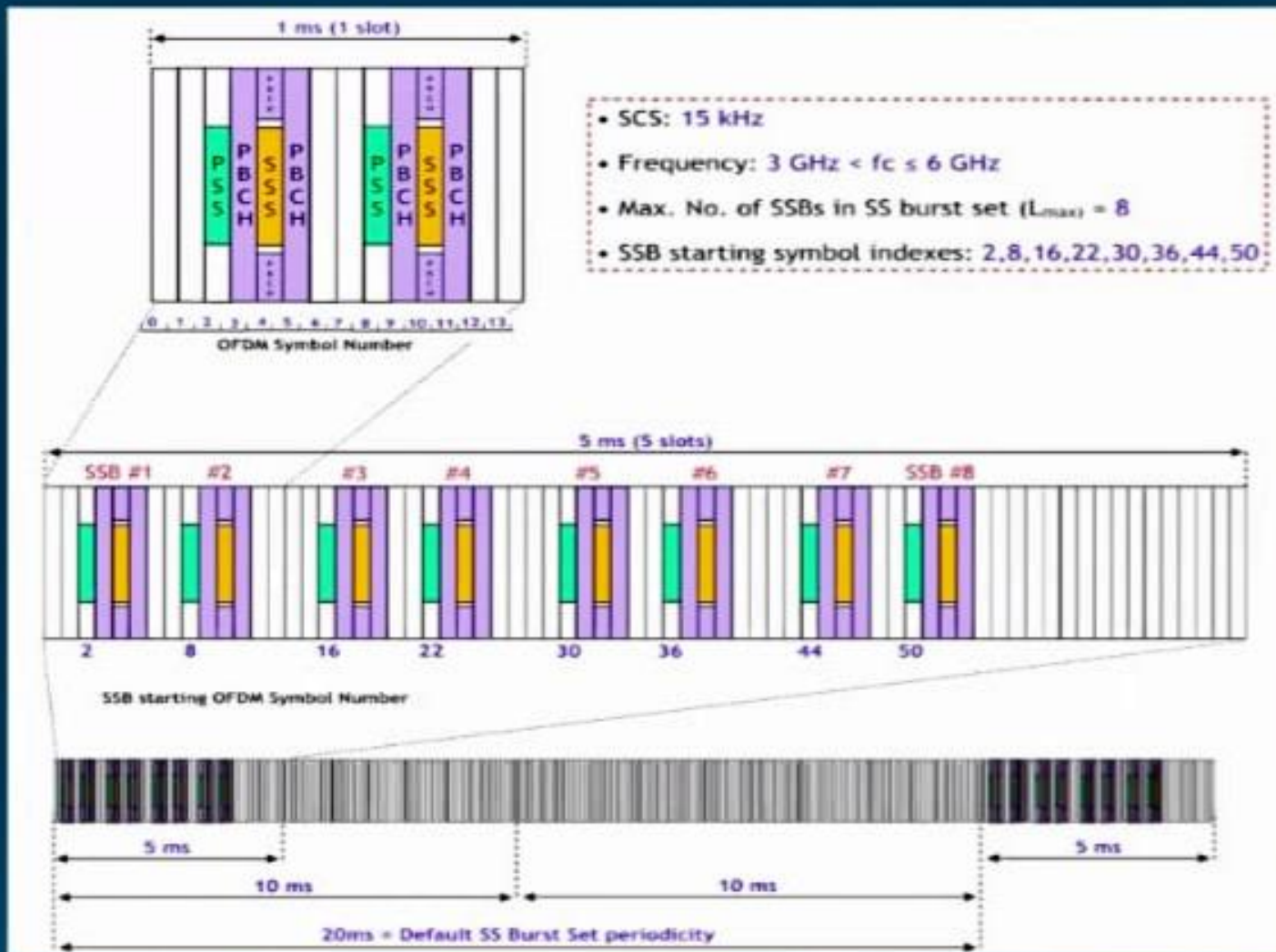
Implementation/algorithm
development/testing

Hardware based
development
• DSP, Analog, FPGA etc.



Testbed Lab in CEWiT

5G Test Bed Project



Source: howltestuffworks, 5G NR: Synchronization Signal/PBCH block (SSB)

Evolution of 5G

Leading the 5G Advanced evolution toward 6G



Source: Qualcomm, What's next in 5G Advanced?

Rel-19

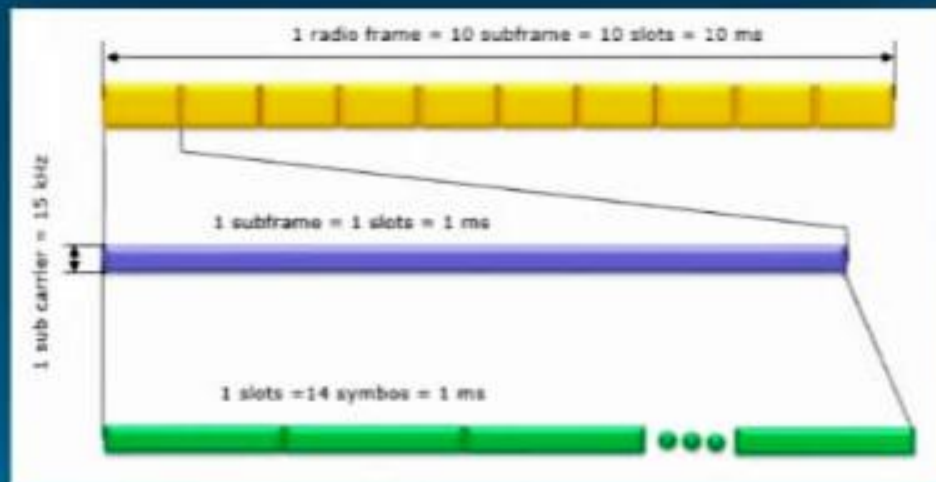


Source: Qualcomm, What's next in 5G Advanced ?

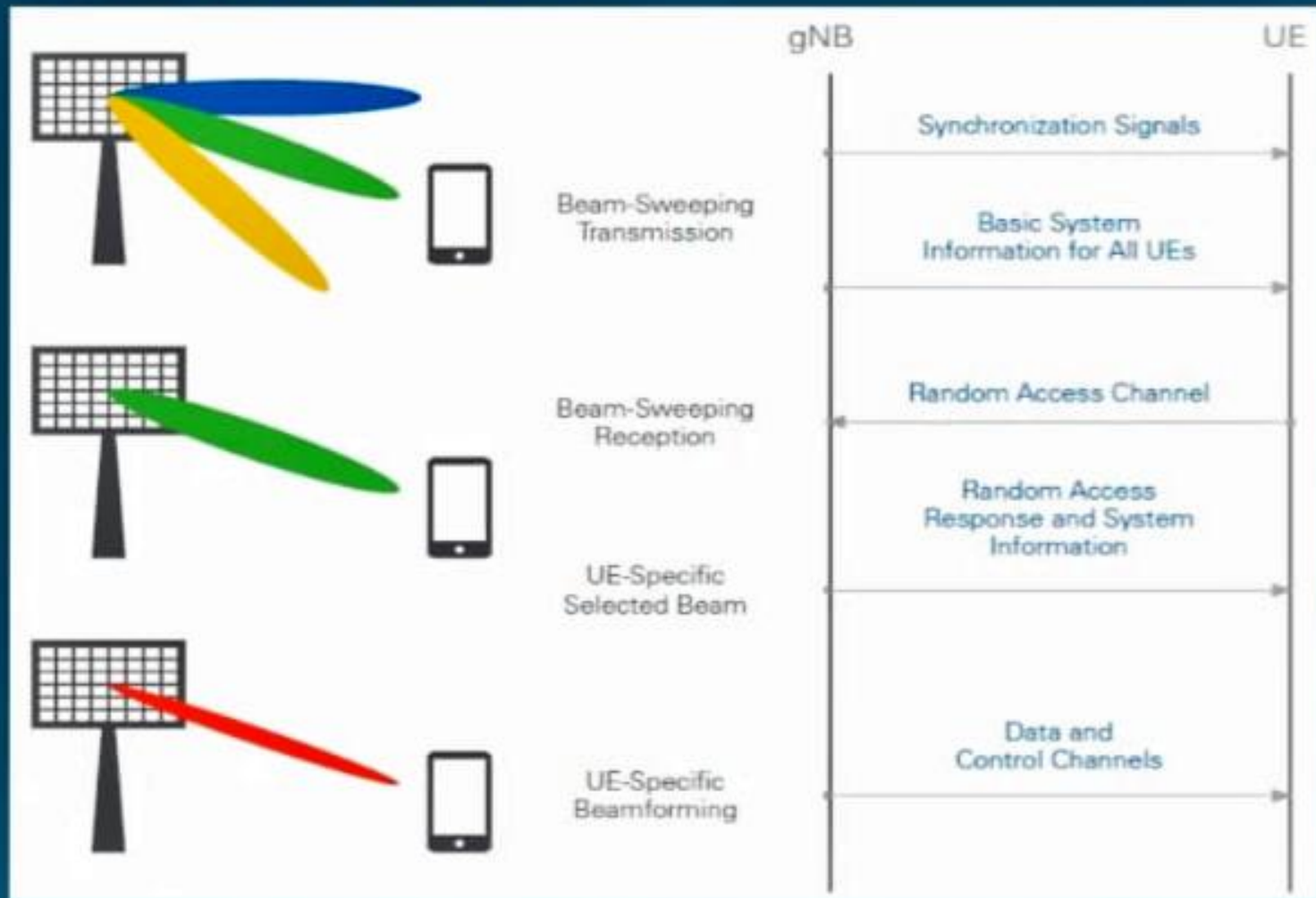
Basics

- Frequency Range: FR1:
 - Sub 6 GHz
 - FR2: greater than 6 GHz
- Bandwidth:
 - Maximum Allowed continuous frequency resources for transmission and reception for a Base Station/User Equipment.
 - Bandwidth Part: subset of BW allotted to a UE

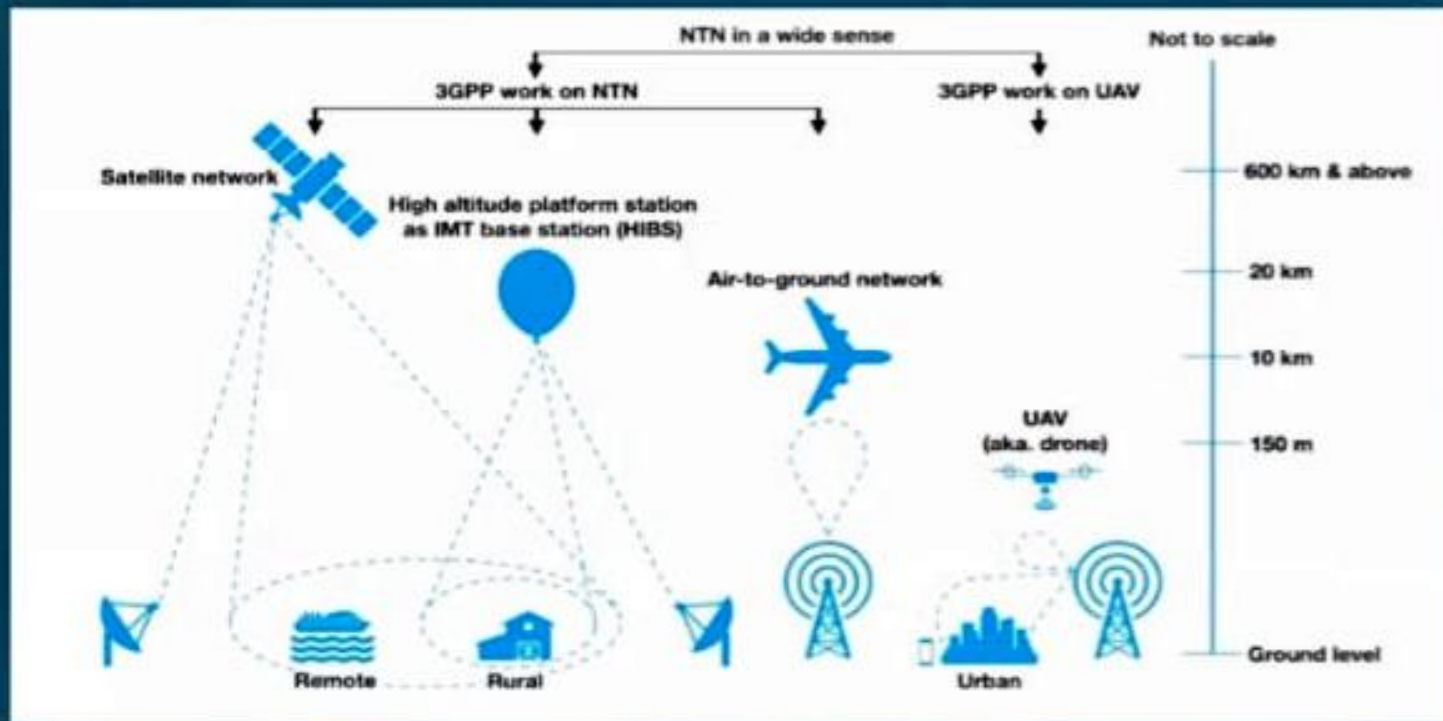
Time Frame:



Initial Access



Source: moniem-tech, What is 5G NR initial access procedure ?



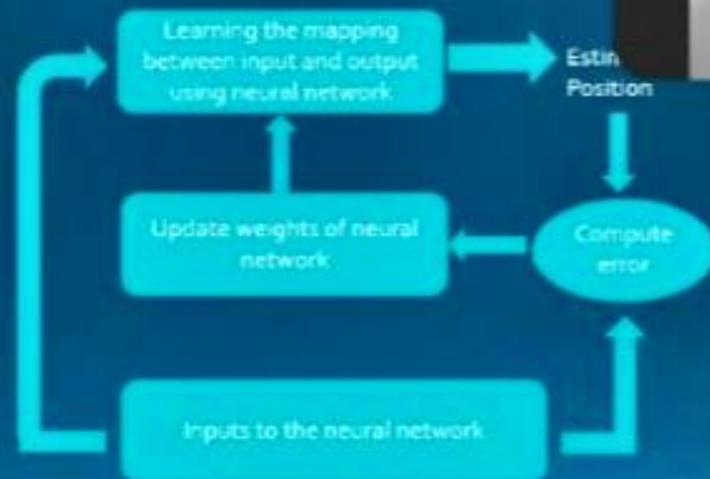
Source: 5G from Space: An Overview of a 3GPP Non-Terrestrial Networks

Non-Terrestrial networks (NTN) and Unmanned aerial vehicle (UAV)

Beam Management

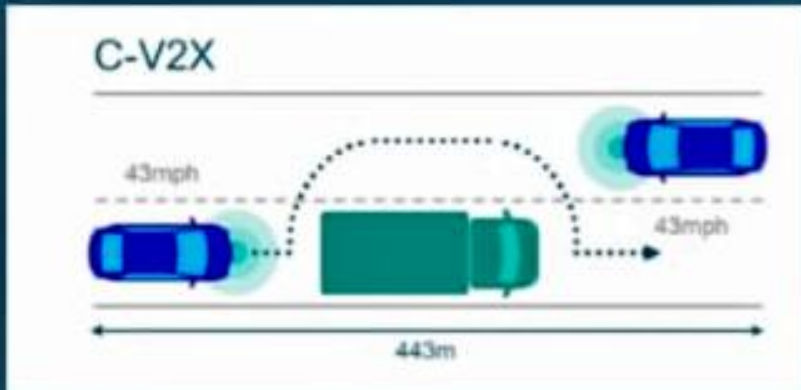
Positioning

Channel state feedback enhancement

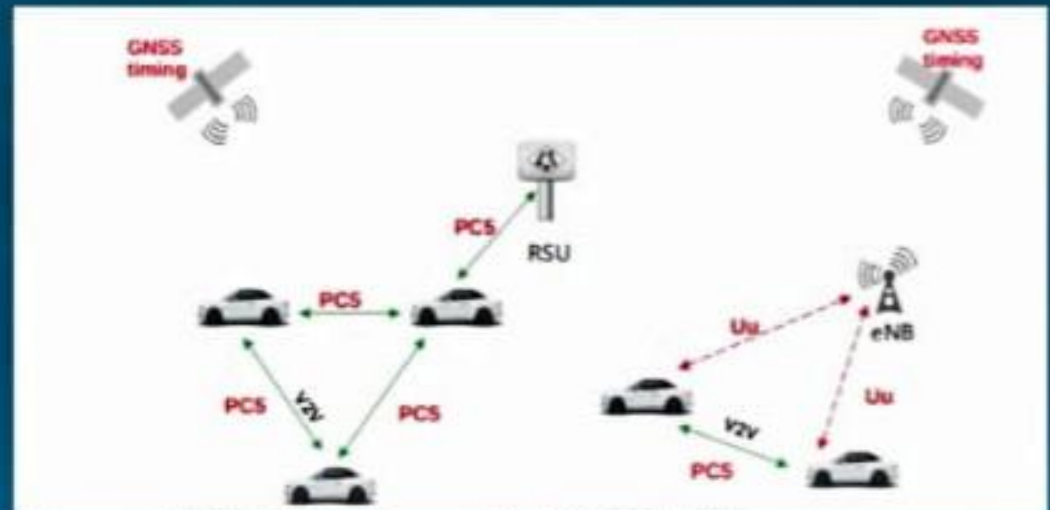


An example of training a neural network for positioning

AI/ML for air interface



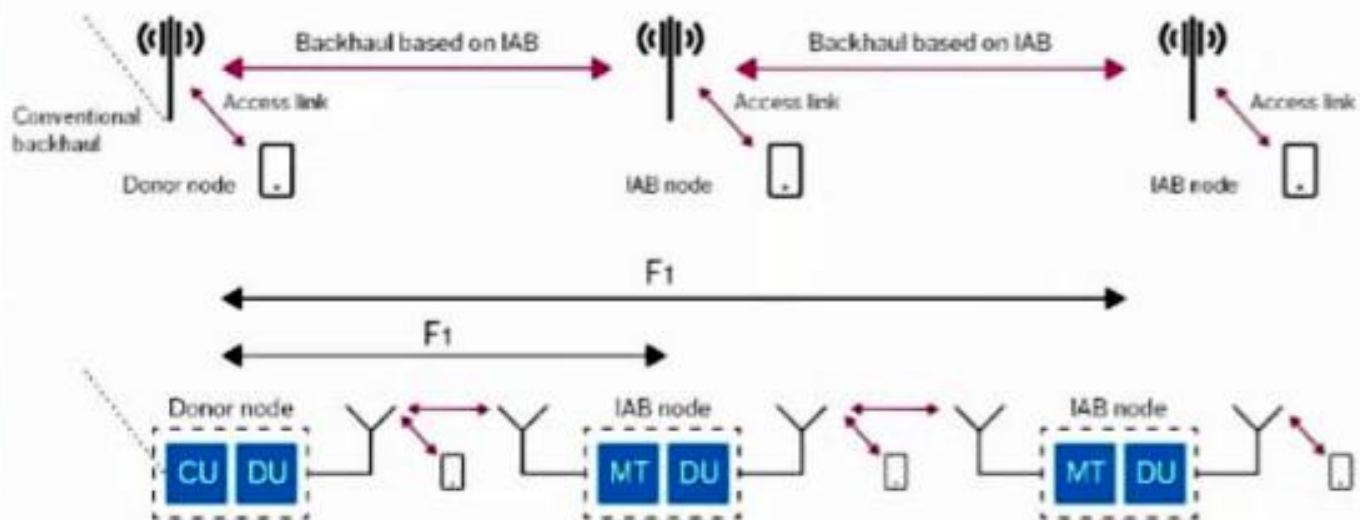
Source: 5G Americas White Paper, Cellular V2X Communications Towards 5G



Source: V2X White Paper by NGMN Alliance

V2X services

IAB



Source: 5G evolution: 3GPP releases 16 & 17 overview, Ericsson

Evolution of 5G



- **Release 15**

- Initial specifications enabled non-standalone 5G (NSA) integrated into LTE(4G) networks, further expanded to 'standalone' 5G SA, with a new radio system complemented by a next-generation core network (5GC).
- URLLC, eMBB & mMTC.

- **Release 16**

- Extensions to V2X communications (i.e., 5G NR-based direct device-to-device communications or sidelink communications) to extend automated and remote driving.
- Industrial Internet of Things (IIoT).
- enhancements to URLLC, (mini slots)
- Integrated Access and Backhaul (IAB) (that brings a relay function to 5G).
- 5G positioning.
- Dynamic spectrum sharing
- Dual connectivity and carrier aggregation

- **Release 17**

- NR-based NTN,
- enhancement in MIMO, integrated access and backhaul (IAB),
- multi-RAT dual-connectivity (MR-DC),
- support for multi-SIM devices for LTE/NR, and NR small data transmissions in an inactive state.

- **Release 18**

- vehicle-mounted relays, smart energy and infrastructure, and enhancements to support residential 5G, AI/ML, model transfer, and training requirements, operations splitting, Sub-band full duplex, NCR

- **Release 19**

- NES, SBFD, Ambient IOT, Positioning, AIML, enhancements in MIMO sidelink, etc



Source: RWS-210181, On Rel-18 NR MIMO enhancements for 5G Advanced, Samsung



Source: What key technology inventions will drive the 5G expansion?, OnQ Blog, Qualcomm

Enhanced MIMO

TH  NK
YOU