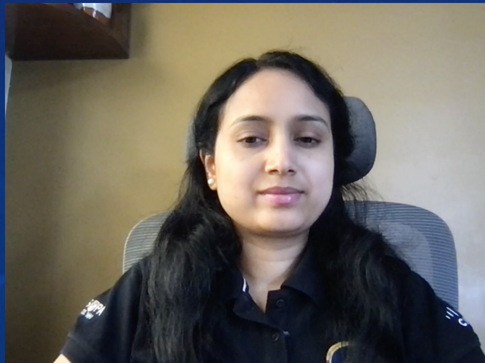
EVOLUTION OF SYNC IN TELECOM, 5G AND BEYOND

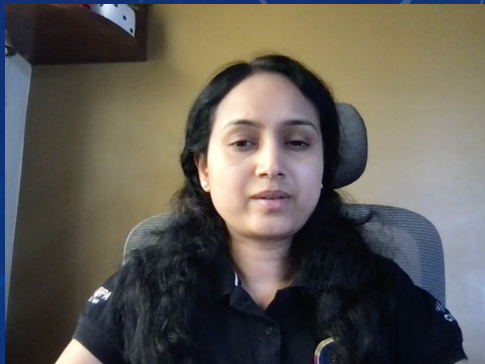
SOWMYA L

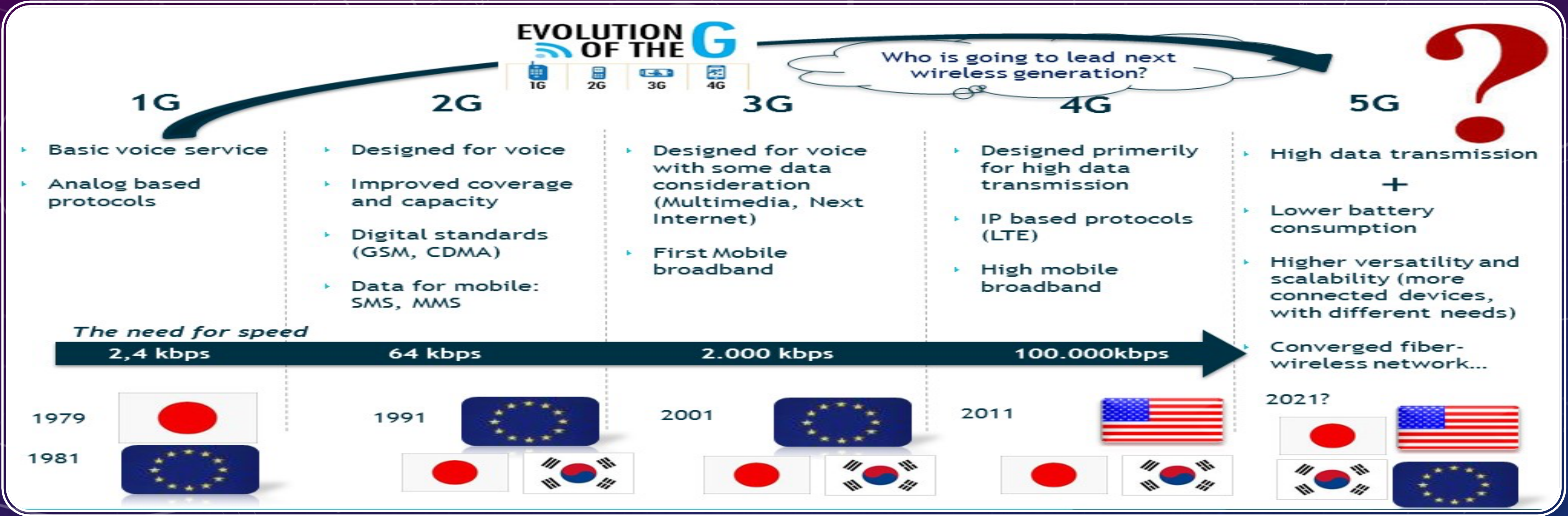
CISCO SYSTEMS



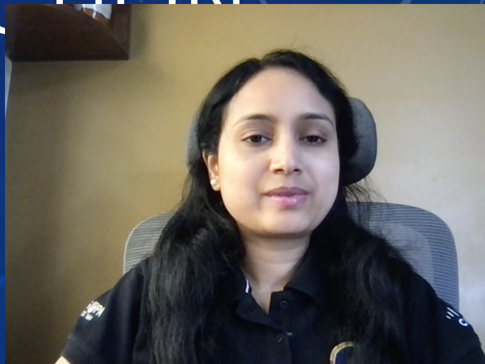
AGENDA

- Introduction
- Challenges in implementing 5G
- Need of Timing and Synchronization
- Evolution of Timing and Synchronization Profiles
- Innovations in implementing 5G
- Summary

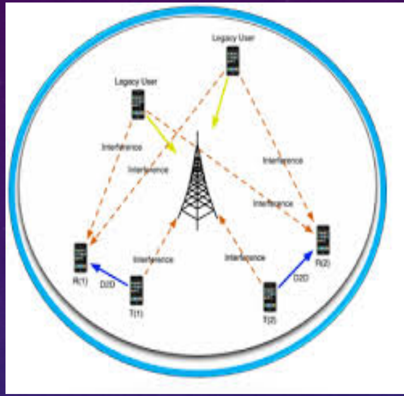


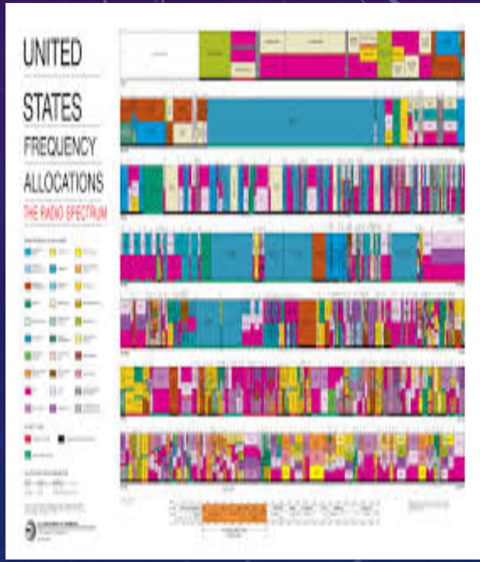


INTRODUCTION

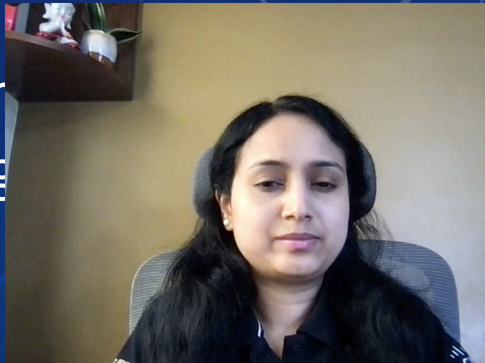


CHALLENGES IN IMPLEMENTING 5G





- ➢ Frequency bands
- ➢ Huge Data Volume
- ➢ Device to Device Communication
- ➢ Ultra Low Latency Service
- ➢ Security
- ➢ Getting TDD synchronization right – With TDD based spectrur comprising up to 80% of total 5G network capacity, timing outag to become significant performance and availability challenges.

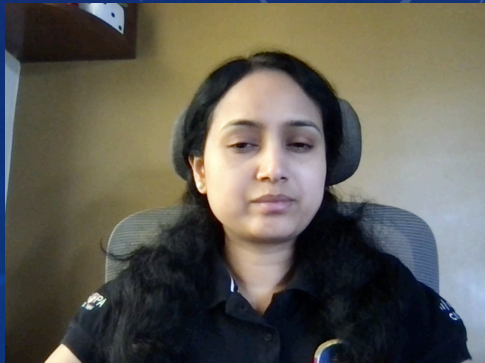


NEED OF TIMING AND SYNCHRONIZATION

- Timing and synchronization are critical components of an efficient LTE-A and 5G mobile deployment. If it is not properly designed, implemented and managed, it can have a dramatic (negative) effect on the efficiency, reliability and capacity of the mobile network.

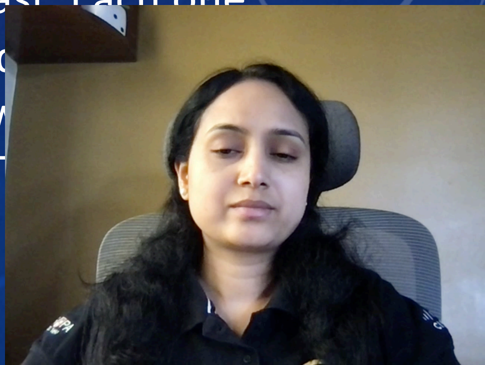
- Subscribers will likely suffer dropped calls, interrupted data sessions, and a generally poor user experience, whilst operators will suffer network instability, loss of efficient usage of the radio spectrum, and unhappy subscribers

- Additionally, because of the move from Distributed (D-RAN) towards Centralized RAN (C-RAN) and Cloud RAN, 5G will demand transport of synchronization and allocation of a time error budget not only in backhaul networks, but also in the fronthaul and midhaul networks



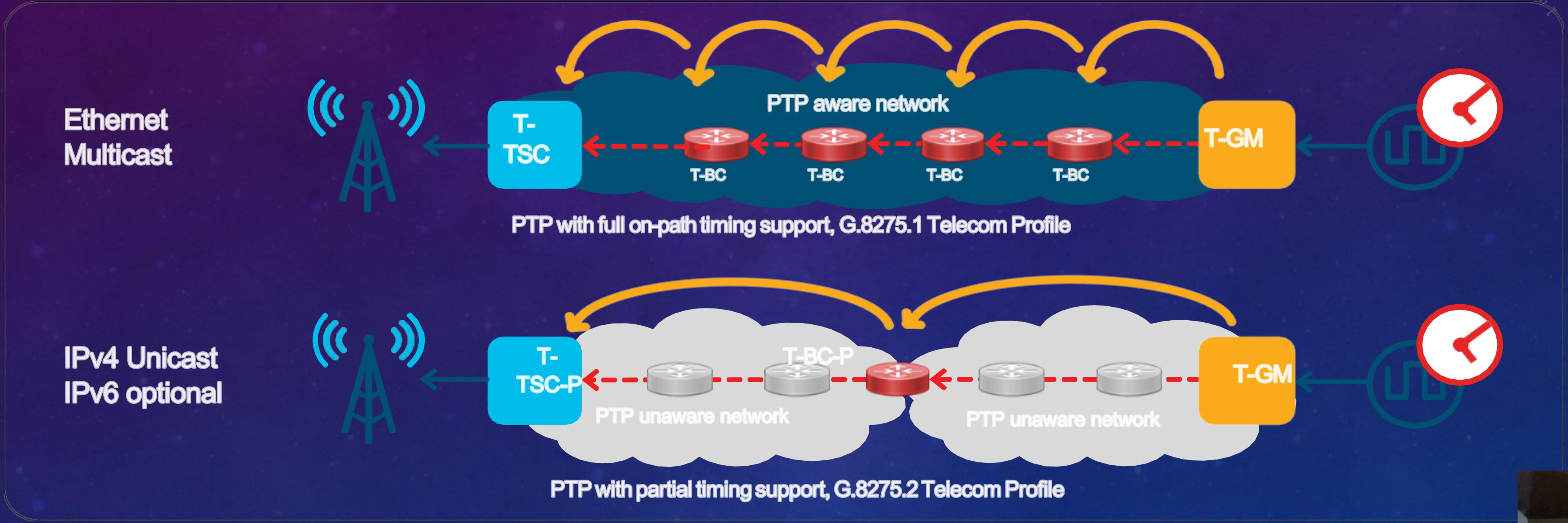
EVOLUTION OF TIMING AND SYNCHRONIZATION PROFILES

- IEEE extended the use of PTP from the LAN to the WAN and introduced the concept of profiles
- Several standards Development organizations have used this capability in order to design PTP solutions to be used for specific use cases or industry segments
- The ITU-T became a keen adopter of this feature when they began to publish their "Telecom Profiles."
- The first ITU-T Telecom Profile, known as ITU-T G.8265.1, was designed to apply a PTP solution to frequency synchronization of telecommunication systems.
- After the success of G.8265.1, two additional profiles were developed to deploy PTP Timing in mobile backhaul networks for frequency plus phase synchronization
- These two PTP profiles specify different transport mechanisms, one based on L2 Multicast and the other on L3 Unicast. Each one is designed to address different network topologies
on the support for PTP in the intervening nodes betw
Telecom – Grand Master (T-GM) and the Telecom – T
Clock (T-TSC).

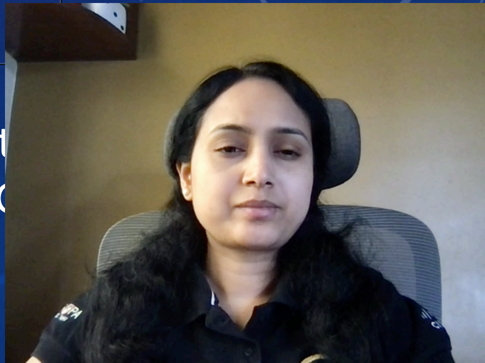


Details of 2 PTP topologies are as below:

- G.8275.1: PTP has full on-path timing support from the network (each node is PTP aware)
- G.8275.2: PTP has only partial timing network support (intervening nodes are not necessarily PTP aware)



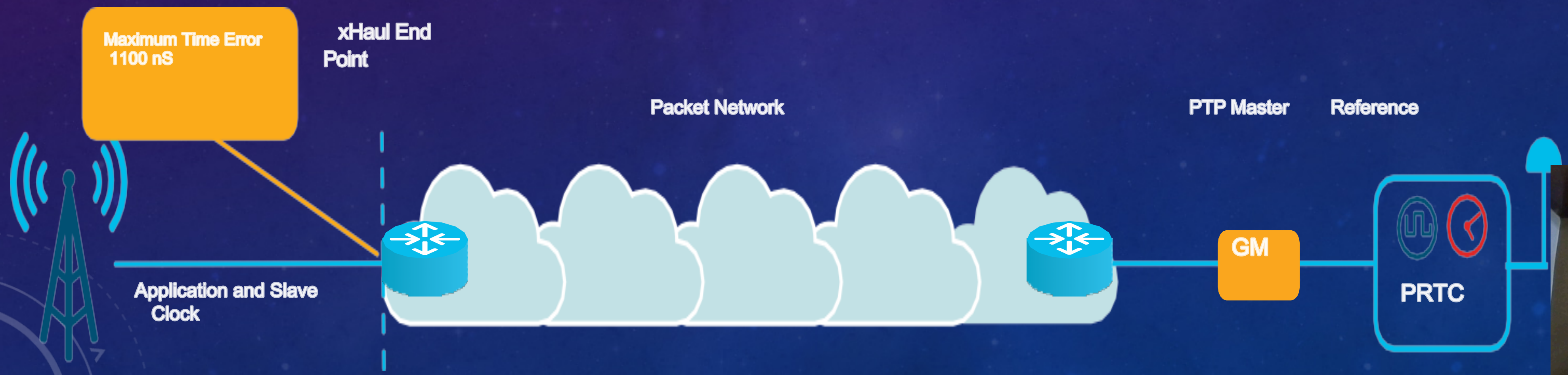
Additionally, each of these profiles should be deployed with frequency distribution via SyncE in addit
distribution using PTPv2 packets, although the SyncE is not a mandatory requirement in the case of (

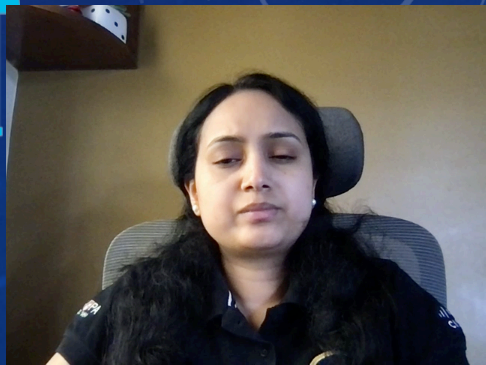


TIMING PERFORMANCE SPECIFICATIONS

The ITU-T standards development process is designed as an end-to-end solution to a specific problem – in this case the synchronization of LTE-Advanced and 5G networks utilizing an assumed Hypothetical network Reference Model (HRM). Since there are currently two different network models, full on-path support and partial on-path support, there are multiple HRMs applicable, one for each case, and they have their own documents:

- G.8271.1 for the case with full on-path support from the network
- G.8271.2 for the case with partial on-path support from the network

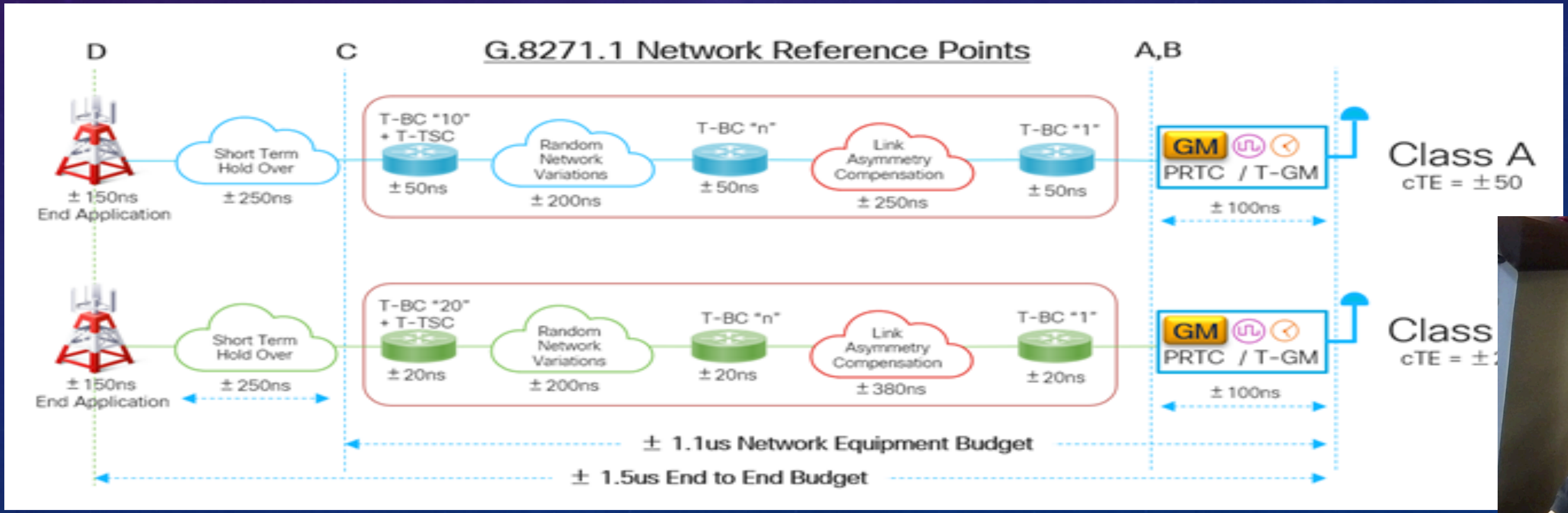


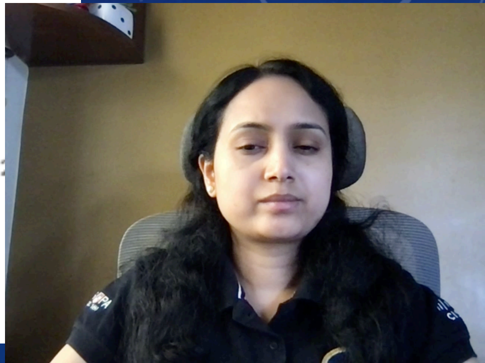


TIMING PERFORMANCE SPECIFICATIONS

The below diagram shows the expected end-to-end performance and the points where the budget is measured and indicating the major requirement that the maximum time error at the final network hop, at the end of the xHaul, is to be less than 1100 ns.

For an engineer building a network to transport timing, the figure of 1100 ns is the maximum time error that the network can ever display at the final hop in their network.
As there is only going to be tighter budgets with the increasing development of 5G radio, some pieces of this end-to-end network chain needs to improve their performance to allow better coordination of the radios with each other. The most likely place this is to happen is in the fronthaul network, especially with C-RAN deployments likely to be deployed in denser urban settings.





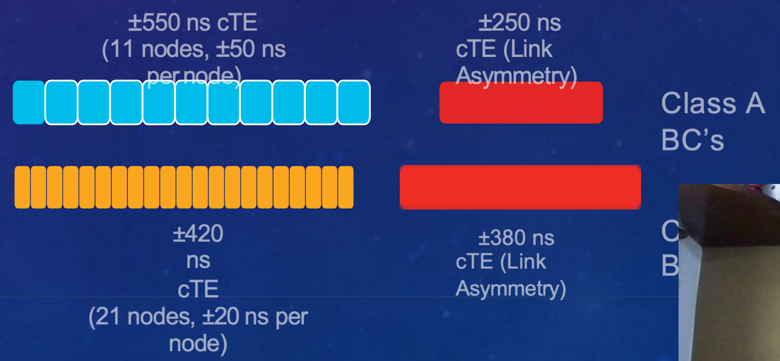
1) There are currently three levels of performance defined in the G.8273.2 recommendation for Telecom Boundary Clocks (T-BC), namely Class A, B, and C (they do the same for T-TC in G.8273.3). There are plans to extend that to higher levels of timing performance (meaning lower time error).

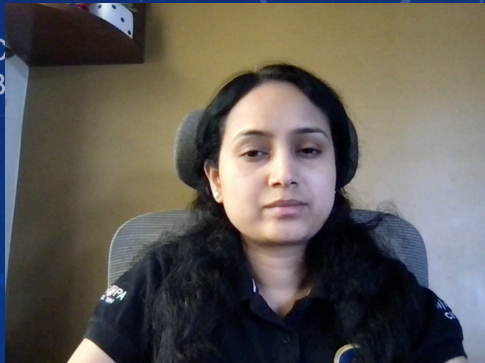
2) The details are slightly complicated, but as general information, here are the values for maximum Time Error (max|TE|) and constant time error (cTE) that are defined for each of the classes.

3) The cTE is the time error averaged over 1000 seconds. There is also a dynamic time error component (dTE) for each case.

4) The below diagram shows that portion of the network between the T-GM and the point C – which is that part of the network where the backhaul nodes are deployed, and shows the budget for the nodes and the links between them.

T-BC Class	Max. Absolute Time Error mas|TE|(ns)	Allowable Constant Time Error cTE (ns)
A	100 ns	±50 ns
B	70 ns	±20 ns
C	60 ns	±10 ns



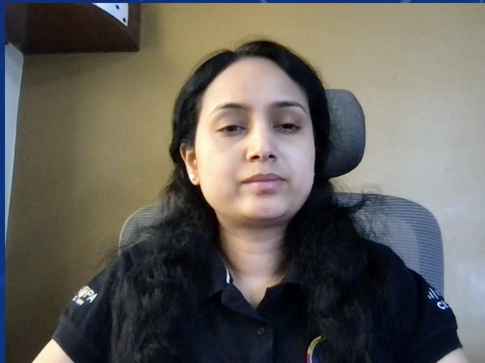


- The forecast requirements to support tighter time error budgets for 5G radio standards, there is a need for updated standards with improved levels of performance. Although the ITU-T now includes T-BCs with class C performance, there is still discussion about the appropriate network topology and budget allocation for class C clocks. Although this use case has not been finalized, it is already clear that the motivation for class C clocks is in the fronthaul and RAN.

- One final note: this process of reducing time error is also occurring at other points in the chain. New performance standards for the PRTC are now published (the improved PRTC-B and the enhanced ePRTC in G.8272.1), which is designed to lower the time error at the beginning of the timing sequence, as well as delivering increased holdover performance during GNSS outages.

- Additionally, improved SyncE performance specifications (G.8262.1) are now published for what is called enhanced Synchronous Ethernet (eSyncE) to improve physical-layer frequency performance.

- Changes have been made to the ESMC protocol to support the carriage of more accurate quality levels contained in the enhanced SyncE Clocks.



FACTORS IMPACTING TIMING PERFORMANCE

There are quite clear factors that impact the timing performance and they can be categorized into three broad fields:

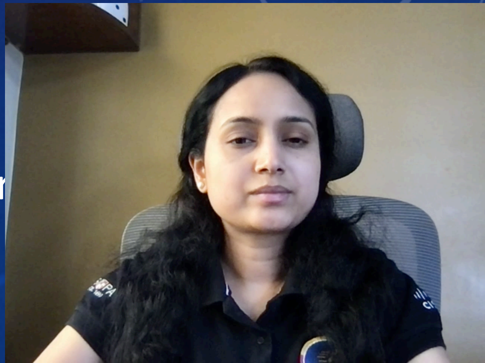
- Implementation of the PTP clocks (mostly hardware, and less so for software
- Network design and engineering
- Transport technologies

Item 1 describes the engineering design and implementation of the platform participating in and/or transporting PTP and SyncE. That is critical, but one also needs to consider the network design in combination with the performance of underlying transport to deploy an effective, robust, and well-designed synchronization network.

Proposed solution:

Given that there are three tools available, namely GNSS, PTP, and physical frequency distribution, there are four valid deployment scenarios to implement these stringent phase and time synchronization requirements:

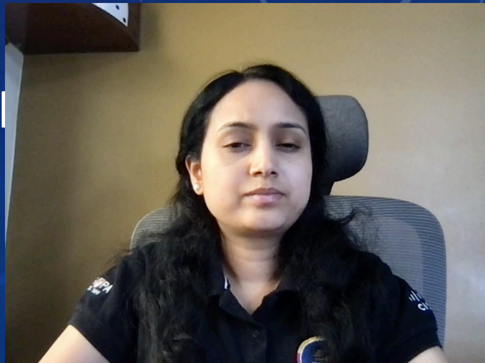
1. GNSS everywhere: GNSS-based PRTC time source everywhere time is needed.
2. Packet distribution: PTP G.8275.1 with full on-path support and SyncE.
3. Packet distribution: PTP G.8275.2 Partial Time Support (PTS) and optional SyncE.
4. Packet distribution: PTP G.8275.2 Assisted-Partial Time Support (A-PTS), GNSS primary solution pair remote PTP T-GM to provide resilience.
5. A mixture of (2) and (3) with multi-profile support and interworking (G.8275.1 - G.8275.2).



SYNCHRONIZATION FEATURES

Cisco develops its product range with all these possible solutions in mind, and helps operators build 5G-capable xHaul networks by incorporating the following timing and synchronization features into its transport products:

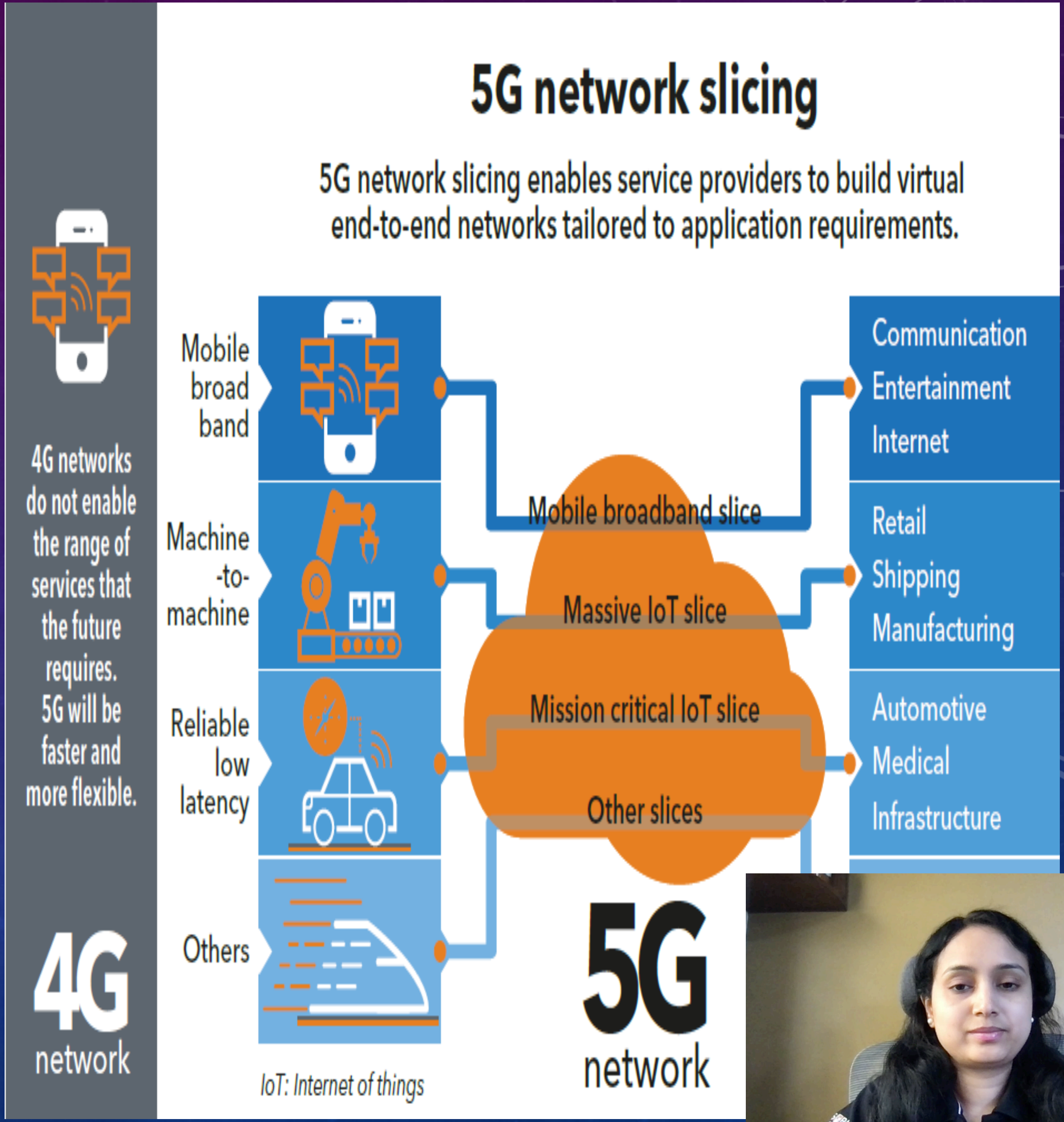
- Class B and Class C T-BC Boundary Clock performance according to G.8273.2
- G.8275.1 (Full On-Path PTP support profile) with L2 Multicast encapsulation
- G.8275.2 (Partial On-Path PTP support profile) with L3 Unicast encapsulation (IPv4 and IPv6)
- External timing ports to allow the connection of stand-alone GNSS receivers as PRTC time sources
- Internal GNSS receiver support in equipment located where this function is appropriate
- Synchronous Ethernet (G.8262) and ESMC support (G.8264) with increasing support for t
  enhanced Synchronous Ethernet or eSyncE (G.8262.1)



INNOVATIONS IN IMPLEMENTING 5G

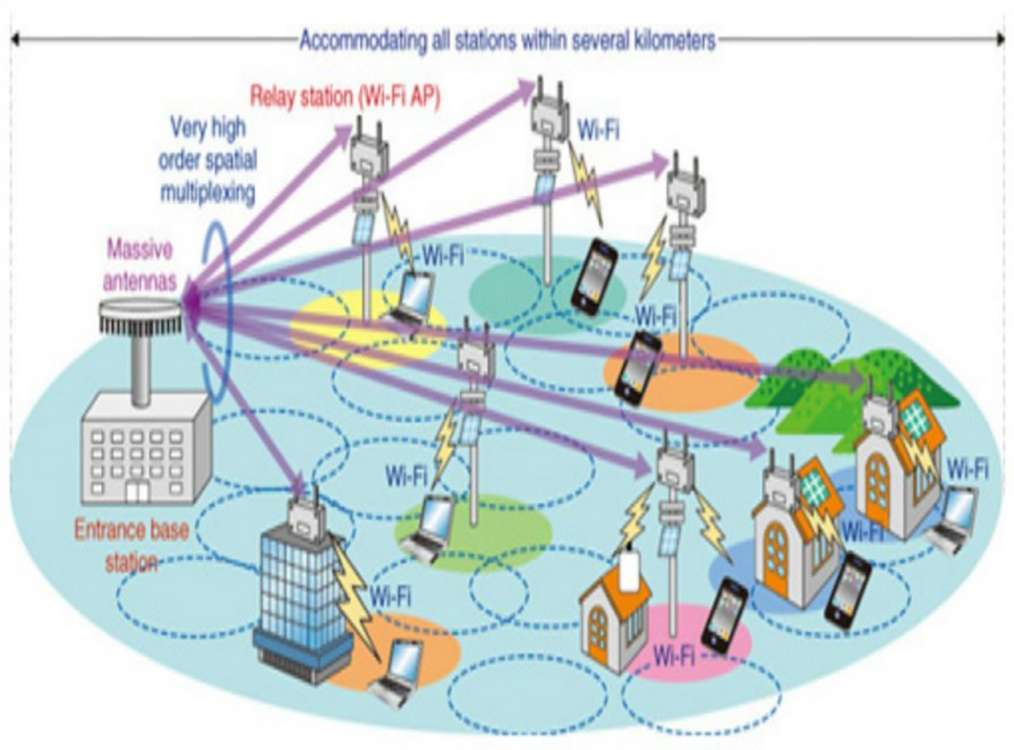
- A network slice is a managed group of subsets of resources, network functions / network virtual functions at the data, control, management/orchestration planes and services at a given time. Network slice is programmable.

- Network Slicing is the capability of a slice to be tightly coupled with services, i.e., the slice instance can be designed that way that it support a specific service or limited number of services only

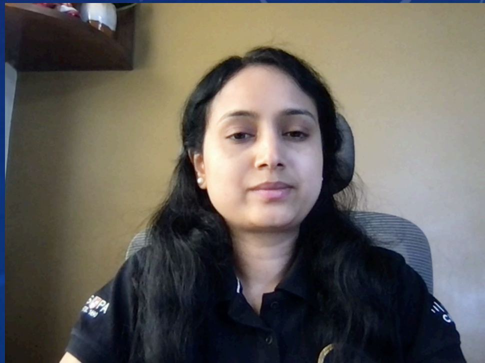


2. MASSIVE MIMO

MIMO antennas, attached to a base station, focus the transmission and reception of signal energy into small regions of space, providing new levels of efficiency and throughput.



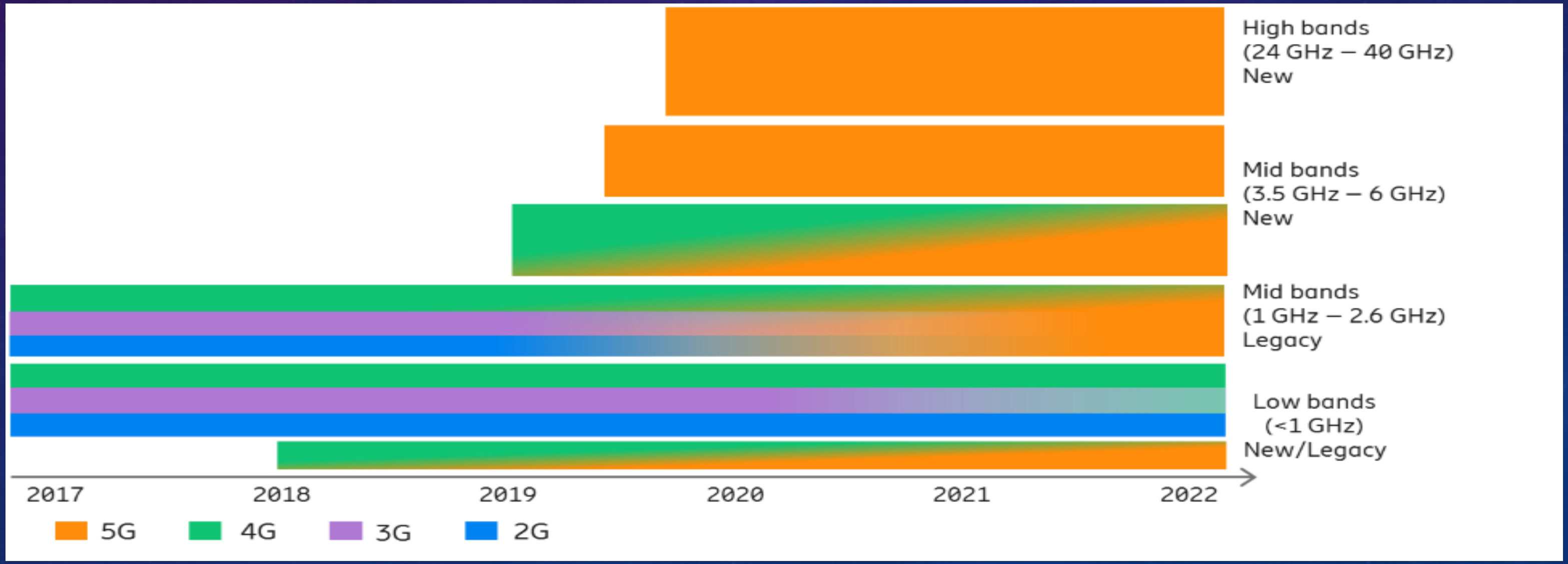
The more antennas that are used, the finer the spatial focusing can be.

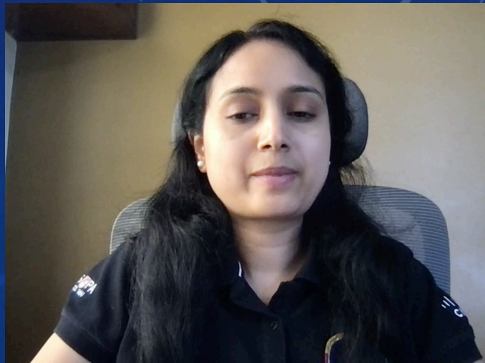


3. INCREASED SPECTRUM

The need for new additional spectrum for the advancing generations of cellular technologies and mobile networks has grown over the years based on growth in mobile data traffic and emergence of new use-cases.

However, managing the current and new additional 5G spectrum while also maintaining operations of existing technologies, is a challenge that is increasing with the complexity of combination of spectrum bands and the infrastructure to use it.



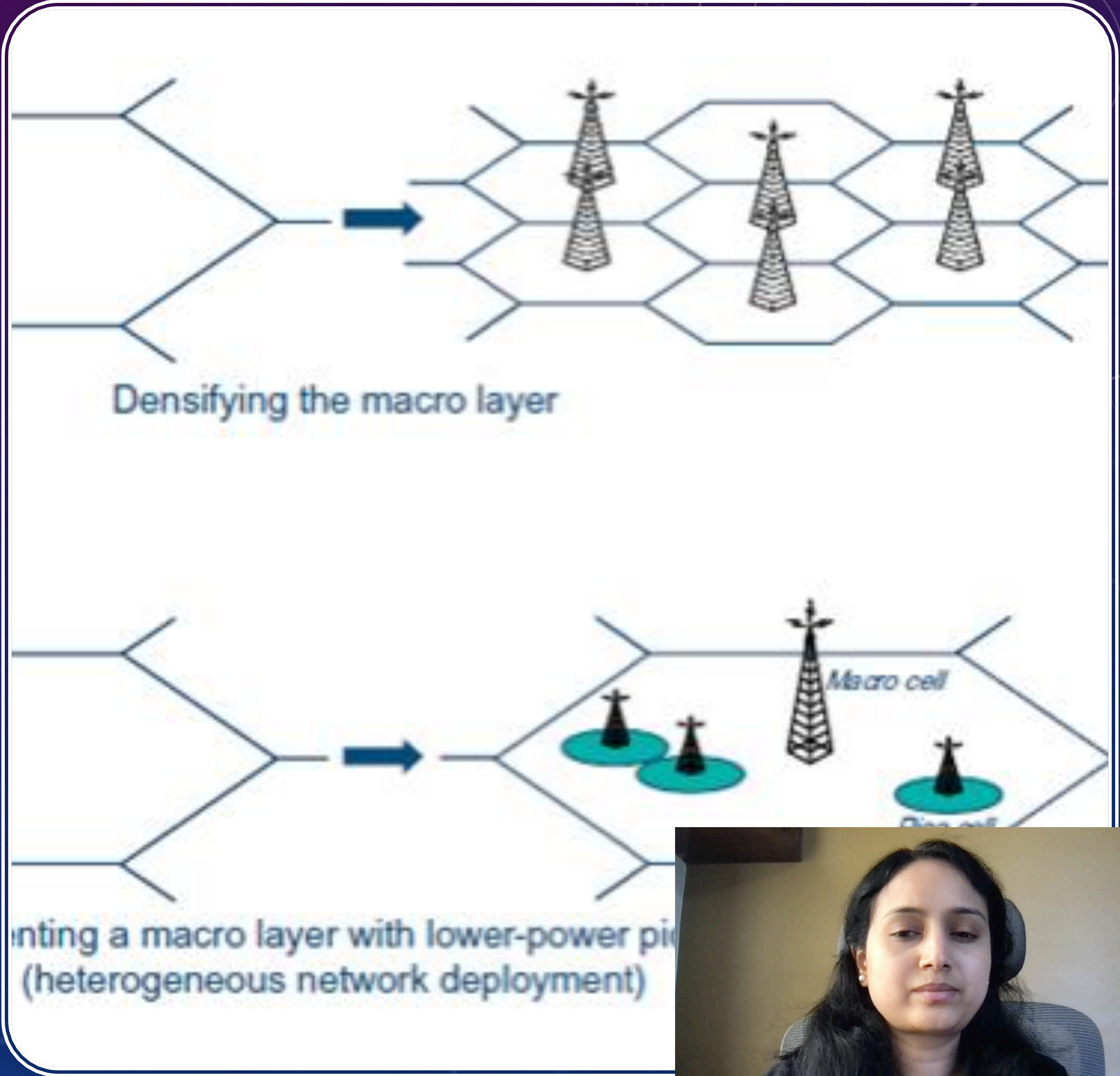


4. NETWORK DENSIFICATION

Large-scale-cost-effective spatial densification is facilitated by self-organizing networks and intercell interference management

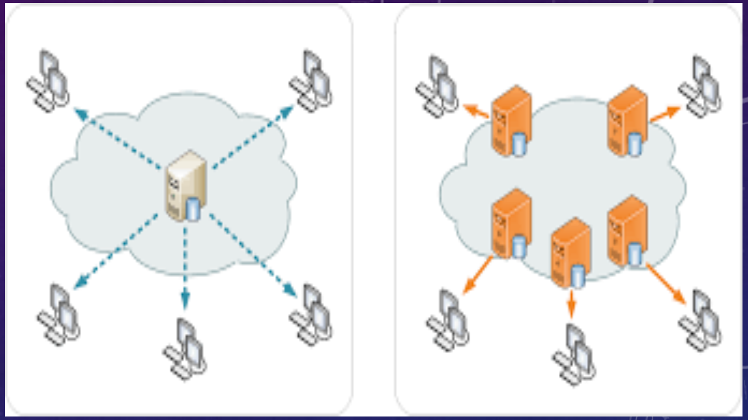
As the distance from transmitters to receivers is greatly reduced in dense networks, signal is more likely to be propagated from long to short range distance

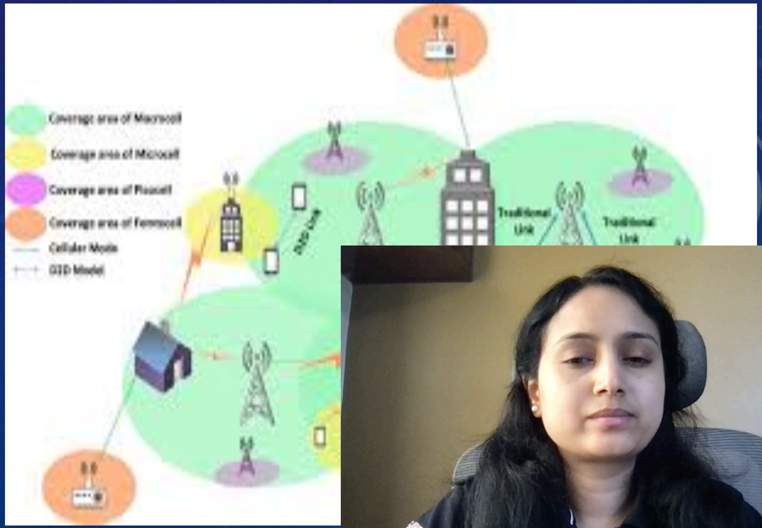
Adding more cell sites to increase the amount of available capacity is network densification



NETWORK DENSIFICATION

- Although the mobile transport network itself does not need synchronization, TDD can provide timing and synchronization to the RAN.
- The specific requirements for RAN Timing and Synchronization are dependent on the radio technology deployed and the spectrum used.
- TDD (Time Division Duplex) spectrum need much tighter time and phase synchronization to ensure against interference between the uplink and downlink.





Pros: Can provide network delivery speeds 10 times faster than 4G maintaining optimal connectivity

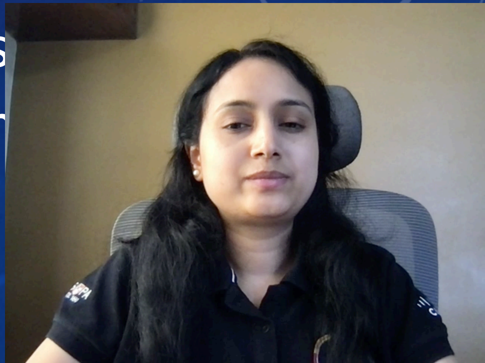
Cons: Managing interference when BSs of different coverage footprints, access schemes, and transmission powers share the same licensed frequency spectrum.

SUMMARY

- Any service provider who wants to deploy 5G in their network, need to evaluate the typical use cases in the locations where it is going to be deployed. Suppose the requirement is in rural area where the mobile data traffic would not be on higher side, then depending on the services like health care, service provider can choose to go for network slicing with each slice programmed for specific service type.

- Suppose the deployment is going to be in urban locations where the mobile data traffic is high, then service provider can opt to transition the existing network with network densification, Massive MIMO or utilizing the high bands of increased spectrum.

- Depending on the use-cases, service provider can choose the appropriate s the network and come up with reduced latency, high system capacity and r device connectivity.



Thank You