Green & soft RAN for 5G

TELCOMA

Proposed smart Green & soft RAN

For Green & Soft RAN :

- Rethink Shannon
- Rethink Ring & Young
- Rethink signalling & control
- Rethink antenna
- Rethink spectrum & air interface
- Rethink fronthaul
- Rethink protocol stalk

GREEN RAN

Green RAN :

- 5G should reflect two major themes : Green & Soft
- In the 5G era , it is expected that millions more base stations with higher functionality & billions more smart phones & devices with much higher dates will be connected.
- If green communications technologies are universally deployed across this network significant energy savings can be realized , enabling larger deployments for 4G & 5G capacity upgrades.

Green RAN :

- Earth has devised an array of new technologies including low - loss antennas , micro direct transmissions (DTX), antenna muting and adaptive sectorization according to traffic fluctuations results in energy savings of 60- 70 %.

SOFT RAN

Soft RAN :

- It is software defined centralized control plane for RAN which abstracts all BSs in a virtual big BS consisting of central controller & radio elements.
- Softair is software defined based system for 5G wireless access.
- In softair system, the control plane which is placed in the networks server is responsible for network management & optimization while the data plane consists of software defined BSs in the RAN & software defined switches in the core.

Soft RAN :

- Software defined hyper cell architecture design is based on the integration of cloud RAN , SDN & air interface separation. This system is divided into three subsystems :
- RRH network
- Fronthaul network
- Virtual BS cloud

Soft RAN :

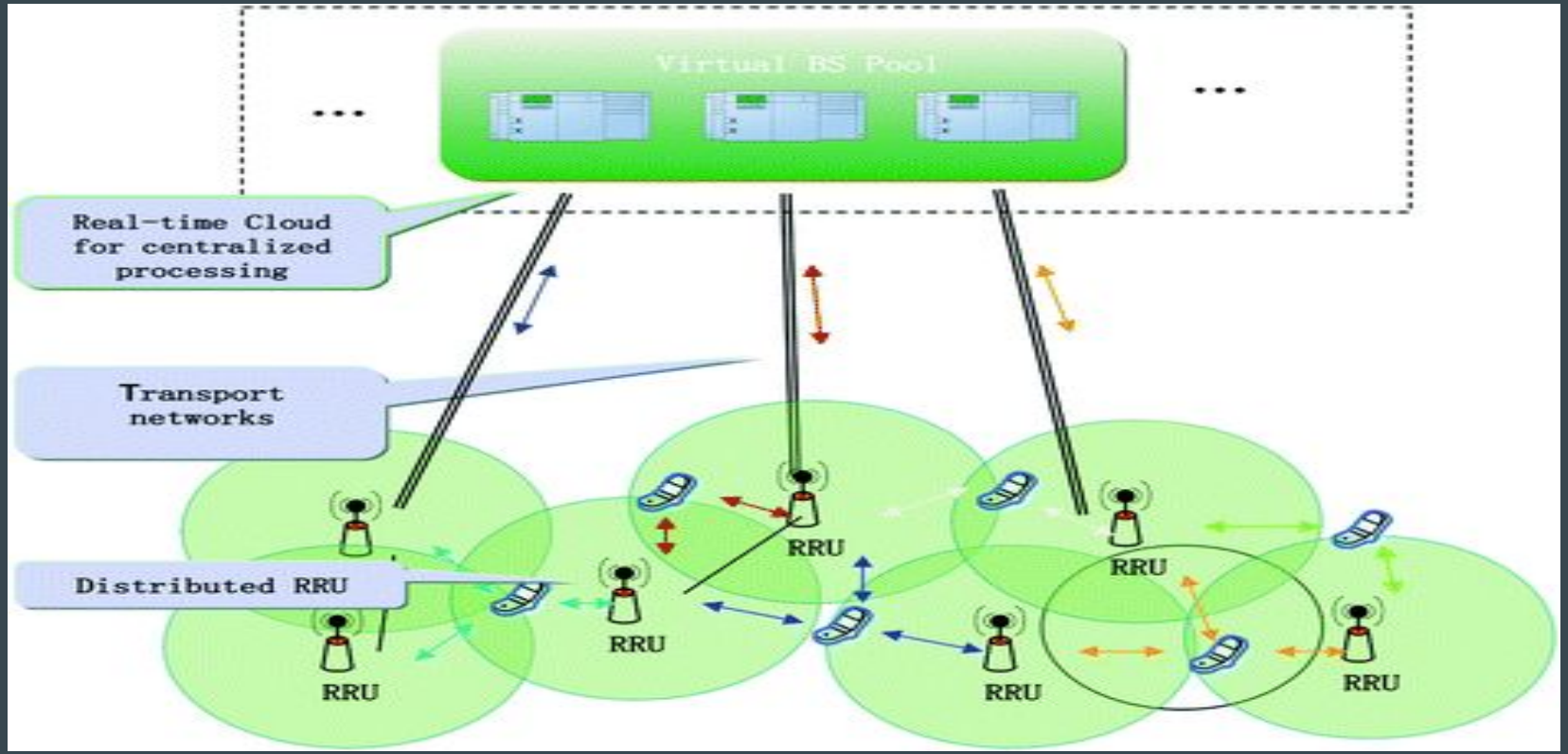
- A novel architecture is proposed in which is based on the deep integration of software defined & virtualized RANs with fog computing which is a good solution for real time data services.
- The SDN controller can operate in three models as :
- Centralized
- Distributed
- Hybrid

ARCHITECTURE

Proposed architecture :

- Architecture should be traffic & density aware.
- Smart & flexible enough to take traffic & density of the users into consideration.

Proposed architecture :



Distributed cloud for central processing :

- To achieve low latency in 5G , there is a need of distributed cloud that spans the end device , edge sites , distributed sites , central sites & public clouds.
- Distributed cloud does support all existing fixed , 3G, 4G and 5G use cases.
- It will be beneficial for smart manufacturing , automotive , media and content delivery, virtual & augmented reality, artificial intelligence, data storage, data analytics etc

Transport network :

- Optical transport network
- Wireless transport
- Submarine cable system

Remote Radio Unit :

- Known as wireless base station
- RRH contains the base station's RF circuitry plus A2D , D2A convertors and up/down convertors.
- RRH also has operation and management capabilities and an optical interface with the rest of base station.

Green & Soft RAN tasks

Tasks :

- Dynamic RRM
- Dynamic functionality splitting
- Dynamic BS type selection
- Dynamic technology selection
- Dynamic framing

Dynamic RRM

Dynamic RRM :

It selects one of the three types of RRMs :

- SD - CRM
- SD - SCRM
- SD - LRM

Centralized RRM algorithm in multicell DL OFDMA systems to maximize throughput of the network. Both carrier aggregation & CoMP (coordinated multipoint) techniques can together improve the performance of the network.

Dynamic RRM :

- The integration of D2D communication , SDN & NFV are used, an information centric virtualization network in SDN is considered & data delivery path is established based on effective capacity maximization.

Dynamic Functionality Splitting

Dynamic Functionality splitting :

- It can be implemented in cloud based networks.
- To balance the processing load of the BS's & decrease delay , the functionality could be abstracted among all BS's.

Dynamic BS type Selection

Dynamic BS type selection :

- A dynamic BS sleeping scheme , where BS's dynamically are turned into sleep mode based on traffic status of the network , under SD based central controller.
- Main purpose is reducing the energy consumption of the network.
- Some dynamic BS on/off switching strategies with the aim of minimizing the energy consumption in wireless cellular networks.

Dynamic BS type selection :

- To reduce the computational complexity , they propose a distributed manner & algorithms with low signalling overheads.
- In the BS type selection, each BS can be turned into CBS, data BS, traditional BS and other types & can be turned into sleep mode , based on network conditions.

Dynamic technology Selection

Dynamic technology selection :

- It is based on various fronthaul & backhaul technologies
- Multiple access types
- Connectivity modes
- Relay modes
- MIMO types etc.

Dynamic Framing

Dynamic Framing :

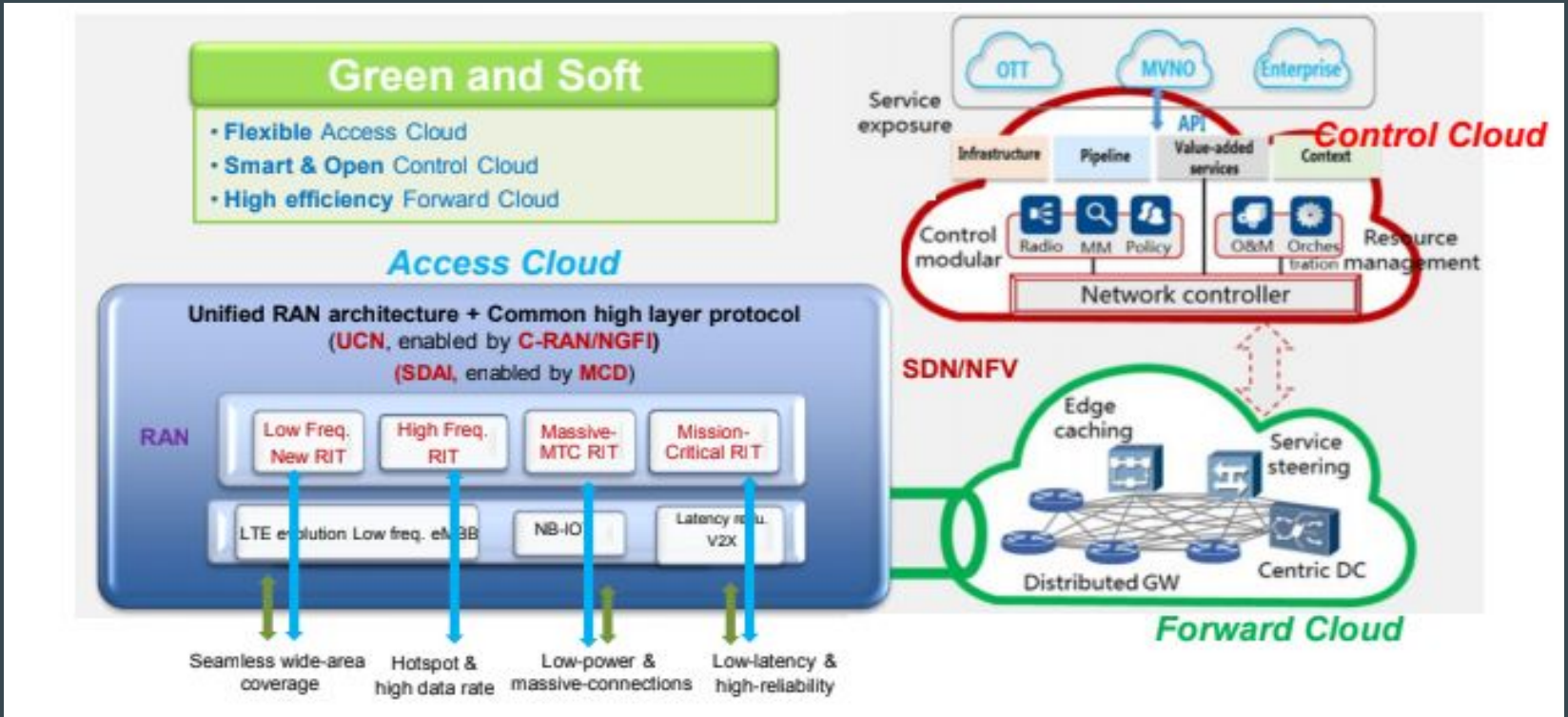
- To tackle heterogeneity in physical layer of 5g networks , the network should be reconfigurable in the frame design based on diverse service requirements .
- 5G requires larger sub-carrier spacing han LTE.

Green & Soft E2E Architecture with three clouds

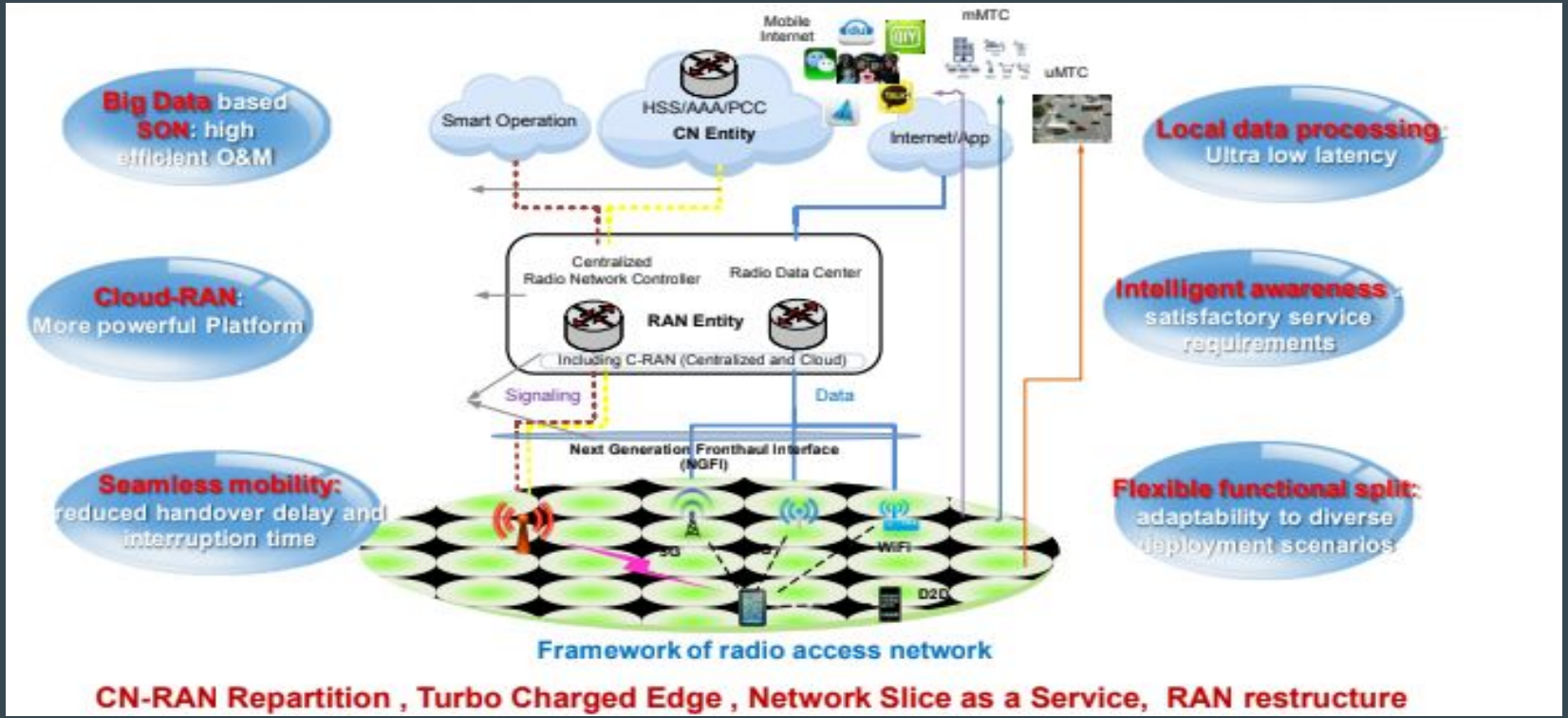
Three clouds :

- Access cloud
- Control cloud
- Forward cloud

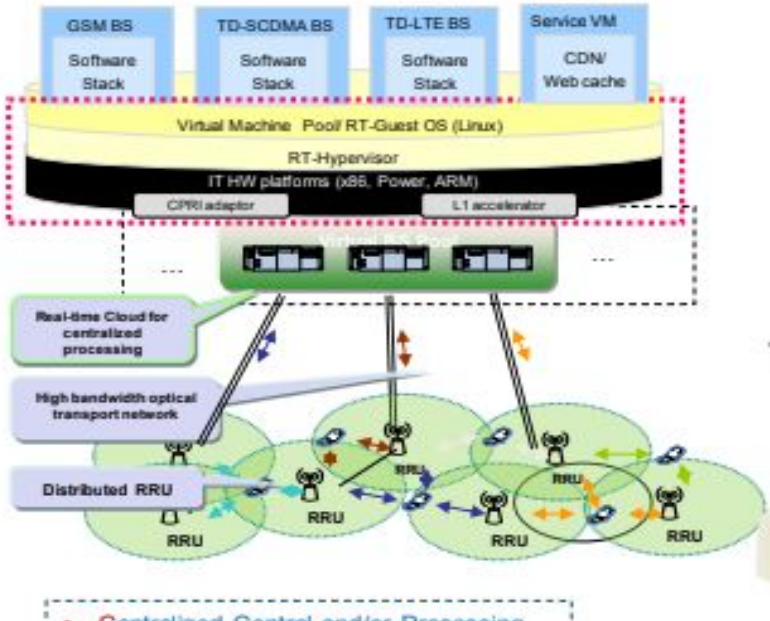
Green & Soft E2E Architecture :

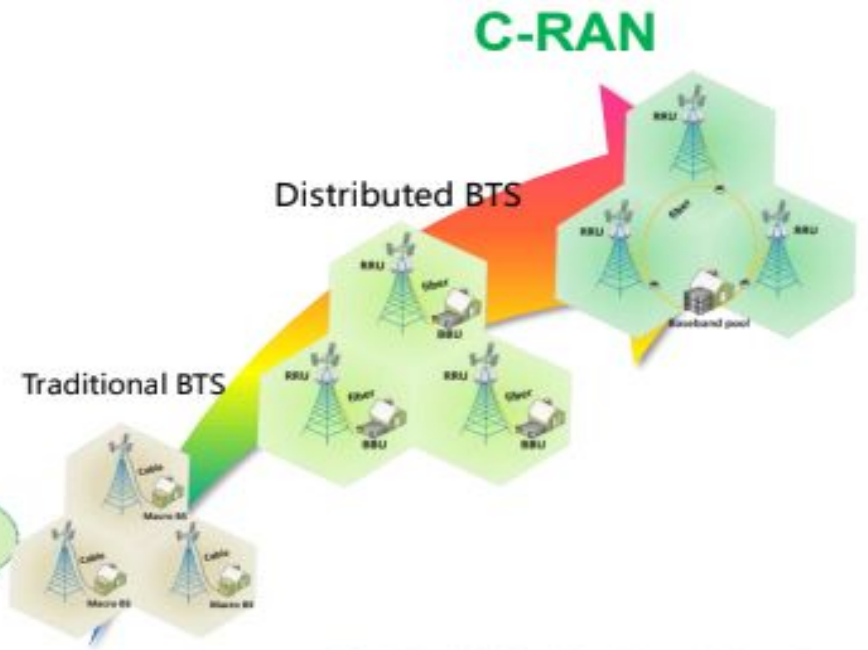


User Centric RAN (UCN) of 5G :



C-RAN : Evolutionary Evolution of RAN :





- Centralized Control and/or Processing
- Collaborative Radio
- Real-Time Cloud
- Clean System Target

WP "C-RAN: The road towards green RAN".[Online]. Available: labs.chinamobile.com/cran

"Recent progress on C-RAN centralization & cloudification" in IEEE Access, 2014

"Cloud Radio Access Networks: Principles, Challenges, and Technologies " in ICC, 2015

Resource Management types

Three types of Resource management :

Soft RAN is able to adopt three types of Resource management based on network status :

- SD - CRM
- SD - SCRM
- SD - LRM

SD - CRM

SD - CRM :

- BBU pool is responsible for baseband processing.
- RRH is responsible for RF functions.
- It is more suitable for the case where user density & traffic volume is high.
- Centralized resource management approaches have more gains as compared to semi - centralized & distributed ones.
- To save more bandwidth & power resources for transmission data in ultra dense scenarios we use SD - CRM algorithms.

SD - SCRM

SD - SCRM :

- In this, BS can perform some baseband processing.
- BS's choose the set of connected users & perform power and sub - carrier allocation.
- Suitable for high & moderate density scenarios.
- SD - SCRM algorithms have lower computational complexity.

SD - LRM

SD - LRM :

- In this type of resource management, BS's with traditional architecture are responsible for both control & traffic signals .
- All baseband processing & RF functions are performed in the BS.

Soft RAN Principle

Soft RAN :

- It supports NR technology with dynamic sub-carrier spacing & TTI tuning in which the spectrum & time - slot duration management , inter - cell interference modelling, synchronization , multiple access schemes & the resource management format have considerable fundamental changes.

Bandwidth & time slot duration mgt. :

- Smart soft RAN has flexible sub-carrier spacing based on corresponding frequency range & wireless bandwidth.
- In this , the network schedular is able to choose the appropriate subcarrier BW based on service type & users velocity.

Soft BS

Soft BS :

- Soft BS in Virtualization/cloudization.
- Virtual BS pool : Real time cloud for central processing.
- High bandwidth optical transport network
- Distributed RRU

Soft BS :

- Centralized control and/or processing
- Collaborative radio
- Real time cloud
- Clean system target

Software defined Air interface :

- Interface is Green & Soft as well as service oriented.
- All programmable building blocks & parameters.
- Adaptive frame structure
- Spectrum
- Modulation & coding
- Waveforms & multiple access schemes
- Spatial processing
- Duplex modes
- Antennas
- Protocols

“Data only” small cell :

- Mobility support : frequent handovers
- Signalling overhead : increase with cell density
- Only UL/DL data channels
- Only UL/DL data related reference signals
- Data only small cells with the help of macro cells only
- All access in macro : access , sync, RRM & handover control

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Rethink : Ring & Young

No more cells :

- The nature of a homogenous cell-centric design is that the cell planning & optimisation, mobility handling , resource management, signalling & control, coverage & signal processing are all done either for or by each BS uniformly.
- In a practical deployment , it is clear this system does not match with traffic variations & diverse environments.
- 5G design should depart from cell based coverage , resource management, and signal processing and lean towards user centric coverage facilitated by C-RAN architecture.

User centric design :

- Decouple signalling & data , UL & DL signals.
- With control & data decoupling scheme, the macro cell is responsible for control & small cell for data only.
- When no traffic in small cell, it can be completely turned off to save energy.

C-RAN :

- Architecture of distributed BS's where radio units are placed outdoors closer to antenna and BBU's are placed indoors at cell sites.
- CRAN goes one step further by bringing BBU's from multiple BS's to a central pool location.
- By virtualising the baseband processing, the new features can be added to the network within months

Fronthaul for C-RAN deployment :

- Fronthaul between RRU & BBU
- Data rate between BBU & RRU using CPRI is as high as 9.83 gbps for 8 antenna TD - LTE , requiring 4 fibers for each carrier with 6G SFP.
- CPRI has critical requirements on synchronization & latency.
- Efficient fronthaul solution is required to enable C-RAN large scale deployment.

Rethink : signalling & control

Signalling & Control :

- Analogous to small sized traffic types , the massive connectivity involved in MTC may not be handled by 3G & 4G.
- It is estimated that only 7% of the total wireless traffic will be from IOT devices in 2020.
- It is well motivated to design a new signalling mechanism that is optimised to handle such a traffic profile with tens of billions nodes or trillions of nodes in the IOT networks.

Aggregation of packet data from multiple MTC devices :

- MTC devices are controlled by an aggregator , which functions as the wireless gateway to the cellular network.
- The service aggregator can be both homogenous and heterogenous and sent to the aggregator in a scheduled manner.

Aggregation of packet data from multiple MTC devices :

- The aggregator will then relay the aggregator data packets to the cellular network in an aggregator manner.
- Based on aggregator packet types and data relay modes , the aggregators will request for aggregator specific RRC mechanism.
- Service aggregation of MTC devices is analogous to the service aggregation of small sized packets from various applications running on mobile devices.

Two proposed relay modes for aggregators ：

- Mode 1 : No RRC state transition (Always connected)
- Mode 2 : RRC connection mode switched to idle mode within window T

Mode 1 :

- Before relaying the aggregator “k” packets in some time window T , the aggregator is already in connected mode.
- After packet transmission , the connected mode will be maintained i.e there is no need for RRC connection setup in the following windows.

Mode 2 :

- The BS allocates all frequency resources to each aggregator , i.e in TDMA mode .
- Before transmitting the aggregator packets to the network , each aggregator will enter into connected mode .
- After transmission, the aggregator enters into RRC idle mode directly.

Invisible base stations with irregular antenna array :

- By integrating the antenna elements into the environment, the BS's can be made virtually invisible.
- Irregular antenna deployment in a practical environment requires a different system design and adaptive signal processing algorithms.
- Advanced algorithms regarding sub-arrays , orthogonal placements or parasites can help optimize the beamforming performance of irregular arrays.

Full duplex radio :

- A full duplex operation is considered in 5G.
- A full duplex BS transmits to and receives from different terminals simultaneously using the same frequency resource at the same time.

5GrEEn

5GrEEn :

- It is a joint efforts of partners tightly connected to the METIS project representing the telecom vendor perspective , the mobile operator view & leading academic institutions.
- It will specifically focus on energy efficiency aspects of 5G mobile networks.

Major challenges :

- Data traffic volumes
- No. of connected devices
- Diverse requirements
- Energy consumption

Data traffic volumes :

- From green design perspective, the deployment of 2G-3G-4G equipment & installation of 5G technology.
- Mobile networks will be dimensioned today in terms of capacity.
- Mobile networks should satisfy the increasing traffic demands by flexible availability of capacity.

No. of connected devices :

- Different kinds of machines such as smart grid devices , sensors and surveillance cameras are connected to the networks.
- They referred to as IOT or M2M communications & means that everything that can benefit from a wireless connection.
- This requires higher signalling overhead.

Diverse requirements :

- Some applications requires low latency , e.g time- critical control functions in industrial applications.
- These applications also requires high reliability.
- Challenge need to be taken care of QoS requirements.

Energy consumption :

- Cost is an important issue to consider in this.
- CAPEX & OPEX need to be at a level where services can be provided at a reasonable level.
- 5GrEEn will target energy consumption 10 times lower than today.

Focus areas & potential solutions

Focus areas & potential solutions :

- System architecture
- Network deployment
- Radio transmission
- Backhauling solutions

System architecture :

- It constitutes a fundamental limit on how low energy consumption that is possible to achieve.
- An energy efficient system needs to be efficient both when transmitting data as well as not transmitting.
- We will assume a logical separation between idle mode operations and user plane data transmission & reception.
- In architecture view, cells can be viewed as UE specific resources for data transfer that are dynamically created and configured to support only active UE's.

Network deployment :

- To handle the future capacity demands & the massive amounts of different devices , it is expected that even denser deployments , so called ultra dense deployments will be necessary.
- 5GrEEn will develop energy - optimized heterogeneous network deployment strategies for different traffic distributions and environments that will provide capacity where it is actually needed and will bring maximum benefit.

Radio transmission :

- MIMO technology is used for transmission.
- Massive antenna configurations , or very large MIMO have gained interest.
- Proper use of technology will boost peak data rates & system capacity in two ways :

Backhauling solutions :

- The architecture may not rely on single technology but it may result in mix of fiber , microwave and copper depending on several factors.
- It will be possible to define new & holistic wireless deployment strategies tailored for wireless backhaul architectures.

Thanks