

Key Issues and Architecture for 5G

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Emerging Key Trends for 5G

- **Diverging requirements supported by Multi-RAT (Radio Access Technology) approach**

- Extremely high speed mobile broadband, and low speed IoT
- Simultaneous connections to multiple technologies including LTE-A, unlicensed
- Flexible new RAT design

- **Add new sub 6 GHz RAT optimized for IOT / Connectionless (~2020)**

- Possible early MBB in 2-18
- Efficient for small packets, IoT, signaling
- Reliable anchor for mmWave operation
- May need new spectrum to avoid “turn around” issues
- Non orthogonal layer 1 design

- **Add new mmWave RAT for speed and capacity (~2022)**

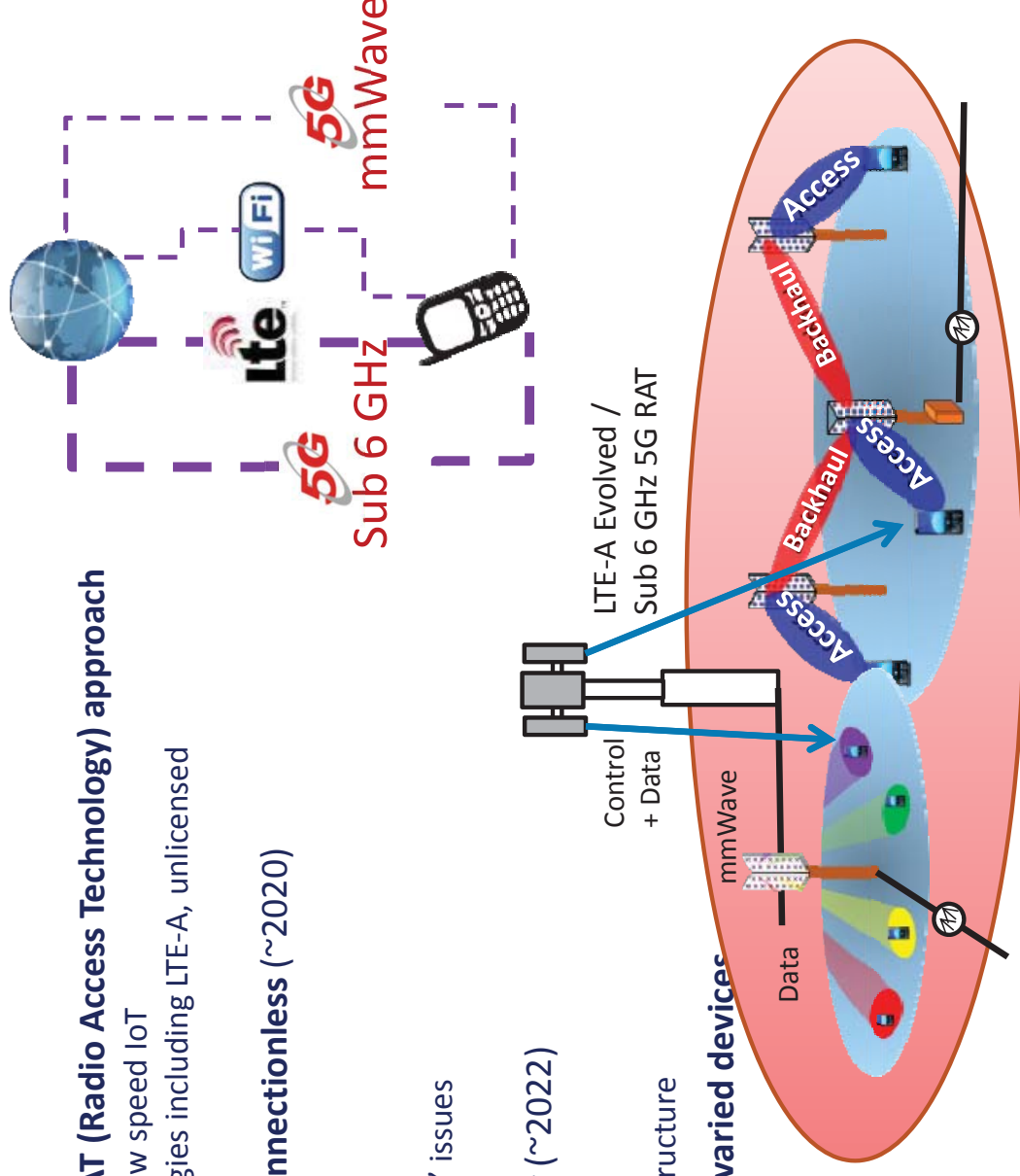
- Large scale array processing
- Full Dimension MIMO / hybrid beam forming
- Self-backhaul to simplify short-range cell infrastructure

- **“Network slicing” to deliver varied services to varied devices**

- Ultra-robot and resilient services
- Low latency services

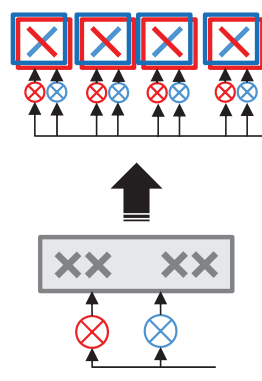
- **SDN/NFV architecture becomes a necessity**

- Increased criticality of Radio Resource Control



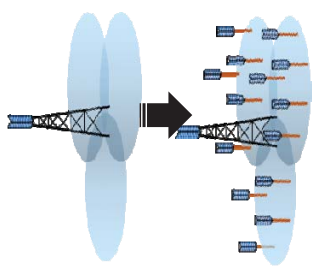
How Do We Achieve The Requirements

Spectral Efficiency



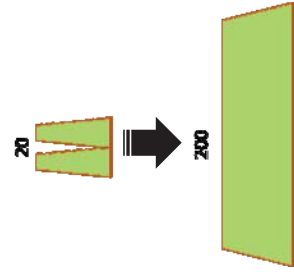
- Massive MIMO and FD-MIMO concepts are central to the 5G theme.
- Potentially large capacity and coverage improvement.
- FD-MIMO work in LTE-advanced is a starting point for developing these concepts for 5G
- Other spectral efficiency improvement through new waveform and overhead reduction

Densification



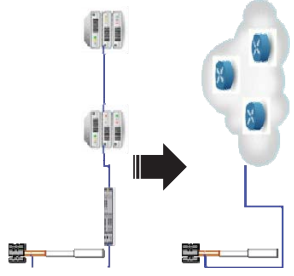
- Densification via small cell build-out key to RAN evolution.
- Current small cell solution is not scalable beyond a certain point.
- Radically new concepts such as separation of control and data plane, new system architecture are key to achieving an ultra-dense network

Spectrum



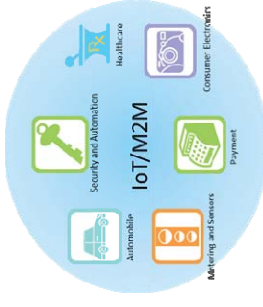
- Design system to operate in much larger channel bandwidth. This requires a careful tradeoff between spectral efficiency and power efficiency
- Operate across new licensing scenarios such as unlicensed, or shared licensed
- Operation in low frequency and in mmWave

SDN/NFV



- A key and central requirement to AT&T as a part of Domain 2.0 efforts.
- Apart from implementation challenges of SDN/NFV for 5G, we also need to develop the 5G RAT which allows for L1/L2/L3 functionality to be distributed

Massive Connectivity

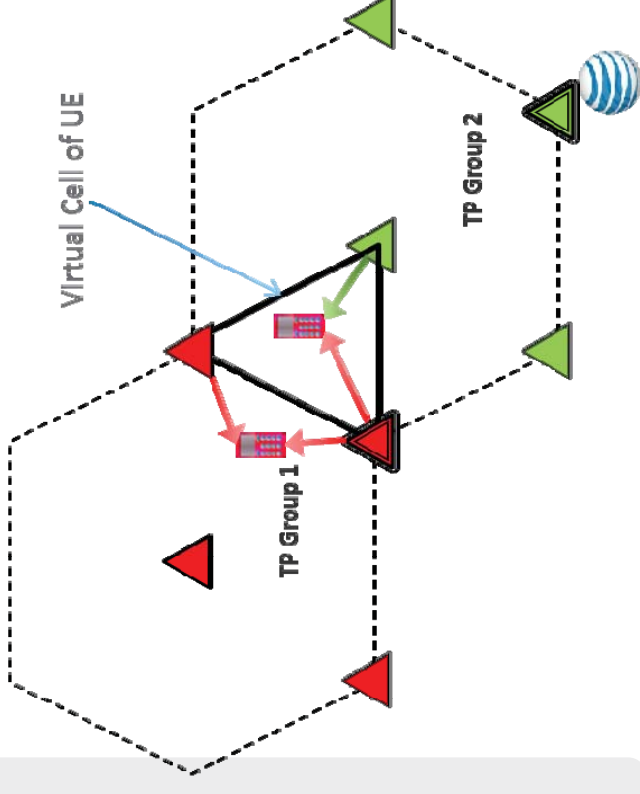
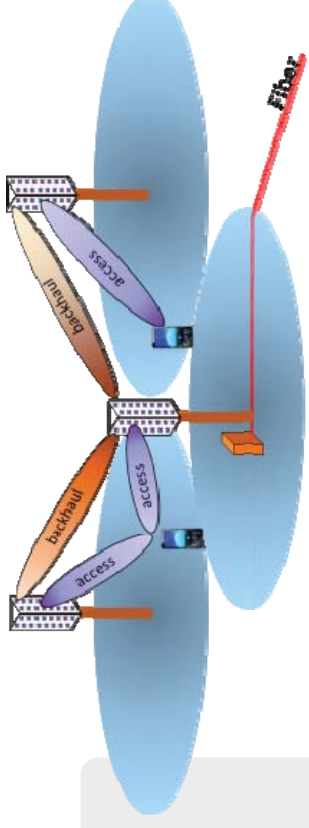


- Design the 5G RAT to allow for network slicing down to the physical layer.
- Lightweight or weightless protocol to support massive connectivity.
- Power efficiency and coverage enhancements

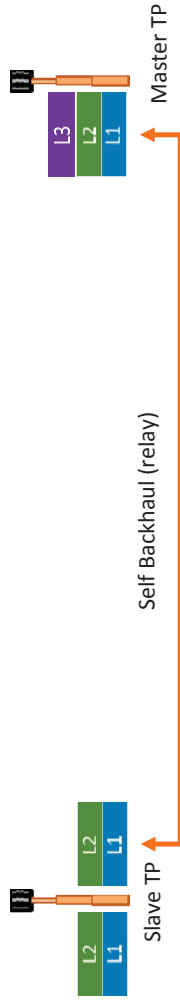


Key 5G Concepts Impacting RAN Architecture

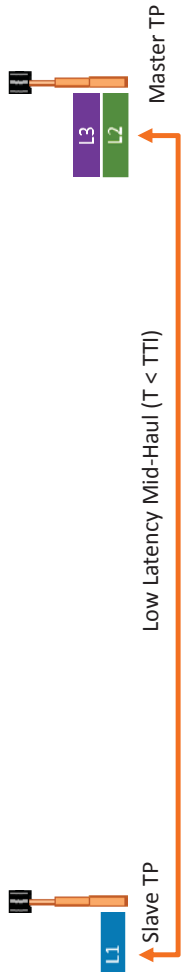
- **Self-backhaul**
 - Access and backhaul are a part of the same system and share time-frequency-antenna resources.
 - No transport (wireless or wireline) is needed to provide backhaul
 - Access links and backhaul/relay links are time-frequency-antenna multiplexed through the scheduler
 - Not ALL TP are self-backhauled
- **Transmission Point (TP) Groups**
 - Low latency transport or self-backhaul (latency \leq TTI) within TP group and high latency transport (latency $>$ TTI) between TP group.
 - Joint scheduling and legacy CoMP schemes possible within a TP Group
 - Distributed scheduling and new CoMP schemes are needed between TP groups
- **Virtual Cells (Distributed Transmission)**
 - Transparent MultiPoint Transmission within TP Group
 - Non-transparent MultiPoint Transmission between TP Groups
 - Requires low latency on the control plane but not on user plane
 - Separate control plane and user plane



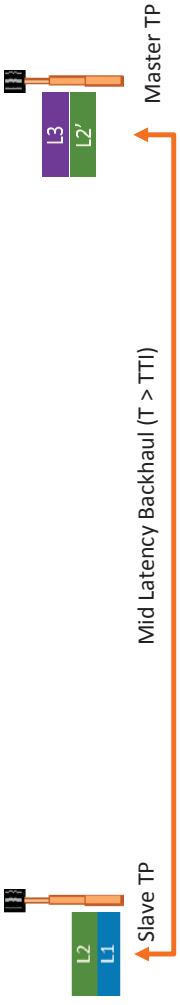
Possible Mid-Haul Scenario and Corresponding Physical Splits



MCS and HARQ is done independently for each link
 The master TP can do some coordinated scheduling (multi-hop scheduling) for efficiency and flow control



L2 and above can be completely centralized
 L1 needs to be distributed since with 5G we will have up to 64TxRU chains and up to 100MHz bandwidth

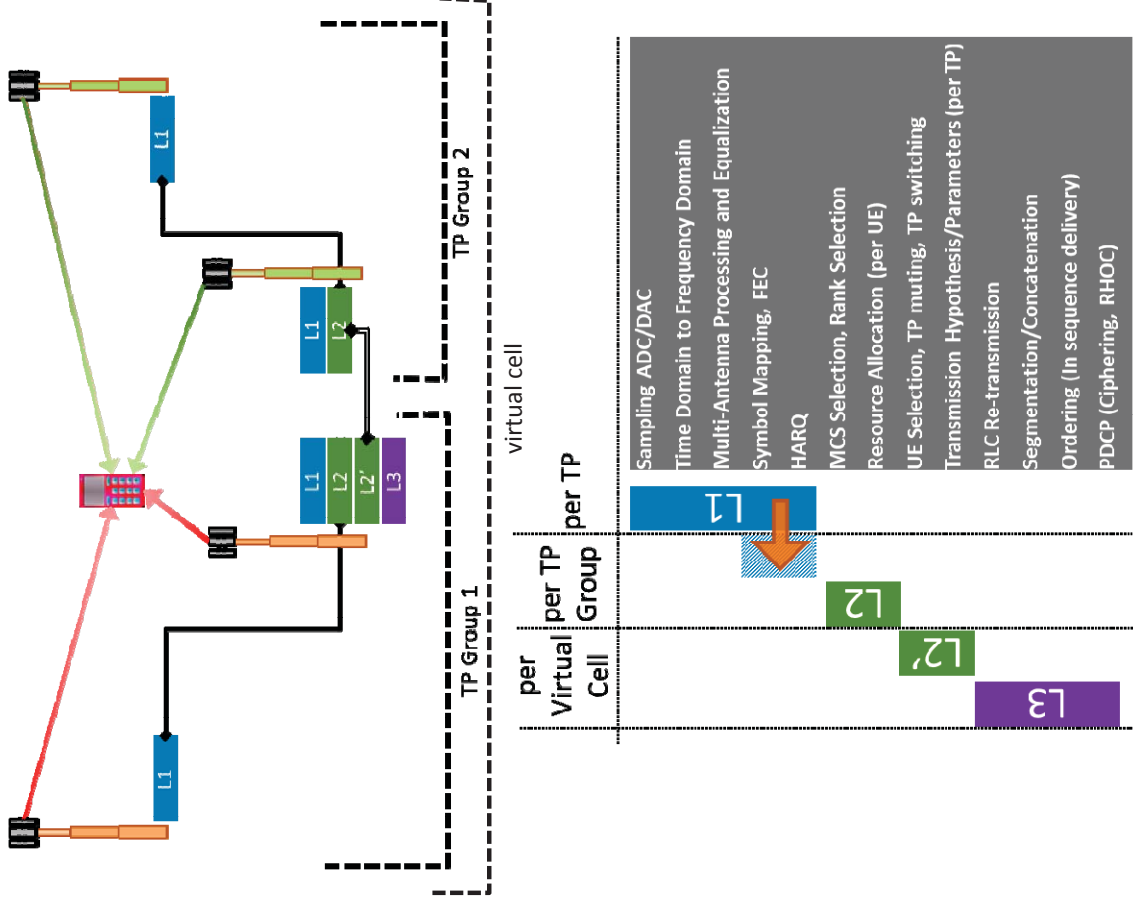


Only the non real time part of the L2 and above can be centralized (see slide 4), everything else is distributed
 Need new type of multi-TP transmission scheme



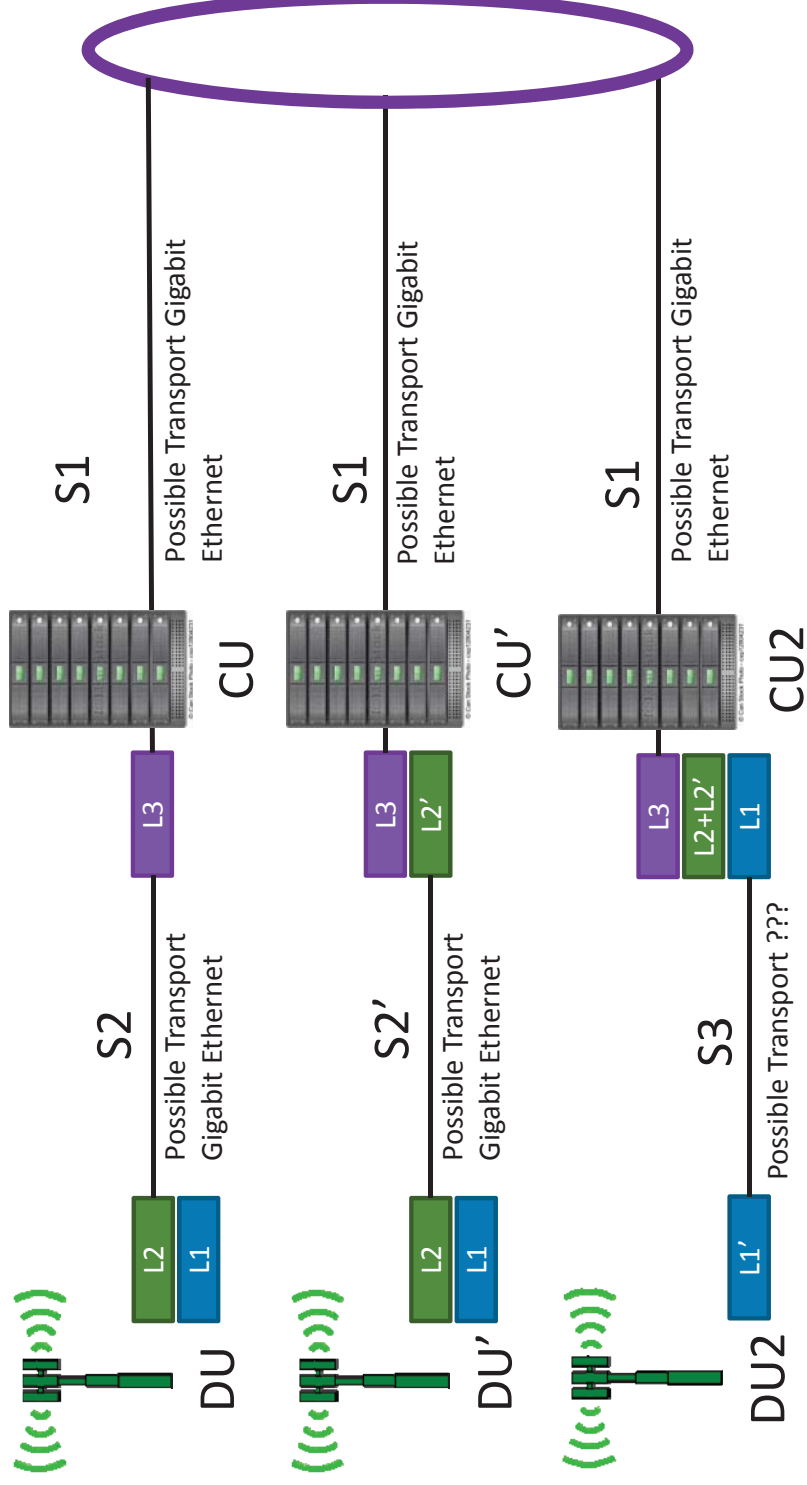
5G RAN Physical View

- **5G protocol impacts:**
 - 5G specs should be designed to be distributed and virtualized
 - Avoid strict timing relationships to allow distributed implementation
- **5G architecture impacts:**
 - Different per-UE processing splits for different TPs
 - Dynamically varying processing needs across different protocol layers making virtualization of processing resources important
 - Different transport requirements for different TPs – none (self-backhauled), ideal, non-ideal



Functional Splits

- Functional Splits must be studied to understand what interfaces might be opened in standards bodies such as 3GPP - Can we define interfaces that allow us to use multiple transport solutions?



5G System Architecture and CN Features

The design principles from NGMN and 4GA and limitations of EPC lead to a new architecture that:

- Minimizes access specific nodes.
- Has separation of user and control plane.
- Provides Mobility on Demand.
- Implements Operator Policies via SDNs.
- Implements QoS in an access agnostic manner.
- Implements AAA in an access agnostic manner.
- Supports use of service specific core via network virtualization and service specific network slicing.

Note: While some of the features like NFV are independent of network architecture and hence can and will be implemented for existing EPC, other aspects like access agnostic QoS and AAA, mobility on demand, access agnostic mobility tunnels, use of SDNs for policies would result in a significant change to the current packet core. Thus, the 5G packet core may not be an evolution of EPC but rather a brand new solution.



AT&T Views on 5G CN

5G CN should be a clean slate solution and NOT an evolution of EPC

- A new 5G System and CN should fulfill our needs of RAN-CN decoupling and access neutral CN
- 5G CN should not carry legacy baggage from EPC. It should be based on access independent features like access neutral QoS model, AAA, mobility and policy framework
- Reuse of EPC concepts for 5G radio will impose legacy system onto 5G radio, making 5G UEs and base stations dependent on EPC
- Developing a new 5G CN will have impact on RAN-CN interface and hence for any deployable 5G system this interface needs to be specified



Thank You

