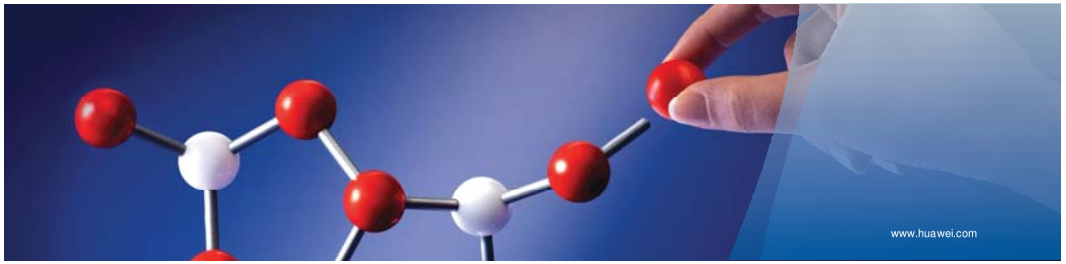
Security Level:



Multi-Stream Aggregation (MSA) for Cloud Network

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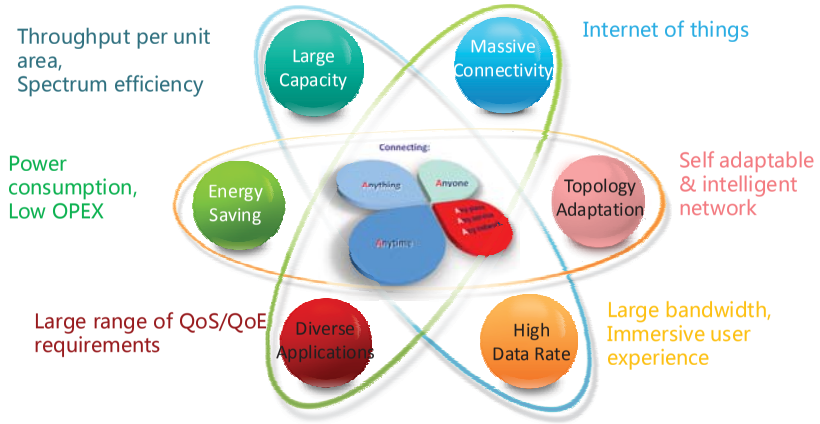
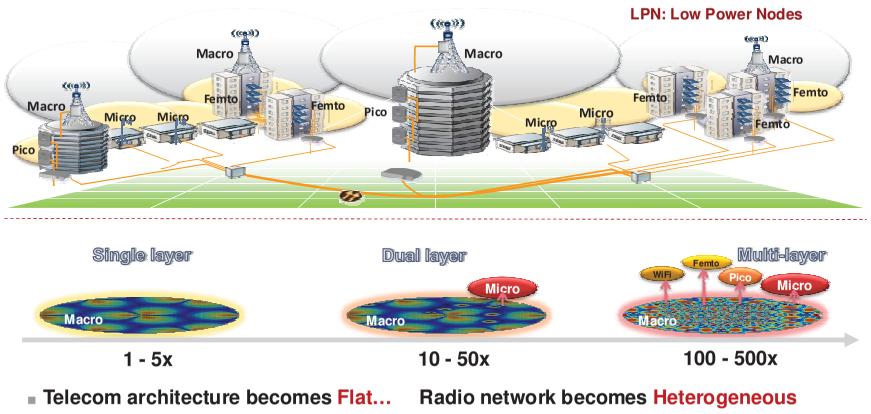
Requirements for Network Evolution

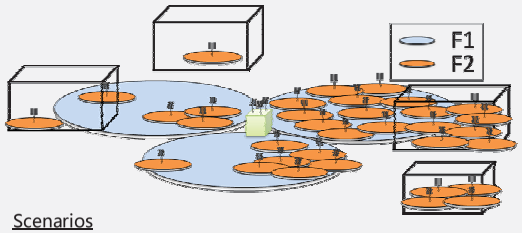


HetNet Increases Capacity with LPN on Multiple Carriers



- Telecom architecture becomes Flat… Radio network becomes Heterogeneous

Deployment Scenarios



Scenarios

- *Scenario1: Macro and pico cells on the same carrier frequency (intra frequency) connected via non-ideal backhaul*
- *Scenario2: Macro and pico cells on different carrier frequencies (inter frequency) connected via non-ideal backhaul*
- *Scenario3: Only pico cells on one or more carrier frequencies connected via non-ideal backhaul typically low and medium UE mobility*

Table 1: Categorization of **non-ideal backhaul**

Backhaul Technology	Latency (One way)	Throughput	Priority (1 is the highest)
Fiber Access 1	10-30ms	10M-10Gbps	1
Fiber Access 2	5-10ms	100-1000Mbps	2
Fiber Access 3	2-5ms	50M-10Gbps	1
DSL Access	15-60ms	10-100 Mbps	1
Cable	25-35ms	10-100 Mbps	2
Wireless Backhaul	5-35ms	10Mbps – 100Mbps typical, maybe up to Gbps range	1

Table 2: Categorization of **ideal backhaul**

Backhaul Technology	Latency (One way)	Throughput
Fiber Access 4 (NOTE 1)	less than 2.5 us (NOTE2)	Up to 10Gbps

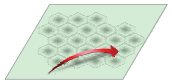
Major Challenges of Cloud Heterogeneous Network

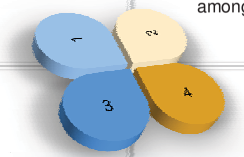
Throughput/Load Management

- Intelligent traffic steering to increase user throughput and to maintain system stability with balanced load allocation

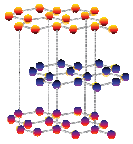
Mobility and Service Continuity

- Coordinated control plane and user plane operations to reduce data interruption during frequent switching among LPNs.





Interference



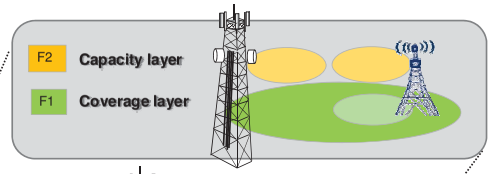
- Coordinate transmissions from neighboring nodes to improve system efficiency

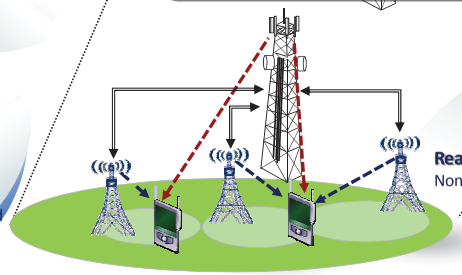
Energy Saving

- Energy saving strategy among LPNs to minimize OPEX of the system

Multiple Data Streams in Multi-layer Multi-point Transmissions

Layered network using multiple frequency carriers
coverage layer + capacity layer

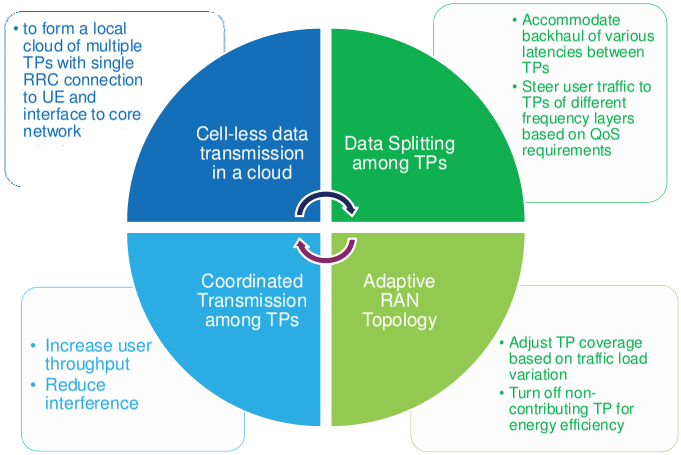




Coordinated multi-point transmission within and across frequency layers:
increased user throughput and reduced interference

Realistic backhauls between TPs:
Non-zero latency and limited bandwidth

Key Technology Enablers



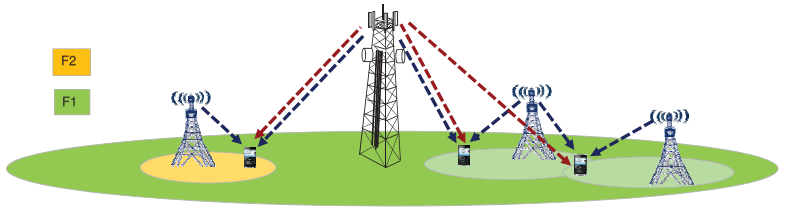
Local Transmission Cloud of Multiple Data Streams

Cell based TP on Coverage Layer

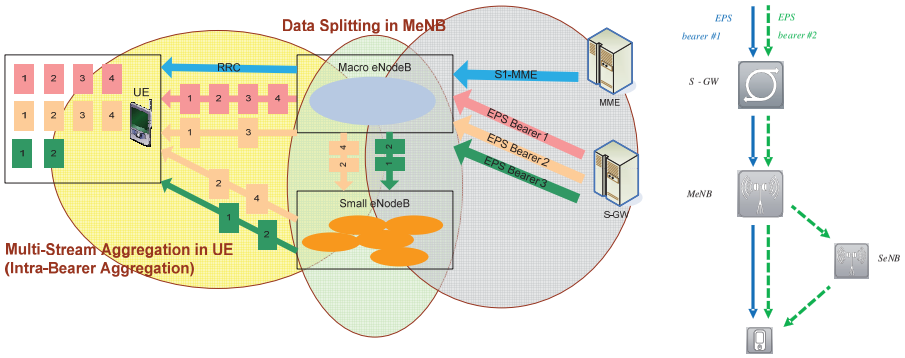
- Has complete CP and UP protocol stacks
- Can be accessed directly by UE
- Cell coverage is statically planned
- Needs handover to switch UE association
- *Coverage is the main objective metric*

Clould TP Overlaid on Capacity Layer

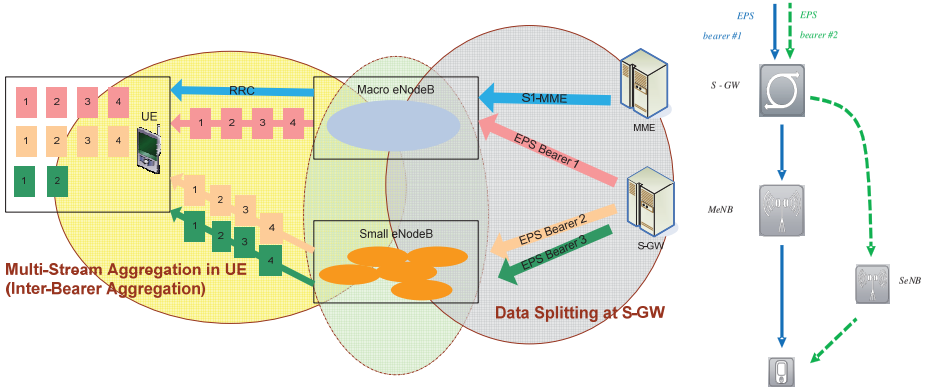
- Only needs part of UP protocols (MAC/RLC/PDCP)
- No handover when switching UE among cloud TPs
- Needs to be paired with a coverage cell for RRC/CP functionalities
- *Capacity* and *Efficiency* are the major objective metrics



Network Architecture: eNB Routing

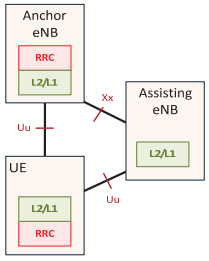


Network Architecture: Gateway Routing

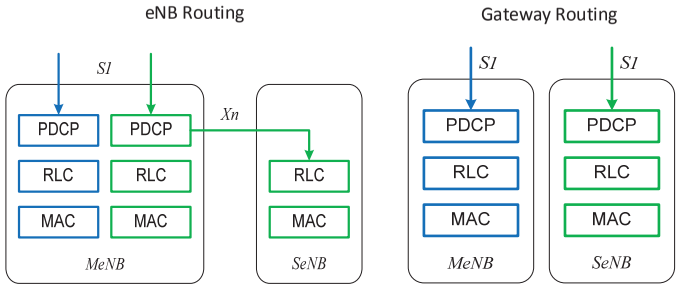


Protocol Stack over the Air Interface

Control Plane Architecture



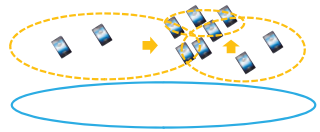
User Plane Architecture

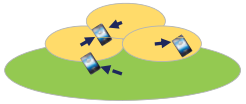


Adaptive RAN Topology

Resource Utilization

Cloud TP's coverage can be adjusted dynamically based on load distribution to direct resource to where it is needed





Interference Coordination

UEs' transmissions can be coordinated in time, frequency, and spatial dimensions to make them look like being served in the center of a cell.

Energy Efficiency

Large number of cloud TPs can be deployed on capacity layer. Their transmission power can be adjusted based on need, and can be completely turned off.

Plain vs. Cloud HetNet: Throughput Evaluation

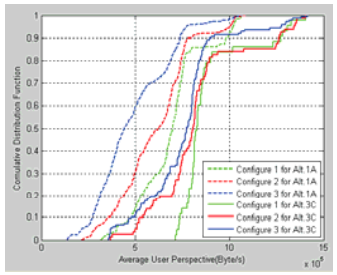


Figure1. UPT CDF for MSA UE

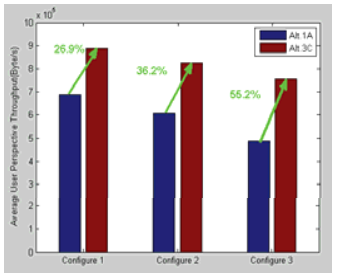


Figure2. Average UPT for MSA UE

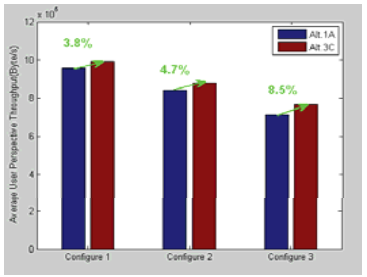


Figure2. Average UPT for All users

Observation: Cloud HetNet (3C) has significant gain on throughput, compared with Plain HetNet (1A).

Plain vs. Cloud HetNet (1A vs. 3C): Signaling Load

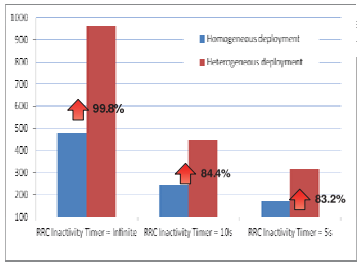


Figure 1 Relative handover increase from homogeneous deployment to heterogeneous deployment

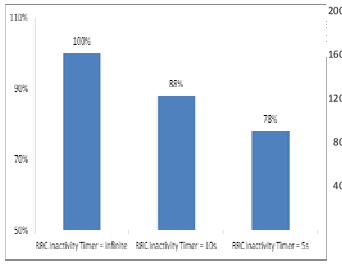


Figure 2 Percentages of handover signaling in the whole core network signaling for heterogeneous deployment

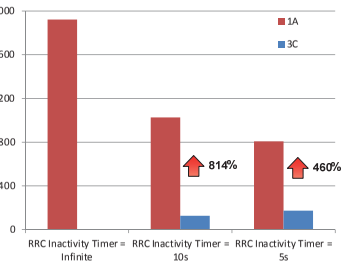


Figure 3 Core network signaling number

Observation 1: The extra signaling load introduced by handovers to the core network in heterogeneous deployment is heavy compared to homogeneous deployment
Observation 2: The signaling load introduced by handovers accounts for a large proportion of the whole core network signaling load in heterogeneous deployment.
Observation 3: For core network signaling number , 1A is about 8 times than 3C in 4 pico/macro. This number will increase when pico cell number increases or inactivity timer increases .

Thank you

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