Joint ITU-GISFI Workshop on "Bridging the Standardization Gap: Workshop on Sustainable Rural Communications"

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LTE Advanced eNB Small Cell System Design Challenges, Network Topologies and Applications

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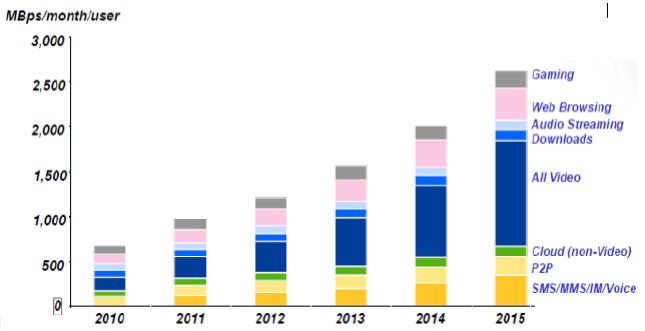
Presentation Out-line

- Key Drivers for the LTE Technology
- Technologies and Network Topologies
- LTE Advanced Small Cell System Design
  - LTE Advanced Technologies
  - LTE Small Cell System Design Challenges
  - LTE Research areas
- 3GPP Standards Technical Gaps
- LTE Network Applications
- Conclusion and Recommendations

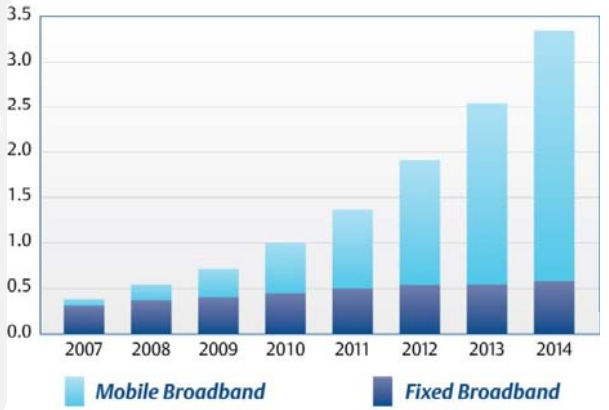
Key Drivers for the LTE Technology

- Key factors drive for the LTE Technology
  - Broadband subscribers to reach 3.4 billion by 2014
  - 80% of the users will be mobile based
  - Fixed broadband growth expected to remain near static
  - Operators are being driven by two unique trends
    - Increase in smart mobile devices
    - Video Applications & Social Media
    - Data centric applications
  - India Mobile data growth rate >15%
- **4G Networks in North America will increase data traffic 26 fold from 2010 through 2015**



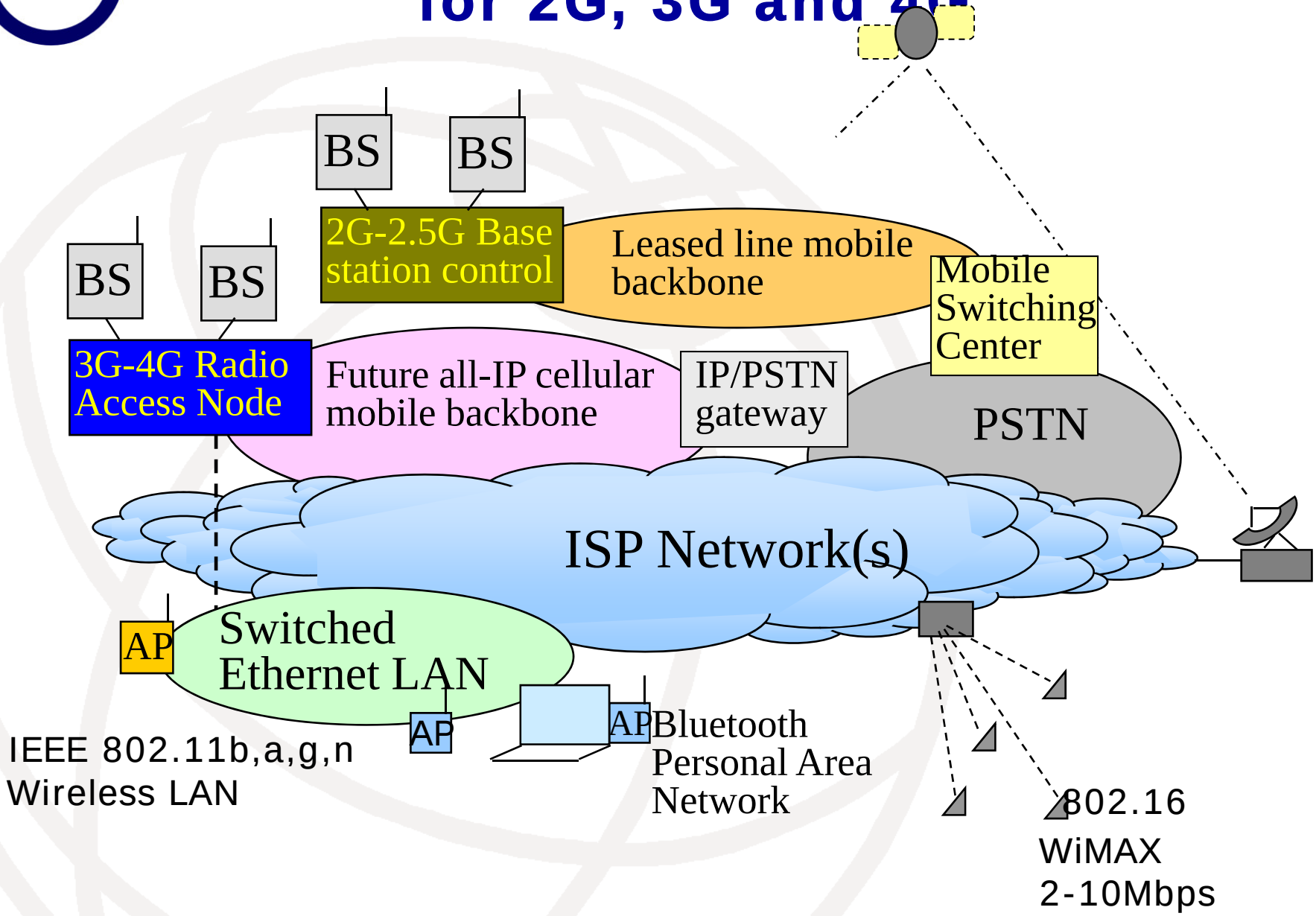
Web browsing, video applications are dominant

Source: Verizon data published



Ericsson White Paper, "LTE – An Introduction", June 2009.

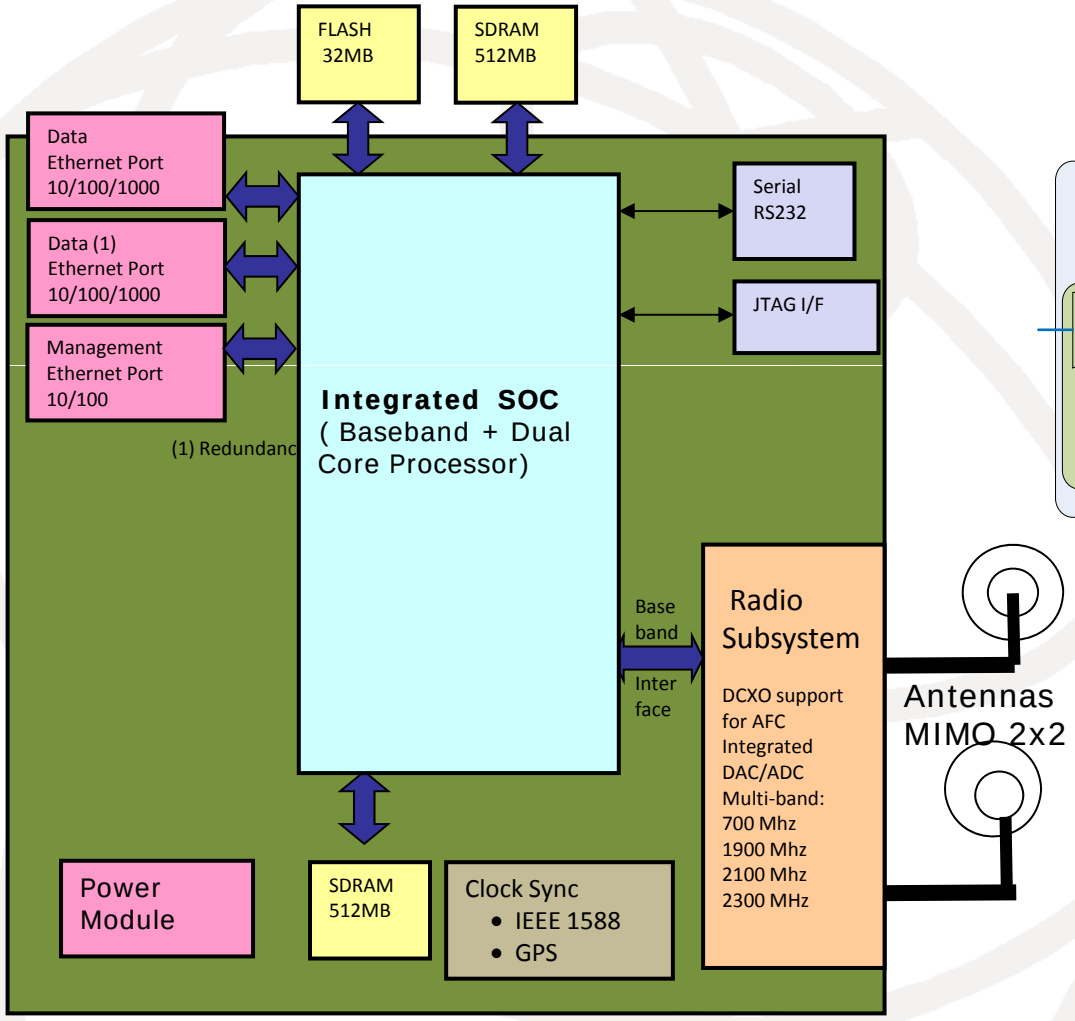
Technologies and Network Topologies for 2G, 3G and 4G



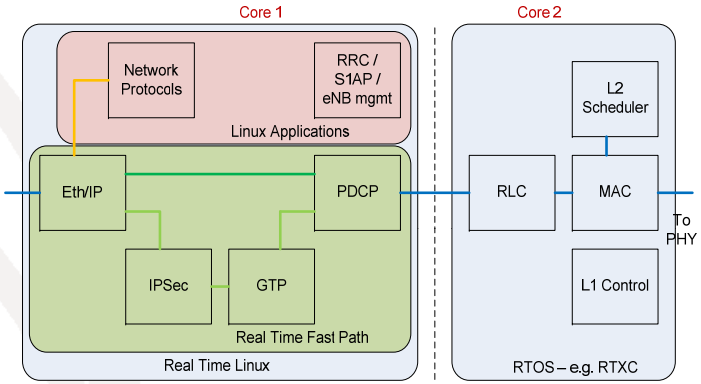
LTE Advanced Small Cell Design

- Small Cell Design supports two design approaches:
  - In-door Small Cell (Femto Cells)
  - Out-door Small Cell (Roof-top Cells)
- Major Challenge is the Backhaul support for the small cells
  - Micro-wave Backhaul
  - OFDM Backhaul Licensed Spectrum versus Unlicensed
  - Custom Licensed Spectrum versus Unlicensed
- Integrated Small cell with Backhaul is best option for Rural deployment

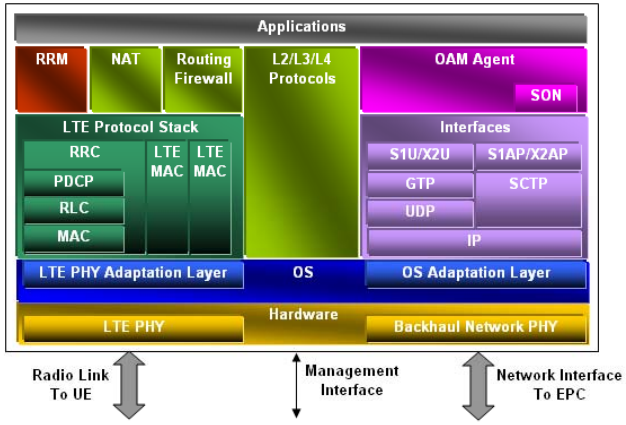
LTE Advanced eNB Small Cell Scalable Architecture



Dual Core CPU – SW Partition



SAI eNB Complete Software

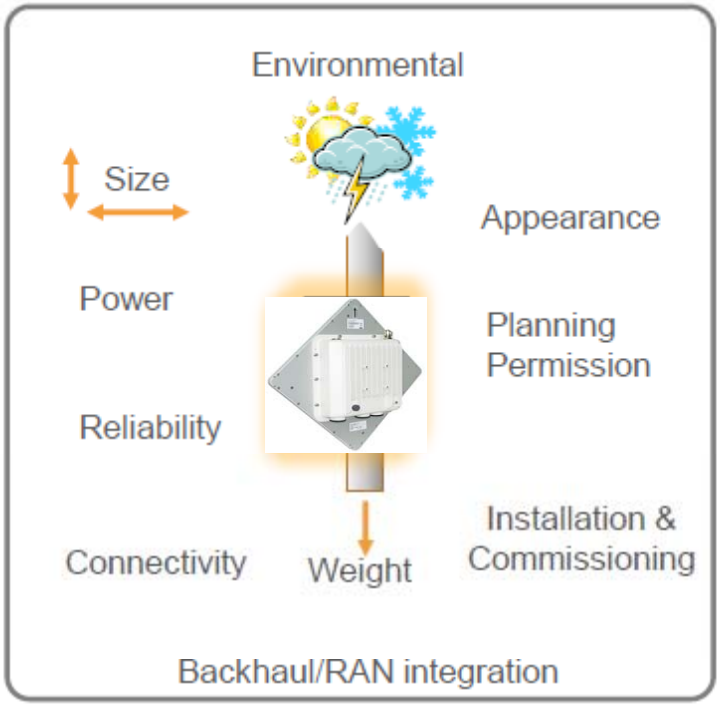


SAI Supports own PHY Layer (L1), L2, L3 and Applications for small cell

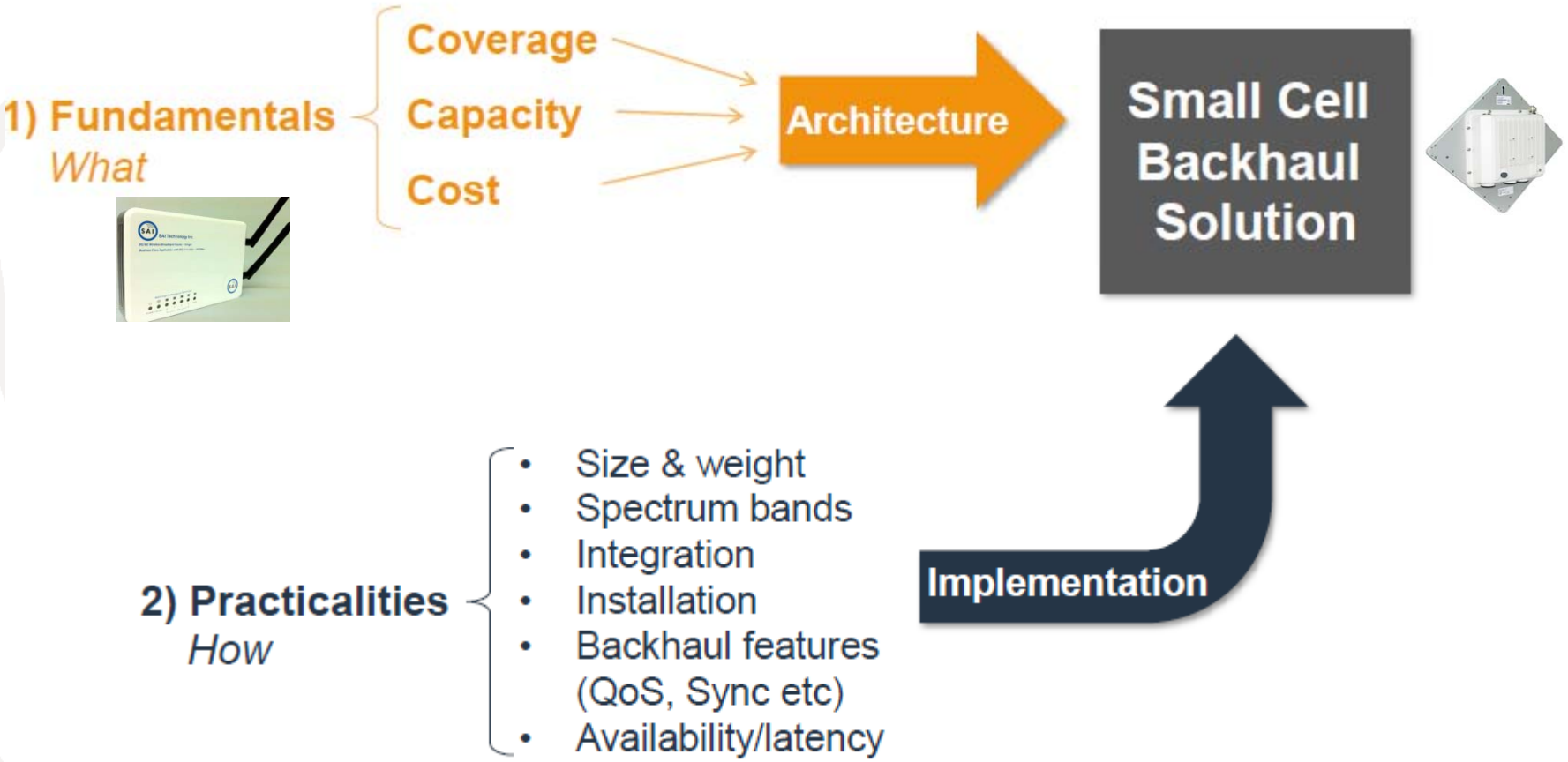
LTE Advanced Small Cell Design Physical Requirements

The small cell and backhaul unit combined should be…

- **Small enough to fit in available street level locations**
  - Planning/zoning may impose volume/dimension restrictions
- **Lightweight to facilitate installation**
  - A one man lift & mount can reduce costs
- **Innocuous rather than sexy**
  - Should not draw attention to itself
- **Touch safe and tamper proof**
  - Some sites may be within reach of the public



LTE Small Cell Integrated with Backhaul



- Integrated Small Cell for Rural Communication is the cost effective solution

LTE Small Cell Design and Deployment Scenario

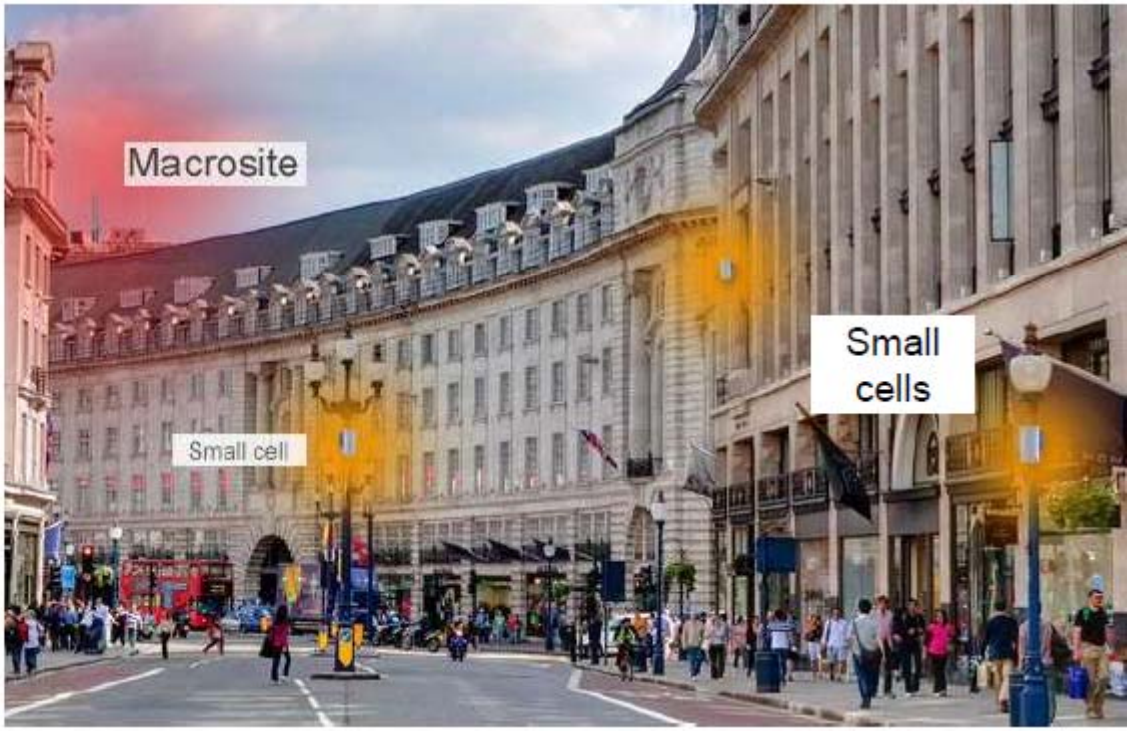
Congestion on fully upgraded macro sites

↓ Need to densify

No rooftop space left smaller units needed to fit available locations

↓ Smaller unit
= less power
= shorter range

Small, low power cells close to users
Near street level

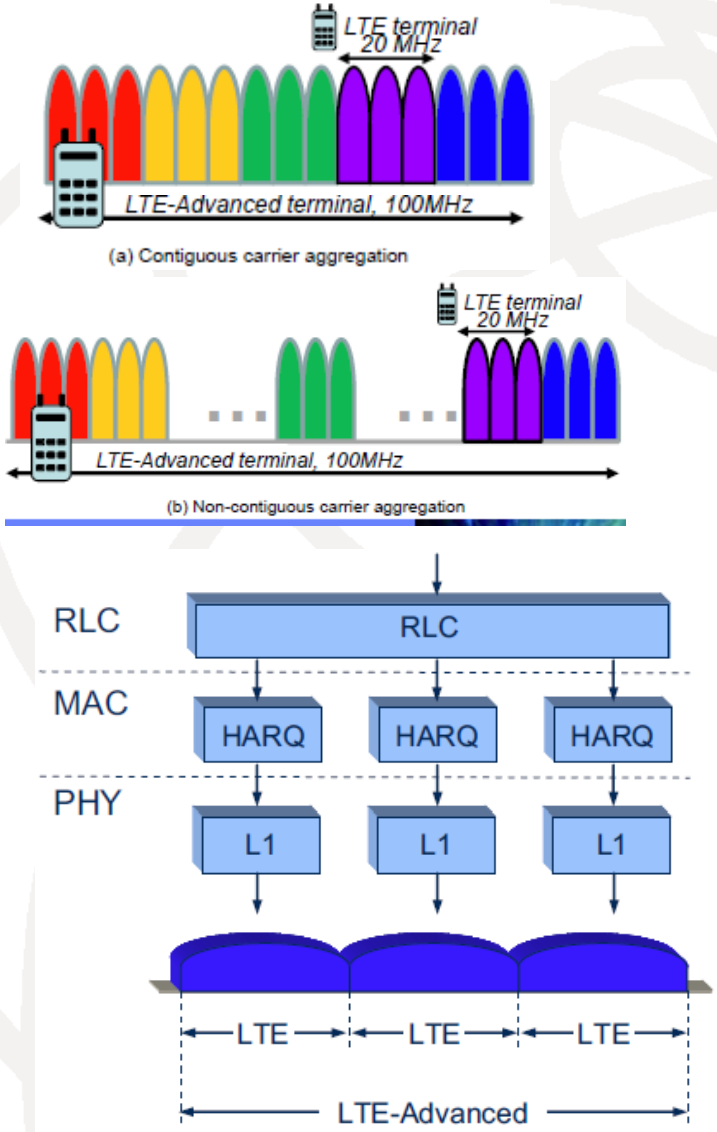


- Small cell sites typically 4-6 m above street level, on sides of buildings or street furniture

LTE Advanced Technologies Impact for Small Cell Design

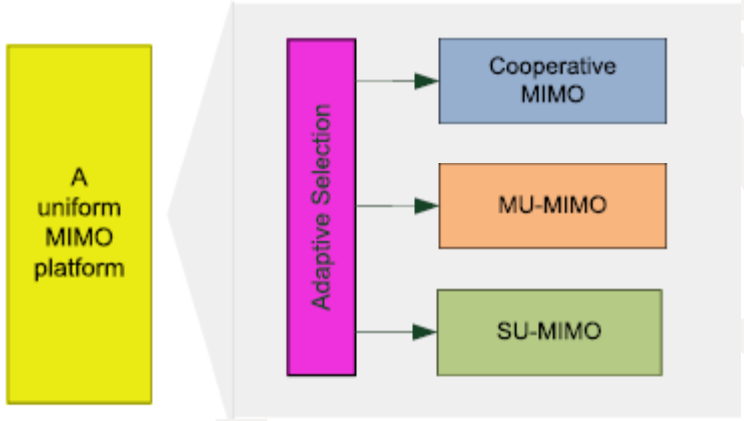
- LTE Advanced Technologies:
  - Carrier Aggregation
  - Advanced MIMO Support
  - Positioning and Tracking
  - CoMP
  - Het Nets
- LTE Advanced technologies impact on LTE eNB Small Cell design

LTE Carrier Aggregation impact on the Small Cell Design

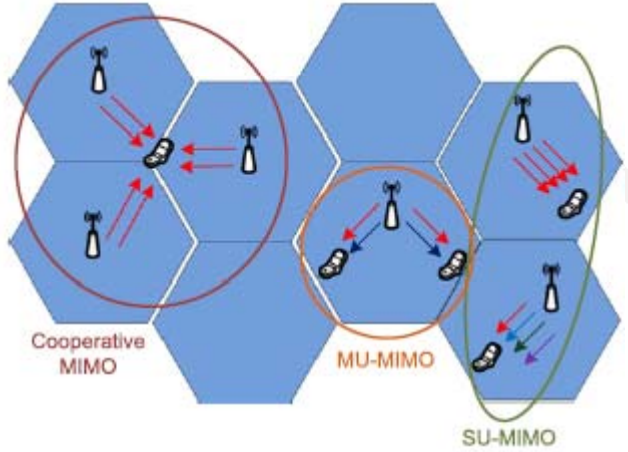


- Carrier Aggregation will significantly enhance DL/UL bandwidth
- Maximum 100 MHz BW
- Non-contiguous implementation is very challenging
- Small Cell will be able to support more number of users with CA
- Small Cell over all design becomes more complex with CA

LTE MIMO Adaptive impact on the Small Cell Design



(a) MIMO Adaptive Switching

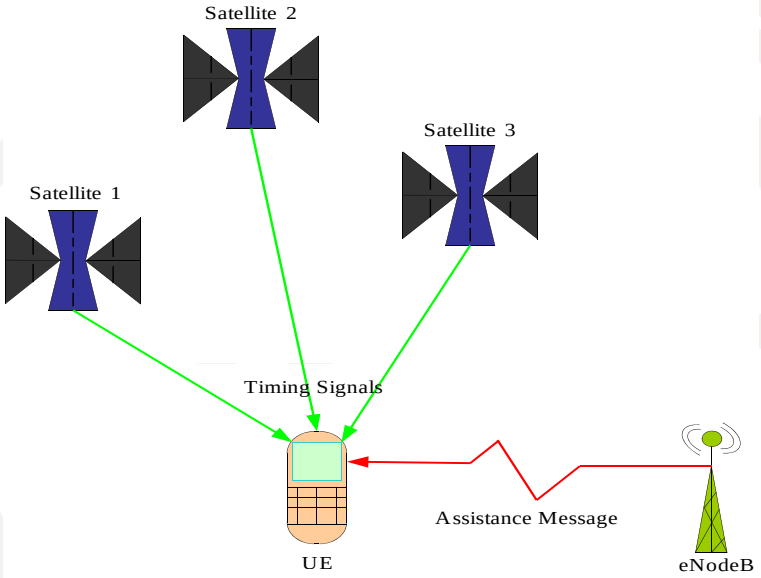


(b) LTE Advanced MIMO Modes

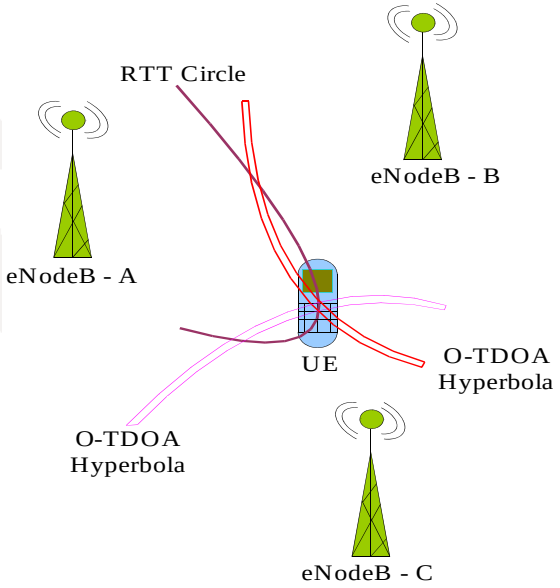
- Selecting the appropriate MIMO Scheme
- Multi-user MIMO offers the best complexity performance trade-off
- Single Site MIMO, we will connect with single eNB with one or multiple UE devices.
- Cooperative MIMO: Cell edge user throughput is boosted
- MIMO will be supported 3 modes of operation:
  - Transmit diversity
  - Receive diversity
  - Spatial multiplexing boost data rate

  OR - Beam forming to increase coverage

LTE Positioning & Tracking impact on the Small Cell Design



(a) A-GNSS working in LTE

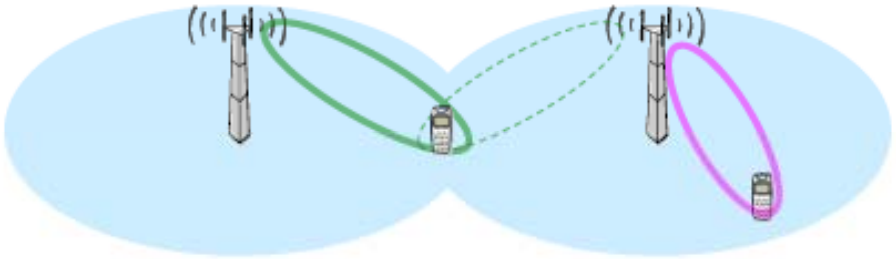


(b) OTDOA working in LTE

- Stand-alone GNSS, A-GNSS provide excellent accuracy
- OTDOA method, the UE estimates the difference in the arrival times of the PRS(Positioning Reference Signal) signals from separate base stations.

LTE Coordinated Multipoint (CoMP) impact on the Small Cell Design

Coordinated Multipoint (CoMP) transmission techniques are considered as promising candidates for efficient interference management to improve cell edge and/or system throughput



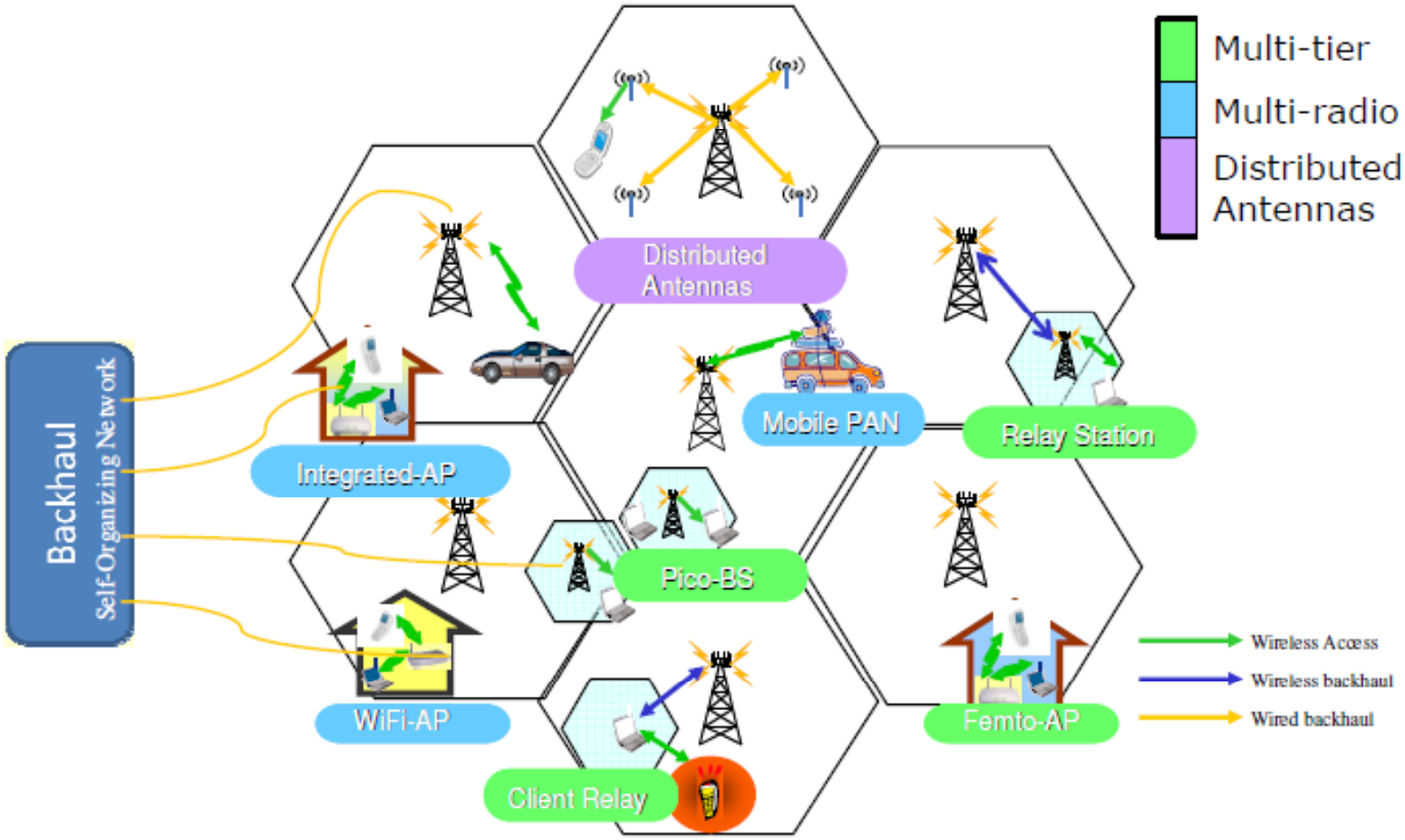
Coordinated Scheduling/Beamforming (Co-Sch/BF) CoMP

Joint Processing/Transmission (JP/T) CoMP

Data sharing not needed
Smaller performance gain
Lower system requirement

Data sharing needed
Larger performance gain
Higher system requirement

LTE Het Net impact on the Small Cell Design



Heterogeneous Network (HetNet): A network that consists of a mix of macro cells and low-power nodes, e.g. Pico, Femto, Relay Node (RN) and Remote Radio Head (RRH)

LTE Advanced Small Cell Design challenges

- Seamless Hand-off & Mobility management
  - Soft hand-off process between 3G, 4G and WiFi
  - Inter-RAT and Intra RAT between legacy and Advanced LTE eNB
  - Non-Cellular Radio's inter-working with LTE for traffic offload
- Service Level QoS and SLA support
  - Early deployments focused on data only. Ensuring Voice, Video, and Gamming etc QoS has certain limitations.
  - SLA Enforcement for the different types of services
- Self Configuration, Plug and Play
  - LTE Small cells required today lot of hand crafting and tuning for performance

LTE Advanced Research Areas specific to small cell

- Inter Channel Interference Coordination (ICIC) Methods and Optimization
- Backhaul Traffic Congestion
- Traffic offload and Load balancing
- Managing the small cells, edge coverage and performance KPI's
- Seamless connectivity between multiple LTE Devices for applications delivery
- Enhanced MIMO, Beam forming and Adaptive Antenna Technologies
- Het Net Robust Mobility Management

LTE 3GPP Standard Gap's

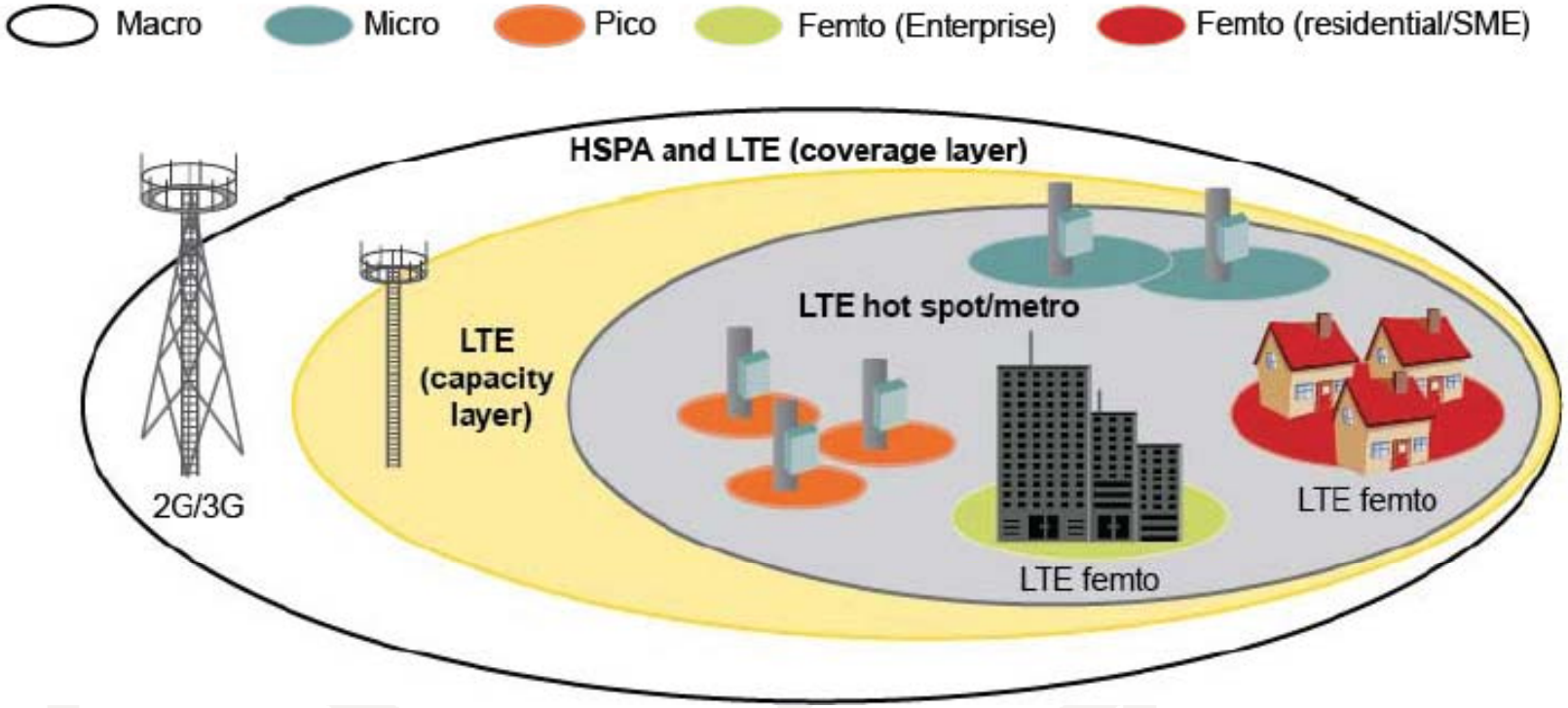
- Carrier Aggregation for non-contiguous channel aggregation typical use case scenarios were not supported by the LTE standard.
  For example: Group a,b,c,d,e has been classified, but no reference to groups d and e.
- Voice Over LTE with ultra low latency and high quality has not been supported by the LTE standard
- Small Cell load balancing has not supported by the LTE Standard

LTE 3GPP Standard Gap's

- Het Nets Robust operational scenario's have not supported by the standard
- Backhaul Security issues have not been adequately addressed by the standard
- AMR Group level registration limitations not addressed by the standard
- Interference management control for small cells, Pico and Micro cells and isolation mechanisms not supported by the LTE standard

LTE Advanced Network for India Rural Communication

- Rural network comprises of WiFi and LTE combination to reduce cost



- CAPX and OPEX has to be optimized

LTE Applications for India
Rural Communication

- Applications: Tele-Medicine, Distance Education, Public Safety, and Disaster Management

Conclusions and Recommendations

- LTE Small cell design challenges need to be addressed
- LTE Advanced Technologies impact on small cell design considered
- LTE Network topology for Rural Communications
- LTE Applications enablement

- LTE Standard gaps specific to small cells:
  - Small cell traffic load balancing need to be implemented
  - AMR Group level registration and support
  - Backhaul traffic management
  - Interference Control for Micro, Pico, and Femto cells
  - Het Nets Robust Mobility management support

Thank You