Maximizing the Performance of LTE in Indoor Environment

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Outline

- Understanding the Technical Requirements for a high Speed, High Capacity LTE and LTE-A network
- In-building Coverage Solution for LTE-Advanced
  - Passive vs Active DAS
  - High, Medium or Low Power Active DAS?
  - Inter-System Interference and PIM Considerations
  - In-building Coverage Strategies and Solution
- Summary and Takeaways
Technical Requirements for LTE and LTE-A Capacity
The LTE OFDM Air Interface

How much capacity is available?

- **Cyclic Prefix**
- **FFT**
- **Sub-carriers**
- **Scalable Bandwidth**

- **Modulation Type**
  - QPSK: 2 bits/sym
  - 16QAM: 4 bits/sym
  - 64QAM: 6 bits/sym

- **Resource Element & Resource Block**
  - One slot: 0.5 ms
  - 7 OFDM sym
  - One RB = 12 x 7 RE = 84 RE

- **Frequency**
  - 12 sub-carriers (180kHz)
  - $\Delta f = 15,000$ kHz

To download @ 5 Mbps:
- 64QAM 4/5: 7 RB
- 16QAM 4/5: 10 RB
- 16QAM 1/2: 17 RB
- QPSK 1/2: 35 RB

- **Scalable Bandwidth**
  - 20 MHz = 100 RB

- **Resource Element & Resource Block**
  - One slot: 0.5 ms
  - 7 OFDM sym
  - One RB = 12 x 7 RE = 84 RE
Basic Requirements for a High Speed LTE Network

- High Order Modulation (HOM)
  - QPSK Modulation: 2 bits/sym
  - 16 QAM Modulation: 4 bits/sym
  - 64 QAM Modulation: 6 bits/sym

- Small Cells

- MIMO
  - 20MHz LTE
  - Up to 75Mbps (SISO)
  - Up to 150Mbps (2x2MIMO)

- Intercell Interference

Spectral Efficiency [bits/s/Hz] vs. SINR [dB]

MIMO

Radio channel

SISO / Diversity ~75 Mbps @ 20MHz BW
Different Dimensions of Improvements in LTE-Advanced

**Leverage wider bandwidth**
Carrier aggregation across multiple carriers and multiple bands

**Leverage more antennas**
Downlink MIMO up to 8x8, enhanced Multi User MIMO and uplink MIMO up to 4x4. Coordinated multipoint (CoMP)

**Leverage HetNets**
With advanced interference management (eICIC/IC)

*Source: Ericsson*
In-building Coverage Solution for LTE-Advanced
Passive, Active, or Hybrid DAS?
Passive DAS for LTE-A?

Pros of Passive DAS
- An all-passive coaxial cable system is highly linear
- Capable of handling multiple downlink carriers with no measurable IM products
  - *IM3 of passive components typically in the range of -120 to -150 dBc*
- High system reliability and Cheap

Cons of Passive DAS
- Feeder cable size is typically limited to 7/8” or 1-1/4”
- Not suitable for buildings that require long feeder runs
  - *Inherent insertion loss limits the size of installation to typically a 35 floor high rise building, or around 50,000 sq m*
- At high frequencies, the system loss becomes very high
  - *Lower DL coverage, poorer uplink sensitivity and reduced SNIR*
- Expensive to implement MIMO for LTE.
High, Medium or Low Power Active DAS?

$NF_h \quad NF_m \quad NF_l$

$NF_l < NF_m < NF_h$
Uplink Performance
Inter-System Interference Considerations

- Spurious / Out-of-Band Emissions
- Blocking Considerations
Uplink Performance
Passive Intermodulation (PIM)

- Intermodulation occurs when two or more carriers mix on non-linear device and create undesired output at other frequencies.

- In a communications system, this means that signals in the downlink may cause interference with adjacent uplink channels.

\[ f_{\text{IMm+n}} = mf_1 \pm nf_2 \]

**IMD3** is always the **worst** case !!!

\[ f_{\text{IM3}} = 2 * f_1 - f_2 \]
\[ = 2 \times 1805 - 1880 \]
\[ = 1730 \text{ MHz} = f_4 \]

\[ f_{\text{IM5}} = 3 * f_1 - 2*f_3 \]
\[ = 3 \times 1805 - 2 \times 1880 \]
\[ = 1730 \text{ MHz} = f_4 \]
In-building Coverage Strategies

1. Focus on TCO
   - Think long term, not short term; Multi-operator not single operator
   - Network should be easily scalable, support future technologies, and provide a flexible upgrade path

2. Ensure good quality connections, not just good coverage
   - In the past there has been a trade-off between coverage and capacity
   - Now, users expect both
   - Move from voice to data capacity – SNIR, MIMO, CA
   - Low noise figures are crucial to ensure maximum data throughput

3. Ability to move capacity rather than always provision for the peak
   - Mobile traffic is bursty and sporadic
   - Historically operators have always had to provision for peak traffic
   - Intelligent in-building coverage should allow the dynamic allocation of capacity to where and when it is needed
   - Capacity no longer needs to be hard-wired
   - Reduction in capex and opex costs as a result
“Smart” DAS MIMO Solution

- Multi-operator, Multi-sector, Multi-band Active and Hybrid DAS
- Supports SISO or MIMO
- Dynamic Capacity Routing

- Intelligent Multi-sector Master Unit (iM2U)
- Network Expansion Unit (NEU)
- Intelligent Remote Unit (iRU) - RADiANT
- High Power Remote Unit (HPRU)
Dynamic capacity routing allows the size of sectors to be changed to accommodate temporary surge in traffic within the DAS network.
“Smart” DAS Components

Smart POI Unit

Smart POI – BTS Card

Smart POI – IM2U

Low Power RU (RADiAnt)

Hybrid Fiber/DC Cable

High Power RU

Modular PA Unit
Summary and Takeaways
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- LTE is designed as a wireless high speed data network.
  - *Requires Small Cell size AND Interference Management*
  - *Maximize SINIR through careful antenna placements to operate at 64QAM and improve MIMO performance*

- LTE-A capacity options
  - *MIMO and Sectorization*
  - *Carrier Aggregation*

- How well can Passive DAS support LTE-A?

- How to enhance upload speeds?
  - *Again, time to rethink on Passive DAS*
  - *Ensure sufficient isolation between co-located systems*
  - *PIM specs – No such thing as cheap and good!*

- Rosenberger is a Total Solutions Provider for multi-operator, IBS equipment and have successfully deployed active and passive IBS solutions in 15 countries throughout Asia Pacific, Middle East, & South America
There is nothing that is a more certain sign of insanity than to do the same thing over and over again and expecting different results.

Albert Einstein
THANK YOU

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