Further Along the Road to 4G: An update on LTE and LTE-Advanced

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Agenda

Wireless evolution 1990 – 2012
Confused by the term 4G?
Understanding 3GPP’s release structure
UMTS Long Term Evolution
LTE Frequency bands
Release 9 summary
Rel-10 LTE-Advanced radio features
Other key radio features in Rel-10 and beyond
Summary of Release 11
Summary of Release 12
Wireless Evolution 1990 - 2012

Increasing efficiency, bandwidth and data rates

2G
PDC (Japan)
GSM (Europe)
IS-136 (US TDMA)
IS-95A (US CDMA)
802.11b
802.11a/g
802.11h
802.11n

2.5G
iMODE
HSCSD
IS-95A (US CDMA)
IS-95B (US CDMA)

deNote2000 (1x RTT)

3G
W-CDMA (FDD & TDD)
TD-SCDMA (China)
E-GPRS (EDGE)
1x EV-DO
cdma2000 (1x RTT)

3.5G
HSDPA
HSUPA
EDGE Evolution

3.9G/4G
HSPA+/E-HSPA

LTE (R8/9 FDD & TDD)
LTE-Advanced (R10 & beyond)
802.16e (Mobile WiMAX)
802.16m / WiMAX2
WirelessMAN-Advanced

WiBRO (Korea)

4G / IMT-Advanced

Market evolution

Technology evolution
ITU – The Source of the “G” in Wireless?

International Telecommunications Union

ITU-Radio Working Party 8F (now WP 5D)

International Mobile Telephony

IMT-2000 “aka 3G”

IMT-Advanced “aka 4G”

All “IMT” technologies have access to designated IMT spectrum
Confused by the Term 4G? So You Should Be!

- The ITU’s “3G” program was officially called IMT-2000
- The ITU’s “4G” program is officially called IMT-Advanced
- The term 3.9G was widely used to describe LTE since it was developed prior to the ITU defining IMT-Advanced (aka 4G)
- LTE-A was intended to be 3GPP’s “official” 4G technology
- The term 4G was informally used to describe WiMAX® (802.16e)
- More recently, some operators describe the evolution of HSPA as 4G
- The ITU initially stuck to an interpretation of 4G as being just for IMT-Advanced but have recently stepped back from this and recently stated

  - “IMT-Advanced is considered as “4G”, although it is recognized that this term, while undefined, may also be applied to the forerunners of these technologies, LTE and WiMAX and other evolved 3G technologies providing a substantial level of improvement in performance.”

- In summary “4G” has lost any useful meaning so beware when using it!
## UMTS Long-Term Evolution

<table>
<thead>
<tr>
<th>Release</th>
<th>Stage 3: Core specs complete</th>
<th>Main feature of Release</th>
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<tbody>
<tr>
<td>Rel-99</td>
<td>March 2000</td>
<td>UMTS 3.84 Mcps (W-CDMA FDD &amp; TDD)</td>
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<td>Rel-4</td>
<td>March 2001</td>
<td>1.28 Mcps TDD (aka TD-SCDMA)</td>
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<td>Rel-5</td>
<td>June 2002</td>
<td>HSDPA</td>
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<td>Rel-6</td>
<td>March 2005</td>
<td>HSUPA (E-DCH)</td>
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<td>Rel-7</td>
<td>Dec 2007</td>
<td>HSPA+ (64QAM DL, MIMO, 16QAM UL). LTE &amp; SAE Feasibility Study, Edge Evolution</td>
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</table>
| Rel-8   | Dec 2008                    | LTE Work item – OFDMA air interface  
SAE Work item – New IP core network  
UMTS Femtocells, Dual Carrier HSDPA |
| Rel-9   | Dec 2009                    | Multi-standard Radio (MSR), Dual Carrier HSUPA,  
Dual Band HSDPA, SON, LTE Femtocells (HeNB)  
LTE-Advanced feasibility study |
| Rel-10  | March 2011                  | LTE-Advanced (4G) work item, CoMP Study  
Four carrier HSDPA |
| Rel-11  | Sept 2012                   | CoMP, eDL MIMO, eCA, MIMO OTA, HSUPA TxD &  
64QAM MIMO, HSDPA 8C & 4x4 MIMO, MB MSR |
| Rel-12  | March 2013 stage 1          | RAN features being decided Jun 2012 |
Frequency Bands

• An important aspect of frequency bands when it comes to the 3GPP releases is that they are “release independent”

• This means that a band defined in a later release can be applied to an earlier release.

• This significantly simplifies the specifications
Greater insight. Greater confidence.  
Accelerate next-generation wireless.

### LTE FDD Frequency Bands

Based on 36.101 Table 5.5-1 (March 2012)

<table>
<thead>
<tr>
<th>Band</th>
<th>Uplink MHz</th>
<th>Downlink MHz</th>
<th>Width</th>
<th>Duplex</th>
<th>Gap</th>
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<td>1980</td>
<td>60</td>
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<td>1755</td>
<td>45</td>
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<td>355</td>
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<td>5</td>
<td>824</td>
<td>849</td>
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<td>45</td>
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<tr>
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<td>880</td>
<td>915</td>
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<td>95</td>
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<tr>
<td>10</td>
<td>1710</td>
<td>1770</td>
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<td>340</td>
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<td>11</td>
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<tr>
<td>12</td>
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<td>787</td>
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</table>

**Points of note**

- There is a lot of overlap between band definitions for regional reasons
- The Duplex spacing varies from 30 MHz to 799 MHz
- The gap between downlink and uplink varies from 10 MHz to 680 MHz
- Narrow duplex spacing and gaps make it hard to design filters to prevent the transmitter spectral regrowth leaking into the receiver (self-blocking)
- Bands 13, 14, 20 and 24 are reversed from normal by having the uplink higher in frequency than the downlink
- Bands 15 and 16 are defined by ETSI (not 3GPP) for Europe only – these bands combine two nominally TDD bands to create one FDD band
LTE TDD Frequency Bands
Based on 36.101 Table 5.5-1 (March 2012)

<table>
<thead>
<tr>
<th>Band</th>
<th>Uplink MHz</th>
<th>Downlink MHz</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>1900</td>
<td>1900</td>
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<td>38</td>
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<tr>
<td>43</td>
<td>3600</td>
<td>3600</td>
<td>200</td>
</tr>
</tbody>
</table>

Points of note
- For TDD there is no concept of duplex spacing or gap since the downlink and uplink frequencies are the same.
- As such, the challenge of separating transmit from receive does not require a duplex filter for the frequency domain but a switch for the time domain.
Future LTE/UTRA Frequency Bands

• The work on defining new frequency bands continues. Currently being considered by 3GPP:

• Band 27  806/824 + 851/869 – Extended 850 lower band

• Other possibilities identified by the ITU:
  • 3.6-4.2 GHz
  • 450–470 MHz
  • 698–862 MHz
  • 790–862 MHz band (European digital dividend)
  • 4.4-4.99 GHz band
Release 9 Summary

• Release 9 adds many small features to UMTS and LTE e.g.:
  – Completion of MBSFN
  – New frequency bands
  – Transmission mode 8 (dual stream beamforming)
  – Positioning Reference Signal (PRS) for Observed Time Difference Of Arrival (OTDOA) positioning

• The most significant radio feature is Multi-Standard Radio (MSR) for BS that support more than one radio format

• MSR is a don’t care for the UE but is a big deal for the BS

• The work involved harmonizing the GERAN and 3GPP specifications then specifying common requirements and conformance tests

• Multi-band MSR is being added in Release 11
Update on LTE-Advanced Overall Aspects

• LTE-Advanced is a subset of Release 10

• A comprehensive summary of the entire LTE-Advanced proposals including radio, network and system can be found in the 3GPP submissions to the first IMT-Advanced evaluation workshop.


• The remainder of this presentation will focus on the key radio aspects
LTE-Advanced Requirements & Proposals

• LTE-A requirements are documented in TR 36.913, V9.0.0 (2009-03) (Requirements for Further Advancements of E-UTRA (LTE-Advanced))

• 3GPP stated intention is to meet or exceed IMT-Advanced requirements

• LTE-A must support IMT-A requirements with same or better performance than LTE

• LTE-A solution proposals can be found in TR 36.814 – “Further Advancements for E-UTRA Physical Layer Aspects”

• Specific targets exist for average and cell-edge spectral efficiency (see next slide)

• Similar requirements as LTE for synchronization, latency, coverage, mobility…

• LTE-A candidate was submitted to ITU September 2009 and formally approved in Jan 2012
# LTE-Advanced Spectral Efficiency Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Sub-category</th>
<th>LTE (3.9G) target</th>
<th>LTE-Advanced (4G) target</th>
<th>IMT-Advanced (4G) target</th>
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</thead>
<tbody>
<tr>
<td>Peak Spectral Efficiency (b/s/Hz)</td>
<td>Downlink</td>
<td>16.3 (4x4 MIMO)</td>
<td>30 (up to 8x8 MIMO)</td>
<td>15 (4x4 MIMO)</td>
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<td></td>
<td>Uplink</td>
<td>4.32 (64QAM SISO)</td>
<td>15 (up to 4x4 MIMO)</td>
<td>6.75 (2x4 MIMO)</td>
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<td>Downlink cell spectral efficiency b/s/Hz 3km/h 500m ISD</td>
<td>2x2 MIMO</td>
<td>1.69</td>
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<td>4x2 MIMO</td>
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<td>2.6</td>
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<td>4x4 MIMO</td>
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<td>3.7</td>
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<td>Downlink cell-edge user spectral efficiency b/s/Hz 5 percentile 10 users 500M ISD</td>
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<td>4x2 MIMO</td>
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<td></td>
<td>4x4 MIMO</td>
<td>0.08</td>
<td>0.12</td>
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</table>

ISD is Inter Site Distance

2x to 4x efficiency of Rel-6 HSPA
### New LTE-A UE Categories

To accommodate the higher data rates of LTE-A, three new UE categories have been defined.

<table>
<thead>
<tr>
<th>UE category</th>
<th>Max. Data rate (DL / UL) (Mbps)</th>
<th>Downlink</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Uplink</th>
<th></th>
<th></th>
<th></th>
<th>Support for 64QAM</th>
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<td></td>
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<td>Max. # DL-SCH TB bits / TTI</td>
<td>Max. # DL-SCH bits / TB / TTI</td>
<td>Total. soft channel bits</td>
<td>Max. # spatial layers</td>
<td>Max. # UL-SCH TB bits / TTI</td>
<td>Max. # UL-SCH bits / TB / TTI</td>
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Release 10 and Beyond Proposals
Radio Aspects

1. Carrier aggregation
2. Enhanced uplink multiple access
   a) Clustered SC-FDMA
   b) Simultaneous Control and Data
3. Enhanced multiple antenna transmission
   a) Downlink 8 antennas, 8 streams
   b) Uplink 4 antennas, 4 streams
4. Coordinated Multipoint (CoMP)
5. Relaying
6. Home eNB mobility enhancements
7. Customer Premises Equipment
8. Heterogeneous network support
9. Self Optimizing networks (SON)

Rel-10 LTE-A proposed to ITU

Other Rel-10 and beyond
Release 10 LTE-Advanced Radio Features

1. **Carrier Aggregation**
   - Flexible Channel Bandwidths
   - Support for up to 5 Aggregated Carriers
   - MHz: 1.4, 3, 5, 10, 15, 20

2. **Enhanced uplink**
   - SC-FDMA with clustering
   - New and improved formula

3. **Enhanced multiple antenna transmission**
   - New for LTE-A
   - 1, 2 or 4 transmitters and 2, 4 or 8 receivers
   - UE
   - 2, 4 or 8 transmitters and 2, 4 or 8 receivers
   - eNodeB
Other Radio Features Being Specified for Release 10 and Beyond

4. Coordinated Multipoint

5. Relaying

6. HeNB mobility enhancements

7. Customer Premises Equipment (CPE)

8. Heterogeneous Networks

9. Self Optimizing Networks (SON)
1. Carrier Aggregation

- Lack of sufficient contiguous spectrum up to 100 MHz forces use of carrier aggregation to meet peak data rate targets
- Able to be implemented with a mix of terminals
- Backward compatibility with legacy system (LTE)
- System scheduler operating across multiple bands
- Component carriers (CC) - Max 110 RB (TBD)
- May be able to mix different CC types
- Contiguous and non-contiguous CC is allowed

Contiguous aggregation of two uplink component carriers
1. Carrier Aggregation

• One of RAN WG4’s most intense activities is in the area of creating RF requirements for specific band combinations.

• In theory there could be as many as 5 carriers but so far all the activity is around dual carrier combinations.

• The original CA work in Rel-10 was limited to three combinations.

<table>
<thead>
<tr>
<th>Band</th>
<th>E-UTRA operating Band</th>
<th>Uplink (UL) band</th>
<th>Downlink (DL) band</th>
<th>Duplex mode</th>
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<tr>
<td></td>
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<td>UE transmit / BS receive</td>
<td>Channel BW MHz</td>
<td>UE receive / BS transmit</td>
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<td>$F_{UL_{low}}$ (MHz) – $F_{UL_{high}}$ (MHz)</td>
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<td>$F_{DL_{low}}$ (MHz) – $F_{DL_{high}}$ (MHz)</td>
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<td></td>
<td>7</td>
<td>2500 – 2570</td>
<td>20</td>
<td>2620 – 2690</td>
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</tbody>
</table>

• In Rel-11 there are now up to 18 CA combinations being specified.
1. Carrier Aggregation Design and Test Challenges

• Not such an issue for the eNB

• Major challenge for the UE
  – Multiple simultaneous receive chains
  – Multiple simultaneous transmit chains

• Simultaneous non-contiguous transmitters creates a very challenging radio environment in terms of spur management and self-blocking

• Simultaneous transmit or receive with mandatory MIMO support add significantly to the challenge of antenna design
2. Enhanced Uplink Multiple Access
Clustered SC-FDMA and PUCCH with PUSCH

Release 8: SC-FDMA with alternating PUSCH/PUCCH
(Inherently single carrier)

- Partially allocated PUSCH
- Partially allocated PUSCH
- Lower PUCCH
- Upper PUCCH
- Fully allocated PUSCH

Release 10: Clustered SC-FDMA with simultaneous PUSCH/PUCCH
(Potentially in-channel multi-carrier)

- Partially allocated PUSCH + PUCCH
- Partially allocated PUSCH + PUCCH
- Partially allocated PUSCH + 2 PUCCH
- Partially allocated PUSCH only
- Fully allocated PUSCH + PUCCH

Frequency
The use of clustered SC-FDMA increases the PAPR above non-clustered SC-FDMA, but not as much as full OFDM which can exceed the PAPR of Gaussian noise.
2. Enhanced Uplink Multiple Access Design and Test Challenges

• Clustered SC-FDMA increases PAR by a few dB adding to transmitter linearity challenges

• Simultaneous PUCCH and PUSCH also increases PAR

• Both feature create multi-carrier signals within the channel bandwidth

• High power narrow PUCCH plus single or clustered SC-FDMA creates large opportunity for in-channel and adjacent channel spur generation
  – May require 3 to 4 dB power amp backoff for Rel-8 PA
  – Some scenarios may require 10 dB backoff

• Due to the spur issues the status of the enhanced uplink is still to be decided for Release 10
2. Enhanced Uplink Multiple Access Design and Test Challenges

This is a typical spectrum of a single carrier signal

Wanted signal: Two RB at channel edge

Derived from R4-100427 [ftp://ftp.3gpp.org/tsg_ran/WG4_Radio/TSGR4_54/Documents/R4-100427.zip]
2. Enhanced Uplink Multiple Access Design and Test Challenges

The presence of two in-channel carriers creates 25 to 50 dB worse spurss.

Derived from R4-100427 ftp://ftp.3gpp.org/tsg_ran/WG4_Radio/TSGR4_54/Documents/R4-100427.zip

Wanted signal: One RB at each channel edge
3. Enhanced Multiple Antenna Transmission

- From 4 antennasstreams to 8 antennasstreams
  - Baseline being 4x4 with 4 UE Receive Antennas
  - Peak data rate reached with 8x8 SU-MIMO
- From 1 antennastream to 4 antennasstreams
  - Baseline being 2x2 with 2 UE Transmit Antennae
  - Peak data rate reached with 4x4 SU-MIMO
- Focus is initially on downlink beamforming up to 4x2 antennas – SM is less attractive

- Challenges of higher order antenna transmission
  - Creates need for tower-mounted remote radio heads
  - Increased power consumption
  - Increased product costs
  - Physical space for the antennae at both eNB and UE
3. Enhanced Multiple Antenna Transmission
New CSI Reference Symbols (CSI-RS)

• Rel-8/9 cell-specific RS (CRS) exist in every subframe and are used by the UE for CSI feedback (CQI/PMI/RI) and demod for up to 4 layers

• CSI-RS (ports 15 to 22) support CSI feedback for up to 8 layers but not used for demod. They are scheduled as required (less often than CRS)

• The mapping and RE per port depend on the number of ports
3. Enhanced Multiple Antenna Transmission Design and Test Challenges

• Higher order MIMO has a similar impact on the need for simultaneous transceivers as does carrier aggregation.

• However, there is an additional challenge in that the antennas also have to multiply in number.

• MIMO antennas also require to be de-correlated.

• It is very hard to design a multi-band, MIMO antenna in a small space with good de-correlation.

• This makes conducted testing of higher order MIMO terminals largely irrelevant in predicting the actual radiated performance in an operational network.

• There is a work item in Rel-11 looking at MIMO Over the Air (OTA) testing which will address antenna performance.
4. Coordinated Multi-Point – (CoMP)

Traditional MIMO – co-located transmission

Downlink
- Coordinated scheduling / beamforming
  - Payload Data is required only at the serving cell
- Coherent combining (also known as cooperative MIMO) / fast switching
  - Payload data is required at all transmitting eNB
  - Requires high speed symbol-level backhaul between eNB

Uplink
- Simultaneous reception requires coordinated scheduling
4. CoMP Status

• Recent simulation by RAN WG1 has shown initial CoMP performance improvement to be in the 5% to 15% range

• This is not considered sufficient to progress this aspect of the proposals within the Rel-10 timeframe

• Recent results from the EASY-C testbed also show limited performance gains in lightly loaded networks with minimal or no interference

• CoMP is now being studied further for Release 11

• It remains unclear what eNB testing of CoMP might entail since it is very much a system level performance gain and very difficult to emulate
5. In-Channel Relay and Backhaul

- Basic in-channel relaying uses a relay node (RN) that receives, amplifies and then retransmits DL and UL signals to improve coverage.
- Advanced relaying performs L2 or L3 decoding of transmissions before transmitting only what is required for the local UE.

- OFDMA makes it possible to split a channel into UE and backhaul traffic.
- The link budget between the eNB and relay station can be engineered to be good enough to allow MBSFN subframes to be used for backhaul of the relay traffic.
- Main use cases:
  - Urban/indoor for throughput or dead zone
  - Rural for coverage
5. In-Channel Relay and Backhaul Design and Test Challenges

• From the UE perspective, Relaying is completely transparent
• The challenge is all on the network side
• For the system to work, the link budget from the relay node to the macro eNB must be good
  – This implies line of sight positioning
• The main operational challenge with getting relaying to work will be in the management of the UE
  – The UE has to hand over to the relay node when in range
  – It must release the relay node when out of range
• If this process is not well-managed, the performance of the cell could go down not up
• Multi-hop relaying for coverage should be easier
  – e.g. a valley with no cabled backhaul
6. Home eNB Mobility Enhancements

• The concept of Home eNB (femtocells) is not new to LTE-A
• In Release 8 femtocells were introduced for UMTS
• In Release 9 they were introduced for LTE (HeNB)
• In Release 9 only inbound mobility (macro to HeNB) was fully specified
• In Release 10 there will be further enhancements to enable HeNB to HeNB mobility
• This is very important for enterprise deployments
7. Customer Premises Equipment (CPE)

- The CPE is a “mobile” intended for fixed (indoor) operation
- The antenna may be internal (omni) or external (directional)
- The max output power is increased to 27 dBm
- Lack of concern for power consumption and a better radio link budget mean the CPE can deliver much higher performance e.g. For rural broadband applications
8. Heterogeneous Network Support

• LTE-Advanced intends to address the support needs of heterogeneous networks that combine low power nodes (such as picocells, femtocells, repeaters, and relay nodes) within a macrocell.

• Deployment scenarios under evaluation are detailed in TR 36.814 Annex A.
9. Self Optimizing Networks (SON)

• Today’s cellular systems are very much centrally planned, and the addition of new nodes to the network involves expensive and time-consuming work, site visits for optimization, and other deployment challenges.

• One of the enhancements being considered for LTE-Advanced is the self-optimizing network (SON).

• The intent is to substantially reduce the effort required to introduce new nodes to the network. There are implications for radio planning as well as for the operations and maintenance (O&M) interface to the base station.

• Some limited SON capability was introduced in Release 8 and is being further elaborated in Release 9 and Release 10.
Looking at the Cost/Benefits of LTE-Advanced Radio Aspects

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Peak data rates, Cell spectral efficiency, and Cell edge performance are beneficial for Carrier Aggregation and Enhanced Uplink. Higher order MIMO has benefits in CoMP (Rel-11) and Relaying. UE cost, Network cost, and UE Complexity are concerns for increasing network and UE complexity.
The first question to ask when people are looking for information on LTE-A timing is "which feature"

LTE-A, Release 10 etc. is a large grouping of backwards-compatible features, none of which are mandatory

The most likely contenders for early LTE-A deployment are:

- Some limited form of carrier aggregation to increase instantaneous bandwidth is particular local operator areas
  - E.g. US operator combining 10 MHz at 700 with 10 MHz at 1700
  - Expensive requires two transceivers unless adjacent

- Uplink MIMO
  - Requires two UE transmitters – expensive, battery issues

- Enhanced downlink e.g. 8x2
LTE-Advanced Summary

• LTE-A is 3GPP’s submission to ITU-R IMT-Advanced “4G” program
• LTE-A is an evolution of LTE and is about two years behind LTE in standards
• Rel-8 LTE almost meets the IMT-Advanced requirements except for UL spectral efficiency and peak rates requiring wider bandwidths.
• Bandwidth up to 100MHz through aggregation of 20 MHz carriers
• Up to 1 Gbps (low mobility) with 8x8 MIMO
• Key new technologies include: carrier aggregation, enhanced uplink and advanced MIMO
• Spectral efficiency performance targets are a step up from the already very challenging Rel-8 LTE targets
• LTE-A Deployment timing is hard to predict and will depend heavily on the rollout of LTE
Release 11 Radio Summary
Work Items (Excluding Carrier Aggregation)

- Extending 850 MHz Upper Band (814 – 849 MHz)
- E-UTRA medium range and MSR medium range/local area BS class requirements
- New Band LTE Downlink FDD 716-728 MHz
- LTE for 700 MHz Digital Dividend
- Relays for LTE (part 2)
- UE Over The Air (Antenna) conformance testing methodology - Laptop mounted equipment Free Space test
- UE demodulation performance requirements under multiple-cell scenario for 1.28Mcps TDD
- Introduction of New Configuration for 4C-HSDPA
- Non-contiguous 4C-HSDPA operation
- HSDPA Dual-Band Multi-Carrier combinations
- Public Safety Broadband High Power UE for Band 14 for Region 2
- Improved Minimum Performance Requirements for E-UTRA: Interference Rejection
- Additional special subframe configuration for LTE TDD
- RF Requirements for Multi-Band and Multi-Standard Radio (MB-MSR) Base Station
- Verification of radiated multi-antenna reception performance of UEs in LTE/UMTS
- LTE in the 1670-1675 MHz Band for US
Release 11 Radio Summary
Study Items

- Study on Inclusion of RF Pattern Matching Technologies as a positioning method in the E-UTRAN
- Study on Interference analysis between 800~900 MHz bands
- Study on Enhanced performance requirement for LTE UE
- Study on Measurement of Radiated Performance for MIMO and multi-antenna reception for HSPA and LTE terminals
- Study on Extending 850 MHz
- Study on UMTS/LTE in 900 MHz band (Japan, Korea)
- Study on RF and EMC requirements for active Antenna Array System (AAS) Base Station
- Study on UE Over The Air (OTA) test method with Head and Hand Phantoms
- Study on Passive InterModulation (PIM) handling for UTRA and LTE Base Stations
- Study on Measurements of radio performances for LTE terminals - Total Radiated Power (TRP) and Total Radiated Sensitivity (TRS) test methodology
Release 12 Summary – System Level Features
Radio Features Not Yet Identified – Workshop in June 2012

• Interworking between Mobile Operators using the Evolved Packet System and Data Application Providers (MOSAP) UID_500031 (Was Rel-11)
• IMS-based Telepresence (IMS_TELEP)
• Service and Media Reachability for Users over Restrictive Firewalls (SMURFs)
• Advanced IP Interconnection of Services (IPXS) for national interconnect (IPXSNAT)
• Integration of Single Sign-On (SSO) frameworks with 3GPP networks (SSO_Int)
• LIPA Mobility and SIPTO at the Local Network (LIMONET)
• Operator Policies for IP Interface Selection (OPIIS) (Was Rel-11)
• SMS submit and delivery without MSISDN in IMS (SMSMI) (Was Rel-11)
• Security aspects of Public Warning System (PWS_Sec) (Was Rel-11)
• Codec for Enhanced Voice Services (EVS_codec)
Questions?