LTE EVOLUTION
BEYOND LTE-ADVANCED

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International Forum on Mobile Communication beyond 4G
Taipei City, September 18, 2012
LTE

› First release, Rel-8, ready in 2008

› Convergence
  – FDD and TDD into one technology
  – 3GPP2/cdma2000 operators migrating to LTE

› First commercial network in 2009

› Today 89 commercial networks in 45 countries, both FDD and TDD*

› In total 338 operators in 101 countries are committed to LTE*

* Source: GSA, July 2012
LTE-ADVANCED

› Rel-10: LTE-Advanced
  – Carrier aggregation, MIMO enhancements, relaying,…
  – Fulfills all ITU’s IMT-Advanced requirements (“4G”)

› Rel-11
  – CoMP, control channel enhancements, further enhancements, …
  – Being finalized now

› Next step now
  – First Rel-12 work and study items approved
BEYOND LTE-ADVANCED
SOME DRIVERS

› Capacity and data rates
  - Mobile data traffic almost doubled 2011Q1- 2012Q2*
  - By the end 2017, we expect x15 mobile data *
  - Video and smart-phones are increasing
  - End-user experience a key differentiator

› Energy efficiency
  - Energy cost is significant part of OPEX
  - Relevant also for off-grid deployments and densification
  - Market, regulatory and customer requirements

Machine-type-communication
  - More than 50 billion devices envisioned by 2020
    Anything that benefits from being connected will be connected
  - New characteristics and requirements

* http://www.ericsson.com/traffic-market-report
BEYOND LTE-ADVANCED
SOME TECHNOLOGY AREAS

› Local-area enhancements (“small cell”)
  – Low power nodes with macro assistance, dynamic TDD, …

› General enhancements
  – Multiple antenna techniques, CoMP, further enhanced UE receivers, network energy efficiency, …

› New applications
  – Machine type communication, Device-to-device, National Security and Public Safety, …

› Enhanced interworking with WiFi, HSPA, …
LOCAL-AREA ACCESS

› Low-power nodes *complementing* wide-area macro layer
  - “Small cells” already with Rel-8, enhancements in Rel-10/11

› Capacity and very high data rates *locally*
  - Indoor and outdoor hotspots

› Enhancements targeting
  - Local-area characteristic
  - Deployment cost/self-optimization
  - Mobility
  - ..
LOCAL-AREA ACCESS
FREQUENCY SEPARATED LAYERS

› More spectrum ⇒ higher data rates and capacity

› Future additional spectrum mainly at higher frequencies
  - More challenging to build wide-area coverage
  - Possibly regulatory restrictions on use

› Focus on frequency-separated wide-area/local-area
  - 3GPP focus has so far been on same-frequency
LOCAL-AREA/WIDE-AREA INTERACTION
DUAL CONNECTIVITY

› Exploit existing wide-area coverage
  – When low-power nodes for capacity and data rates

› Robust and efficient mobility
  – Wide-area macro layer available for signaling
  – Assist efficient UE operation and discovery

› Energy efficient load balancing and coordination
  – Activate low-power nodes only when needed
  – Intra-/inter-layer interference coordination
  – Self optimization
LOCAL-AREA/WIDE-AREA INTERACTION
DUAL CONNECTIVITY

› Lean low power node transmissions
  – Common control signaling from macro
  – Active only for data, minimum overhead, interference reduction

› Uplink-downlink separation
  – Different power and load in different nodes
    ⇒ different nodes for uplink and downlink

› Consider “any” backhaul
  – Low-latency backhaul beneficial, but not a strict requirement
LOCAL-AREA ACCESS
DYNAMIC TDD

› Wide-area: aligned, static UL:DL configurations in all cells
  – Avoid BS-to-BS (DL-to-UL) interference

› Local-area: benefit of dynamic UL:DL configuration
  – Lower node output power, below rooftop deployment,
  – Larger traffic variations ⇒ Adapt to instantaneous traffic
  – UL-DL interference coordination
GENERAL ENHANCEMENTS
MULTIPLE-ANTENNA/POINT TECHNIQUES

› Further enhancements to existing techniques
  – For example channel state information feedback

› Coordinated multipoint for “non-ideal” backhaul
  – CoMP not only RRU-type of deployments

› New implementations: active array antenna systems
  – RF components integrated with the antenna
  – Improved performance, smaller footprint, simpler installation
  
  – *May be an enabler for more advanced techniques with many “degrees of freedom” also in elevation…*
GENERAL ENHANCEMENTS
ELEVATION BEAMFORMING

› Beamforming with vertically stacked sub-elements
  – User specific beamforming, cell shaping, carrier specific tilt, vertical sectorization,…

› Benefit expected to be highly scenario dependent,
  – User distribution, cell size, propagation conditions,…

› Channel modeling an important first step
  – Then, understand if LTE toolbox needs to be extended

GENERAL ENHANCEMENTS
ADVANCED UE RECEIVERS

› Single-user MIMO receivers
  – Including support for SIC

› Intercell interference rejection (IRC)
  on the table today

› (Partial) intercell interference cancellation/mitigation
  – Cell specific reference/sync signals,…

› Next step: more advanced receivers with more cancellation
  – Network assistance to achieve manageable UE complexity?
General Enhancements

Network Energy Efficiency

› Important for existing as well as future radio access
  - Wireless communication part of the solution not the problem
  - Significant reduction possible with existing LTE

› Reduce always-on signals with new lean carrier
  \[macro and low power nodes\]
› Lean low power node transmission
  \[wide-area/local-area interaction\]
› Low power node activation

– Note: Less un-necessary transmissions ⇒ less interference
Wide range of application areas with diverse requirements
- Coverage, cost, reliability, data rates, ...

- Low-cost devices: reduce bandwidth, peak-rate, duplex, ...
- Reduced power consumption: longer DRX, simplified signaling, ...
- Coverage enhancements, large number of devices, ...

Improvement areas
Many use cases…but which are relevant?
  - Drastically different requirements

Network assisted proximity-detection a natural first step
  - Network assistance improves performance and resource/energy efficiency

Study potential benefits of D2D communication later
  - Proximity detection and service discovery major issues

Device-to-device of interest for NSPS
FURTHER INTO THE FUTURE

› Vision
  - A world with unlimited access to information and sharing of data available anywhere and anytime to anyone and anything

› Challenges
  - Massive traffic growth
  - Massive growth in number of devices
  - Wide range of requirements and use cases
FURTHER INTO THE FUTURE

› New scenarios, e.g. usage of very high frequency bands?
  - Lots of spectrum available ➔ Extreme capacity and data rates
  - Small wave length ➔ Possibilities for massive antenna solutions
  - Not ubiquitous coverage ➔ integrate with wide-area network

Current spectrum range

millimeter band

300 MHz  3 GHz  30 GHz  300 GHz
Long term challenges
- Massive traffic growth
- Massive growth in number of devices
- Wide range of requirements and use cases
- Energy efficiency

LTE Advanced evolving to address challenges
- Rel-12 candidates include local area enhancements ("small cells"), general enhancements, and new applications