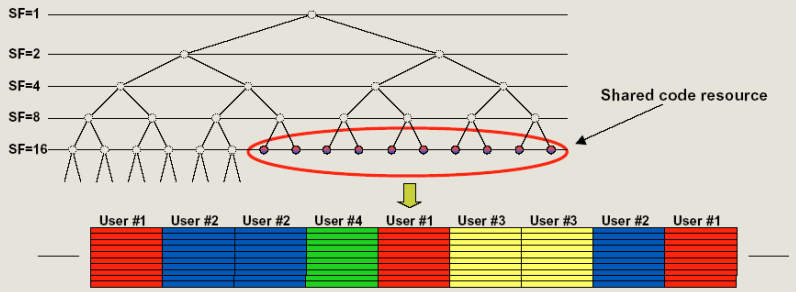
Dimensioning, configuration and deployment of Radio Access Networks.

part 5: HSPA and LTE

HSDPA

- Enhanced Support for Downlink Packet Data
  - Higher Capacity
  - Higher Peak data rates
  - Lower round trip delay time
- Part of release 5
- Similar to cdma2000 EV DO
- Shared Channel Transmission
- Higher order Modulation
- Fast Link adaptation
- Fast hybrid ARQ
- (MIMO to be considered for later releases)

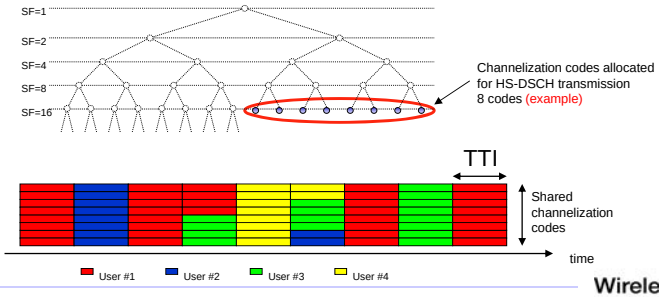
Shared Channel Transmission



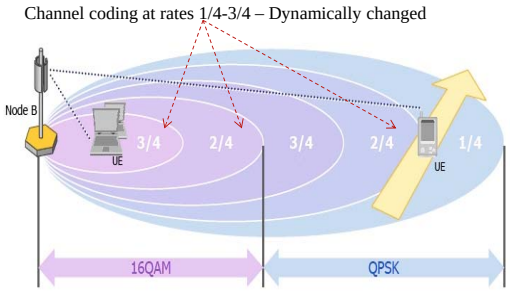
A set of codes dynamically shared between users in time
- Downlink Shared Channel (DSCH) for R99/R4
- High-Speed Downlink Shared Channel (HS-DSCH) for R5

HSDPA - Shared channel transmission

- Efficient code and power utilization by dynamically sharing radio resources among multiple users
  - Time domain (TTI = 2 ms)
  - Code domain (up to 15 codes)
- Not all UEs are capable to receive data in consecutive TTI (Minimum inter-TTI time > 1)
- CC are not orthogonal due to multipath propagation → self interference generated in the cell affecting capacity



Channel coding and throughput



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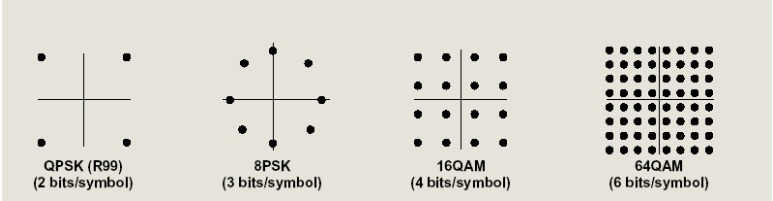
Higher order Modulation



- Allows for higher peak data rates
  - QPSK 480kbps channel bit rate per code
  - 16QAM 960kbps channel bit rate per code
- Requires higher SNIR
  - Smaller cells
  - Shared channel transmission

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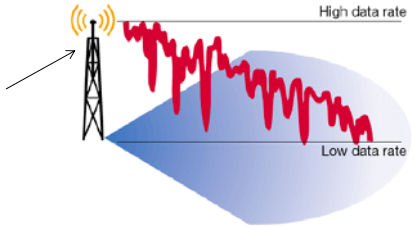
Fast link adaptation

- Radio channel conditions changes fast due to:
  - Interference variations
  - Path loss and shadowing
  - Multipath fading
- HS-DSCH channel rate control = constant power
  - Adaptive channel coding
  - Adaptive modulation (QPSK <-> 16QAM)
- Fast adaptation - TTI=2 ms
- Available rate is adjusted by selecting a Transport Format and Resource Combination (TFRC)
- The achievable rate dependent on:
  - Available HS power
  - Radio conditions
  - UE category
  - Available # HS codes
  - 16QAM availability
  - Load



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Modulation, coding and data rate

Modulation	Coding rate	Throughput 5 CC	Throughput 10 CC	Throughput 15 CC
QPSK	1/4	600 kbps	1.2 Mbps	1.8 Mbps
	2/4	1.2 Mbps	2.4 Mbps	3.6 Mbps
	3/4	1.8 Mbps	3.6 Mbps	5.4 Mbps
16QAM	2/4	2.4 Mbps	4.8 Mbps	7.2 Mbps
	3/4	3.6 Mbps	7.2 Mbps	10.8 Mbps
	4/4	4.8 Mbps	9.6 Mbps	14.4 Mbps

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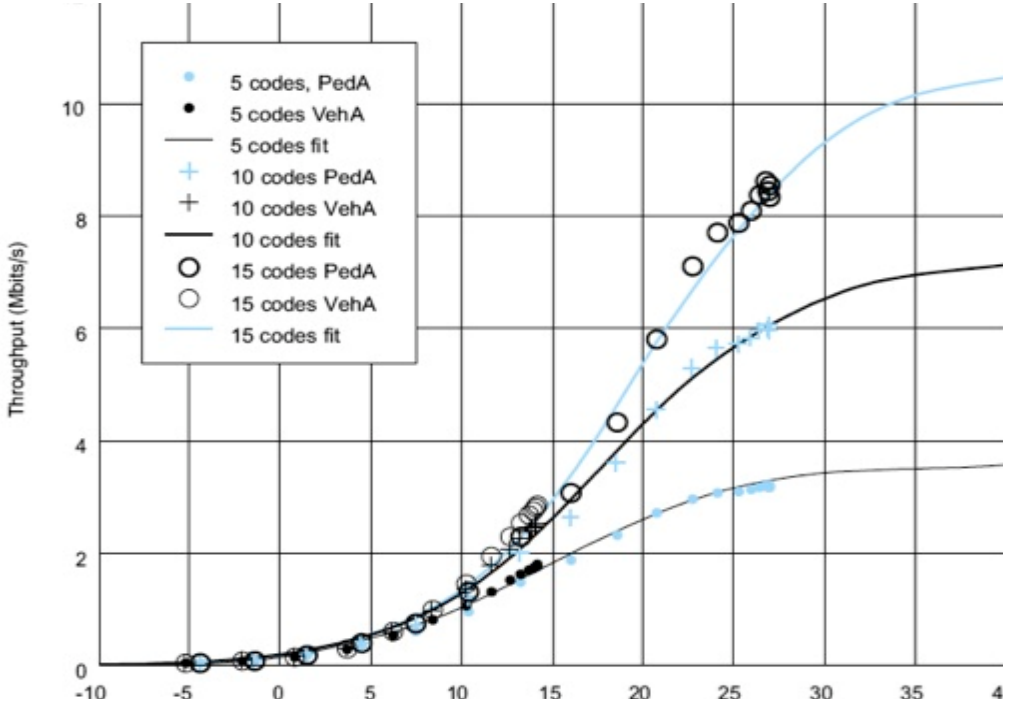
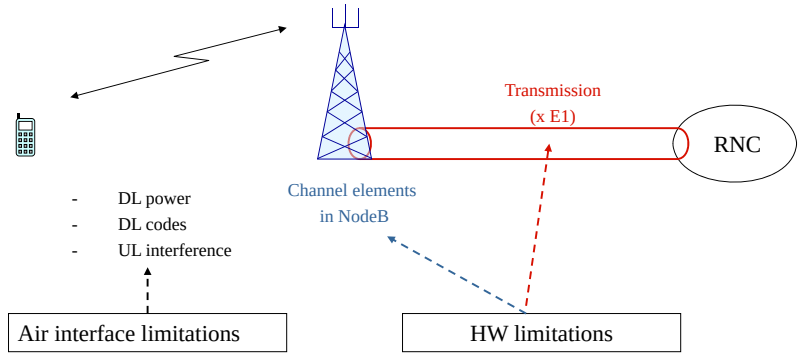


Capacity management overview – 3G RAN



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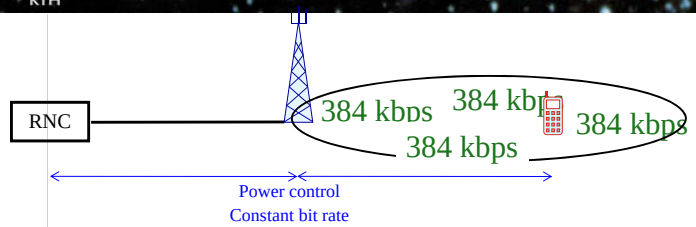
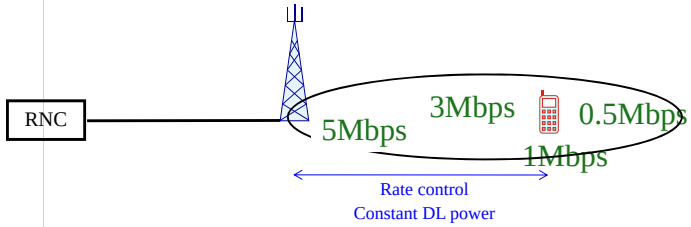
Power control and rate control



R99
Power controlled



R5
Rate controlled

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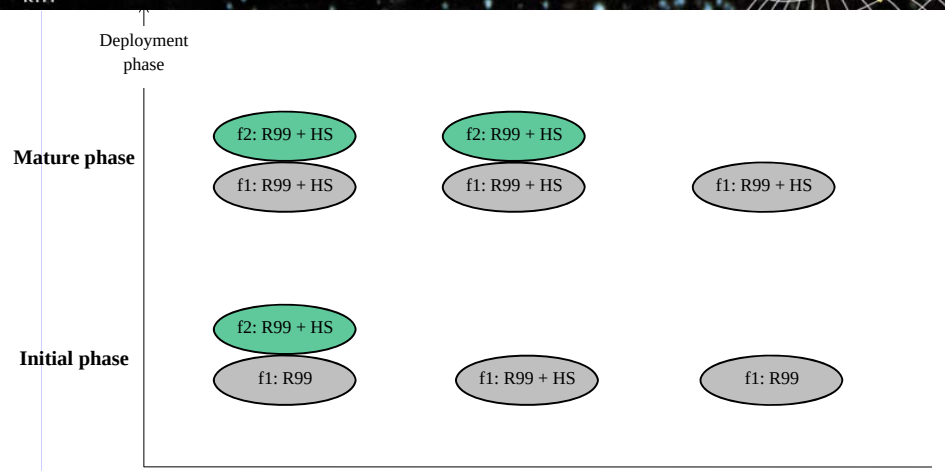
Deployment strategy example



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LTE – 4G Mobile Broadband

A SHORT SUMMARY ON BEHALF OF ERICSSON

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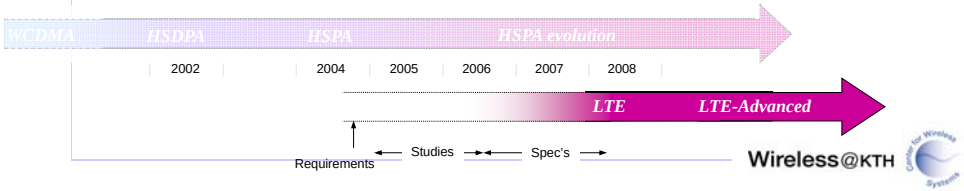
HSPA and LTE = Mobile Broadband

- HSPA – *High-Speed Packet Access* (”Turbo-3G”)
  - Gradually improved performance in existing 3G networks
- LTE – *Long-Term Evolution* (”4G”)
  - Significantly higher performance and user experience *in a wide range of spectrum allocations*
  - Packet-switched services only
  - Fulfills IMT-Advanced requirements



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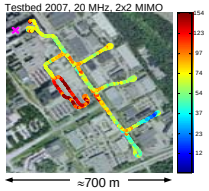
LTE – 4G Mobile Broadband

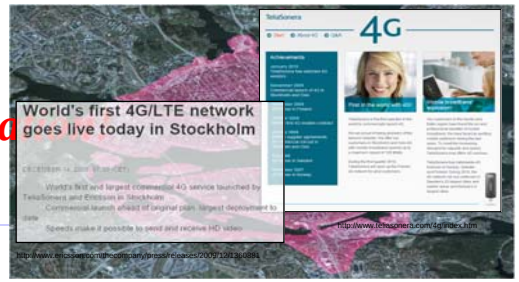
From early studies…



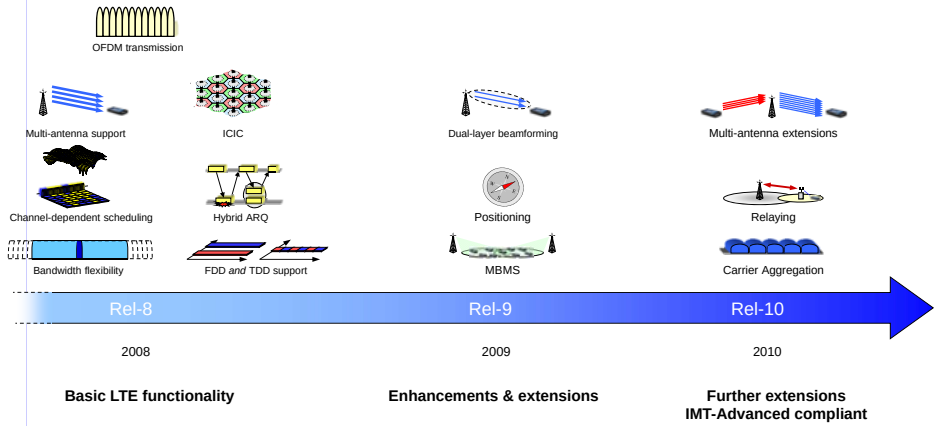
LTE Testbed 2007

…via trials…

…to commercial opera



LTE – Basic Radio-Access Principles



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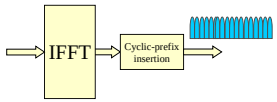
Transmission Scheme

Downlink – OFDM

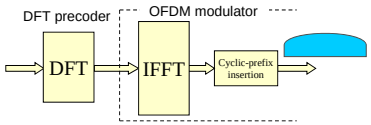
- Parallel transmission on large number of narrowband subcarriers



› Benefits:
  – Avoid own-cell interference
  – Robust to time dispersion
› Main drawback
  – Power-amplifier efficiency

Uplink – DFTS-OFDM

- DFT-precoded OFDM



› Tx signal has single-carrier properties
  ⇨ *Improved power-amplifier efficiency*
  – Improved battery life
  – Reduced PA cost
  – **Critical for uplink**
› Equalizer needed ⇨ Rx Complexity
  – **Not critical for uplink**

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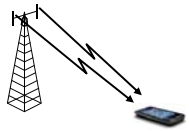
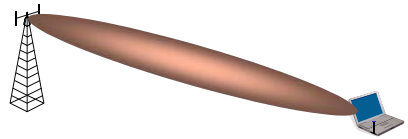
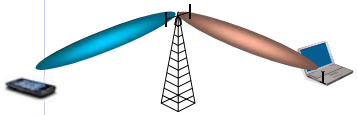
Multi-antenna Transmission



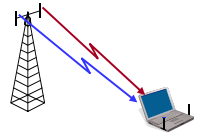
Diversity for improved system peformance (robustness)



Beam-forming for improved coverage (less cells to cover a given area)



SDMA for improved capacity (more users per cell)

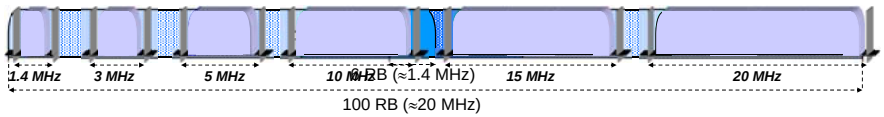


Multi-layer transmisson (”MIMO”) for higher data rates in a given bandwidth

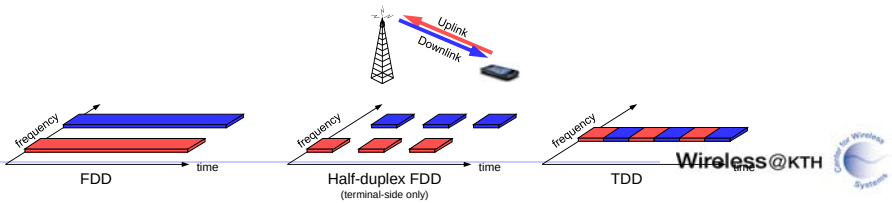
The multi-antenna technique to use depends on what to achieve

Spectrum Flexibility

- Operation in differently-sized spectrum allocations
  – Core specifications support any bandwidth from 1.4 to 20 MHz
  – Radio requirements defined for a limited set of spectrum allocations



› Support for paired *and* unpaired spectrum allocations
with a single radio-access technology ➡ economy-of-scale



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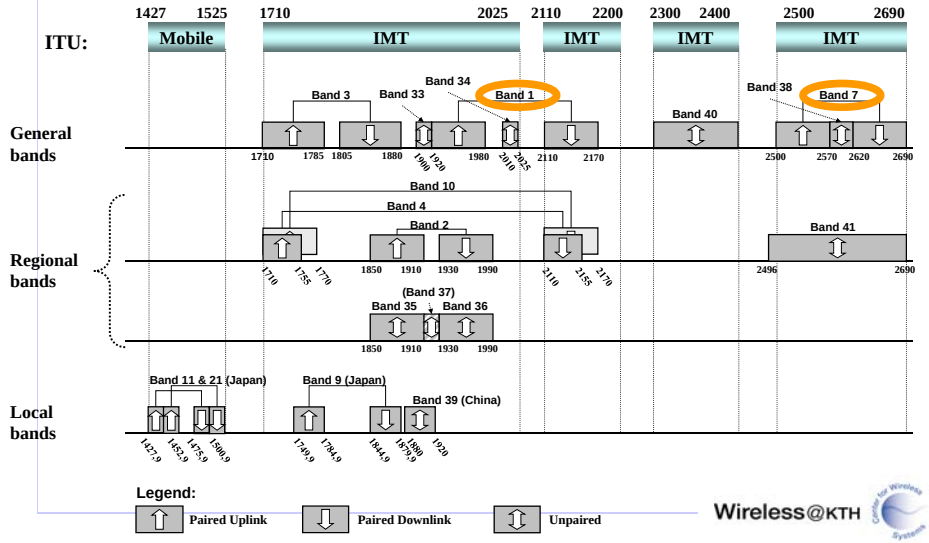
Supported Frequency Bands



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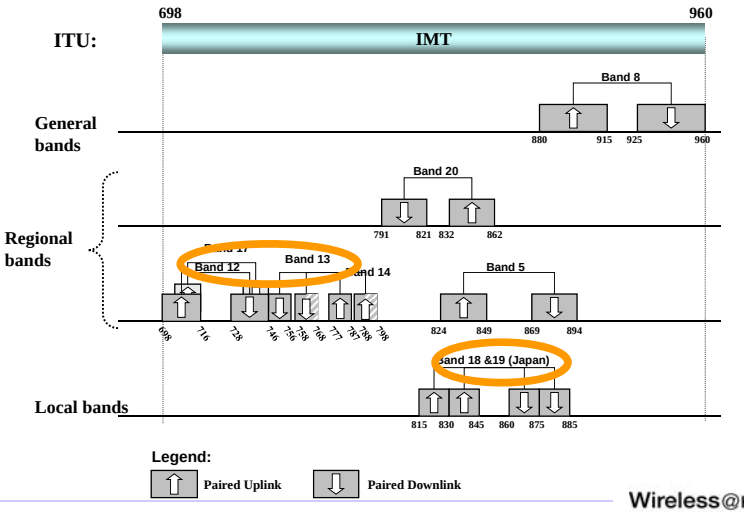
Supported Frequency Bands



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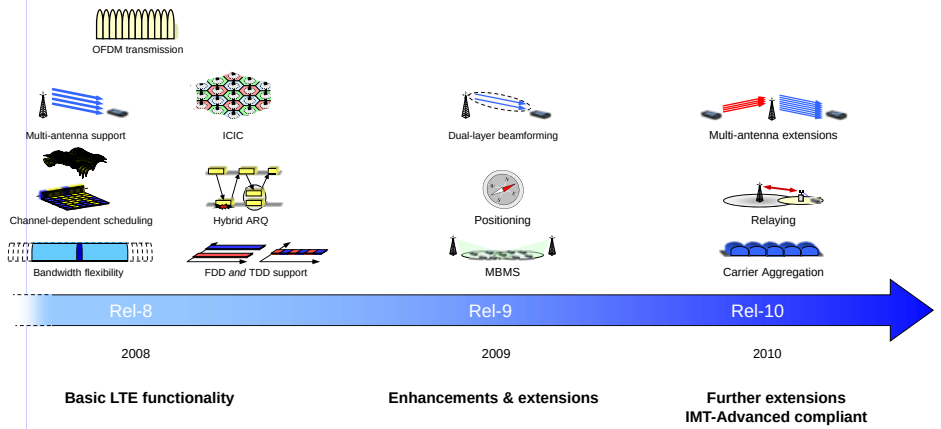
LTE – Continuous Evolution



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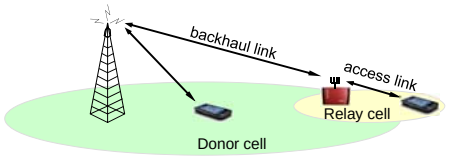
Relaying

- Repeater
  - Possible already in Rel-8, simply amplifies and retransmits recevied signal
- Relaying (added in Rel-10)
  - Relay = small base station connected to RAN using LTE radio resources
  - Mainly interesting if fibre/microwave backhaul is more expensive than using LTE spectrum



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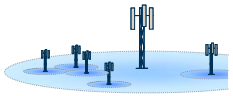
HetNets



- *What?*
  Low power nodes placed throughout a macro-cell layout
  - *Heterogeneous Networks*

› *Why?*
High data rates ➡ dense infrastructure...but non-uniform user distribution
- Macro for coverage, pico for high data rates

› *How?*

› "Conventional"
- Independent pico cells

› "Relay"
- Independent relay cells
- Relay connected to macro

› "RRU"
- Remote "pico antenna", processing in macro
- No new pico cells

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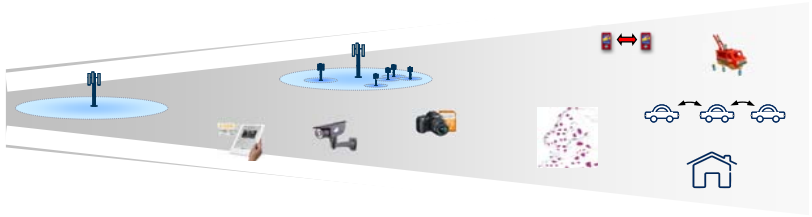
The Wireless Evolution



Additional functionality and capabilities ⇒
- Improved performance
- New application areas

Everything is connected ⇒
- 50 billion devices
- Need for new business models?

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More Reading…

Open the 3GPP specifications...

...or read The Book!

Available in English, Chinese, Korean and Japanese.

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