



FUTURE WIRELESS ACCESS

5G

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FUTURE WIRELESS ACCESS – 5G



A Heterogeneous Network

Use cases

- High-quality mobile broadband *for everyone*
- Billions of sensors
- Critical communication for infra-structure, traffic safety, medical applications, ...
- Smart homes, education, ...
- ...

Spectrum



- Sub-GHz to mmw
- Different duplex arrangements
- Different spectrum regimes

Technology

2G

3G

4G

WiFi

New “5G” radio-access technology

Deployment

- Wide-area to local-area
- Outdoor and Indoor
- Public, enterprise, residential, ...



FUTURE WIRELESS ACCESS



A wide range of requirements

High data rates everywhere



Very low latency



Very high traffic capacity



Massive number of devices

Very low device energy consumption



Very low device cost

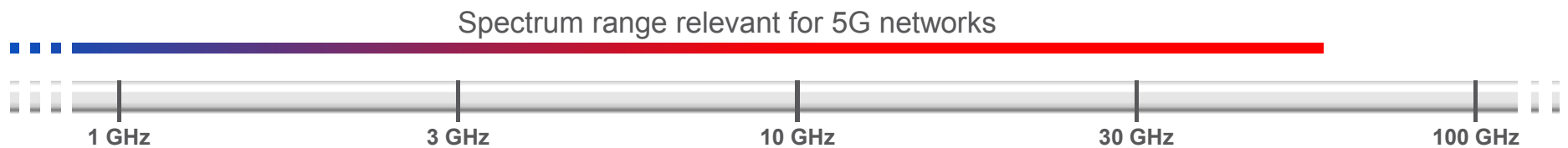


Ultra-high reliability

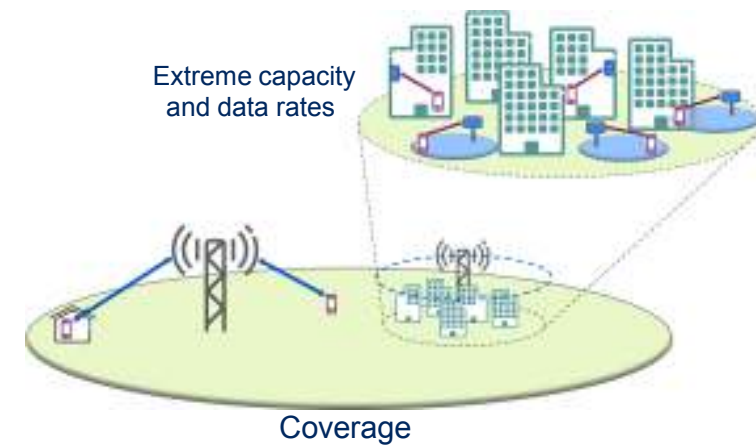


Affordable and sustainable

SPECTRUM



- › Lower frequencies for full area coverage
- › Complementary use of higher frequencies
 - For extreme capacity and data rates in dense scenarios



DUPLEX ARRANGEMENT



FDD dominating in lower (licensed) bands

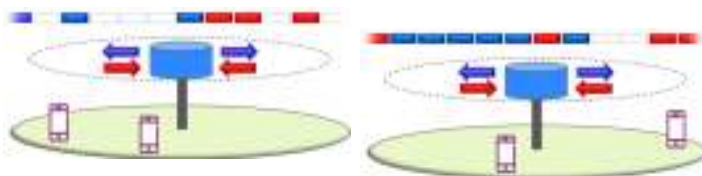
- Coverage benefits
- Avoids some nasty interference situations (BS ↔ BS, device ↔ device)

TDD more relevant for higher bands targeting very wide bandwidths in dense deployments

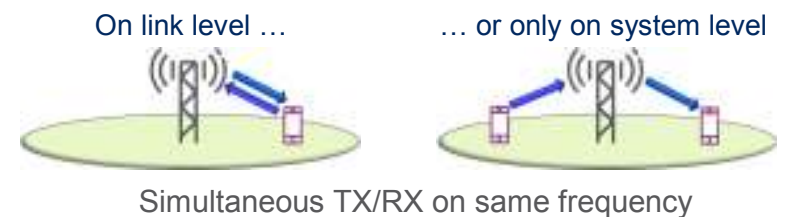
- Easier to find unpaired spectrum
- Access nodes and devices becoming more similar
- More dynamic traffic variations



Dynamic assignment of downlink/uplink resources



Full duplex may eventually be introduced



SPECTRUM ASSIGNMENT



Dedicated licensed spectrum

Will remain the backbone of IMT

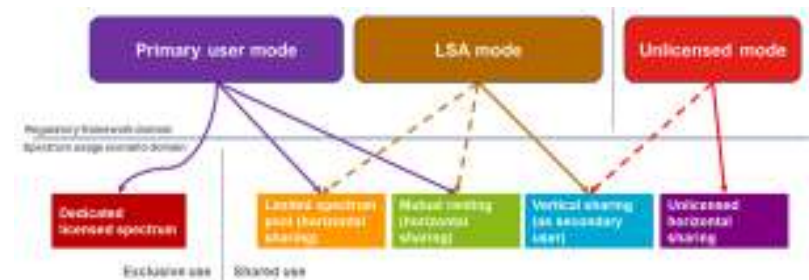
- Controlled interference ⇒ “Guaranteed” quality
- Efficient at high load
- > Complemented by unlicensed spectrum
 - To get access to more spectrum
 - WiFi or unlicensed LTE

Spectrum sharing

- > Becoming more relevant for very wide bandwidths in dense deployments
 - Difficult to find dedicated spectrum for multiple operators
 - More dynamic traffic variations



- > Unlicensed
- > Shared licensed spectrum
- > What about network sharing?



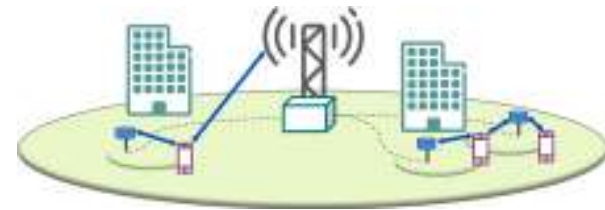
MULTI-ANTENNA "TECHNOLOGY"



- › For both low and high frequencies
- › Beam forming for coverage
- › Multi-user MIMO for capacity

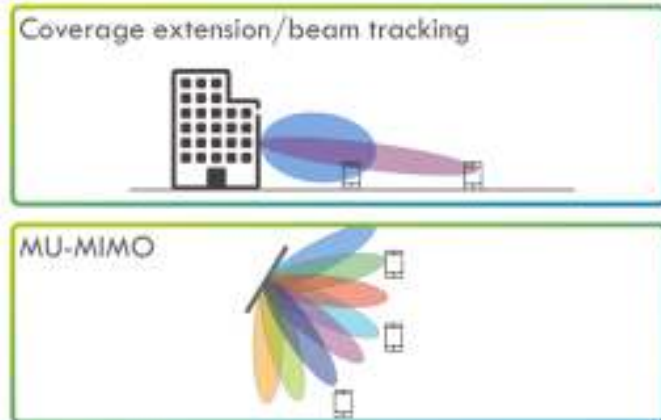
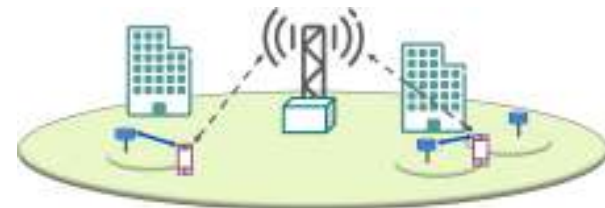
Multi-site transmission/reception

- › Multi-antenna TX/RX extended to multiple sites



Multi-layer connectivity

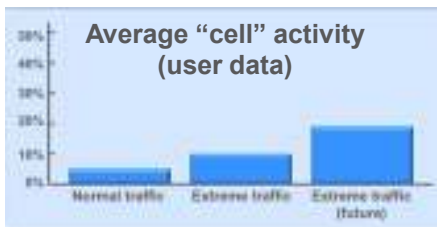
- › RRC connectivity to overlaid layer
- › Robust mobility for (ultra) dense deployments



LEAN DESIGN



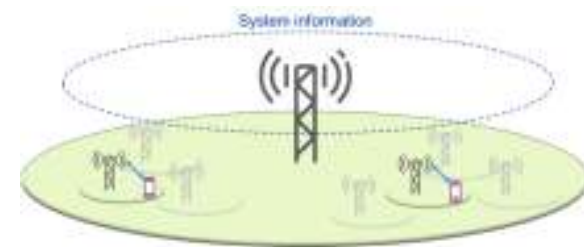
- › Networks lightly loaded on average
- › Will not change dramatically in the future
 - Much more traffic but also much more network nodes



- › Network transmissions not related to user data
 - Reference signals, system information, ...'
 - *Contributes to network energy consumption*
 - *Interference limits the achievable data rates*

Lean design

- › *Minimize transmissions not related to user data*
- › *Minimize broadcast of system information*
 - Main part provided on a per-need basis
- › *Separate user-data plane from system information*
 - System information broadcast wide-area
 - Underlaid nodes only active when user-data to convey



Higher achievable data rates
Enhanced energy efficiency

BACKHAUL



Today: Massive use of wireless backhaul

- P2P mmW line-of-sight links to macro sites using dedicated technology in dedicated spectrum

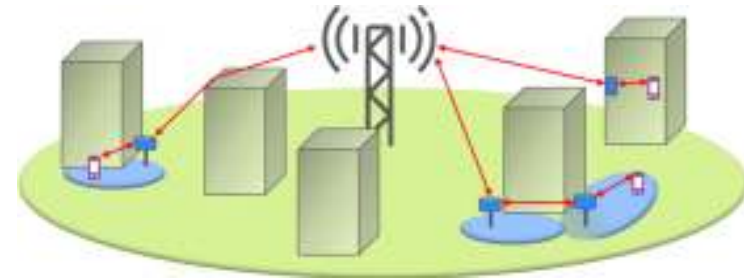


Tomorrow: Large number of low-power nodes

- Targeting very high data rates
- Indoor and outdoor
- *Backhaul is a major issue*

Access/Backhaul integration

- › Same technology for access and backhaul
- › Same spectrum for access and backhaul
 - mmw bands as well as lower frequencies



- › Do not distinguish between access and backhaul
 - Get from point A to B without a wire

DEVICE-TO-DEVICE COMMUNICATION

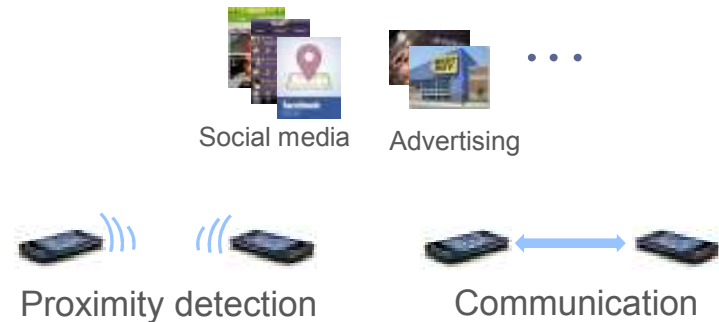
Already in LTE

Public Safety



In and outside network coverage

“Commercial” applications



Always under network coverage

Why D2D?

DEVICE-TO-DEVICE COMMUNICATION

“Today”

Mainly high-power stationary base stations above roof-top



Low-power, typically non-stationary devices
outdoor on street-level and indoor

Radio-wise a clear difference
between base-stations and devices!

“Tomorrow”

Still many high-power base stations above roof-top



But more and more low-power base stations
outdoor on street-level and indoor ...

... and even non-stationary
“base stations” ...

... at least some of which may be user deployed

Radio-wise not so clear difference
between base-stations and devices!

What is a “base station” ?

What is a “device” ?

BASE STATIONS VS. DEVICES?



- › Maybe one should not differ between “base stations” and “devices” ...
... but rather between “high-power” nodes and “low-power” nodes
- › Maybe one should not differ between downlink spectrum and uplink spectrum ...
... but rather between “high-power” spectrum and “low-power” spectrum?
- › Maybe there should just be different types of “devices” communication with each other?
 - Some devices move around, some do not!
 - Some devices provide wired connectivity, some do not!
 - Some devices “belong” to operators, some do not!
 - ...

Or maybe not?



Thank you!