mmW Small Cells: Challenges and opportunities

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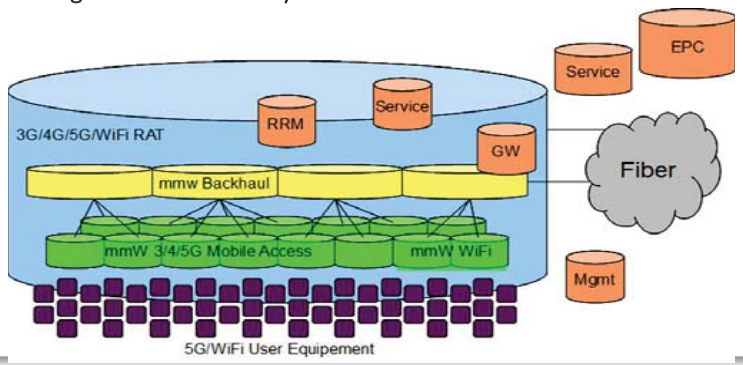
Beyond 2020 Networks: Open Challenges & Opportunities

Heterogeneous network with mmW small cells and backhaul

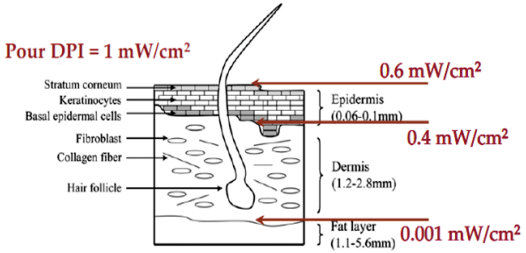
mmW Small Cells can provide up to:

- **250 Mbps** of typical data rate per user (a factor x25 compared to LTE)
- **mmW wireless backhaul : 10 Gbps** aggregate capacity (a factor x10)
- **15 Gbps peak** capacity
- **seamless combination** WiFi and 3GPP **small-cell technologies** and is managed and **overlaid** by LTE or **5G macro network**



Blue Radio: EMF Reduction over all Network

- **High-directivity beam-steering antennas**:
  - significant **benefit in terms of EMF exposure** of the general public
  - very weak power densities will be radiated in unintended directions
- **high free space attenuation** and atmospheric absorption
- **Reduced skin penetration (with mmW)**
  - very short (< 2 mm, Fig. 6), which explains why no potential health effect has been identified to date for such power densities



Skin penetration @60GHz (source: IETR/Inserm)

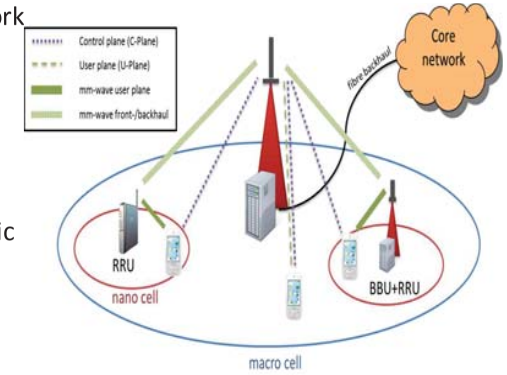
Green Radio: Reduction of power consumption

Reduction of the power consumption of the access and small cell backhaul links

- reduced emitted power (energy per bit in nJ/bit)
  - **factor of 100** for the **access link**
  - **factor of 10** for the **back-haul link**.
- **directive antennas** in the **short distance links** (user access and small cell backhaul) results in:
  - more efficient transmitter implementation
  - better spectrum efficiency
  - Less local interference
  - a reduction of the energy per bit in nJ/bit by

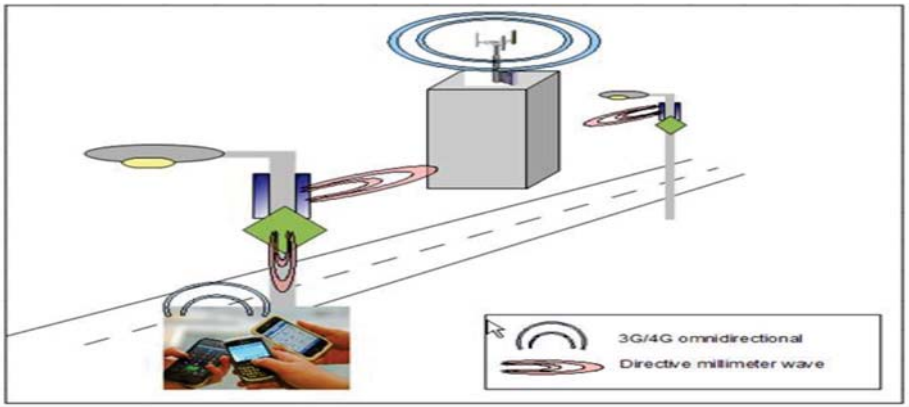
Splitting data and signalling with mmW

- Splitting the data and signalling traffics between the mmW and the 3G/4G/5G sections of the network
  - **data hungry application** traffic to fibre network available close to the small cell AP
  - **control and signalling** of the network access and hand-over can be handled by the conventional cellular network
- Advantages:
  - larger **flexibility** and **robustness**
  - **Offload capacity** from the conventional cellular network
  - **Increase the QoS** for priority traffic



mmW Wireless Backhaul

- **Wireless Backhaul** systems and access points will be typically installed close together on urban utility poles, street lamps or buildings



Unlicensed mmW Bands

mW: defined between 30 and 300 Ghz

- unlicensed band: **60-GHz (57-66 GHz) band**
- 'Light-licensed' E band: **71-76 GHz, 81-86 GHz**

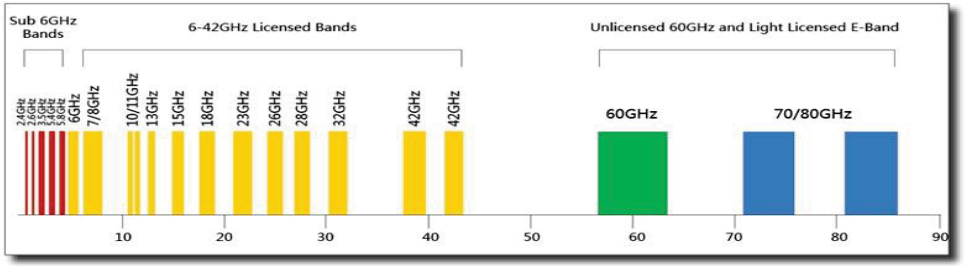


Figure: main frequency bands for wireless communications between 2 and 90 GHz

Compact Equipments at mmW

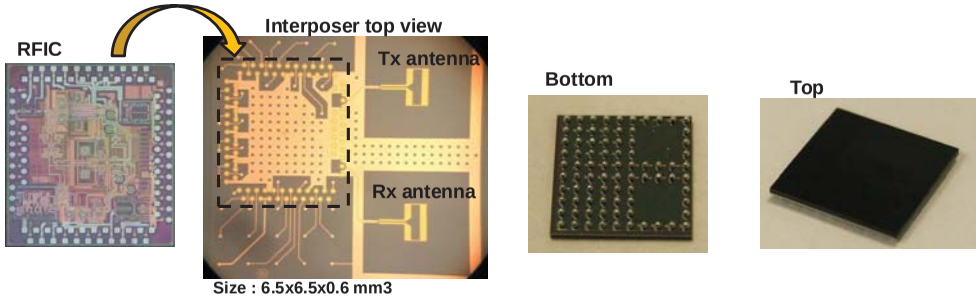
- **Radio equipments :** very compact at mmW frequencies
- **Small-cell access-points & Backhaul radio heads**:
  - compact and easy to embed in urban appliances
  - aesthetic advantage over current microwave access-points or base-stations

- Exemple:
  - for 20-50 m range communications,
  - 25 to 30-dBi antennas

→**access-points and backhauling will exhibit a typical size of 40-80 mm² only**

Exemple of Radio Module for Short mmW Range Communications

- State-of-the-art 60-GHz mmW transceiver module for short-range communications:
- High-Resistivity silicon interposer technology
- CMOS 65 nm transceiver, integrated antennas on silicon
- Small size: 6.5x6.5x0.6 mm3.
- The system operates over the 4 IEEE channels between 57 and 66 GHz.
- Demonstrated transmission of Wireless HD data frames at 7 Gbps (OFDM 16QAM) over 1 m range.
- Longer communication distances can be reached by associating this module to a focusing lens (e.g. next slide).



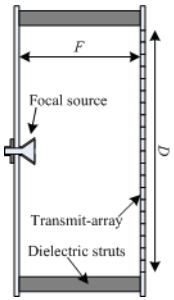
Size : 6.5x6.5x0.6 mm3

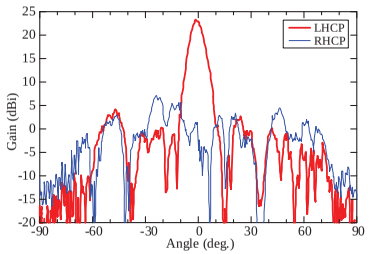
Y. Lamy, L. Dussopt, O. El Bouayadi, C. Ferrandon, A. Siligaris, C. Dehos, P. Vincent, "A compact 3D silicon interposer package with integrated antenna for 60 GHz wireless applications," IEEE Int. 3D Systems Integration Conference (3DIC), Oct. 2-4, 2013, San Francisco, CA, USA.

Exemple of High Gain Antenna for Long Range mmW Communications

60-GHz high-directivity discrete-lens antennas for long-distance P2P communications:

- **Low-cost** standard printed board technology
- Excellent demonstrated performances:
  - Wideband : > 12GHz (18.7%), **high efficiency**: 55%, high gain: 23 dBi
- Under development:
  - Electronic beam-switching for reconfigurability of the wireless link.
  - High-gain antennas: 36 dBi for communications up to 1 km range.

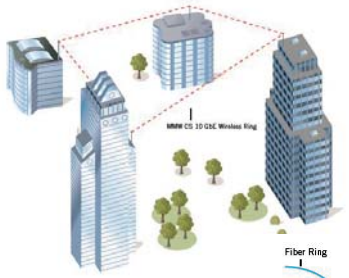




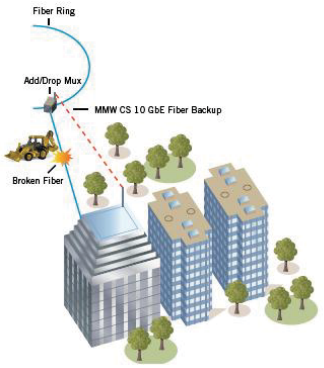
Size : 50x50x20 mm3

H. Kaouach, L. Dussopt, J. Lantéri, T. Koleck, R. Sauleau, "Wideband low-loss linear and circular polarization transmit-arrays in V-band," IEEE Trans. Antennas and Propagation, vol. 59, no. 7, pp. 2513-2523, July 2011.

Other challenges: 60-80GHz outdoor

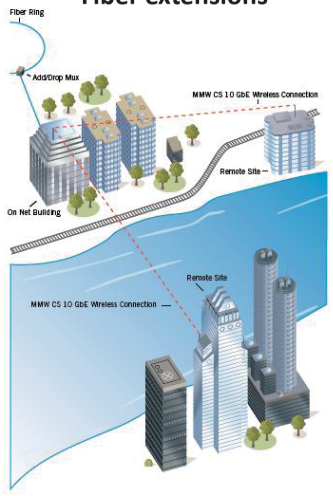


Private networks
Enterprise LAN extensions



Fiber backup
Diversity
Connections

Fiber extensions



To conclude

- mmW communications require high performance components and agile Radio resource management:

  ➔ **CEA-LETI is developing solutions and prototypes**

mmW Open Opportunities

- **High Capacity**:
  - **250 Mbps** typical data rate per user (a factor x25 compared to LTE)
  - **mmW wireless backhaul : 10 Gbps** aggregate capacity (a factor x10)
  - **15 Gbps peak** capacity
- **Green** (Low Power)
- **Blue** (low EMF) :
  - Best option from reducing the exposure to EMF
  - Allows a reduction of the traffic in the 3G/4G base stations, which also contributes to an overall reduction of the EMF
- **Spectrum**:
  - Exploit unlicensed mmW Bands
- Compact Equipments at mmW

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Thanks for your attention

Proposal for Cooperation

VTC2014-Spring SEOUL Connecting the Mobile World

- Opportunities: IEEE VTC workshop on Small Cells
  - Contact: emilio.calvanese-strinati@cea.fr

BACK UP SLIDES

Miwaves: Consortium

Research institutes
- CEA-LETI (France)
- VTT (Finland)

Universities
- Technische Universität Dresden (Germany)
- Université de Rennes 1 (France)
- University of Surrey (UK)

Large companies
- Orange (France)
- Telecom Italia (Italy)
- Nokia Solutions and Networks (Finland)
- Intel Mobile Communications (Germany)
- STMicroelectronics (France, Italy)
- Signalion (Germany)

Small-Medium Entreprises
- Sivers IMA (Sweden)
- Optiprint (Switzerland)
- TST (Spain)

Miwaves: Consortium