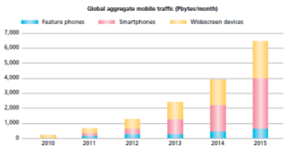
Energy Efficient E-Band Transceiver for the Backhaul of Future Networks

INTRODUCTION

Digital Agenda 2020

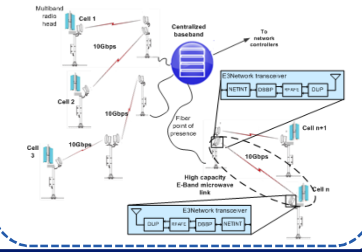
- High-speed broadband crucial infrastructure of 21st century.
- By 2020
  - 30 Mbps for all
  - 50% or more of European households subscribing to internet connections > 100 Mbps.



- The subscriber wants to use handsets in the same way as internet connections at home
  - **Demand of high and peaky bandwidth**
  - **Stress current network infrastructure**

- **Ubiquitous high-speed broadband**
  - Convergence and interoperability of mobile, wired and wireless broadband network topologies
- **Bottleneck**
  - **Backhauling infrastructure**
    - Connects core network to small subnetworks at the edge of the entire hierarchical networks
    - Only 2% of citizens in Europe are connected to ultra-fast internet via fibre networks.

Objective: High capacity 10 Gbps E-band microwave link for backhaul of Future Networks

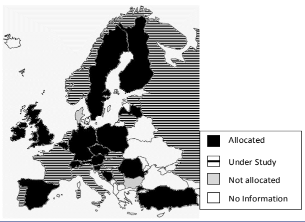


CHARACTERISTICS OF THE SPECTRUM ALLOCATED IN THE E-BAND CHANNEL

E-Band: 71-76 GHz and 81-86 GHz

- ✓ Largest segment of spectrum licensed by **FCC (FCC R&O 03-248)** and **CEPT (ECC/REC/(05)07)**
- ✓ Pencil beam transmissions
- ✓ High degree of frequency reuse
- ✓ Low atmospheric attenuation
- ✓ **High capacity microwave link**
  - 10 Gbps connectivity

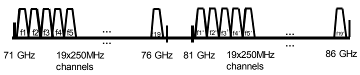
- Wireless fronthaul, backhaul and network extension
- Point-to-point fixed wireless system
- "light license"



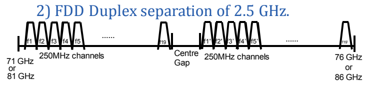
- **E-band Channel: Rec. ITU-R F.2006**
  - Channels of size multiple of 250 MHz
  - FDD or TDD arrangement
  - Duplex separation of 2.5 GHz or 10 GHz.

- **Examples of implementations**

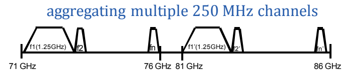
1) FDD Duplex separation of 10 GHz.



2) FDD Duplex separation of 2.5 GHz.



3) FDD Duplex separation of 10GHz, aggregating multiple 250 MHz channels



CHANNEL LOSSES IN E-BAND

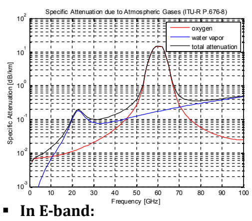
- **E-band channel:**
  - LOS
  - Losses due to Fresnel zone invasion ≈ 0

- **Free Space Loss**
  - From ITU-R P.525-2:

$$A_{FS} = 92.44 + 20\log_{10}(f) + 20\log_{10}(d)$$

f frequency in GHz
d the distance between TX and RX in km.

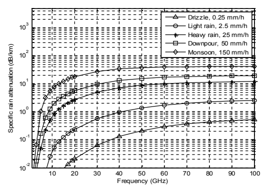
- **Atmospheric attenuation**
  - The transmitted signal is affected by atmospheric conditions: gases, dust, particles, water, etc
  - From ITU-R P.676-9, for P=1013hPa, T=15ºC, water vapour density=7.5g/m^3



- **In E-band:**

$$A_{AT} \leq 0.4 \quad \text{dB/km}$$

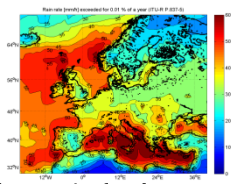
- **Rain attenuation**
  - For E-band, raindrops size ≈ radio wavelengths ⇒scattering of radio signal
- **Specific rain attenuation** (dB/km)
  - From ITU-R P.838-3:



- **Path attenuation exceeded for 0.01% of the time**:

$$A_{0.01} = \gamma_{R0.01} d$$

- $\gamma_{R0.01}$ rain rate (in mm/h) exceeded for 0.01% of the time. From ITU-R P.837-6:



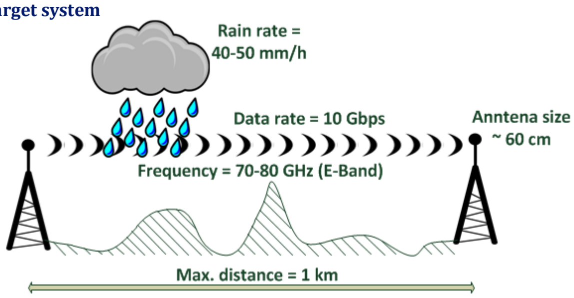
- **Path attenuation for other percentages of time *p*** in the range of 0.001% to 1%:

$$A_p = A_{0.01}\, C_1 p^{-C_2 + C_3 \log_{10} p}$$

C_1, C_2 and C_3 are constants that depend on f, as defined in ITU-R P.530-14.

SYSTEM OVERVIEW

- **Target system**



- **Technical challenges**
  - **Highly-integrated RF part for E-Band and high-order modulations**
    - SiGe mmW front-end for E-Band (71-76 and 81-86GHz Bands)
    - High P-1dB SiGe mmW PA (P-1dB=18dBm)
    - SiGe Low Phase noise Local Oscillators
  - **High resolution and sampling rate ADCs/DACs**
  - **High-speed processing in digital baseband for high wideband signals**
    - 10 Gbps data rates
    - Around 2 GHz signal bandwidth
    - Prototype using high-speed platforms

CONCLUSIONS

- A link capacity of 10 Gbps is needed for the mobile and fix backhauls
- E-band microwave could be useful for this link.
  - LOS between RX and TX can be assumed.
  - Free space loss, atmospheric attenuation and rain attenuation must be taken into account.
- A system architecture able to achieve the required system gain while offering a link capacity of 10 Gbps is challenging but feasible.

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