Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

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Re: [mmW IG Call For Papers and Participation, IEEE P802.15-03/397r2]

Abstract: [Description of document contents.]

Purpose: [mmW IG November 2003 meeting contribution]

Evolution of WLAN/WPAN towards higher frequencies and higher throughput: bridging 5 and 60GHz?

Motorola Labs – USA and France
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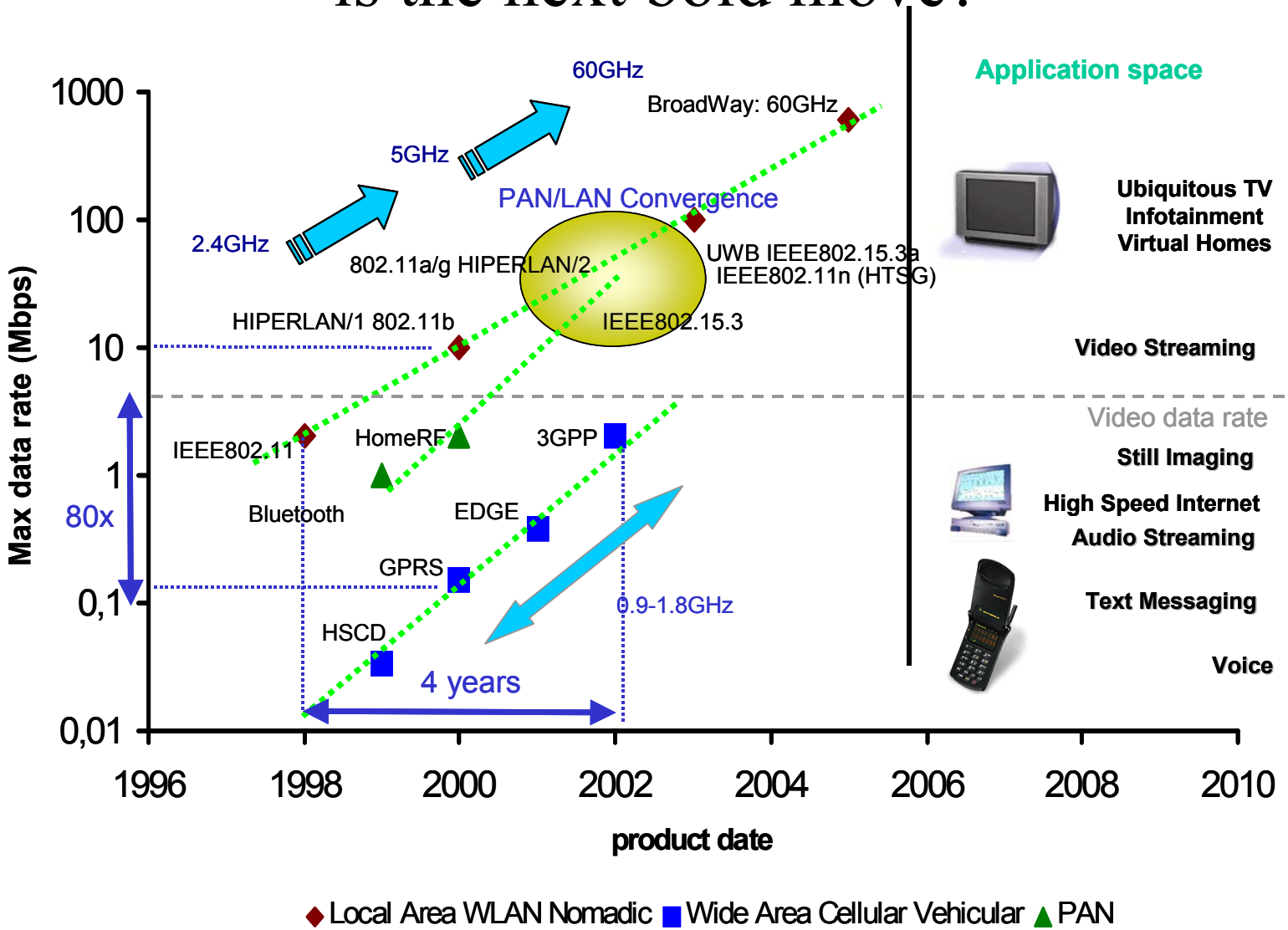
Motivation

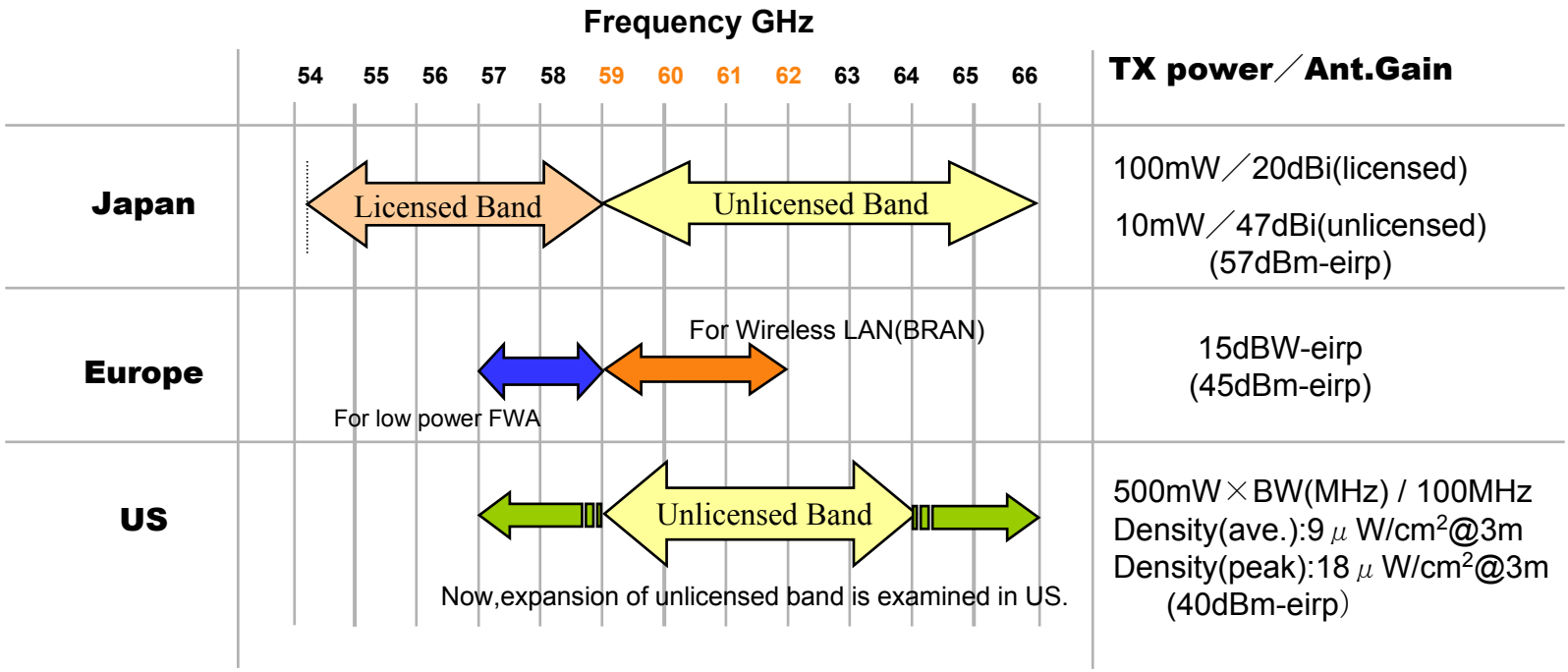
- **Observation:**
  - Current WLAN/PAN technologies is an initial necessary step stone towards massive multimedia content wireless access in very dense urban environments
- **One of the short range WLAN/WPAN goals:**
  - Provide high multimedia reliable data links in the home but also complement and enhance 3G network capabilities in order to provide public download hot spot services
- **Challenge:**
  - face large deployments of short range services and avoid spectrum congestion
- **A solution worth considering:**
  - need for higher capacity motivates the investigation of new bands providing a larger amount of spectrum available
- **Purpose of this presentation:**
  - study possible extensions of existing short range solutions in the 60GHz band in order to provide a solution to dense urban deployment granting nomadic terminal mobility in combination with higher throughput (300Mbps)

Short range technologies roadmap and evolutions: what is the next bold move?



60GHz Spectrum panorama

- Spectrum opportunity: 3GHz (59-62GHz) of bandwidth available worldwide



60GHz initiatives

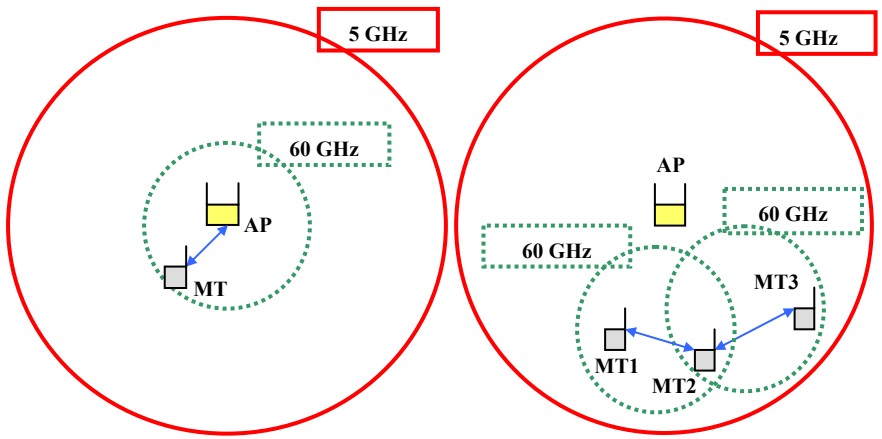
- **Some relevant collaborative projects tackling with 60GHz…**
  - The early ACTS MEDIAN
  - The completed RNRT COMINDOR (Thomson, FTR&D)
  - The on-going IST BROADWAY: bridging the 5GHz and the 60GHz bands
  - The FP6 Magnet/Winner projects : specific PHY evaluation dedicated to short range systems will be focused on mm-radio transmission
- **Standardization groups**
  - Japan: ARIB MMAC has considered the 60GHz band since the very beginning of WLANs standardization
  - Europe: ETSI BRAN is discussing creation of working group on 60GHz
  - USA: IEEE 802.15 has created a 60GHz Interest Group at the July 2003 meeting!

A possible solution for migrating towards higher frequencies: the BROADWAY project

- The vision:
  - **extend and complement 5GHz broadband wireless LAN systems in the 60GHz range for providing a new** solution to very dense urban deployments and hot spot **coverage without sacrificing the user throughput expectations**
  - **guarantee nomadic terminal mobility in combination with higher throughput**
- The key objectives:
  - bridge the 5GHz band and 59-65GHz bands **by conceiving a dual frequency hybrid WLAN**
    - **granting smooth evolution from existing 5GHz OFDM to 60GHz**
    - **allowing backward compatibility to 5GHz systems**
    - **providing total system throughput >350Mbps through bandwidth expansion**
  - **philosophy: restrict proliferation of heterogeneous technologies, 60GHz HIPERSPOT based on extensions of current 5GHz OFDM hardware**
  - **leverage existing 5GHz products for a low cost 60GHz product**

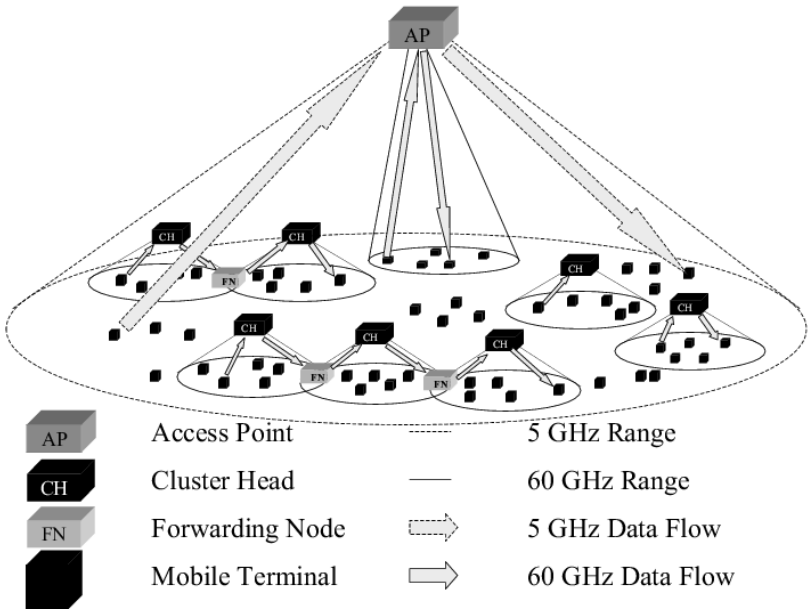
System considerations for 5/60GHz operation

- Dual mode 5/60 GHz access point (AP) covering both bands full time
- Mobile terminals (MT) utilize one band at a time
- At 60 GHz exploit P2P to achieve high data rate
- Ad-hoc clustered architecture limited to 1-2 hops to alleviate shadowing effects
- Manage ad-hoc networking using TDD friendly frame structure to preserve QoS
- Address applications for vendor hot spots, public internet access, home, enterprise, and campus environments



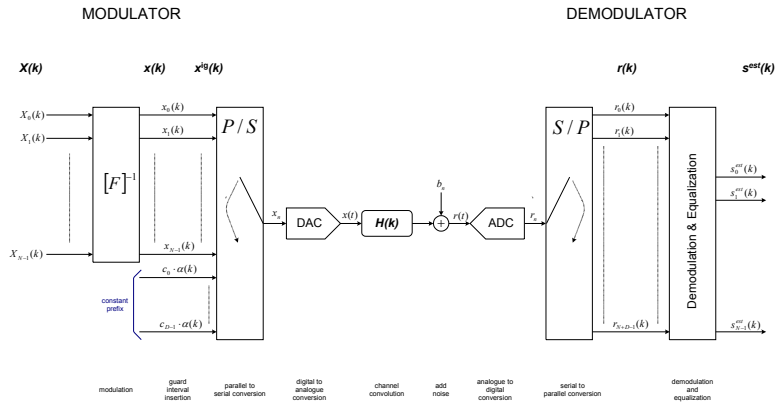
Broadway System

- **Possible architecture for dual-mode operation:**
  - Leverage centralized architecture, a clustered structure has been defined for peer-to-peer communications in the 60 GHz band
  - The AP is responsible for the management of the system in both bands
  - Using a discovery and routing algorithm at 60 GHz the AP specifies clusters, cluster heads, and forward nodes
  - DLC/CL protocol stack has also been specified for AP and MT



PHY layer evolutions

- **Higher throughput solutions will definitively be ultra wide band for coping with link budget and granting enough range.**
- **Build on current technologies: muticarrier based solution?**
  - maintain compatibility without sacrificing innovation
    - research is constantly renewing OFDM: OFDM-CDMA, ZP-OFDM, PRP-OFDM, SC-OFDM…
    - frequency hopping over small number of bands: multiband OFDM?
  - achieve full coverage through Single Frequency Networks with remote antennas solving the shadowing issues
  - be robust in presence of multipath avoiding the system to collapse in extreme situations
- **Alternate candidates**
  - MIMO: IEEE802.11n (HTSG) spectrum efficient
  - UWB: IEEE802.15.3a
- **Relevance for 60GHz:**
  - Amount of spectrum available doesn't require to strive for spectrum efficiency
  - UWB is still regulatory challenged in some regions



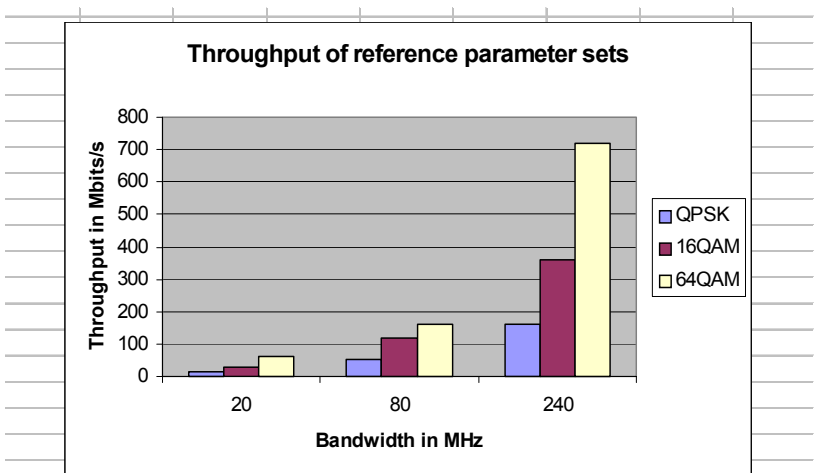
------ $\alpha_k \cdot$ Prefix | OFDM symbol $\#k$ | $\alpha_{k+1} \cdot$ Prefix | OFDM symbol $\#k+1$ | $\alpha_{k+2} \cdot$ Prefix | OFDM symbol $\#k+2$ ------

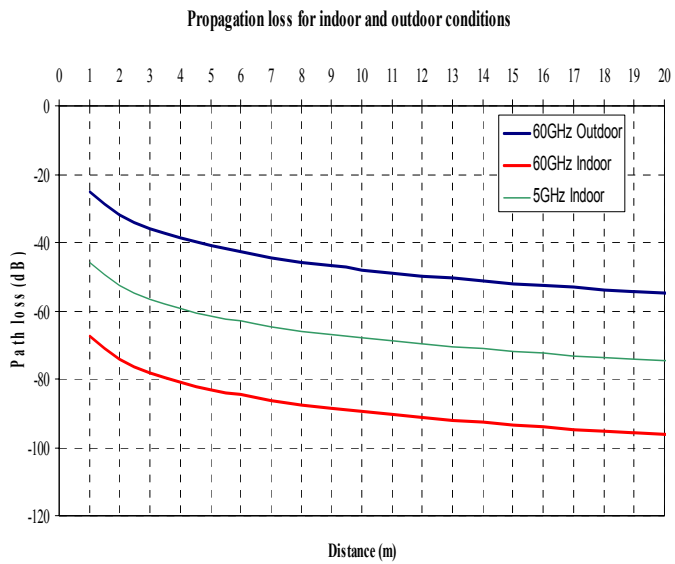
Path Loss and Range Analysis for an OFDM solution compatible with 5GHz technologies

- **Goal: maintain 5 GHz system carrier spacing**
  - Limit channel bandwidth to multiples of 20 MHz (40 to 240 MHz)
  - Limit number of subcarriers from 64 to 768 for the various bandwidths
  - Limit sub-carrier spacing from 312.5 kHz to 625 kHz
  - Enable range of 2-4m using 240 MHz and 26 m using 20 MHz
- System parameters for preliminary range analysis
  - OFDM parameters:
    - Carrier spacing: 625 kHz
    - Guard interval size: 800 ns
    - Oversampling rate 0.75
  - Transmit power: 10 dBm
  - Antenna gain: G_{Tx} =3 dBi, G_{Rx} =3 dBi
  - Rx noise figure: 8 dB
  - Hardware impairment margin: 2 dB

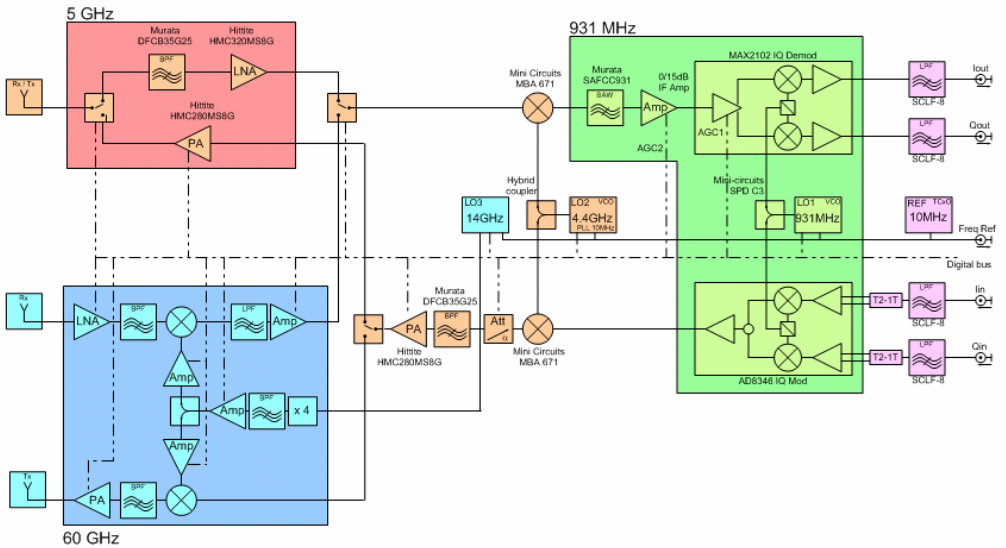
Path Loss and Range Analysis Continued

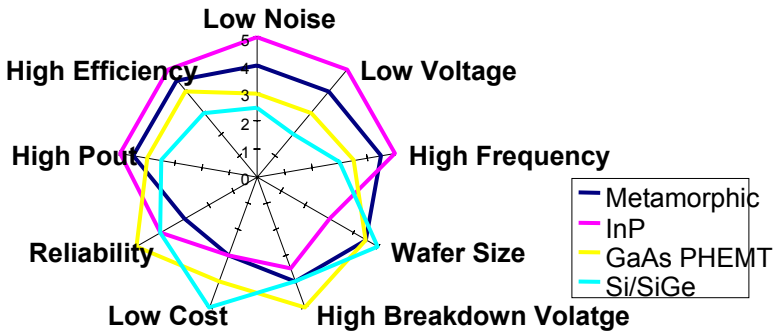
- **Conclusions:**
  - For the enumerated system parameters 5m is achievable at 360 Mbps
  - For a given bit rate an increase in bandwidth is preferable over an increase in constellation size to realize more range, i.e.
    - 180 Mbps with 64QAM, R=3/4, 80 MHz with 128 carriers → 3.3 m range
    - 180 Mbps with 16QAM, R=9/16, 160 MHz with 256 carriers → 6.6 m range
    - 160 Mbps with QPSK, R=1/2, 320 MHz with 512 carriers → 10.3 m range

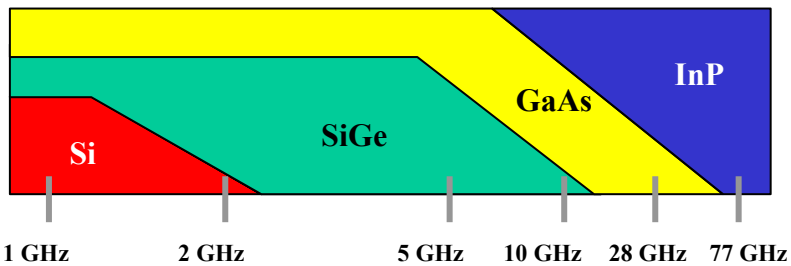




A dual band mobile terminal concept and technology trends







- 60 GHz MMIC realization has begun
- Link budget at 5 and 60 GHz has been completed

Conclusions

- Motorola is interesting in contributing to the 60GHz mm wave interest group
- This contribution proposes an instanciation of a solution for migrating to 60GHz while maintaining backward links with current 5GHz technologies
- 60GHz will likely be UWB because of the spectrum available: we need to define a rationale for picking the right modulation scheme.