Drahtlose Breitbandkommunikation – Frequenzregulierg.

Humboldt-Universität zu Berlin, Institut für Informatik,
IHP, Leibniz Institut für innovative Mikroelektronik, Frankfurt (Oder)

Vorlesung Drahtlose Breitbandkommunikationssysteme

Prof. Dr. Eckhard Grass grass@ihp-microelectronics.com
grass@informatik.hu-berlin.de

http://www.informatik.hu-berlin.de/~grass/bbk

Termine

Prüfungstermine Informatik/BBK:

https://www.informatik.hu-berlin.de/de/studium/plan-muendliche-pruefungen.pdf

Institut für Informatik - Prüfungsplan Wintersemester 2017/18

Mündliche Prüfungen

Anmeldung: **- Die Frist für die Prüfungsanmeldung endet zwei Wochen vor dem Prüfungstermin.**
- Termine für die Anmeldung entnehmen Sie bitte der Tabelle.

Abmeldung: **Die Frist für die Rücknahme der Prüfungsanmeldung endet eine Woche vor dem Prüfungstermin.**

...

Drahtlose Breitbandkommunikation

Prüfungsart	Prüfer/in	Termin/e	Ort	Anmeldung	Abmeldung
mündliche Prüfung	Prof. E. Grass	28.02.2018 09.03.2018 06.04.2018 11.04.2018	RUD 25, 4.323	- ab: 29.01.2018 - bis: siehe Hinweis oben - bei: Frau Schoch RUD 25, 3.302	- bis: siehe Hinweis oben - unter: schochsi@informatik.hu-berlin.de

Wesentliche Prüfungsthemen:

- **Shannons Kanalkapazitäts-Gleichung**
- **Friis Pfadverlust Gleichung**
- **Link-budget Berechnung**
- **Kanaleigenschaften und Kanalmodellierung**
  - Delayspread
  - Dopplerverschiebung
  - Frequenzoffset
- **Modulationsarten**
  - AM, FM, PSK, QAM
  - Spread Spectrum, CDMA
- **Struktur und Funktionsweise eines OFDM-Basisbandprozessors**
  - Modulation, Kanalkodierung
  - Synchronisation, Kanalschätzung / -Entzerrung
- **Entwurf eines OFDM-Systems**
  - Guardintervall / Cyclic Prefix
  - Unterträgerabstand
  - Anzahl der Unterträger

Welche Vereinfachungen wurden im Praktikum getroffen?

1. Feste Framegrösse (4+20 OFDM Symbole)
2. Kein Signalfeld (Parameter werden per Hand festgelegt)
   - Modulationsart (BPSK, QPSK, 16 QAM, 64 QAM)
   - CodeRate / Punktierung (1/2, 2/3, ¾, …)
3. Kein Scrambler implementiert -> lange Sequenzen von ‚0‘ oder ‚1‘ können Probleme verursachen
4. Kein Interleaver implementiert -> Burst-fehler können Probleme verursachen
5. Keine Automatic Gain Control (AGC) implementiert -> Empfänger-Verstärkungseinstellung per Hand)
6. Für eine echte Implementierung ist Festkomma-Arithmetik notwendig -> Skalierung der einzelnen Parameter muss sorgfältig gewählt werden, um overflow/underflow zu vermeiden.
7. Optimierung notwendig für:
   - Verarbeitungsleistung
   - Puffergrössen
   - Antwortzeiten (Acknowledgement) …

Implementierungsaspekte: Averaging Filter

A great advantage of the moving average filter is that the filter can be implemented with an ***efficient*** algorithm which is very ***fast!***

Example: 9-point moving average filter:

y[30] = x[26] + x[27] + x[28] + x[29] + x[30] + x[31] + x[32] + x[33] + x[34]

y[31] = x[27] + x[28] + x[29] + x[30] + x[31] + x[32] + x[33] + x[34] + x[35]

x[27] to x[34] must be calculated for y[30] and y[31] !

If y[27] has already been calculated, the most efficient way for y[31] is:

y[31] = y[30] + x[35] - x[26]

General equation:
y[i] = y[i-1] + x[i+p] - x[i-q]; with: p = (M - 1) / 2, q = p + 1

From: Embedded Systems 2002/2003 (c) Daniel Kästner.

Implementierungsaspekte: Complex Multiplication

Aufgabe: ***(a + jb) * (c + jd)***

Standardlösung:

= a*c – b*d + j(a*d + b*c)

- 4 Multiplikationen!
- 2 Additionen

Alternativ (besser):

p1 = (a + b) * (c + d)

p2 = (a*c)

p3 = (b*d)

= p2 –p3 + j(p1-p2-p3)

- 3 Multiplikationen!
- 5 Additionen

Frequenzy Regulation

International Telecommunication Union – ITU (UN):
Radio Regulations – International Treaty
Updated in World Radiocommunication Conferences – WRCs (ca. every 4 years)

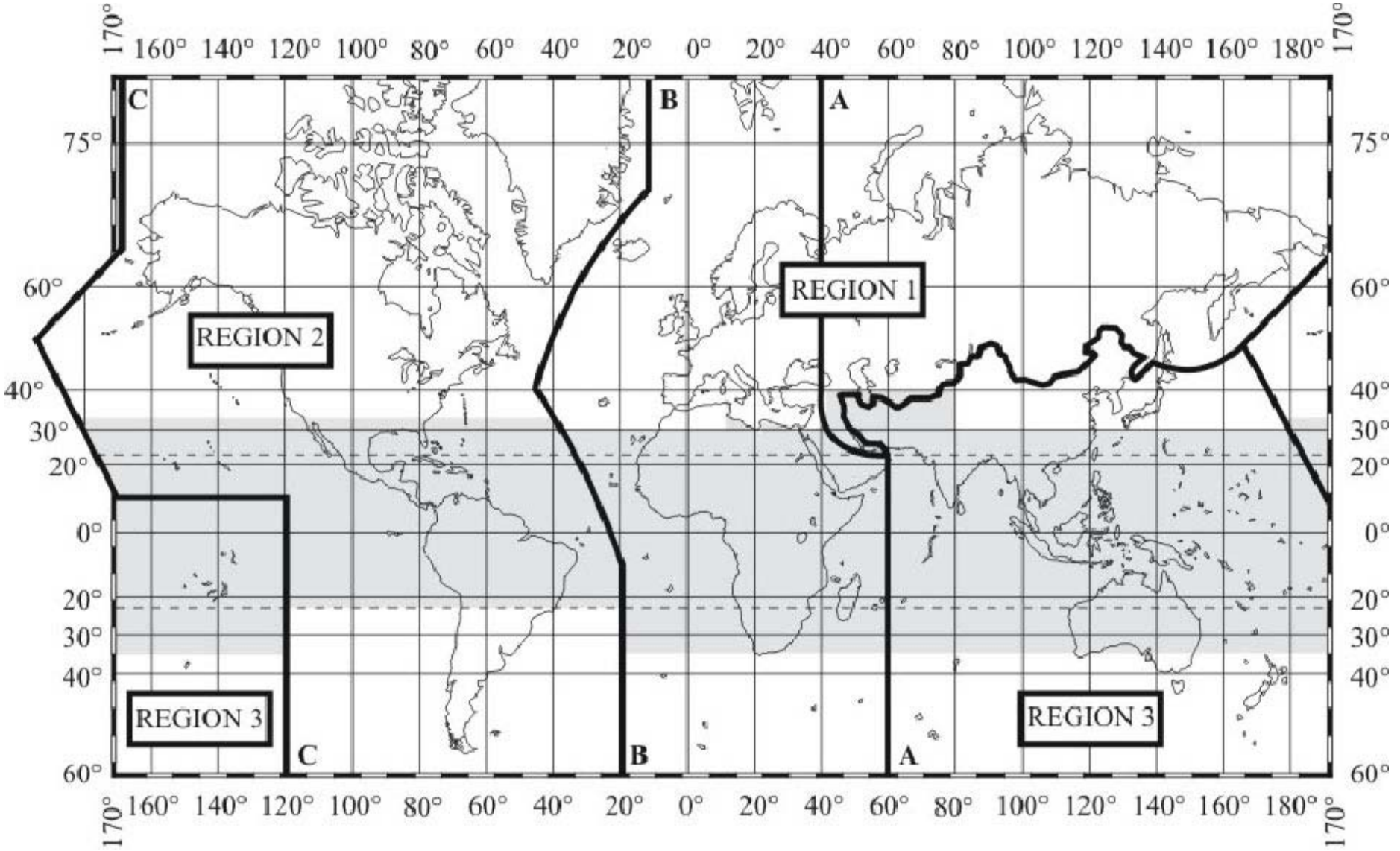
USA
FEDERAL COMMUNICATIONS COMMISSION (FCC)
OFFICE OF ENGINEERING AND TECHNOLOGY (POLICY AND RULES DIVISION)

Europa
European Conference of Postal and Telecommunications Administrations (CEPT)

- Electronic Communications Committee (ECC)
- THE EUROPEAN TABLE OF FREQUENCY ALLOCATIONS

Deutschland
- Bundesnetzagentur (BNetzA) Telekommunikation
- Frequenznutzungsplan

ITU Regions



From: http://www.itu.int/ITU-R/information/promotion/e-flash/03-2008/ITU-regions.jpg

Regional Regulations in Europe

- European Common Allocation Table (CEPT harmonization over Europe)
- Decisions, Recommendations and Reports (CEPT)
- Regulatory Directives (EC)
- Standards (ETSI, CENELEC)

From: www.iucaf.org/sschool/titus/iucafss.ppt

Example Frequency Regulation Documents

- EU Frequency Regulation Document (ECC-CEPT)
- United States ***Graphical*** Table (FCC)
- United States Textual Frequency Regulation Document (FCC)
- German Frequency Regulation Document Document: Frequenznutzungsplan (BNetzA)

Unlicensed Frequency Bands (ISM Bands)

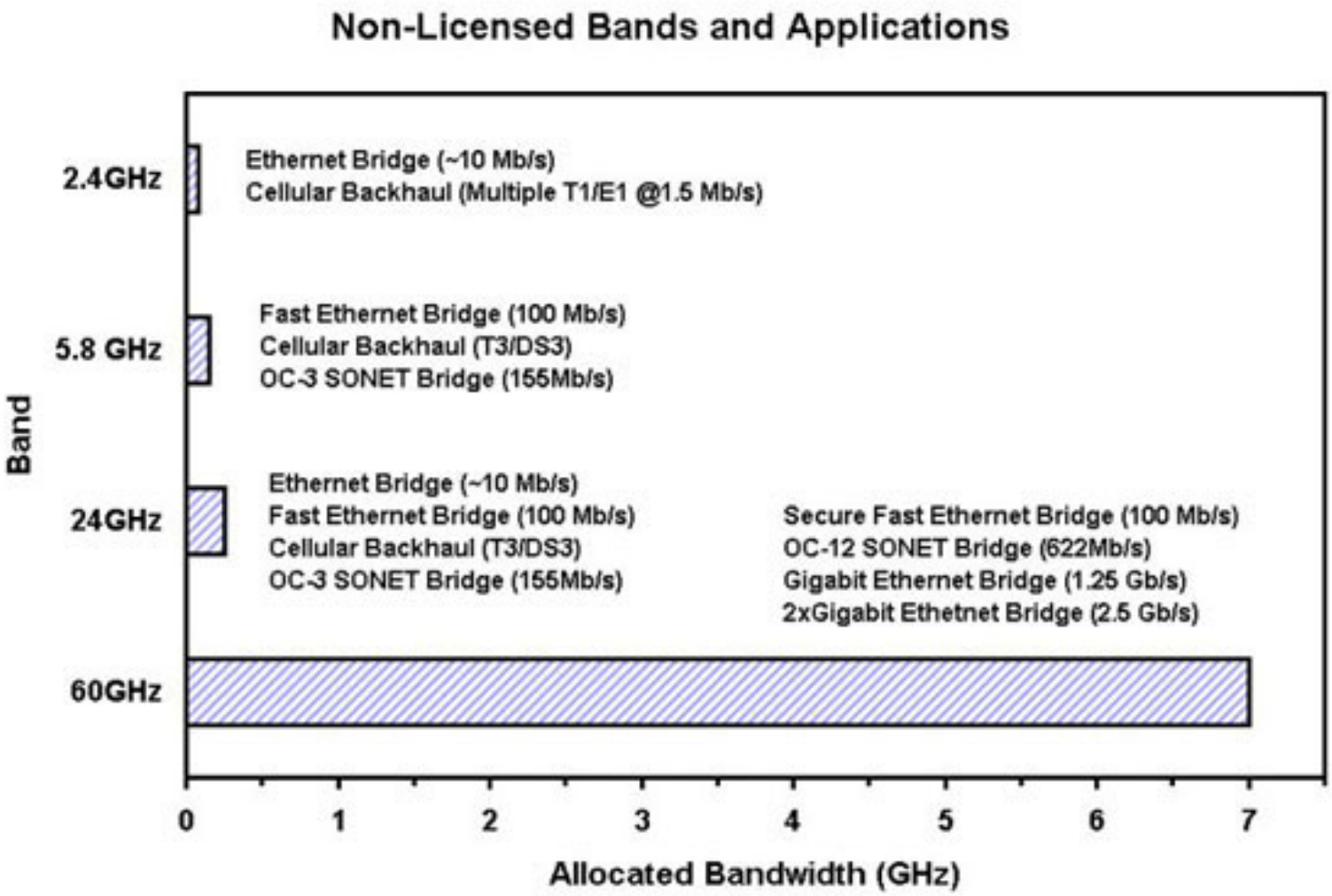
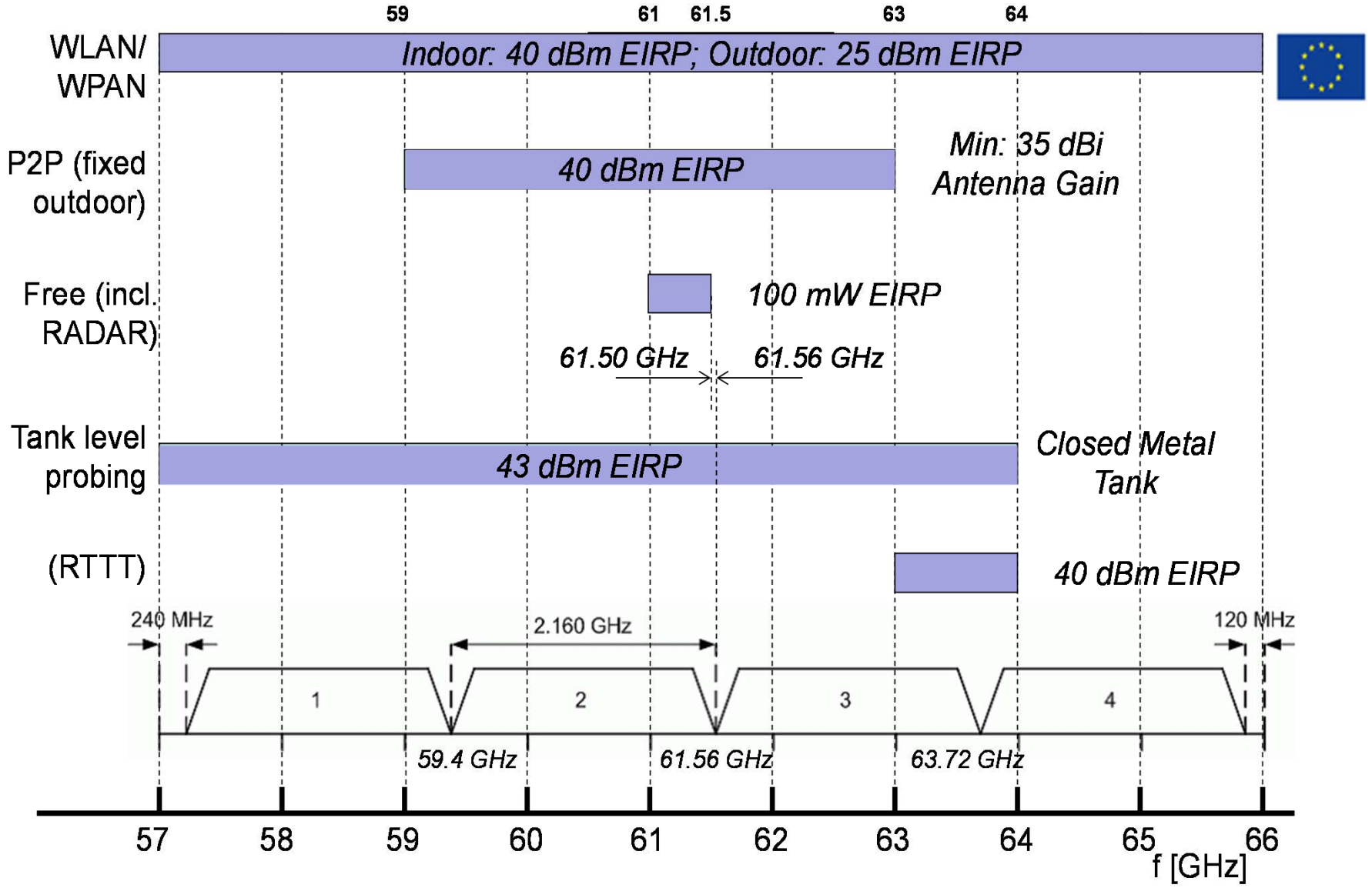


Figure 1 - Non-Licensed Bands and Typical Applications

Source: Terabeam, http://www.terabeam.com/solutions/whitepapers/benefits-60ghz.php

Frequency Regulation in EU + Channel Plan



60 GHz Standards

Currently, three international standards for wireless communication in the 60 GHz Band:

- ECMA 387 released 2008
  (max. 6 Gbps)
- IEEE802.15.3c released 2009
  (max. 6 Gbps, WirelessHD)
- IEEE802.11ad released 2012
  (max. 7 Gbps, WiGig)
- IEEE802.11ay to be released ~2018
  (30 … 100 Gbps)
- IEEE802.11az to be released ~2018
  (in-door localization)

60 GHz Standardization Groups

ECMA-387	IEEE802.15.3c	IEEE802.11ad
Status:	**Status:**	**Status:**
• *Released 2008*	• *Released 2009*	• *Proposal 05/2010*
Consortia:	**Consortia:**	**Consortia:**
• *Non, but* *Philips, Samsung, … were key players*	• *WirelessHD* • *COMPA (incl. FT + IHP)*	• *WiGig (Intel, Broadcom, …)*
Features:	**Features:**	**Features:**
• *Channel bonding* • *No common mode* • *Beamforming*	• *No channel bonding* • *Common mode* • *Beamforming*	• *WLAN Support* • *IEEE802.11 protocol* • *Up to 7 Gbps*

Main PHY Parameters for ECMA & IEEE Standards

Property or Parameter	ECMA 387 (Type 1)	IEEE802.15.3c (HSI-OFDM)	IEEE802.11ad (Draft 1.0)
Number of OFDM subcarriers	512	512	512
OFDM Sampling rate	2592 MHz	2640 MHz	2640 MHz
SC-Chip rate; Symbol rate	1728 MHz	1760 MHz	1760 MHz
OFDM Symbol duration	222.23 ns	218.18 ns	242 ns
OFDM Data rate	1.008 to 4.032 Gb/s	1.540 to 5.775 Gb/s	0.693 to 6.757 Gb/s
SC Data rate	0.397 to 6.350 Gb/s	0.361 to 5.280 Gb/s	0.385 to 4.620 Gb/s
Support of Beamforming	Yes	Yes	Yes
Support of unequal error protection (UEP)	Yes	Yes	No
Duplex mode	TDD	TDD	TDD
Channel Access in Command Exchange Period	CSMA/CA	CSMA/CA	CSMA/CA
Address space for Terminals	16 bit	8 bit	48 bit
Support of Channel-Bonding	Yes (1, 2, 3 and 4)	No	No

60 GHz Standard Documents

ECMA-387 Standard:

ECMA-387

IEEE 802.15.3c Standard

IEEE802.15.3c

IEEE 802.11.ay Standard

IEEE802.11ay
(working documents)

IEEE 802.11.ad Standard

IEEE802.11ad

Unsuccessful Standards

UWB:

- IEEE802.15.3a (OFDM <-> Pulse UWB)
  - cancelled 2006
- ECMA-368
  - High-rate UWB standard
  - No implementation known so far

60 GHz:

- ECMA-387
  - No implementation known up to now
- IEEE802.15.3c
  - No Implementation known up to now (only WirelessHD)

WLAN

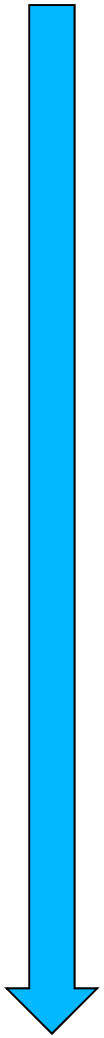
- Hiperlan II (ETSI) -> lost competition with IEEE802.11a

WMAN (WiMAX)

- IEEE802.16 -> Very small market penetration

IEEE 802 Standardization Flow

Process takes about 3 years



- Study Group
- PAR (Project Authorization Request)
- Task Group
- 1st Standard proposals
- Down-selection + Merging
- Base-line document
- Comment – resolution phase
- Sponsor Ballot
- Finished Standard -> released -> possible Amendments

Industry Consortia

- On the basis of standards,
  - usually industry consortia promote and support interoperability between devices
- Examples for industry consortia:

merged 2013

MBOA
(multiband OFDM alliance)

Conclusions

- Standards are very important to guarantee interoperability of devices
- Most popular standards define communication systems operating in unlicensed (ISM) frequency bands
- Usually industry consortia support the standard specification and the interoperability procedure
- To release a standard, about 3 years of work are required
- Generally, IEEE802.11 standards are most successful
- Frequency regulation is legally binding!!!
- Standards are not binding!!!