



Wireless Sensor Networks

0. Organization

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Technische Fakultät

Rechnernetze und Telematik

Albert-Ludwigs-Universität Freiburg

Version 16.04.2016

- Web page

- <http://cone.informatik.uni-freiburg.de/lehre/aktuell/wsn-ss16>

- Forum

- <http://archive.cone.informatik.uni-freiburg.de/forum3/viewforum.php?f=46>

- for discussions, remarks, critics, funnies, etc.

- Lecture

- Lecturers:

- Christian Schindelhauer (mostly)

- Johannes Wendeberg (localization)

- Monday, 14:15-16:00, room 101-01-009/013

- Wednesday, 08:15-09:00, room 101-01-009/013

- Exercises

- Tutors:

- Amir Bannoura

- Joan Bordoy

- wednesday, 09:15-20:00, room 101-01-009/013

- starts 27.04.2016



- Basics
 - Wireless Communication
 - Computer Networks
 - WSN technologies
 - Case studies
- Physical Layer
- Medium Access
- Routing
- Data aggregation
- Sensor coverage
- Energy & Lifetime
- Resilience
- Localization
 - ToA, TDOA, RSSI, Cell-based, anchorless

→ Wireless Sensor Systems
(Reindl)

→ lab course Winter

→ Rechnernetze / Systeme II

- Oral exam
- 30 minutes
- Questions form
 - lectures
 - exercises
- closed book exam
- Exam registration online

- <http://cone.informatik.uni-freiburg.de/lehre/aktuell/wsn-ss16>
- Slides
- Exercises
- Recordings
- General information

- Ilyas, Mahgoub, Handbook of Sensor Networks: Compact and Wired Sensing Systems, CRC Press
- Agrawa, Zeng, Introduction to Wireless and Mobile Systems, Thomson, 2003
- Schiller, Mobile Communications, Addison-Wesley, 2000
- Karl, Willig, Protocols and Architectures for Wireless Sensor Networks, Wiley, 2005
- Zhao, Guibas, Wireless Sensor Networks – An Information Processing Approach, Morgan Kaufmann, 2004
- Wu, Handbook on Theoretical and Algorithmic Aspects of Sensor, Ad Hoc Wireless, and Peer-to-Peer Networks
- Boukerche Handbook of Algorithms for Wireless Networking and Mobile Computing, CRC 2005
- research papers from the field
- more to be announced



Wireless Sensor Networks

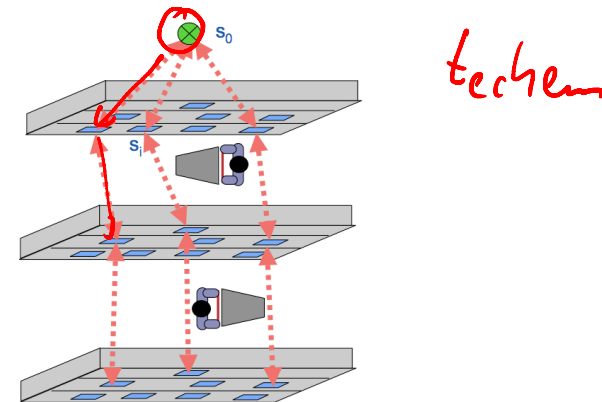
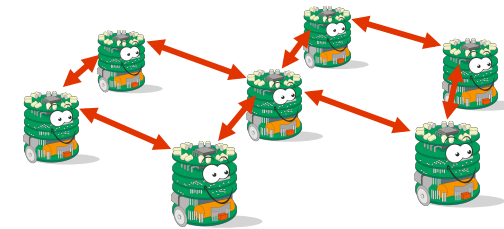
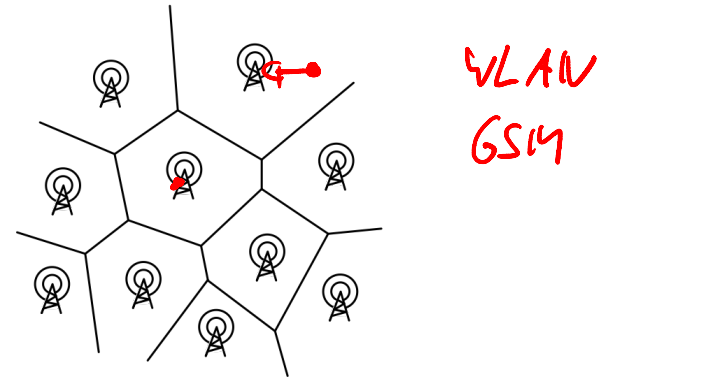
1. Basics

Christian Schindelhauer
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Networks Types

- Cellular networks
 - one or more access stations
 - each access station covers a cell
 - e.g. mobile telephones, WLAN
- Mobile ad hoc networks
 - self-configuring network of mobile nodes
 - nodes serve as end-points or routers
 - without any dedicated infrastructure
- Wireless sensor network
 - connecting sensors and actuator units wireless communicating with one or more base stations
 - base station is more powerful than other nodes



Some Relevant Wireless Networks

- GSM (Global System for Mobile Communications)
- GPRS (General Packet Radio Service)
- ○ EDGE (Enhanced Data Rates for GSM Evolution)
 - Smartphones, PDAs, Laptop/netbook, Tablets, Phablets
- UMTS (Universal Mobile Telecommunications Systems)
- ○ HSDPA (High Speed Downlink Packet Access)
 - - ~~3rd~~ generation mobile communication standard
- LTE (Long Term Evolution)
- ○ - 4th generation standard
- IEEE 802.11 a/b/g/n/ac – Wi-Fi (Wireless Fidelity) –
- ○ Wireless Local Area Network (WLAN)
 - computers, cameras, printers
- Bluetooth (IEEE 802.15.1)
- - several version, Bluetooth v4.0, ~~Bluetooth low energy~~ *→ Pico nets*

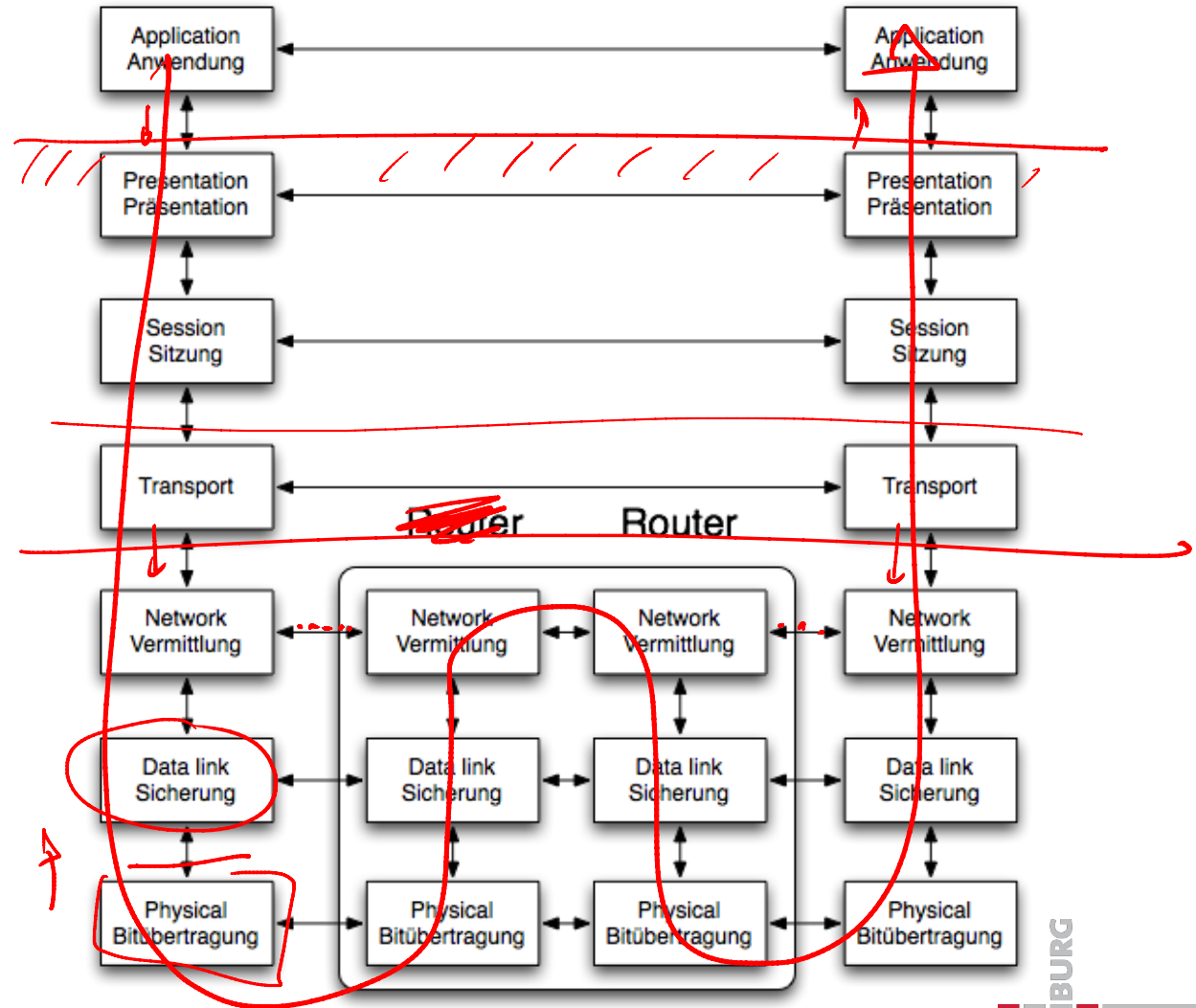


Some Relevant Wireless Networks

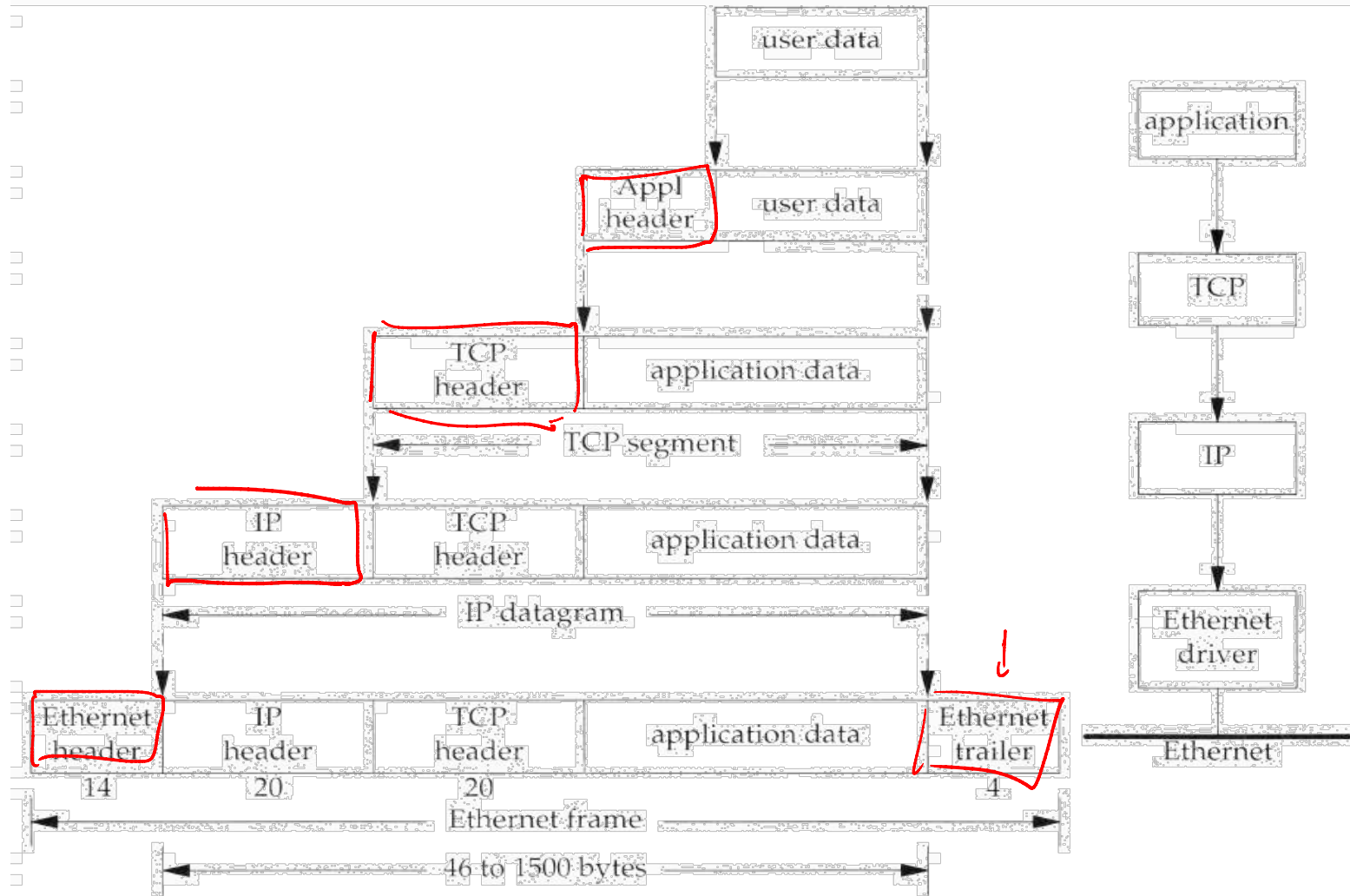
- IEEE 802.15.4 + Zigbee
 - Wireless Personal Area Network (WPAN)
 - Wireless sensor networks
 - Zigbee Alliance
 - ~~defined higher protocol layers~~
- DECT ULE (Digital Enhanced Cordless Telecommunications Ultra Low Energy)
 - adapted standard for ~~cordless phones~~
- Low-Power Wide-Area Network (LPWAN)
 - LoRaWAN (Long Range Wide Area Network)
- Narrow-Band Internet of Things (NB-IOT)
 - narrowband radio technology specially designed for the Internet of Things (GSM/LTE)
- ...

ISO/OSI Reference model

- 7. Application
 - Data transmission, e-mail, terminal, remote login
- 6. Presentation *Security*
 - System-dependent presentation of the data
- 5. Session
 - start, end, restart
- 4. Transport
 - Segmentation, congestion
- 3. Network
 - Routing
- 2. Data Link
 - Checksums, flow control
- 1. Physical
 - Mechanics, electric



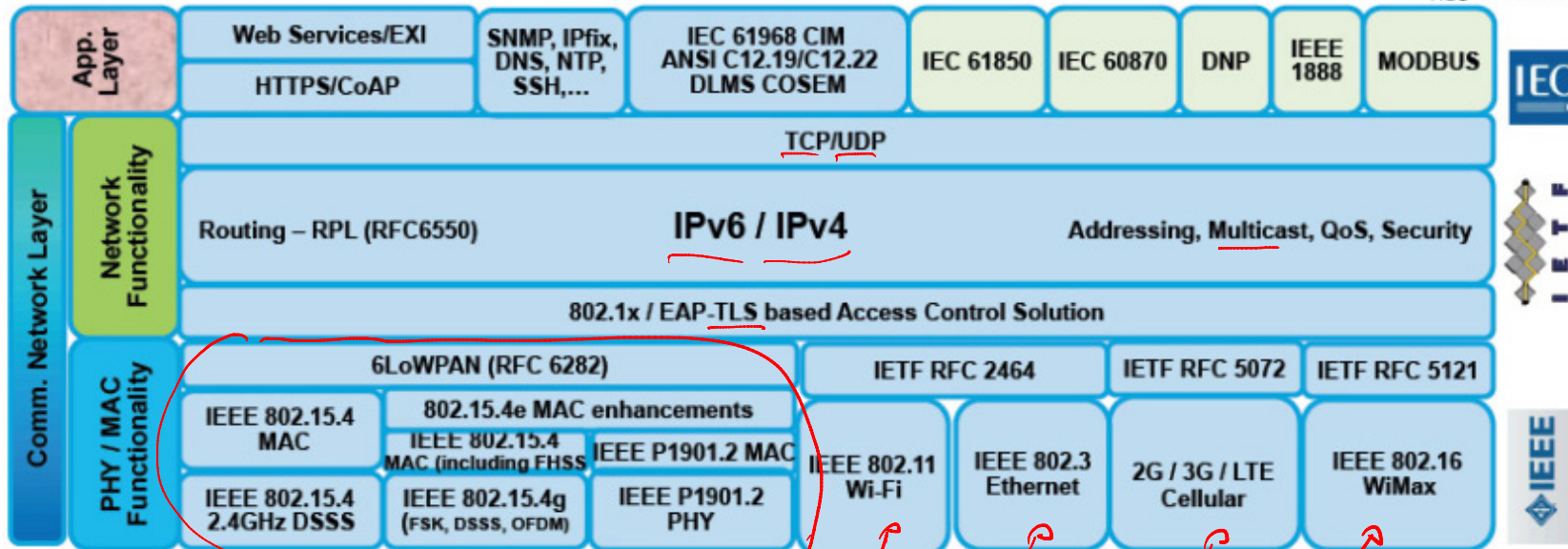
Data/Packet Encapsulation



Stevens, TCP/IP Illustrated

IPv4 32 bits
IPv6 128 bits

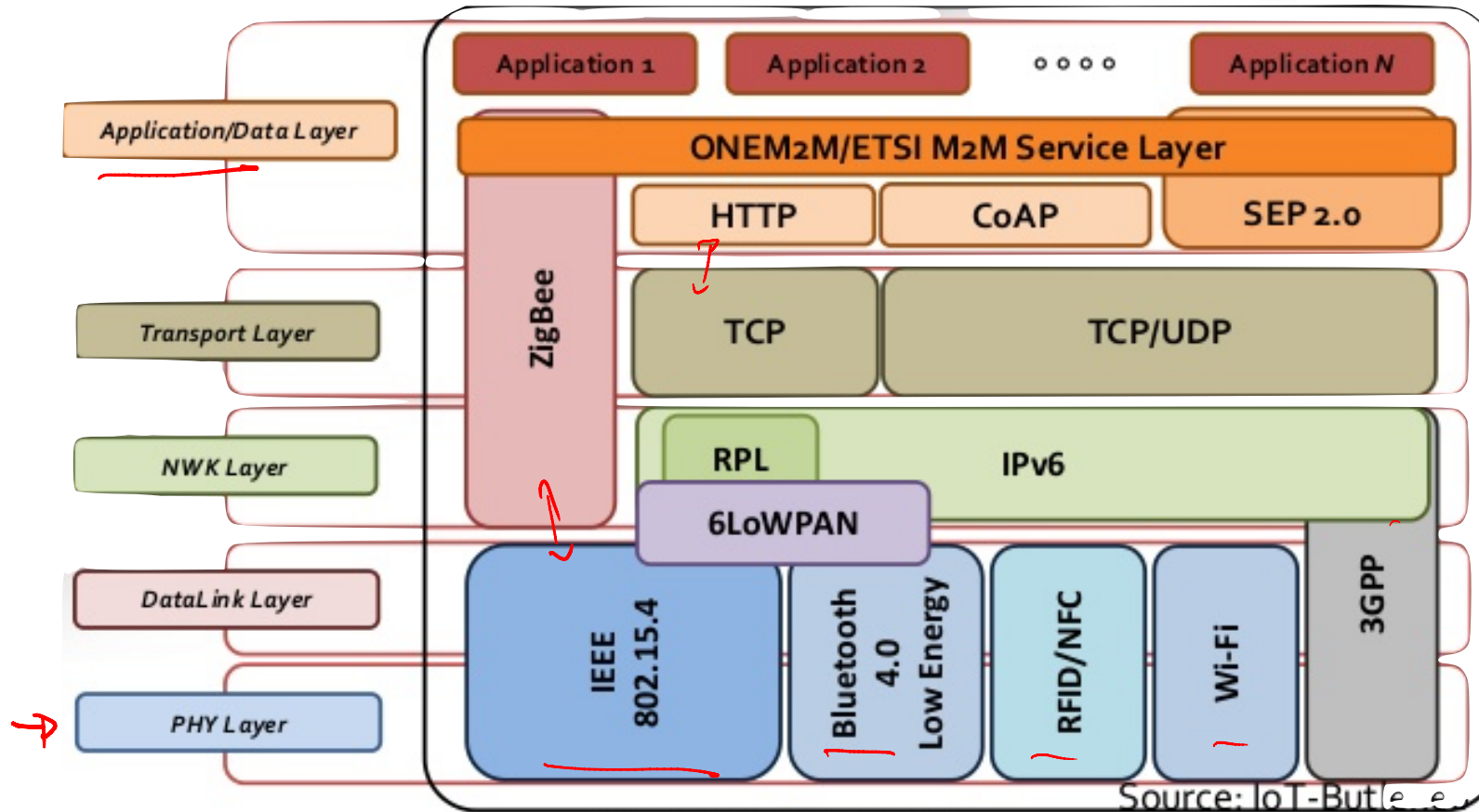
Open Standards Reference Model



The Internet of Every Thing - steps toward sustainability CWSN Keynote, Sept. 26, 2011

Example Stacks

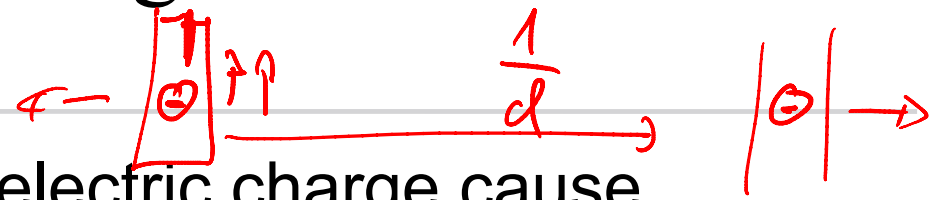
TOR



CTTC 2015 seminar by Prof. AA. Economides

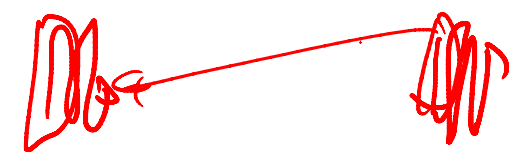
Source: IoT-But(e)...

Physics – Background



- Moving particles with electric charge cause electromagnetic waves

- frequency f : number of oscillations per second
 - unit: Hertz

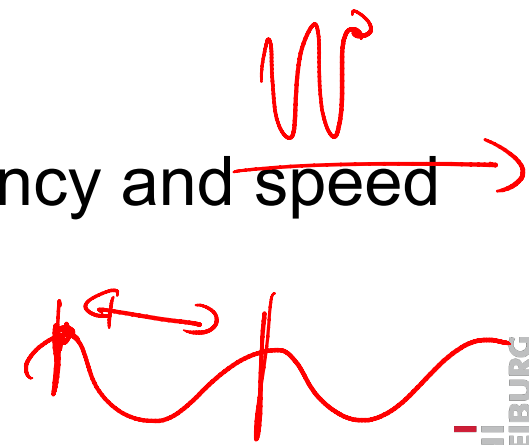


- wavelength λ : distance (in meters) between two wave maxima
- antennas can create and receive electromagnetic waves
- the transmission speed of electromagnetic waves in vacuum is constant
- speed of light $c \approx 3 \cdot 10^8$ m/s

- Relation between wavelength, frequency and speed of light:

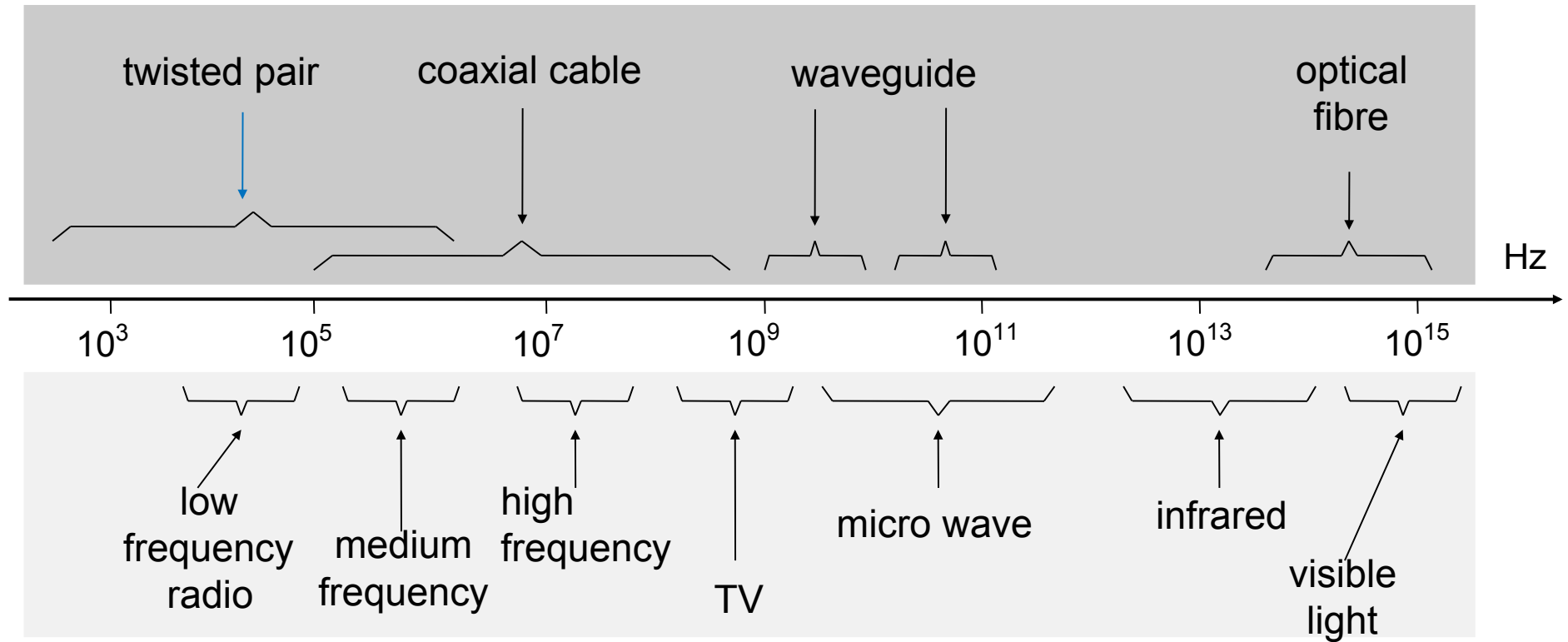
$$\lambda \cdot f = c$$

c



Electromagnetic Spectrum

guided media



unguided media

Bands

- LF Low Frequency
- MF Medium Frequency
- HF High Frequency
- VHF Very High Frequency
- UHF Ultra High Frequency
- UV Ultra Violet light

