Problems compared to fixed networks

Higher loss-rates due to interference
- emissions of, e.g., engines, lightning, in general:electro-smog

Restrictive regulations of frequencies
- frequencies have to be coordinated, useful frequencies are almost all occupied

Low transmission rates
- local some Mbit/s, regional currently, e.g., 53kbit/s with GSM/GPRS

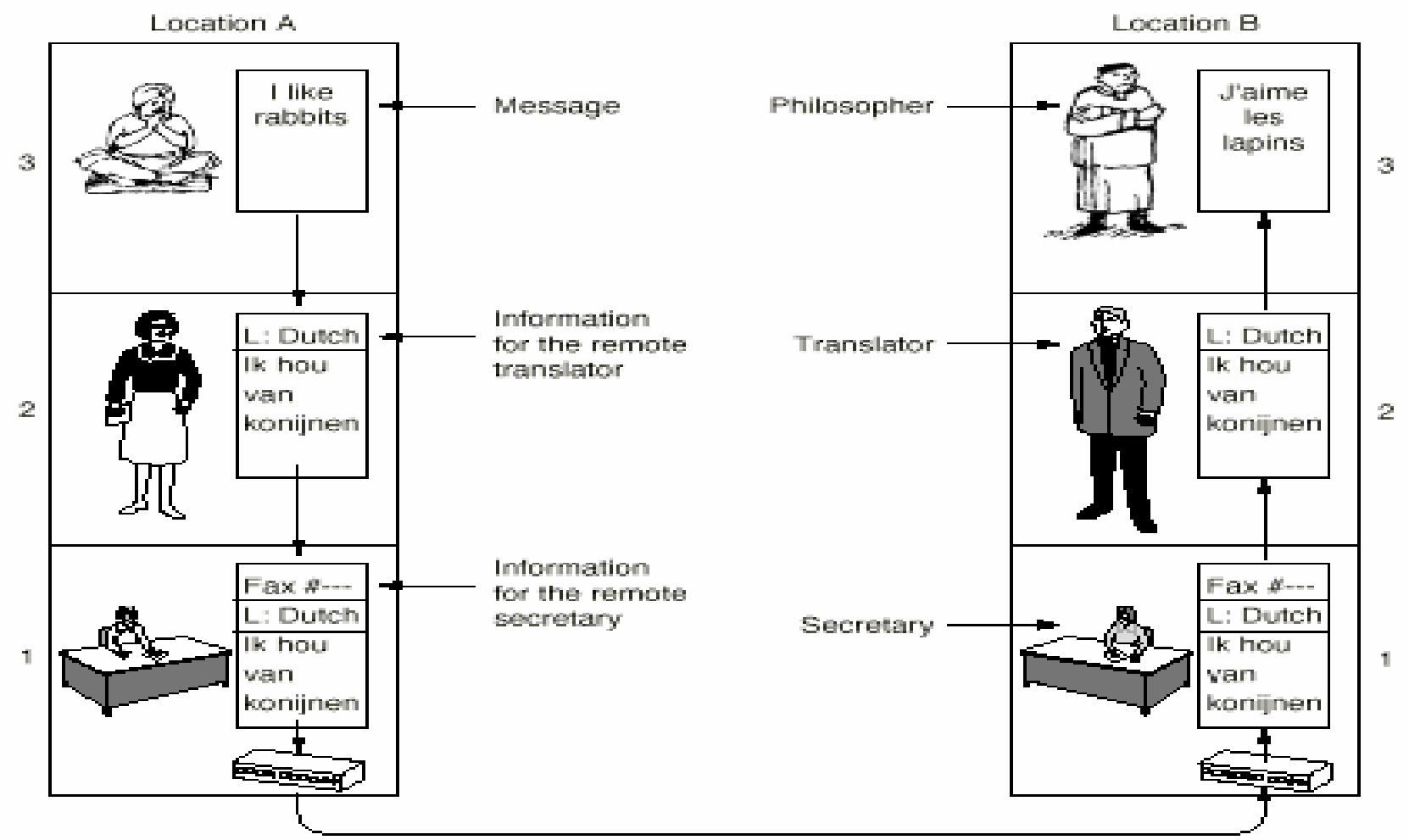
Higher delays, higher jitter
- connections asymmetric since direction dependent

Lower security, simpler active attacking
- radio interface accessible for everyone

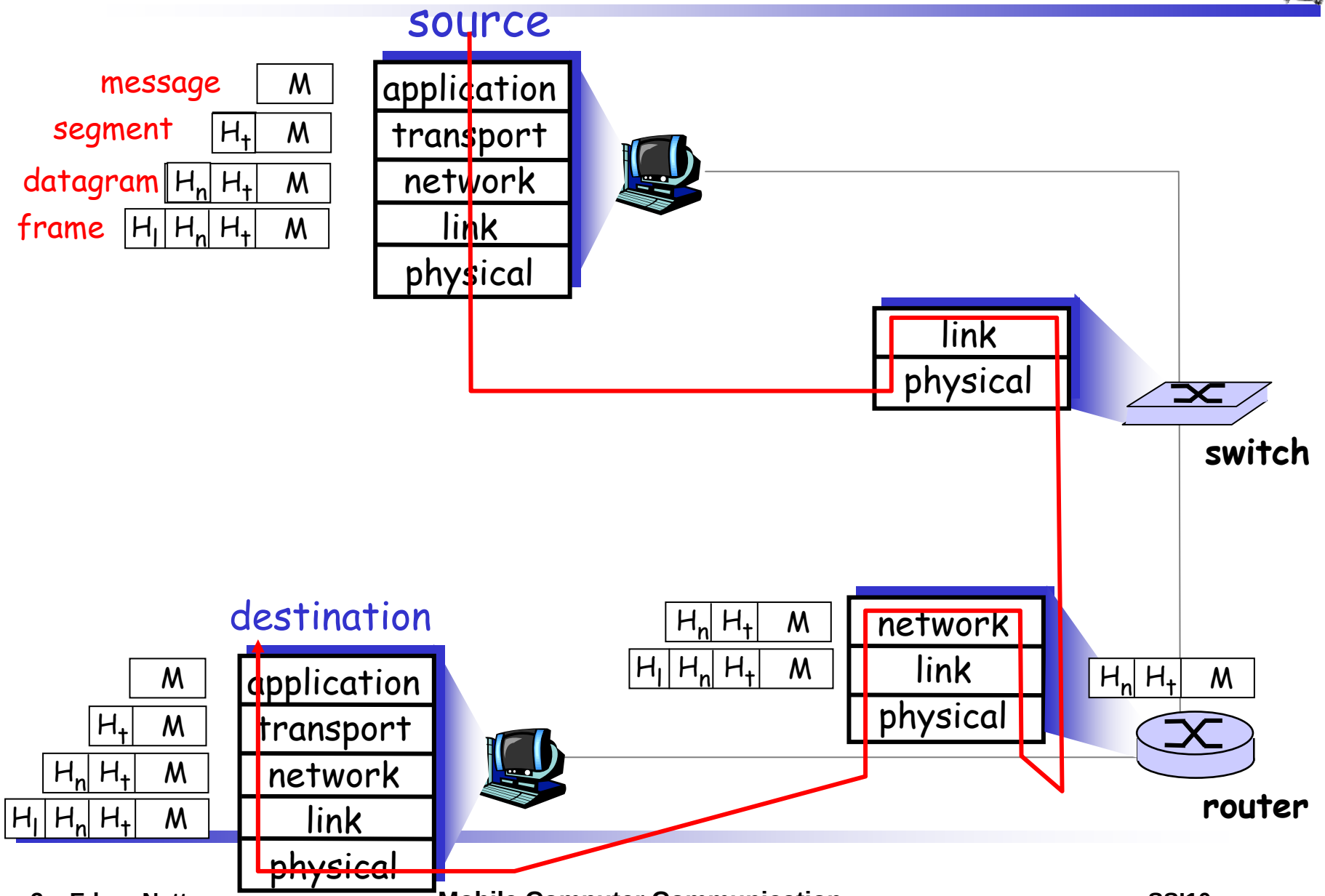
Always shared medium
- reliable access mechanisms important

Ad-Hoc-Networks
- routing, service localization, reachability

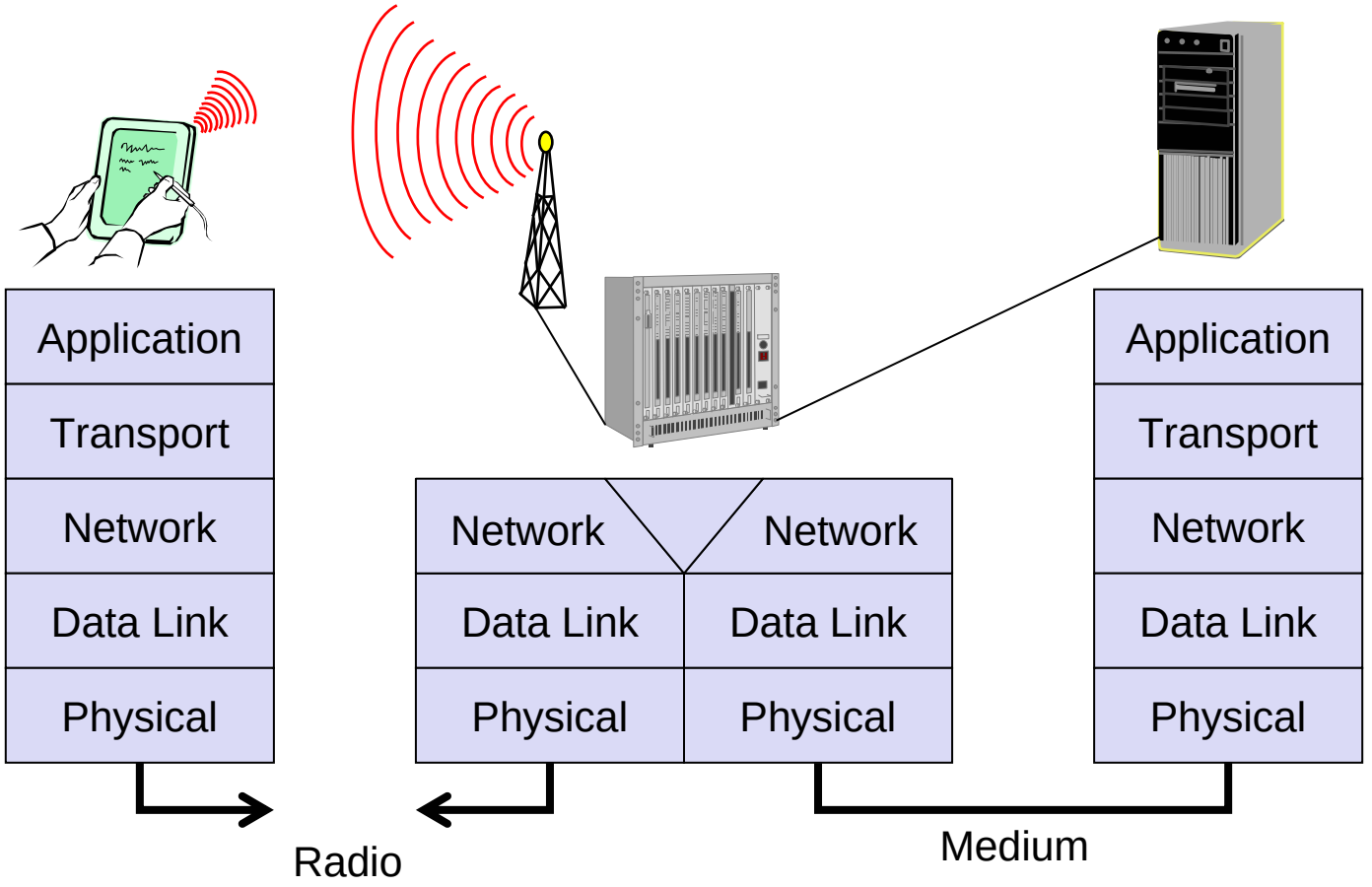
Layering: The philosopher-translator-secretary architecture



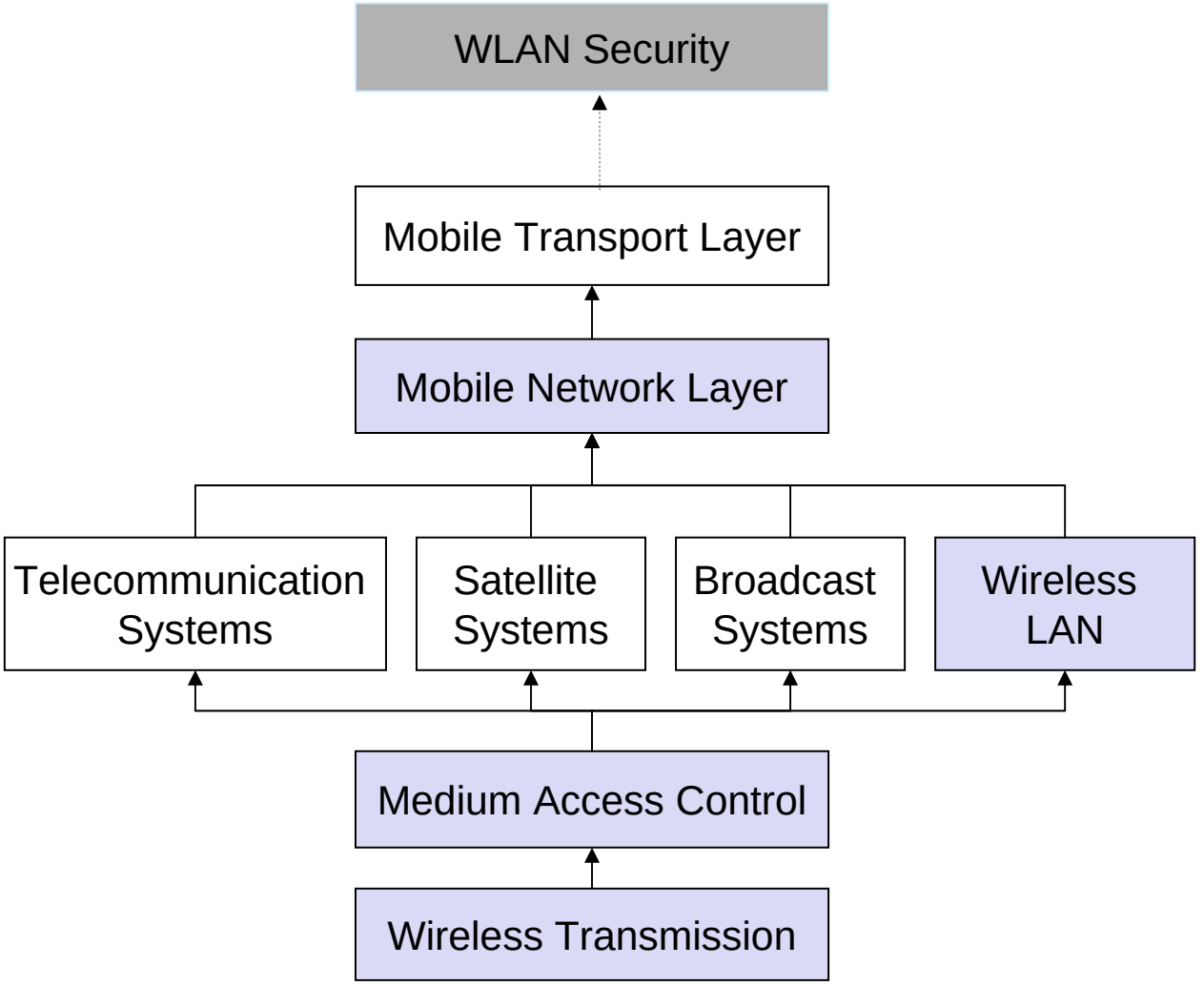
Physical path data takes and the concept of layering



Internet (TCP/IP) reference model also used



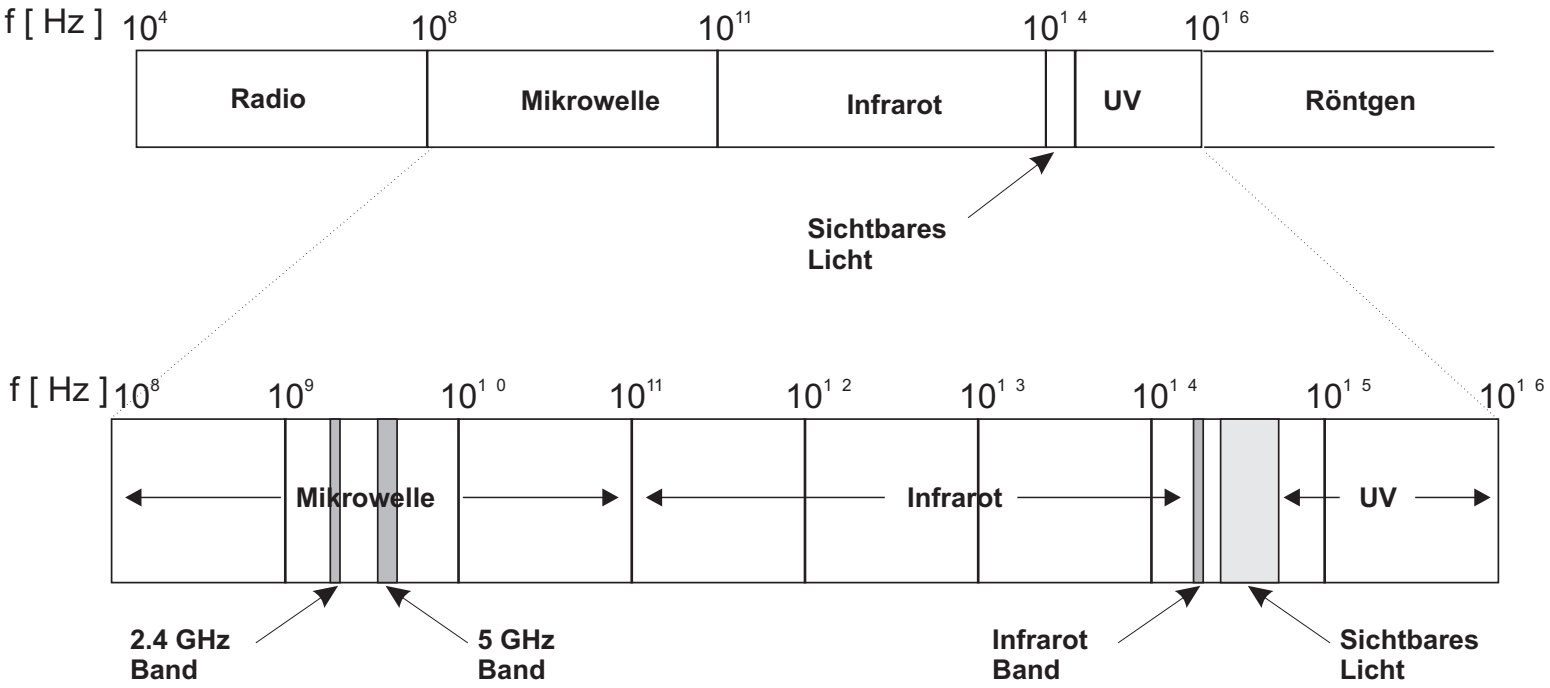
General Overview



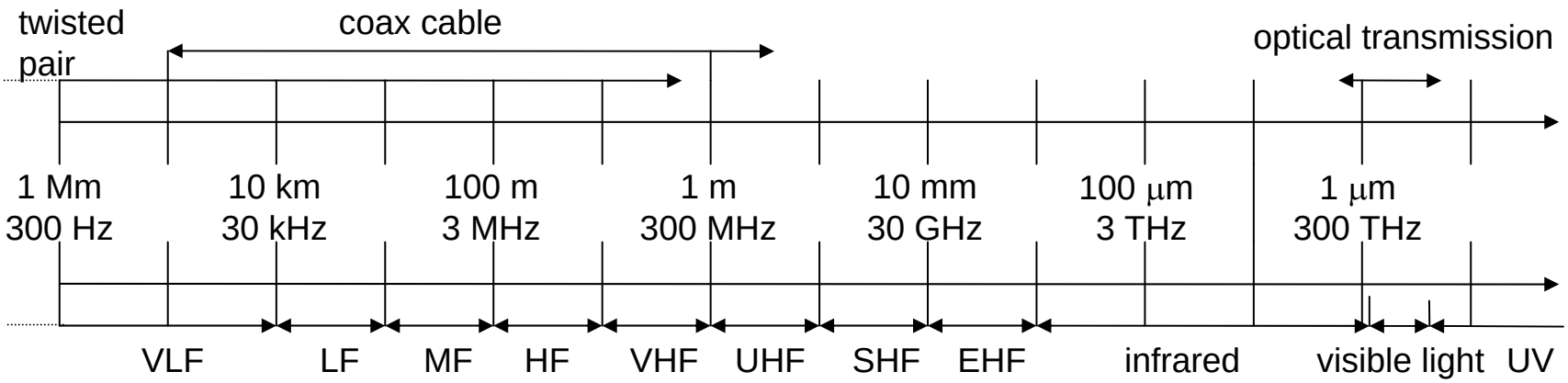
Wireless Transmission
(Physical Layer)

Frequencies for communication (1)

Coarse structuring of the electro-magnetic spectrum:



Frequencies for communication (2)



VLF = Very Low Frequency
LF = Low Frequency
MF = Medium Frequency
HF = High Frequency
VHF = Very High Frequency
UHF = Ultra High Frequency
SHF = Super High Frequency
EHF = Extra High Frequency
UV = Ultraviolet Light

Frequency and wave length:

$\lambda = c/f$

wave length λ, speed of light $c \cong 3x10^8 m/s$, frequency f

Signals (1)

- physical representation of data
- function of time and location
- signal parameters representing the data values
- signal parameters of periodic signals with given period T: frequency f=1/T, amplitude A, phase shift φ
  - sine wave as special periodic signal used in wireless communication:

$$s(t) = A_t \sin(2 \pi f_t t + \varphi_t)$$

- (digital) modulation: digital data is translated into an (analog) signal
- Fourier representation of periodic signals:

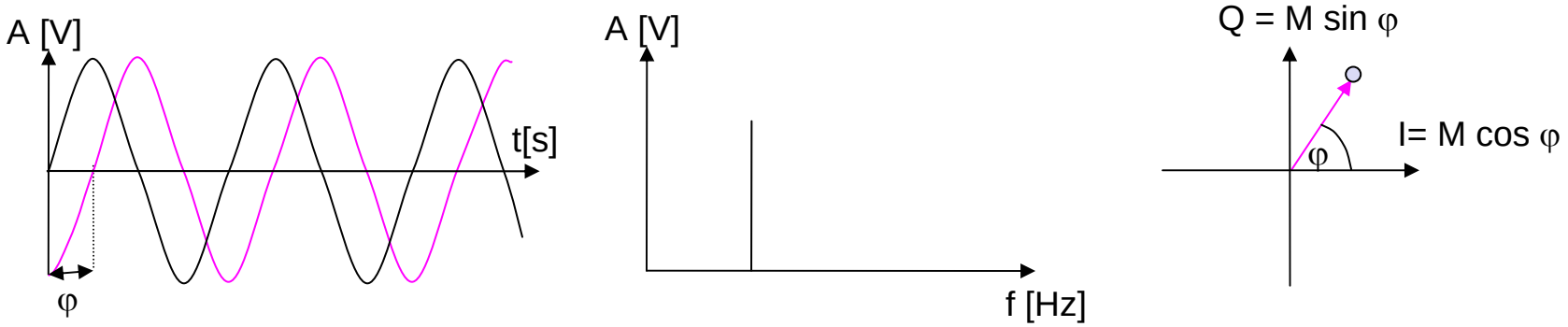
$$g(t) = \frac{1}{2}c + \sum_{n=1}^{\infty} a_n \sin(2\pi nft) + \sum_{n=1}^{\infty} b_n \cos(2\pi nft)$$

➔ every transmitted signal can be represented by a sum of sine waves

Signals (2)

Different representations of signals

- amplitude (amplitude domain)
- frequency spectrum (frequency domain)
- phase state diagram (amplitude M and phase φ in polar coordinates)

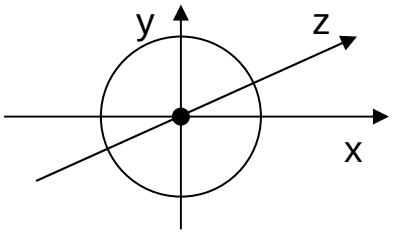


Digital modulation

- digital data is translated into an analog signal (baseband)
- basic schemes: ASK, FSK, PSK

Ideal Antennas: isotropic radiator

- Radiation and reception of electromagnetic waves, coupling of wires to space for radio transmission
- Isotropic radiator: equal radiation in all directions (three dimensional) - only a theoretical reference antenna



ideal isotropic radiator

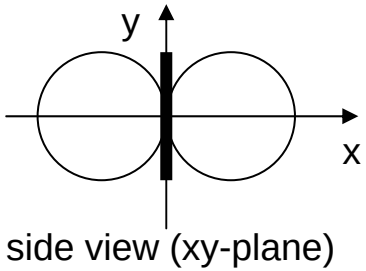
- Real antennas always have directive effects (vertically and/or horizontally)
- Radiation pattern: measurement of radiation around an antenna

Antennas: simple dipoles, directed antennas

Real antennas are not isotropic radiators

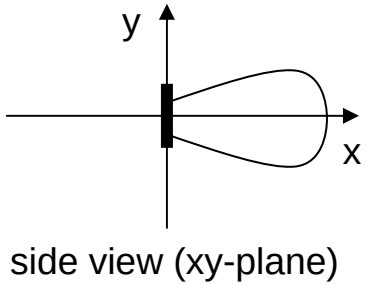
- ➔ Radiation is not equal in all directions
- ➔ Strength (intensity) of the signal received depends on the receiver's position

Example: Radiation pattern of a simple Hertzian dipole



simple dipole

- ➔ Use of antennas with specific, directed radiation antennas (directed antennas) might be useful



directed antenna
(e.g. satellite antennas)