Basics of Low Power Radio Data Transmission

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Low Power Radio Solutions (LPRS)

Originally written by Michael Schröttle.

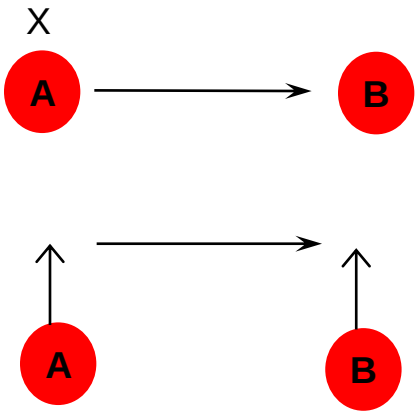
Low Power Radio Solutions

Two Rivers Industrial Estate
Station Lane
Witney
OX28 4BH
United Kingdom

T: +44 (0) 1993 709418
F: +44 (0) 1993 708575
E: sales@lprs.co.uk

1. Radio-Data Transmission - for what?

- Communication (transmitting digital data):
  - Task: transport information package 'X' from place A to place B through a defined communication channel.



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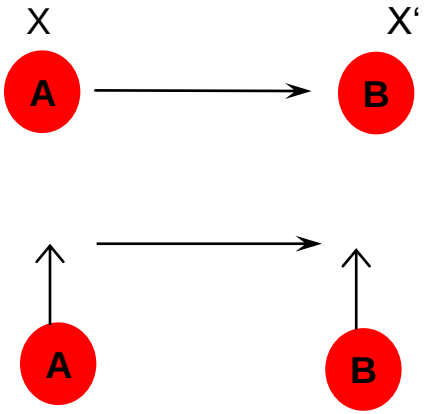

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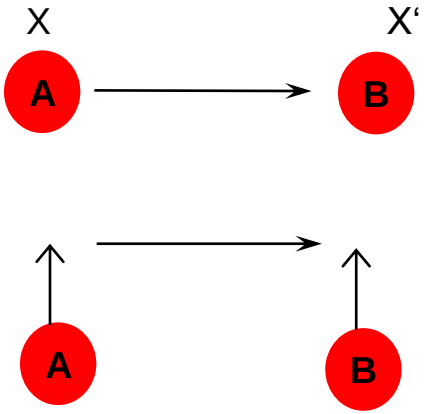

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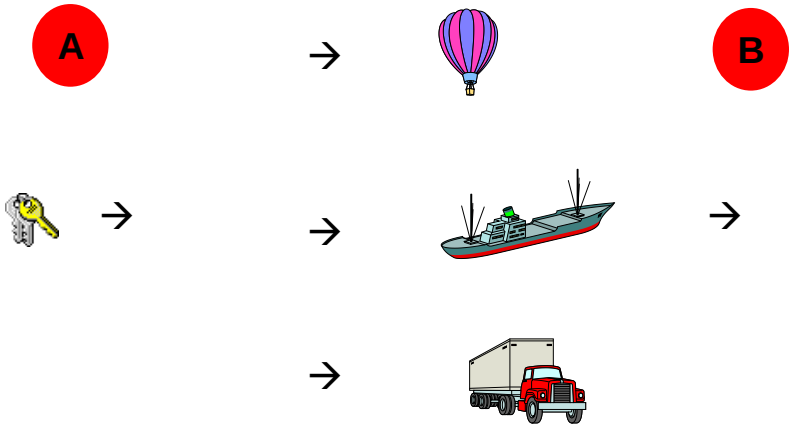

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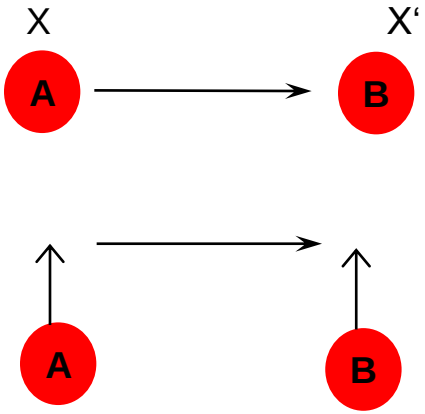

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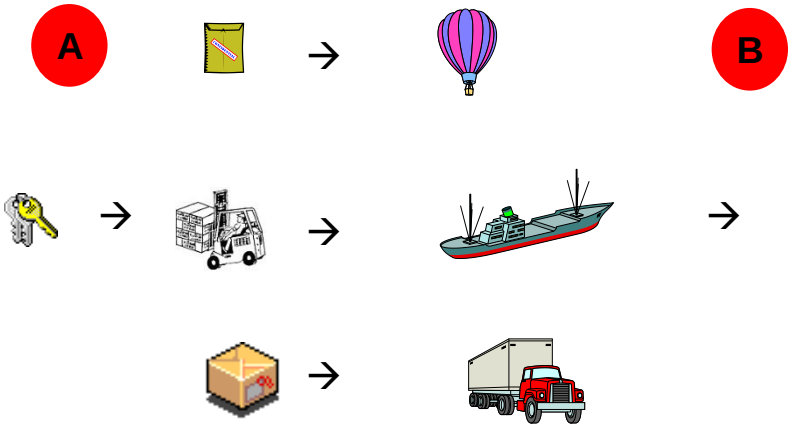

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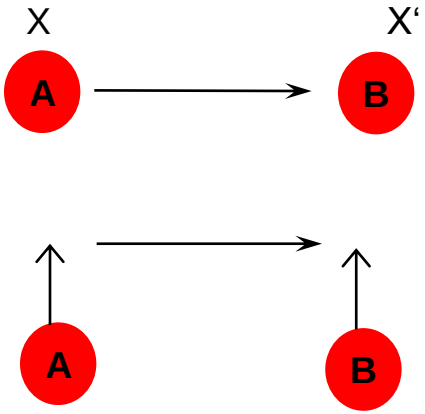

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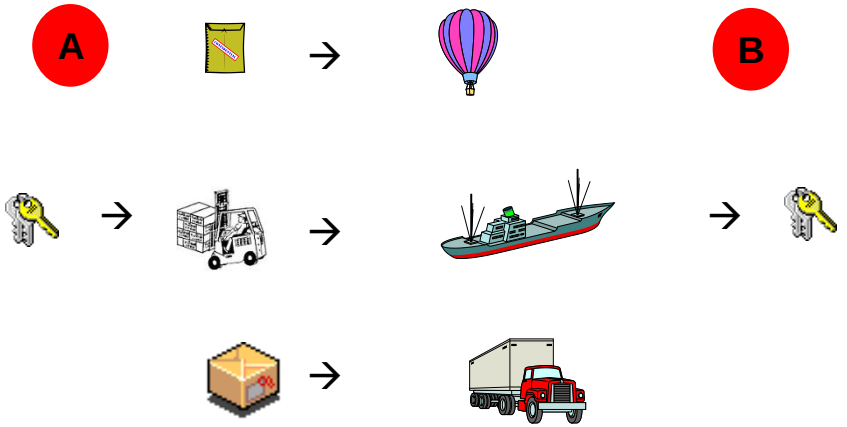

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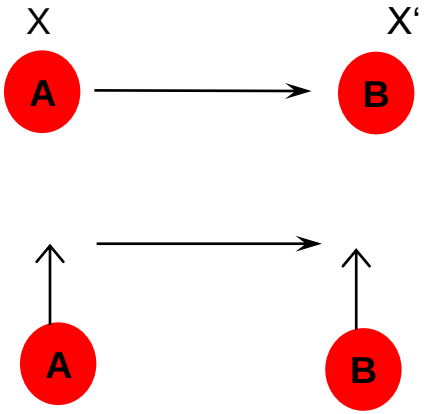
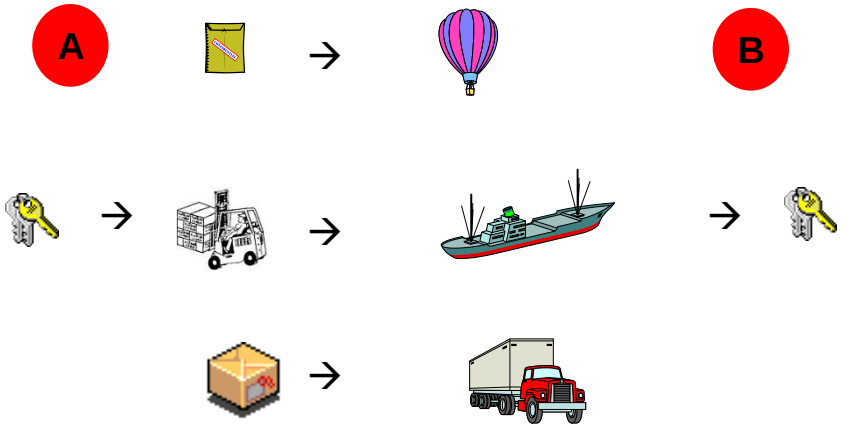
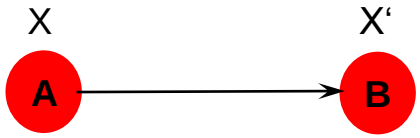


- The Transmission Process:
  - Chose appropriate communication channel (medium).
  - Prepare information package (1)
    (= optimal match to communication channel).
  - Send information package (2).
  - Receive and unpack information (3).

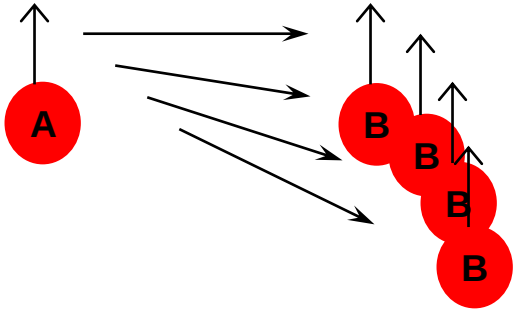


1. Radio-Data Transmission - Advantages & Disadvantages

- Motivation – advantages radio vs. wires:
  - convenience (freedom of movement), more choices
  - New possibilities for communication

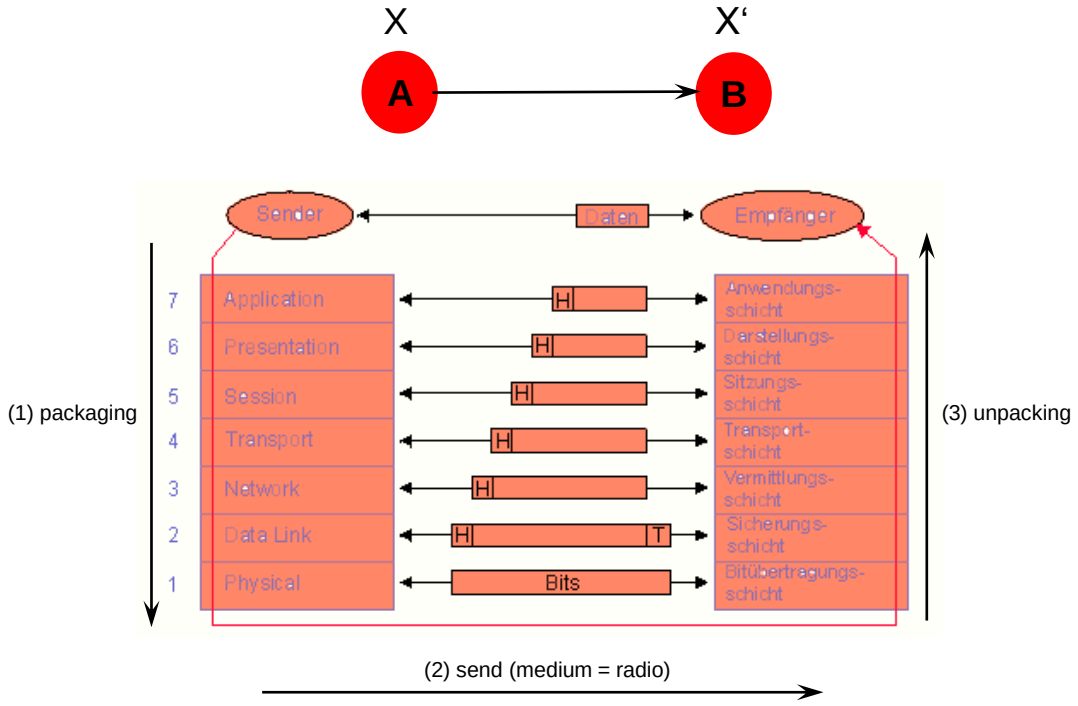


- Problems:
  - Communication medium with different characteristics (air instead of wires)
  - Correlation of Communication partners no longer implicit (-> addressing, network, security issues)



2. ISO/ OSI - Layer Model for Data Radio

- **7 Communication Layers (from bottom up):**
  - 7 Application Layer: data-interpretation, meaning of data in view of the communication, application specific.
  - 6 Presentation Layer: presentation of data (figures, bars, charts, colors, etc.) application specific.
  - 5 Session Layer: logical communication channel, application specific, independent of medium.
  - 4 Transport Layer: packet protocol, packet acknowledgements.
  - 3 Network Layer: addressing communication partners.
  - 2 Data Link Layer: CRC for bit-error detection.
  - 1 Physical Layer: bit-coding for matching to radio channel (Manchester code, etc).



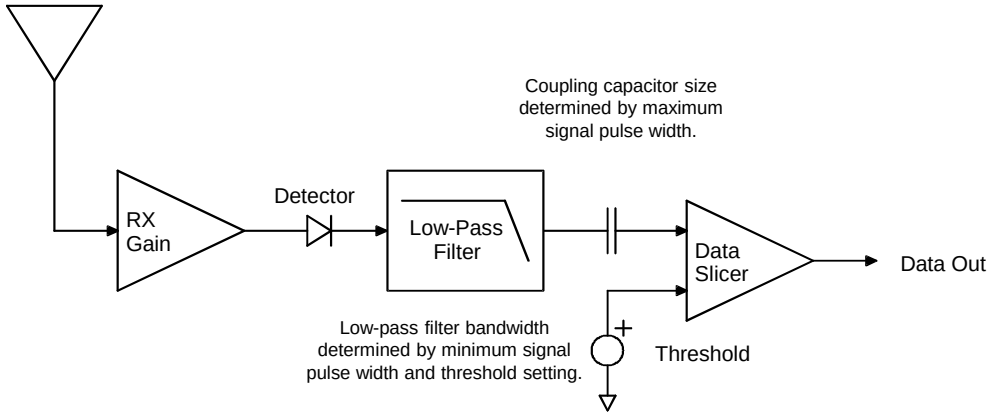
Purpose of communication: transmit data from sender to receiver.

Technical approach: split task into 7 layers for physical transmission (red).

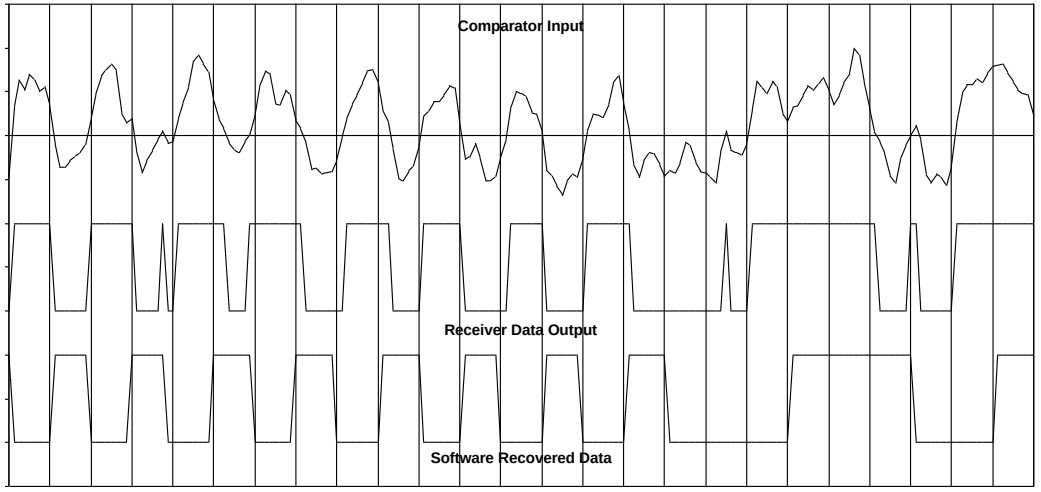
3. Transmission Layers in Detail: 1 - Physical Layer

- Matching to channel characteristics:
  - DC-balanced code:
    Manchester, 8-in-12, etc.
    → up to 12 dB coding gain
    (range) can be achieved.
  - Sending a preamble before data
    for training the coupling capacitor.

- Matching to channel characteristics:
  Bit-Sampling necessary due to fading
  (→ jitter) and glitches,
  (no UART operation possible).

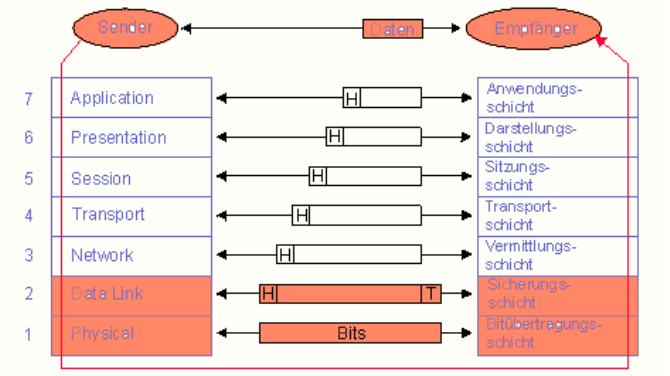


Reception with Heavy Noise
(expanded scale)

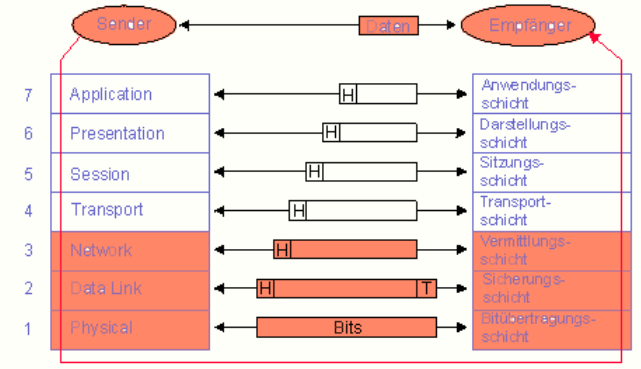


3. Transmission Layers in Detail: Data Link Layer (2) and Network Layer (3)

- Data Link Layer (2): for purpose of error detection-
  - Header and CRC (T) added to telegram.
  - Bit-error recognition and evtl. Correction.
  - Redundancy.

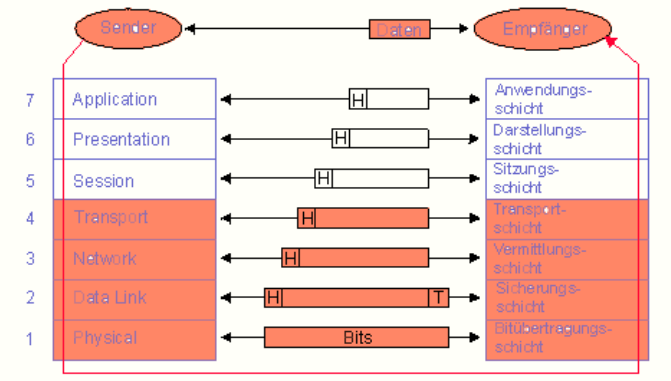


- Network Layer (3): Addressing source and target:
  - Source and target ID's are added to telegram.
  - Define correlation of sender(s) and receiver(s).



3. Transmission Layers in Detail: 4 -Transport Layer

- Transport Layer (4): establish transmission security
  - Combine telegrams into packets
  - Transmit packets and receive acknowledgement
  - Transmission retry if ACK has not arrived within a predefined time period.



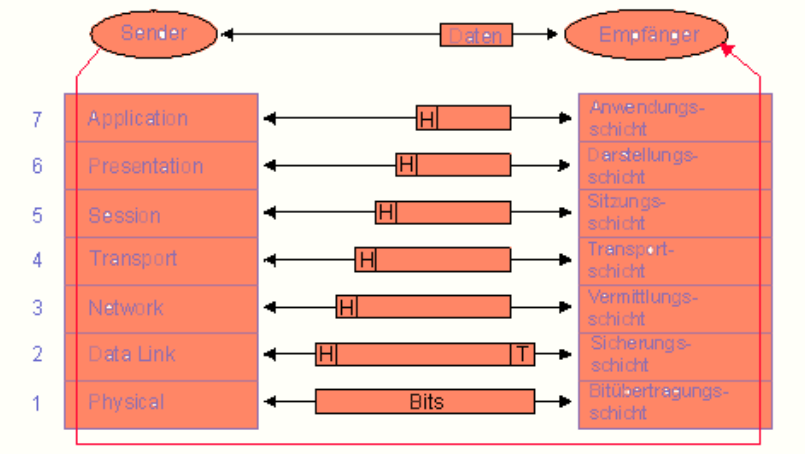
- Typical protocol scheme (Layers 2 – 4):

/ss/pre/to/fr/pn/cmd/siz/DATA/fc1/fc2/ ← Layer 1 telegram

- Ss: Start symbol
- Pre: Preamble
- To: Target address
- Fr: Source address
- Pn: Packet number
- Cmd: Command
- Siz: Length of data package
- Data: Data
- Fc1: Frame-Check 1
- Fc2: Frame-Check 2

3. Transmission Layers in Detail: Layers 5 - 7 application specific.

- Layer 5: Session Layer
  - Logical communication channel for access of the above layer
  - Media independent access from application point of view
- Layer 6: Presentation Layer
  - Presentation of data in appropriate form for the application (figures, bars, lines, colours, etc.)
  - Rules for operations on data (syntax)
- Layer 7: Application Layer
  - Interpretation of data viewed from the application
  - Meaning of the communication (make sense)



4. Setup of a Typical Low Power Radio Project.

- Tasks during the realisation of a data radio solution:
  - Ia: RF-hardware design: based on a chip (semiconductor) or in a discrete way the required RF-function (transmitter, receiver or transceiver) needs to be designed (Layer 0).
    Problem: **RF-Design knowhow** is a must.
  - Ib: Baseband-hardware design: the required baseband-functionalities (modulator and demodulator) need to be designed as well (Layer 0).

  - IIa: Firmware design for clock and data-bit recovery (receiver – Layer 1)
  - IIb: Firmware design for bit coding (transmitter – Layer 1)
  - III: Firmware design for bit-error detection (Layer 2)
  - VI: Firmware design for addressing (Network - Layer 3)
  - V: Firmware design for transmission security (Layer 4)

  - Integration in target application (= Definition of Interface between Layers 4 and 5)

Layer 2 – 4 = „Protocol“

5. Advantages of Radio Modules.

- Depending on the type of radio module the designer can skip certain development tasks (I – V):
  - Simple radio modules provide the hardware for RF- and baseband functions (Layer 0)
  - More complex modules also provide the necessary firmware for Layers 1, 2 (and partly 4) and can be used with UARTs (i.e. Easy-Radio)
  - Complex modules provide complete firmware for Layers 1 – 4 and can be directly addressed from the Session Layer (i.e. AeroComm; all types of radio modems, BT modules, WLAN ...)

- Radio modules help save development time and development cost (for tasks I – V);
  their per unit cost is higher than parts cost in own developments.
  - Advantage: Faster to market: saves 15 – 24 months (→ rapid prototyping)
  - Advantage: Lower development cost: saves ca. 100 k€
    (→ Major factor for low volume projects < 10 k pieces per year)

6. Product Matrix.

ISO/OSI Layer	Function	Products
L3	Network Layer (Addressing)	All radio modems: RS232 or WLAN (CTWLAN), all AeroComm-modules (AC4486, AC4424, AC5124), BT.
L4	Transport Layer (Protocol w/ ACK)	easyRadio from LPRS (partly).
L2	Data Link Layer (Detection of bit-errors)	easyRadio from LPRS.
L1	Physical Layer (Bit-coding scheme)	
L0		RFM, Circuit Design from LPRS, etc.
‚below Zero'		RF-chip sets or discrete designs.