TSTE17 System Design CDIO

http://www.isy.liu.se/en/edu/kurs/TSTE17

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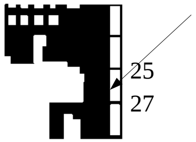


Course Classification

CDIO (Concieve, Design, Implement, Operate)

LiTH, Chalmers, KTH, and MIT

Effort in the Y-program to increase the engineering skills

LIPS project model described in Lecture 6
Thursday 10/9 10.15-12.00

Course details

- Project course (7 out of 12 ECTS points)
  - Lab 1 ECTS
  - Handin 1 ECTS
- Task: Build the physical layer of an OFDM based Communication System
- Introduce OFDM WLAN techniques, especially 802.11a (54 Mbit/s @ 5 GHz)
- Emphasis is put on the first parts (C and D) of CDIO
- Use fast prototyping tools to create an FPGA solution

Other CDIO courses

- Common Entrepreneurship teaching (3 ECTS)
  - Not included if you already attended another CDIO course (e.g., TSEK06 VLSI design)

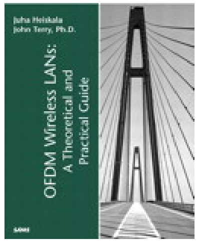
Course details cont.

- Course covers complete semester (almost)
- Project deadline: Friday 18 December 2020 15.00
  - Project size 180-200h of work (each)!
- Multiple deadlines (time plan, requirement specification, design specification, architecture specification etc.)
- Important locations
  - http://www.isy.liu.se/edu/kurs/TSTE17
  - Computer lab Mux1 (2nd floor, corridor C, close to my office)

Course details, cont.

- Examination
  - Pass/Fail grading
  - Lab, Hand-ins, project execution, project report, oral presentation
  - NOTE: possible for individuals to fail even if the rest of the project group get pass
  - NOTE: possible to pass project task even if design does not work
- Staff
  - Kent Palmkvist, 281347, Kent.Palmkvist@liu.se

Course material, book



OFDM Wireless LANs: A Theoretical and Practical Guide

Authors:
Juha Heiskala, John Terry

ISBN: 0672321572

SAMS 2001

Other interesting literature listed on the web pages

Course material, cont.

- Main webpage: http://www.isy.liu.se/edu/kurs/TSTE17
  - Important to check the news page
- All material for the course (beside the book and document templates) will be on the web (either as pdf or openoffice documents)
- Project directory will be used during the projects (common area accessible only by the project group members)

Lectures

- 7-9 Lectures
  - System Design
  - Introduction to WLAN
  - Basic telecom knowledge
  - Rapid prototyping tools
    - Matlab/Simulink
    - Altera DSP Builder
    - Xilinx System Generator

Labs and project

- There is no difference between lab and project!
  - Same location, same tools, same people
- Use the first sessions to learn the tools
  - Supervisor available in the lab
  - Notes available on the web
- Use the rest (plus additional time) to carry out the project
  - No supervisor in the lab
- Examined by lab task and handin

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Lab task definition

- Carried out in groups of 2 students each
- Practice the design flow
  - Model (Simulink), simulation
  - Synthesis, simulation
  - Hardware test
- Create a simple counter design
  - Lab notes available on web
  - Present result at one of the lab sessions
- Deadline: Monday 14/9 21.00

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Handins

- Verify that theory and simulation models are understood
- Simple questions
  - Fill in answers in a template document and email me
- 1 week to complete answers
  - 26/10 - 2/11
- Answered individually!

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Project

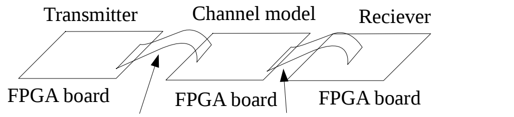
- Build physical layer (excluding RF) of an OFDM communication system
  - Do this by step-wise refinement of a model
- Manage the project according to the LIPS model
  - Special LIPS lecture on Thursday 10/9 10-12
  - Time plan, meetings, specifications, reports
- OpenOffice/Libreoffice to be used (some templates available)
- Use fast prototyping tools
  - Automatic Simulink model -> FPGA design
- Shared directory available for each project group
  - /courses/TSTE17/proj/projgrpXX

Project Requirements

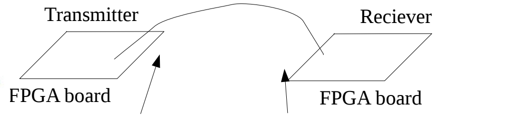
- One project group this year
  - Make sure you are registered for the course
- Follow the Lips project model
  - Requirement and design specification, time plan, project plan, time reports, final report and presentation etc.
- Weekly meetings with agendas required.
- Meeting transcripts must be sent to supervisor within 2 days after the meeting!

Project end result

- Physical setup
  - 2 options
  - different complexity



Digital parallel data, corresponding to samples sent/received to D/A and from A/D converters that in turn is modulated into 5 GHz ISM band in real systems



Analog baseband signals, corresponding to signals modulated into 5 GHz ISM band in real systems

Computer tools

- Openoffice/Libreoffice
  - Documentation
  - Available on Linux, Windows, Mac
- Matlab/Simulink
  - Simulation, design entry
- Altera DSP Builder and Quartus
  - Simulation, synthesis, and FPGA programming
- Modelsim
  - Simulation of VHDL
- CentOS 7

Computer Networks

- Circuit based vs Packet based
  - Telecom system (e.g. Wired phone systems) usually use circuit based approach where a connection first is created, data sent, and finally removed.
    - Guaranteed bandwidth
    - Amount of used information does not influence amount of allocated resources
  - Computer networks usually send small packets with data that includes a destination address. No communication resources allocated in advance.
    - High resource utilization (shared with other users)
    - Compare with classic mail distribution

WLAN Background

- Early tests
  - First wireless computer network: ALOHANET (Hawaii, 1971)
  - 1980's: HAM nodes (amateur radio hobbyists)
- Interoperability requires standards
  - IEEE: Institute of Electrical and Electronics Engineers
  - ISO: International Organisation for Standardization
  - IEC: International Engineering Consortium
  - Wi-Fi alliance: testing interoperability

WLAN standards

- 1985: FCC defines free use of ISM (Industrial, Scientific, Medical) at 450 MHz and 2.4 GHz
- Late 1980's: IEEE 802 working group starts
- 1997: 802.11 standard defined (2 Mbit/s)
- 1999: 802.11a (54 Mbit/s @ 5 GHz) and 802.11b (11 Mbit/s @ 2.4 GHz) standards defined
- 2003: 802.11g defined (54 Mbit/s @ 2.4 GHz)
- 2008: 802.11n defined (600 Mbit/s, @ 2.4 and 5 GHz)
- 2009: 802.11ad (7Gbit/s @ 60 GHz)
- 2012: 802.11ac (1Gbit/s @ 5 GHz)

WLAN standards, cont.

- 2017: 802.11ax (>10GBit/s @ 5GHz)
- 2017: 802.11ay (20-40GB/s @60GHz)
- 2018: rename into WIFI-4 (11n), WIFI-5(11ac), WIFI-6 (11ax)

Related standards

- WIMAX
  - Fixed broadband infrastructure using wireless
- xDSL
  - Wired broadband connections
- DRM
  - Digital Radio Mondial
- DAB, DVB
  - Terrestrial and Satellite radio and TV transmission
- 4G LTE, LTE-A
  - High speed mobile standard
- 5G

Protocol stack principle

- Divided in layers
  - OSI: 7 layers
  - IEEE 802: 4 layers
- Each layer communicates with corresponding layer in other equipment
- Lot of different functions
  - Electrical interface
  - Error correction
  - Flow control
  - Retransmitts
  - Routing

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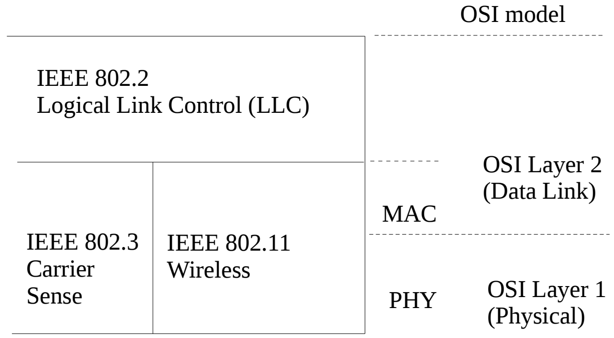
IEEE 802 standard family protocol stack



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Shared vs point-to-point media

- Shared media requires access control
  - Avoid collisions
  - Keep track of other units connected
- Control must be close to the physical layer
  - Wired connections can detect collisions
    - Example: coaxial cable based bus topology
  - Wireless can not detect collisions
- Shared media benefits from shorter data packets
  - Resend more likely due to collisions or interference
- Centralized or distributed control of access
  - Accesspoint vs ad-hoc network

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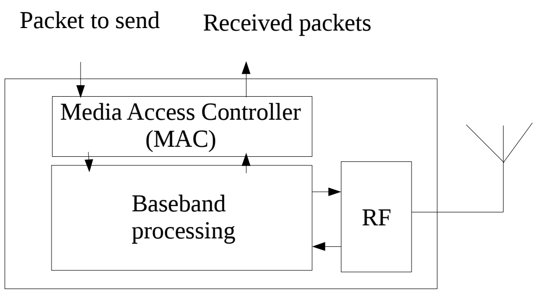
Physical layer implementation

- Most of the protocols stack implemented as software
- Dedicated hardware for levels closest to media



Wired vs Wireless

- Security
  - Easy to listen to communication
  - Encryption in current standards may be weak (WEP)
  - Man-in-the-middle attacks
- Coverage
  - Wireless has a limit dependent on the environment
  - Time variant wireless coverage
  - All units connected to a wired subnet can both listen and send data to each other

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Wired vs Wireless, cont.

- Non-continuous transmission
  - Mobile units must preserve power
  - Data transmission split into small packets
  - Radio spectrum shared between multiple users
  - Some frequency bands are license free => any user may use it

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Wired vs Wireless, cont.

- Multiple access
  - Wired systems can listen to their own transmission to detect collision (CSMA/CD)
  - Wireless systems can not detect collision
  - Wireless may experience 3rd node problems (Node A and C can hear node B, but node A and C can not hear eachother. It is then possible that A and C sends at the same time to B, which will then lead to collision.) Solved by sending short RTS and CTS packets before sending data to show to all other stations that transmission will be done. (CSMA/CA)

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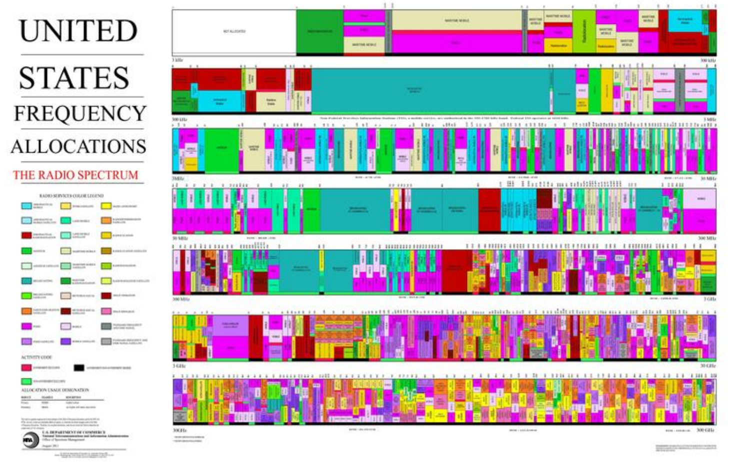
Wired vs Wireless, cont.

- Mobile units
  - must accept changing network topology while connected to the network
  - Power consumption more important for mobile (usually battery powered)

Wireless networks

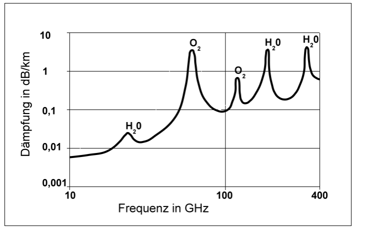
- Large competition for radio spectrums
- Regulated nationally and internationally
  - Globally: ITU
  - Sweden: PTS
  - US: FCC
  - Europe: CEPT
- Rules differs, e.g. 2.4GHz ISM band
  - US: 11 channels
  - Japan: 14 channels
  - Europe: 13 channels

US radio frequency use 2011



Radio limits

- Signal power reduces with distance (attenuated)
- Frequency dependent power attenuation
  - Higher frequency have larger attenuation
- Objects in signal path reduces signal power



Analog vs digital communication

- Analog communication
  - Example: FM radio
  - Continuous analog signal to transmit
  - Some preprocessing can be done
    - Amplitude compression, e.g. Dolby
- Digital communication
  - Digital symbols should be mapped to analog domain
  - Possible to do a lot of processing
    - Reduce amount of data to transmit
  - Possible to correct bit errors
    - checksums/coding

Simple digital communication

- Simplest: Send voltage level
  - Impossible on radio
- Simple approach: On-off signaling
  - 0 : no signal
  - 1 : send carrier frequency
  - Used in IR transmissions (with some modifications)
- Additional problem: Timing
  - How to synchronize bit rates?
  - How to find the start of bit stream?
  - How detect sequence of ones?

Next lecture

- Design flow
- Project details
- Tool description
- Digital communication