Course information

- IST NET1
  - 8 classes (x 2h)
  - 1 lab (x 4h)
  - The slides are for me, you should take notes, read books, blogs and articles
  - Written report for the lab, demonstrating your understanding of the studied phenomena
  - Razvan Stanica, Telecom engineer (2008), PhD in Computer networks (2011)

Course information

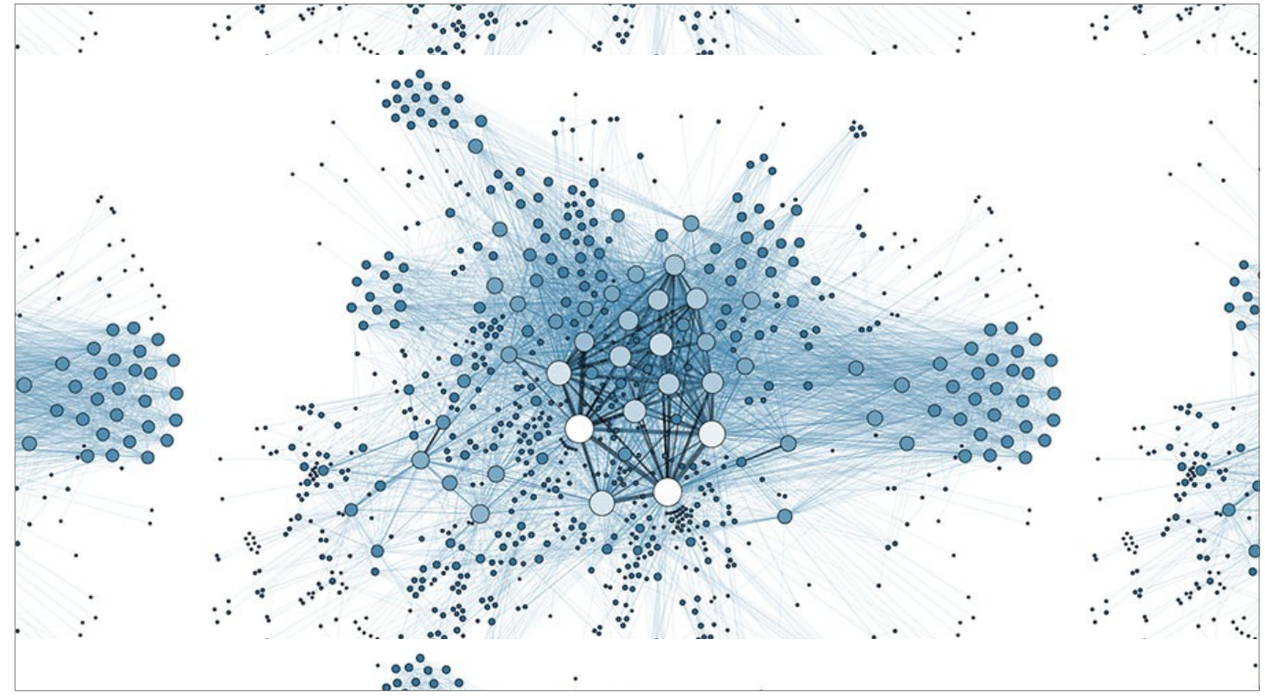
- 3TC MAC
  - A. Tanembaum – "Computer Networks" (at the library)
  - G. Pujolle – "Les Réseaux" (at the library)
  - O. Bonaventure – "Computer Networks" (link on moodle)
  - Good materials (a little biased) from the Cisco Academy
  - Interesting discussions on Twitter and Reddit
  - Not everyone on the Internet is a reliable source of information

Objectives

- Network "Theory"
  - Network architecture
  - Network layers
  - Protocols
  - Mechanisms
  - Services
  - Primitives
- Medium Access Control
  - Multiple access
  - Aloha
  - Carrier sense
  - Collision detection
  - Ethernet
  - WiFi

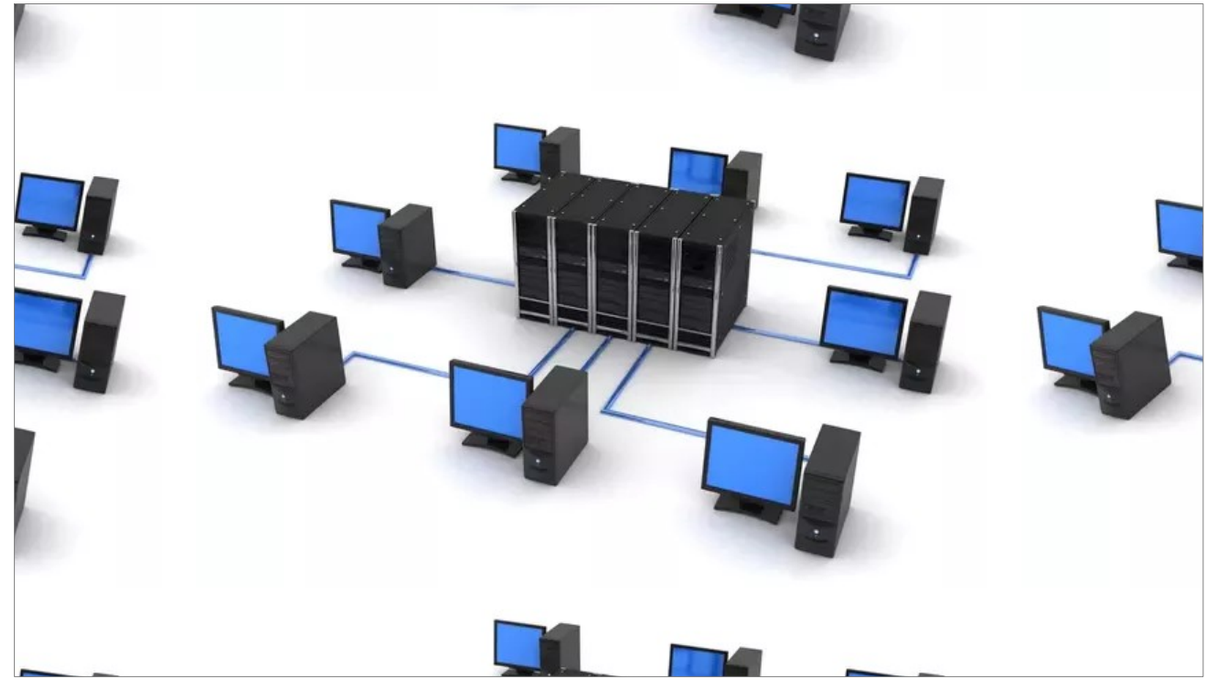
What is a network ?

- General definition
  - A group or system of interconnected people or things
  - Network science optional class in 5TC
  - e.g. Road network
  - e.g. Social network
  - e.g. Biological network
  - e.g. Transactions network



What is a network ?

- General definition
  - A group or system of interconnected people or things
  - Network science optional class in 5TC
- Computer networks
  - A set of computers connected together for the purpose of sharing resources



Computer networks

- Network architecture
  - Design elements of a communication network
  - Framework for the specification of the physical components and their functional organization and configuration
  - Describes operational principles and procedures, as well as data formats
  - More and more about virtual function placement

Computer networks

- Layered approach
  - Complex system : from the electronic components to the user interface
  - Modularity is a necessity
  - Structure the different functions of the network
  - Allow people and companies to gain expertise only on a subset of functions
  - Permit changes in a layer without impacting other layers

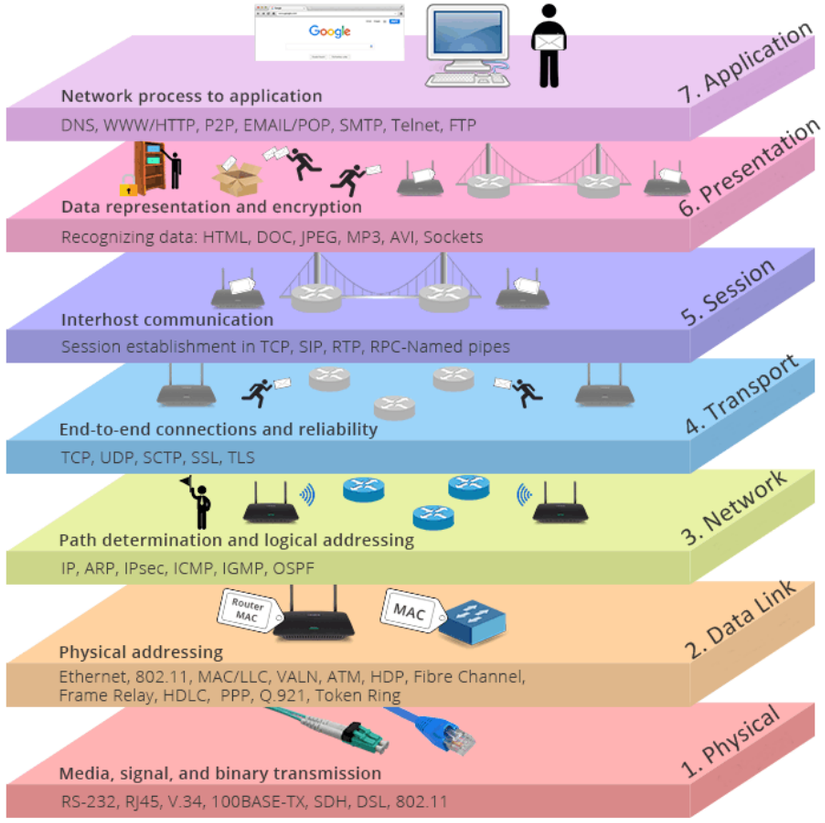
Computer networks

- Standardization
  - Essential process in the field (very few exceptions)
  - Equipment produced by Cisco, Nokia, Huawei, HP, Apple, (etc) need to communicate with one another
  - A long process, resulting in hundreds of pages of specifications
  - Many, many (many) standardization organisations : ISO, ITU, ETSI, IEEE, IETF, 3GPP ...

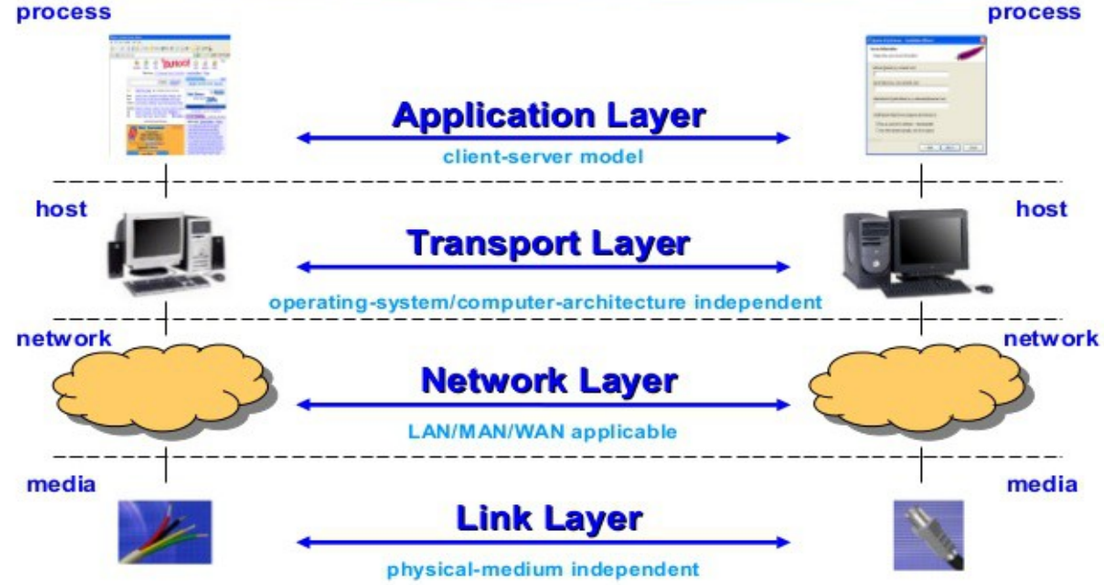
Computer networks

- Architectures

OSI (from ISO)

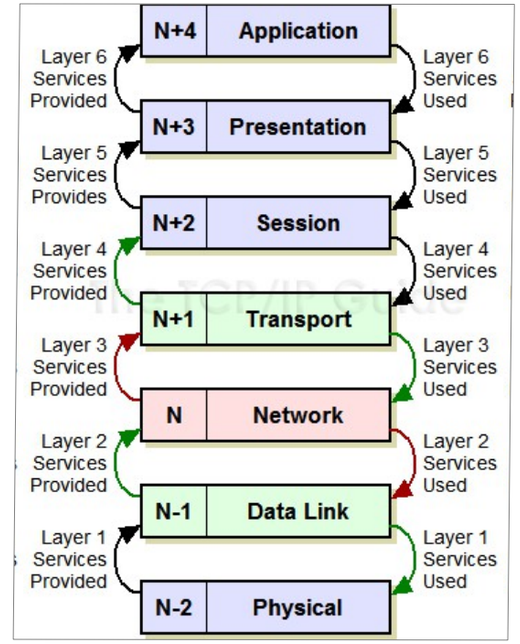


TCP/IP (from IETF)



Network vocabulary

- Service
  - The functions a layer exposes to the upper layer
  - Provides the expectations of the lower layer in terms of format
  - e.g. "I can transfer a message of maximum size 1500 bits and a minimum size of 100 bits"
  - Service Data Unit (SDU) – unit of data passed from the upper layer to the lower layer

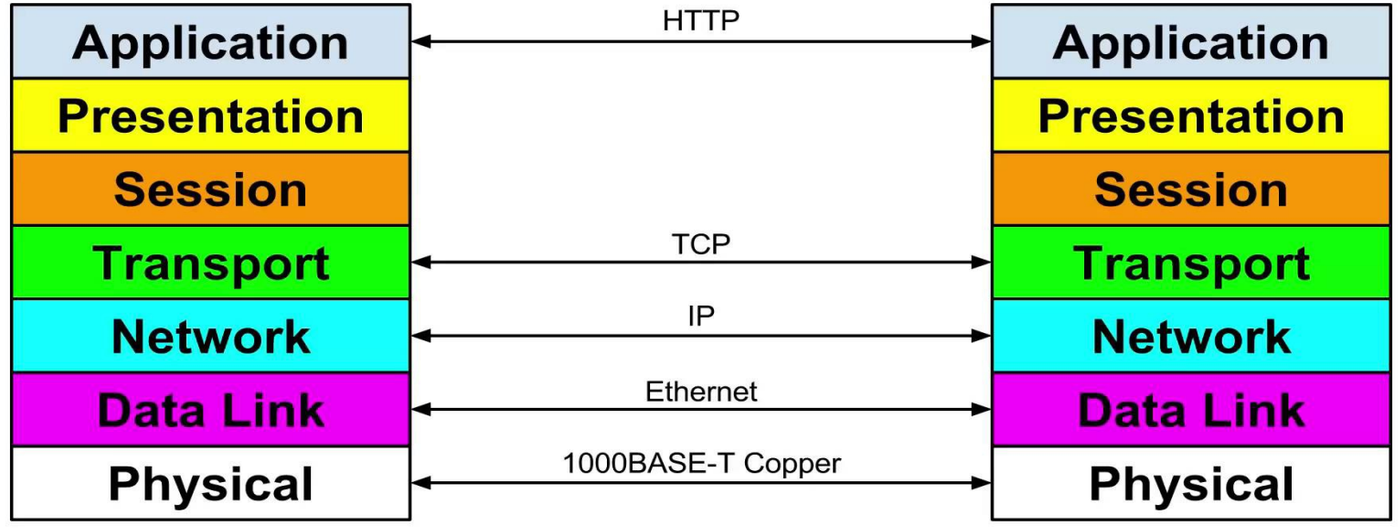


Network vocabulary

- Primitive
  - Formal way of implementing a service
  - Similar to a procedure call in programming
  - X.request() - request towards the lower layer to transmit an information
  - X.indication() - indication towards the upper layer than information has been received

Network vocabulary

- Protocol
  - Set of rules that governs the communication at a given layer
  - Protocol Data Unit (PDU) – unit of data exchanged by two peer entities

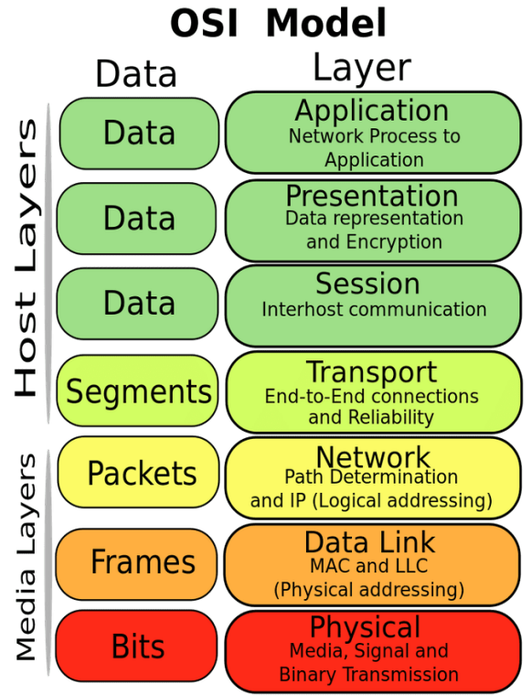


Network vocabulary

- Mechanism
  - An atomic part of a protocol
  - A set of instructions to be executed under certain conditions
  - "Classical" mechanisms integrated in different protocols
  - e.g. Three-way handshake connection mechanism
  - e.g. Back-off mechanism to reduce collision probability
  - e.g. Timeout-based retransmission mechanism

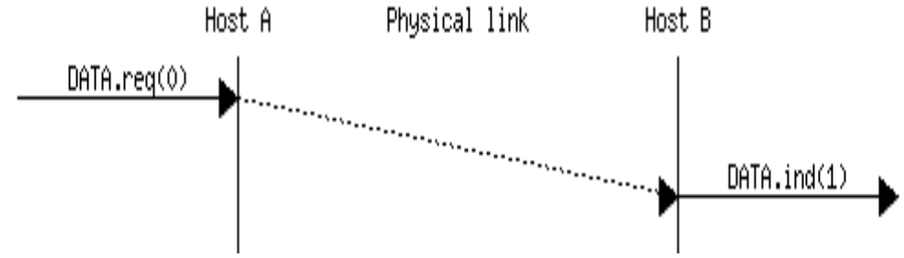
Network vocabulary

- Messages
  - Lower layers encapsulate information from upper layers
  - Each layer adds its own header, defined by the corresponding protocol
  - SDUs become PDUs (and then again SDUs)
  - PDUs at lower layers (2-4) have specific names



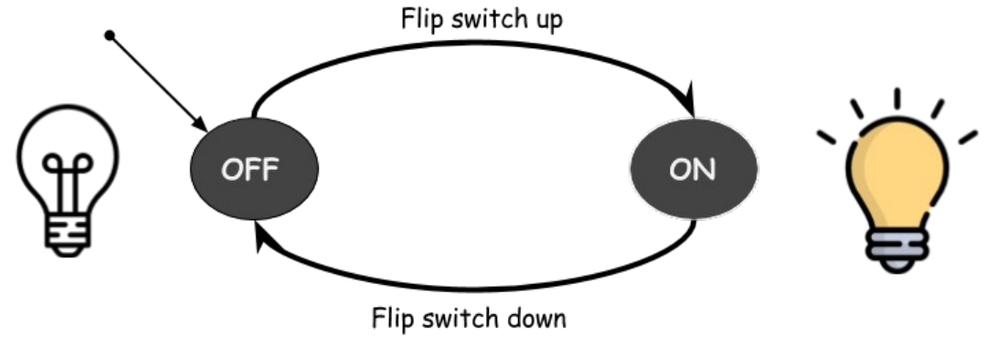
Network vocabulary

- Time sequence diagram (chronogramme)
  - A way to represent message exchange in a network
  - Can represent processing, transmission and propagation delays
  - Most basic tool to understand the performance of a network



Network vocabulary

- Protocol state machine
  - A way to model the functioning of a protocol
  - A host is always in one state, out of a finite number of states
  - Transitions between states : PDU or SDU reception, timeout, external action …
  - First debugging tool when designing a protocol

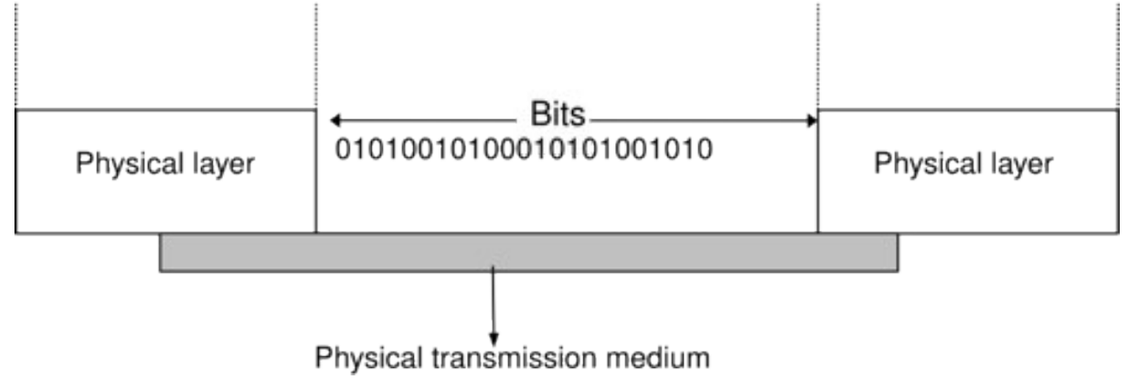


Physical layer

- Connecting two hosts
  - Electrical cable
  - Optical fiber
  - Wireless
- Signal manipulation
  - To be seen in all the classes from the syscom domain

Physical layer

- Provided services
  - Transfers bits of information using an electromagnetic field
  - Unit : bits per second
  - 1 Kbps = 1000 bps (unlike 1KB= 1024 B)



Physical layer

- Host synchronization
  - **Implicit** – the receiver knows when and where to listen for data
  - The fastest solution
  - Requires control traffic and can waste ressources (padding)
  - **Explicit** – a known sequence is used to mark the start of a transmission
  - Simpler, but with some complications (the sequence can not be used during the communication)
  - What about the end ? - another sequence or duration indication

Data link layer

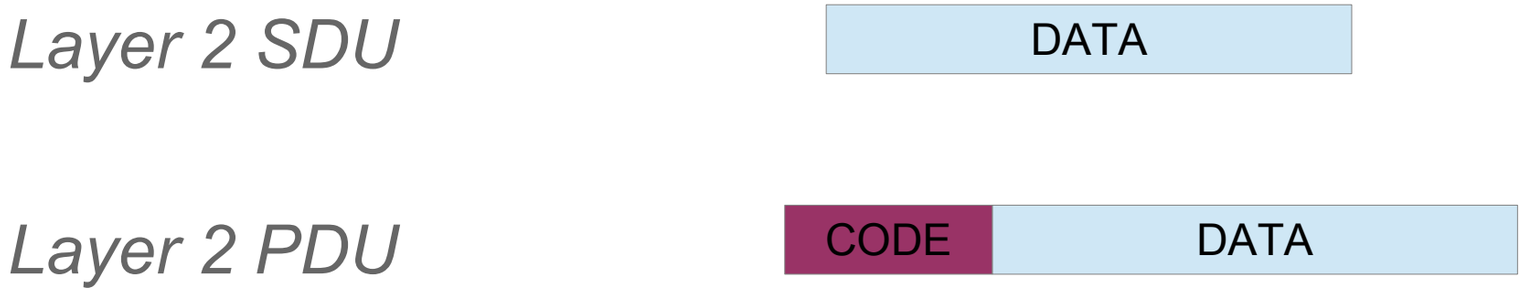
- Framing
  - With a perfect PHY layer, simply send a continuous stream of bits (e.g. reading a DVD)
  - Real PHY layer introduces errors (less on an optical fiber, more on a wireless medium) – usually bursty
  - Split the stream of bits in frames
  - In case of errors, only concerned frames are lost

Data link layer

- Error control
  - Frames can be corrupted by transmission errors
    - *Random isolated errors modifying the value of one bit*
    - *Random bit creation of removal*
    - *Burst errors that impact n consecutive bits*
  - Frames can be lost entirely due to buffer overflow

Data link layer

- Transmission errors
  - Add redundant information as *error detection codes*
  - Instead of *N* bits, transmit *N+r* bits



Data link layer

- Error detection (1)
  - Simplest error detection code : parity bit
  - Even parity or odd parity
  - Create an even (or odd) number of 1 in the transmitted frame

3 bits string	Odd parity	Even parity
000	1	0
001	0	1
010	0	1
011	1	0
100	0	1
101	1	0
110	1	0
111	0	1

Data link layer

- Error detection (2)
  - Checksum – used by the TCP/IP stack and by most security mechanisms
  - Basic idea (but different flavours exist) : break the data into *words* of *r* bits and compute the XOR of all those words
  - Easily implementable in software

0	0	1	0	0	1	0	0
1	0	1	1	1	0	0	0
1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	1
0	1	1	0	0	0	1	0