# Digital Communications II

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Computer Science Tripos Part II

Part1: Course Introduction and Layering Overview

## Structuring Communication Systems

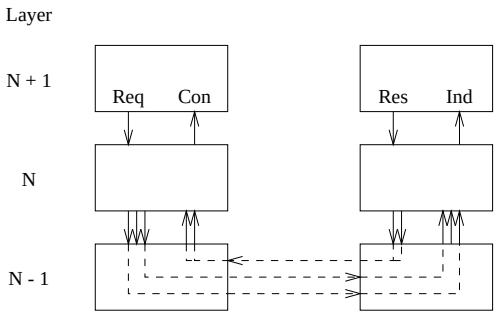
Sometimes we need to partition problems:

- Implementation in hardware or software
- Function the responsibility of the network or host?
- Separate private from public
  – more generally to separate enterprises
- Separate distinct suppliers

Partitioning for comprehension – two elements:

- abstraction
  – define interfaces and semantics
  – allow implementation choices
  – hence allow future replacement
- layering
  – one restricted view of module inteaction

# Layering




Abstraction with modules in a stack:

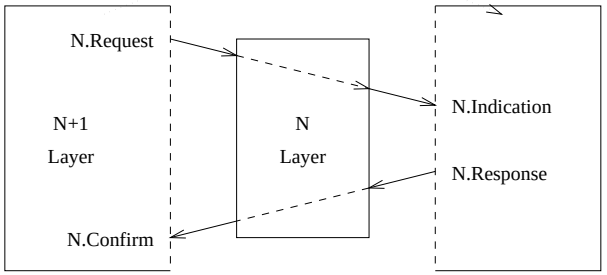
- at the bottom, wire or fibre
- at the top, applications

**layer n uses layer n-1 to provide a service to layer n+1**

Typically interface described in terms of:

- Request / Confirmation
- Indication / Response
- (implied time relationship)

# Service abstraction




Terminology:

- PDU: a layer talks to its peers with *Protocol Data Units*
- SDU: the service primitives take *Service Data Units*
- SAP: you say who you want to talk to by quoting its *Service Access Point*

For exmaple:

```
rc = sendto (sock_addr *sap, void *buf, int len);
```

- An SDU (coded as three arguments),
- Which contains a PDU of length `len` at `buf`
- To be sent to peer SAP defined by `sap`

# Standards

Communication requires agreement about representation of information (coding) and about procedures for exchanging information (protocol).

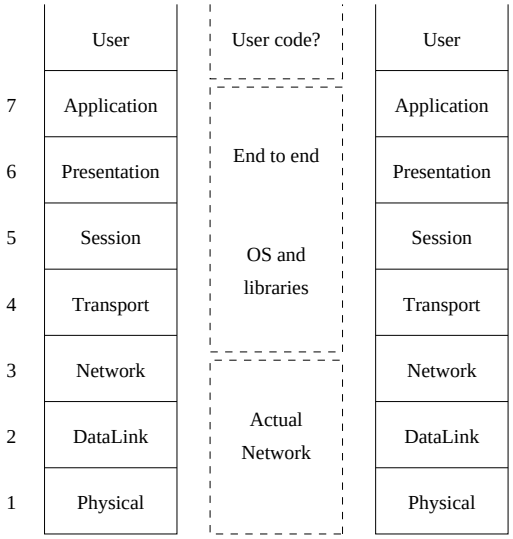
*Standards* are such agreements amongst suppliers, users, PTTs, etc. Standards organisations are the forum in which these standards are reached.

Different implementations adhering to the same standard will communicate

Organisations:

- ISO (Open Systems Interconnection – OSI)
  Composed of national and geopolitical entities:
  - ANSI, BSI, ETSI
- ITU-T, was CCITT (eg X and V series)
  Telecommunications suppliers and operators
- IETF (Internet Engineering Task Force
  Internet Drafts, Request For Comments (RFCs)
- IEEE (e.g. 802.x LANs)
- ECMA (manufacturers)

# OSI Reference Model




- OSI: Open Systems Interconnection
- seven layer model
- defines functions of different layers
- levels 1 to 3: traditional network levels
- levels 4 to 7: end system components

# OSI Reference Model

*Important to distinguish OSI reference model from OSI protocol standards*

OSI reference model:

- defines a 7 layer abstraction for communications
- aims to collect similar functions in the same layer
- provides a terminology for functions
- provides a framework in which to define abstract interfaces

OSI protocol standards:

- set of specific protocols, defining
  - PDU coding
  - state machine transitions
  - SAP coding

# Application

- High-level building blocks for applications
- file transfer and management (FTAM)
- job transfer and manipulation (JTM)
- electronic mail, message handling service (X.400, SMTP)
  - user agent
  - message transfer agent
- directory services (X.500)
- virtual terminal (VT)
- '`fetch_url`', '`render_url`'
- many other applications need such services, so:
  - programs
  - libraries

# Presentation

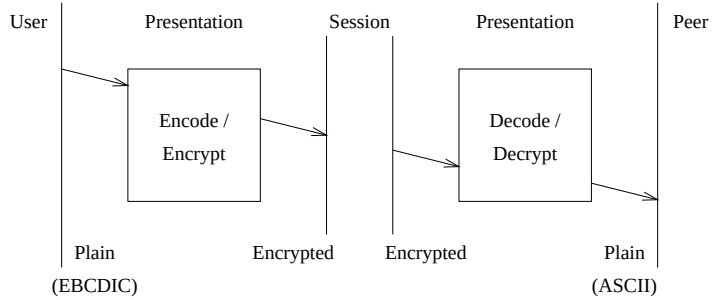
- representation of data and data semantics
- machine / architecture independent
- notation for datatypes (e.g. ASN.1)
  - primitive types: BOOLEAN, INTEGER, BITSTRING, ...
  - constructors: SEQUENCE, SET, CHOICE

```
FILE_OPs ::=
  BEGIN
  PDU ::= CHOICE {
            READ,
            WRITE }
  READ ::= SEQUENCE{
            fileName[0] IA5String,
            offset[1] INTEGER,
            length[2] INTEGER
  ...
```

- various sets of encoding rules, e.g. Basic Encoding Rules (BER):
  - ASN.1 type identifier
  - coding length
  - contents
- Extensible Markup Language (XML)
- provides transformation from application representation to network representation

# Other codings

Encryption/decryption is a presentation function:




- Text
  - EBCDIC, ASCII
  - CRLF, LF
- Voice/Audio
  - linear PCM : 12/16 bit, signed/unsigned
  - companded (lossy) to 8 bits
    - $\mu$-law, a-law
  - transform coding
    - ADCPM, RealAudio, MP3, SDMI etc.
- Images/Video
  - Raw: RGB *vs.* YUV colour space
  - Spatial: JPEG, M-JPEG, JPEG2000
  - +Temporal: MPEG 1, MPEG 2
  - +Model based: MPEG 4

## Session

- Co-ordinating tasks that require multiple transport level streams
- Synchronization
  - Tokens enforce data phases and controlled termination
  - Tokens as synchronization points
- e.g. FTAM for lots of files:
  - Major token per file
  - Controlled release for safe termination
- Choose from:
  - Negotiated release
  - Half duplex
  - Synchronization
  - Activity management
  - Exception reporting
- Having well-defined subsets of these to make life easier for application programmer
- multi-media synchronization
  – audio/video/animation

## Transport service

- ISO TP4 service:
  - end-to-end
  - connection oriented
  - sequenced packets
  - error free data
  - flow control
- TCP as above, but byte-stream oriented
- datagram services e.g. UDP
- Other useful variants possible e.g.
  - no retransmissions for real-time data
  - no packet sequencing or partial order
- implementation depends on network and datalink level, may have to do:
  - multiplexing
  - error detection
  - error recovery
  - flow control
  - retransmission

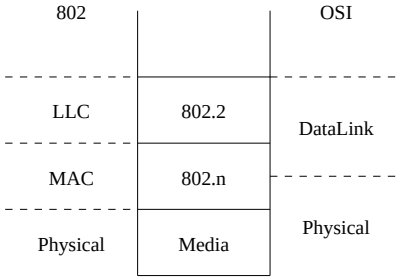
# Network level

- Inter-networking: Unifying underlying network technologies
- E.g. Internet Protocol, (ATM)
  - Connection oriented (CONS) *vs.* connectionless (CLNS)
  - Global (hierarchical) addressing
  - Forwarding
  - Segmentation and reassembly
  - QoS specification
  - (congestion notification)
- In ISO model, 3 sub layers:
  - Subnet independent convergence protocol
  - Subnet dependent convergence protocol
  - Subnet dependent access protocol

**Network Routers operate at L3**

# DataLink

Consists of two IEEE 802 layers:




- Logical Link Control: delineating frames
- Media Access Control: sharing the media
- (Mostly implemented in hardware)
- LLC example : 802.2 (Ethernet, FDDI, etc)
  – preamble
  – 48 bit src & dest address, 16 bit type, data
  – CRC, postamble (no length)
- MAC examples:
  – CSMA/CD (shared media Ethernet: IPG, backoff)
  – Token bus (timeliness, e.g. process control)
  – Token ring (efficiency at high load)
- Other DataLink examples: SLIP, PPP
  – IP encoding over "serial lines"
  – header compression

**Network 'switches' and 'bridges' operate at L2**

# Physical

*Sockets / pins / volts / wires / optics etc.*
*generate and recover clocked bitstream:*

- RS232, V.24
  - asynchronous (two end clocks can run free)
  - main signals: TxD, RxD, RTS, CTS
- V modem standards, e.g. V.90 (56kb/s digital)
  - negotiation from lower standards e.g. (V.32)
  - echo cancellation, error correction and comp.
- 802.3 lower levels: 10base-T 10base-2 10base-5
  - Manchester encoding over different media
- 100base-TX, 100base-FX, 1000base-FX
  - 8B10B coding for DC balance and framing
- Plesiochronous and Synch. Digital Hierarchy
  - Scramblers
- 1000base-TX, Cable Modems, xDSL, HomePNA
  - exotic coding e.g. QAM-16, OFDM
- 802.11 wireless
  - Direct Sequence *vs.* Frequency Hopping

**Network 'hubs' operate at L1**

# OSI Model Summary

*Application* – application specific services eg terminal, file system, mail

*Presentation* – application layer and architecture dependent coding

*Session* – synchronisation control, common control for application above and beyond "reliable data transfer"

*Transport* – end-to-end reliable delivery of information

*Network* – getting the bits across the network, reliably or not

*Link* – getting the bits across a link, reliably or not, including media access (eg an Ethernet is a link)

*Physical* – bit encoding, clock recovery, connectors, media

## Remote Procedure Call and the OSI Model

- RPC does application layer and architecture dependent coding (marshalling and unmarshalling)
- RPC does recovery from failures over and above reliable transfer of information (at most once, at least once, exactly once semantics)
- operates at (at least) presentation and session layers
- look at an implementation — is the presentation / session split apparent?
- where do you encrypt in RPC?

## OSI Model Conclusions (mine)

- has delivered a useful vocabulary, ways to compare systems
- perhaps a bit restrictive: often one runs a network layer over another network layer; model doesn't really allow this
- useful tool, not a master
- don't be concerned with things that don't fit the model e.g.:
  - application level gateways
  - firewalls
  - per-flow queueing routers
  - layer-7 switches
  - transparent HTTP proxying