Lecture 2.b

Networking 1

Protocol Stacks

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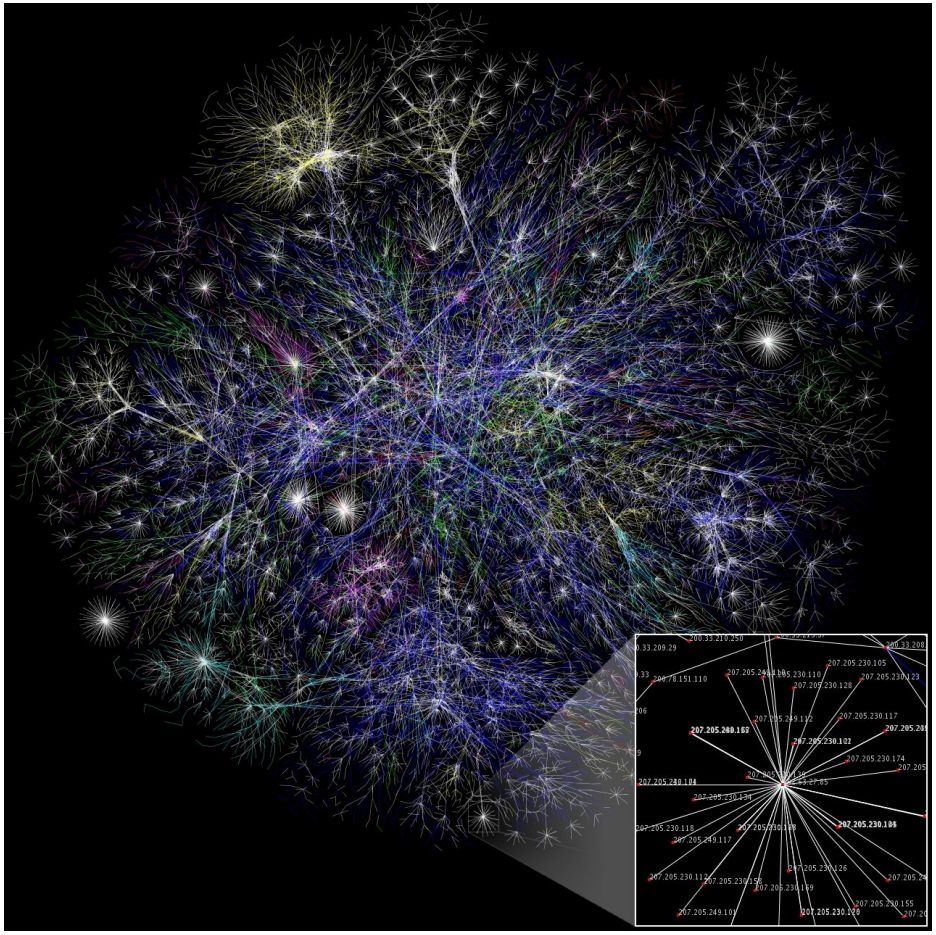
Networking: Handling Complexity



Networking: Handling Complexity

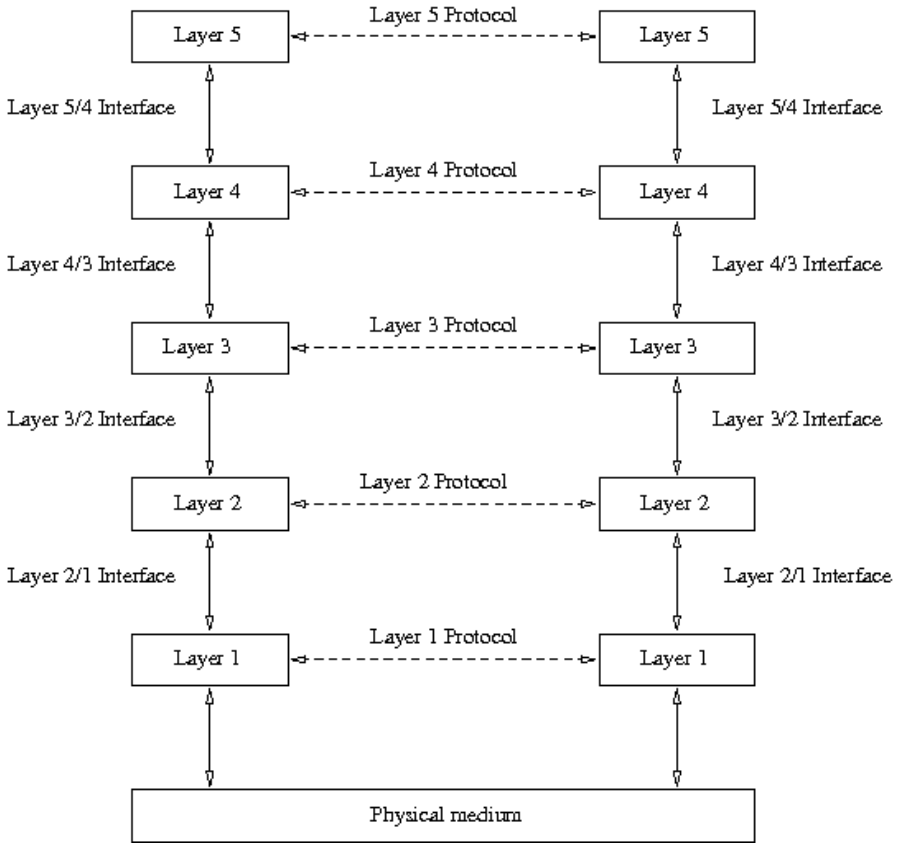
- **Network communications are complex**, and are made out of many pieces
  - hosts
  - routers
  - various media

- Is there any hope of organizing the structure of network communications? Or at least our discussion of network communications?

- Divide up communication task into different smaller tasks, each task relying upon the work done by another.

Protocol Hierarchies

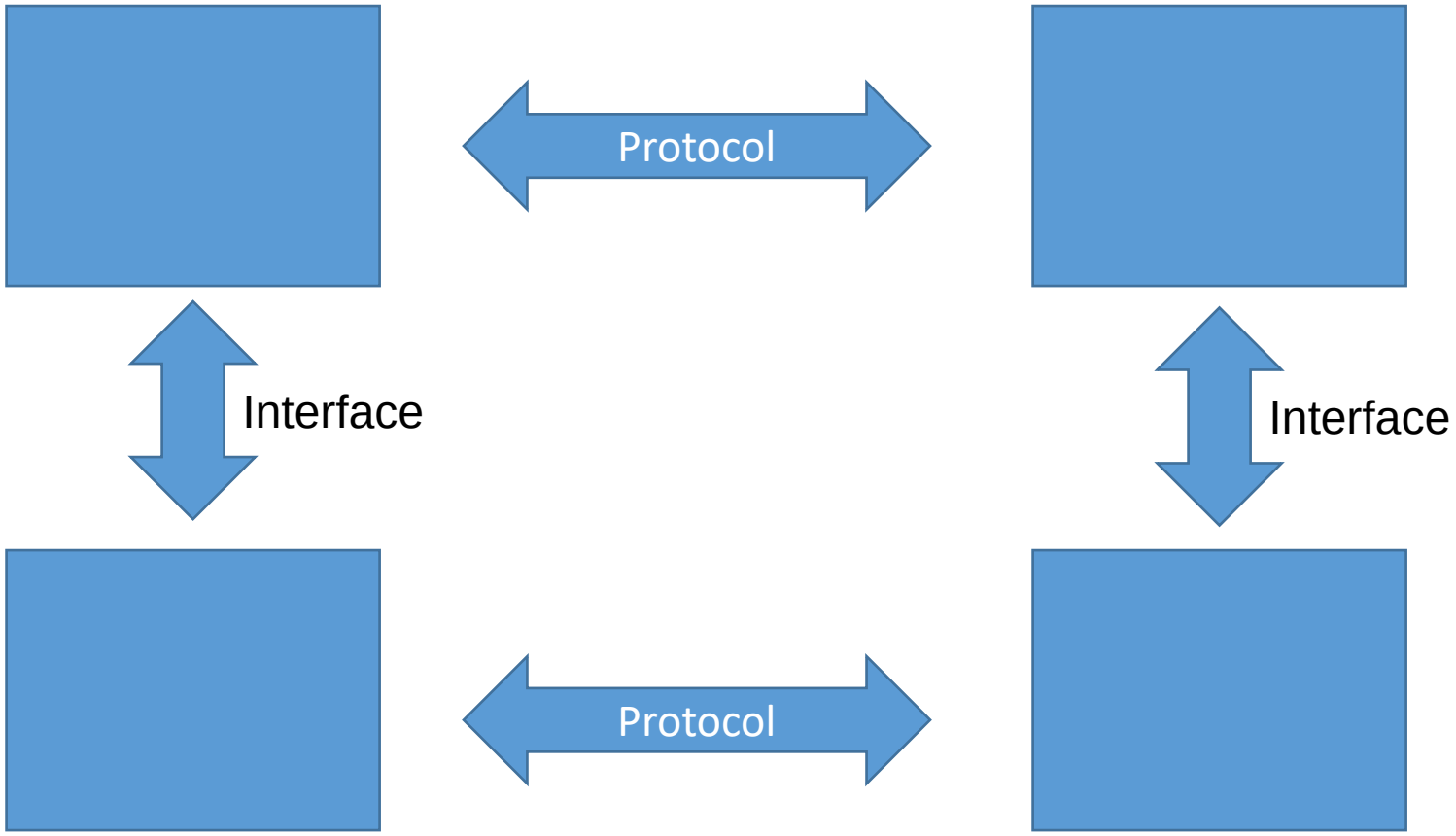
- Reduce the complexity of network communication design
- Organise network communication as a series of layers



Layers

- Layering the model allows us to solve a different problem at each layer.
  - Each layer builds on services of the layer below it to other higher level services to the layer above it - ***interface***
  - Higher layers are shielded from lower level implementation details –***transparency***
- Physical communication takes place at the lowest layer.
- Logically layer n on one machine carries on a conversation with layer n on another machine
  - Equivalent layers are known as peers
  - Notice though that the actual communication takes place down the layer stack
- Rules and conventions used in a logical conversation are called the layer n protocol

Layers



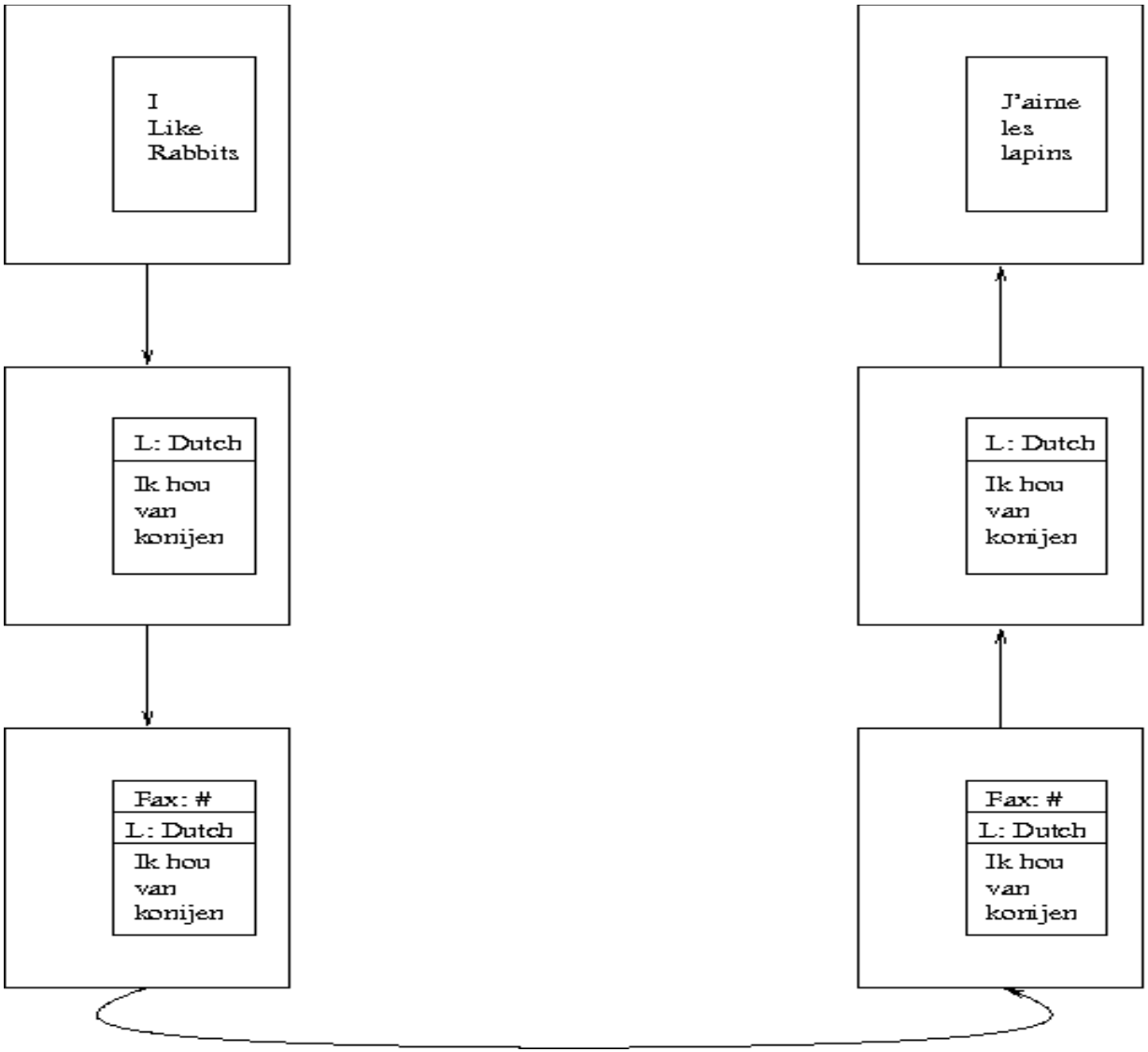
Protocol Hierarchy 1

- Lets draw an analogy to introduce the idea
  - Assume two philosophers need to converse:
    - Philosopher A speaks Urdu and English
    - Philosopher B speaks Chinese and French

- Since neither have a common language they each employ a translator, The translators agree a common language: Dutch

- Each translator employs a secretary who has a fax machine, email and telephone on his desk

Protocol Hierarchy 2



Protocol Hierarchy 3

- Lets examine the features of this three layer protocol suite:
  - Each layer carries out a distinct task
  - Each layer offers a service to the layer above it.

- On each layer, on one side there is an entity which is having a conversation with an entity on the same layer (its peer) on the other side
  - Philosopher to philosopher
  - Translator to translator
  - Secretary to secretary

- These are called peer entities
- The conversation they are having is called *logical communication*

Protocol Hierarchy 4

- The peer entities (philosopher, translator, secretary) take responsibility only for the their own task.

- For instance, the only thing the philosopher takes responsibility for is making and listening to philosophical pronouncements.
  - Philosopher A speaks in English, and expects replies in English
  - Philosopher B speaks in French and receives replies in French
  - No concern with the translator or the intermediary language

- As far as philosopher A is concerned he is having a direct conversation with philosopher B

- The choice of philosophy as the subject is the protocol in the philosopher-philosopher layer (layer 3)
  - A and B assume a particular type of discourse is about to occur
  - They understand the rules of philosophical discourse

Protocol Hierarchy 5

- The translator's responsibility is to accept reams of paper shoved through their letter box and translate these into Dutch/English
  - Doesn't care about the philosopher's preoccupations
  - Only concerned about translation
  - I.e. Translator A receives Dutch from Translator B and translates it into English. Also translates English placed in the letterbox by the philosopher into Dutch.
- Each translator is under the assumption that he/she is having a direct communication with the other
- The choice of Dutch as the language is the protocol in the translator-translator layer (layer 2)
- Translators can agree to change languages (say, to Swedish) without informing the other layers as long as they offer the same service to the upper layer - translation

Protocol Hierarchy 6

- Responsibility: accept pieces of A4 with writing on it and send them to the secretary at the location specified.

- Secretary can make the choice to send the document by fax, email or to read it over the telephone without informing the other layers
- The secretaries have agreed a form of physical transmission (and perhaps timing arrangements)

- Again, each secretary assumes one to one communication with the other. (in this case, true)

- In this layer the protocol is the arrangement agreed by the secretaries for transmission

Headers

- Each entity may add some additional information intended only for its peer
  - Each translator may include translator's notes and clarifications, or if there are several translators working on either side, a translator name
  - Secretary may attach a cover sheet to the fax, or a greeting in the email message
- These extra pieces of information are stripped away by each peer on the other side before passing the message on to the higher layer

Protocol Suite/Stack

- A set of related protocols that are designed for compatibility is called a **protocol suite**

- Protocol suite designers:
  - Analyse communication problem
  - Divide problems into sub-problems
  - Design a protocol for each sub-problem

- A well-designed protocol suite
  - Is **efficient and effective** - solves the problem without redundancy and makes the best use of network capacity
  - Allows replacement of individual protocols without changes to other protocols (this is called “**modularity**")

Why layering ?

- Allows network designers to break up the complex issues in communication.
  - Explicit structure allows identification and modelling of the relationships of the pieces of a complex system
  - Generally we use the 7-layered OSI model as a reference model
  - Breaking communication task into modules eases maintenance and updating of systems
    - Change of implementation of any layers service should be transparent to rest of the system.
    - i.e. change in procedure in one layer shouldn't effect the rest of system.

Designing a protocol

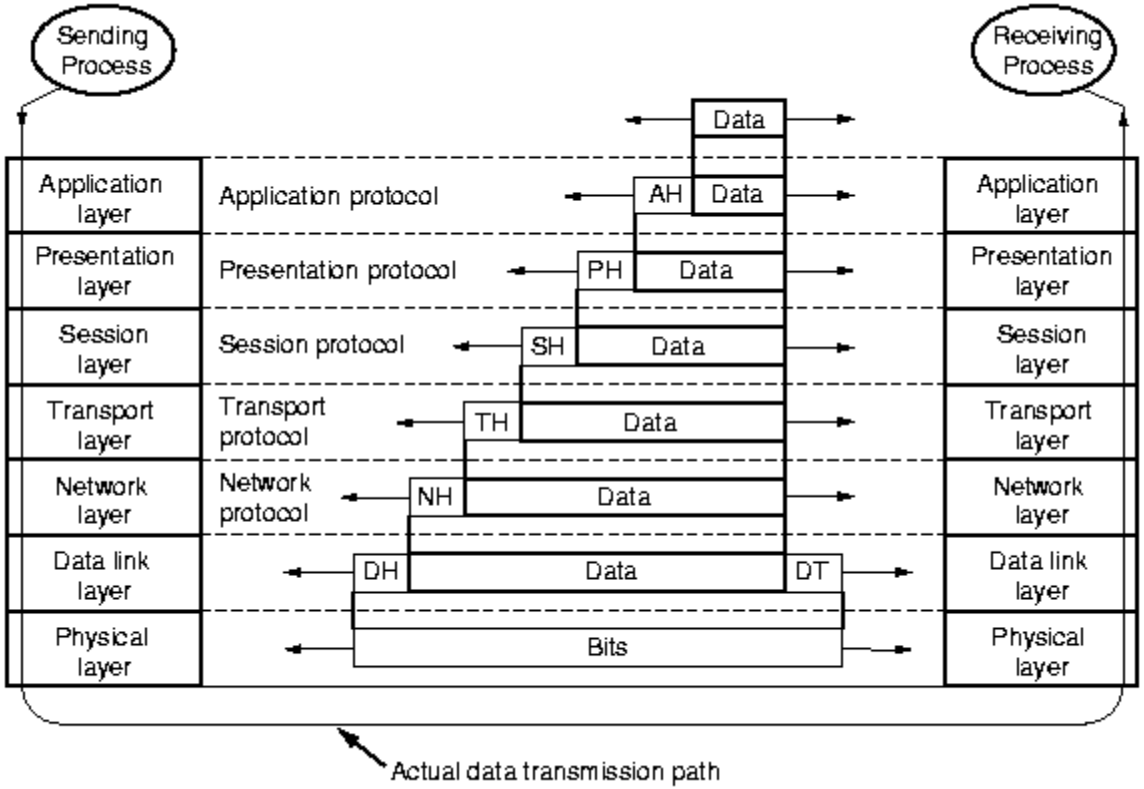
- Transmission of data on a network needs to address the following issues:
  - Physical Transmission (What media?)
  - Addressing (Identifying senders and receivers)
  - Encoding Techniques
  - Flow Control (Simplex, half duplex or full duplex)
  - Error Detection and Correction(Physical communication circuits are not perfect how will errors be handled?)
  - Sequencing (Messages can arrive out of order how will this be handled?)

How many layers ?

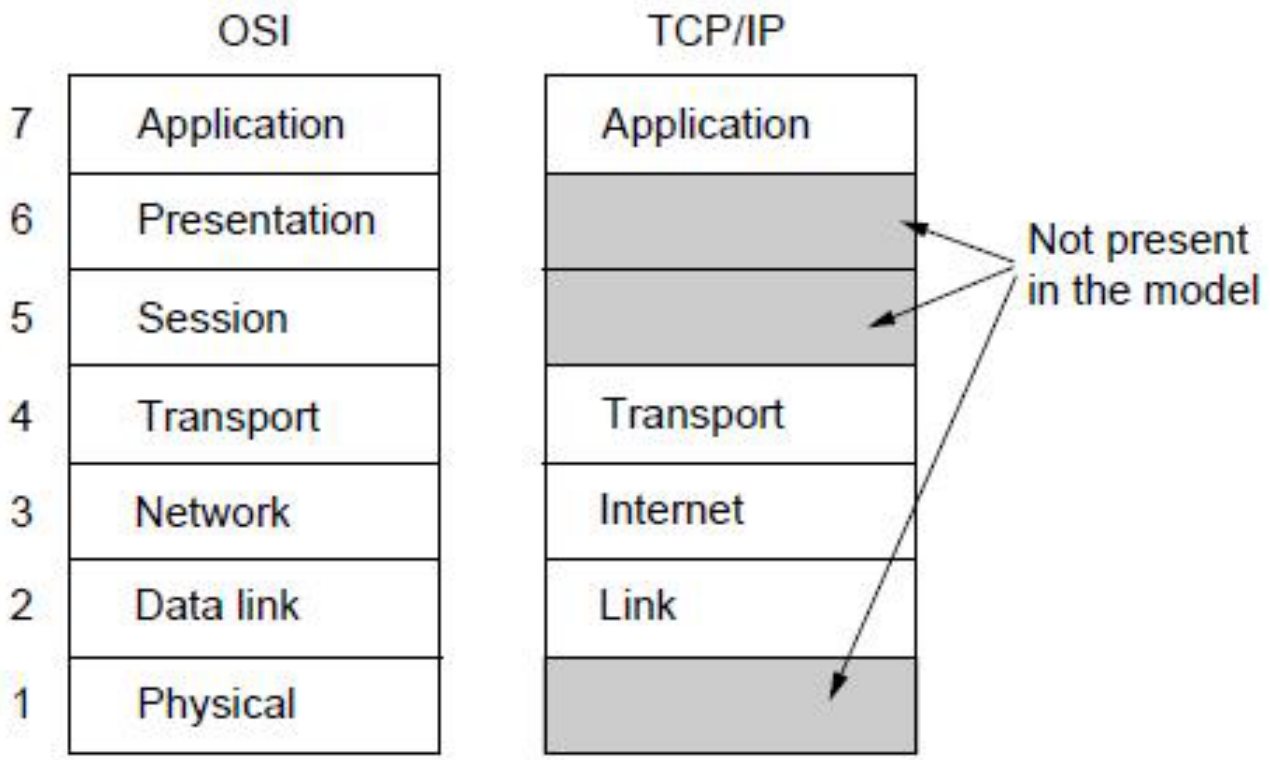
- A protocol stack should divide up these issues so that:
  - A layer is created where a different level of abstraction is needed
  - Each layer has a well defined function
  - Function of each layer should be chosen with an eye towards defining internationally standardized protocols
  - Layer boundaries should be chosen to minimise information ow across layer interfaces
  - The number of layers should be large enough so that distinct functions are not thrown together in one layer out of necessity
  - The number of layers should be small enough so that the protocol does not become unwieldy

OSI Reference Model

- The ISO have divided up these issues over a layered hierarchy of 7 levels called the **ISO Open Systems Interconnection (OSI) Reference Model**



OSI vs TCP/IP


OSI
TCP/IP
7
Application
6
Presentation
5
Session
4
Transport
3
Network
2
Data link
1
Physical
Application
Transport
Internet
Link
Not present
in the model

Internet Protocol Stack (TCP/IP)

- **Application**: how one particular application uses the network. This Species details of how an application program on one machine makes a request and how the application machine responds.

- **Transport**: details of reliable data transfer between two hosts (perhaps distant)
  - Fragments incoming byte stream (from application layer) into segments and passes them to the internet layer (which routes them)
  - At the destination, the receiving TCP process reassembles the segments in to an output stream
  - Handles flow control - fast sender cannot swamp a slow receiver
  - Congestion control: slows down if it detects network congestion

- **Network**: details of routing of datagrams from source to destination
  - Permit hosts to inject packets into any network and have them travel independently to the destination (often via another network)
  - Analogy with snail mail
  - IP, routing protocols

Internet Protocol Stack (TCP/IP)

- **Link**: Controls the link between adjacent nodes
  - Concerned with using physical layer to transmit chunks (frames) of information reliably from node to node
  - Handles sharing of the medium
  - Provides flow control and error handling
  - Provides frame transmission/reception service to the layer above it

- **Physical**: Implements a “bit pipe”
  - Provides unreliable bit transmission/reception service to layer above
  - Concerned with wiring and electrical standards