Network Layers

Standardization Cruelty

"The good thing about standards is that there are so many to choose from"

Andrew S. Tanenbaum

Standards

- We need networking standards
  - Ensure interoperability
  - Large market, lower cost (mass production)
- Vendors need standards
  - Good for marketing
- Vendors create standards
  - Bad for competitors, hard to catch up
- But: Slow standardization processes freeze technology...

Who Defines Standards?

- ISO – Anything
- IETF – Internet
- ITU-T – Telco Technologies
- ATM Forum
- Frame Relay Forum
- IEEE – LAN Protocols

Standards Types

- De facto standards
  - Anyone can create them
  - E.g. Internet RFCs
- De jure standards
  - Created by a standardization organization
  - E.g. ISO/OSI, ITU-T

Note

Standardization is applied to *network layers* and *interfaces* between them

Network Layers

- Divide task of communication in multiple sub-tasks
- Hierarchically organized
  - Each layer *receives* services from the layer below
  - Each layer *serves* for the layer above
- Good for interoperability
  - Capsulated Entities and Interfaces
- But increases complexity

Where to Define Layers

- Group functions (services) together
- When changes in technology occur
- To expose services
- To allow changes in protocol and HW
- To utilize existing protocols and HW

The ISO/OSI Model

- International Standards Organization (ISO)
  - International agency for the development of standards in many areas
  - Founded 1946
  - Currently 89 member countries
  - More than 5000 standards until today
- 1988 US Government OSI Profile (GOSIP)
  - Requires Government products to support OSI layering

Purpose

- OSI model *describes* communication *services* and *protocols*
- No assumption about
  - Operating system
  - Programming Language
- Practically, the OSI model
  - Organizes knowledge
  - Provides a common discussion base

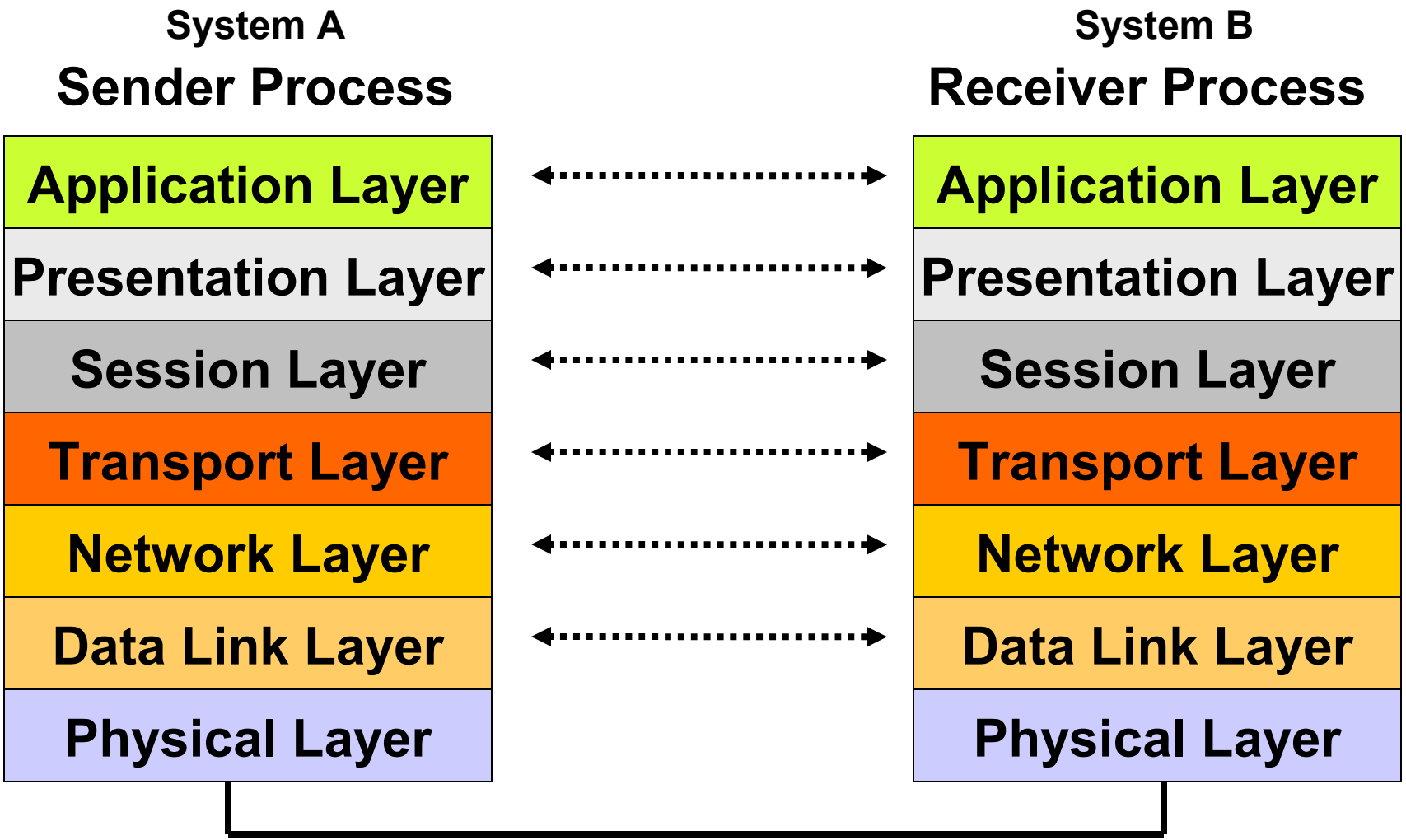
OSI Basics

- Point-to-Point, no shared media
- Nodes are called
  - End Systems (ES)
  - Intermediate Systems (IS)
- Each layer of the OSI model detects and handles errors (FCS)
- Dumb hosts and intelligent network
  - Compared with Internet: dumb network, intelligent hosts

The OSI Truth

- OSI model was created before protocols
  - Good: Not biased, general approach
  - Bad: Designers had little experience, no ideas in which layers to put which functionality...
- Not widespread (complex, expensive)
- But serves as good teaching aid !!!

The 7 OSI Layers



Physical Layer

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- Mechanical and electrical specifications
- Access to physical medium
- Generates Bit stream
- Line coding and clocking
- Examples
  - LAN: Ethernet-PHY, 802.3-PHY
  - WAN: X.21, I.400 (ISDN), RS-232

Link Layer

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

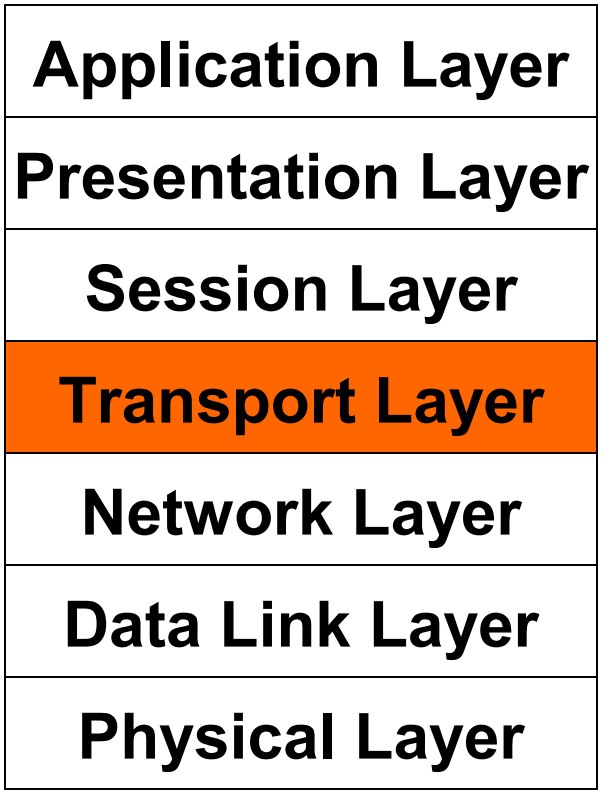
- Reliable transmission of *frames* between two NICs
- Framing
- FCS
- Physical Addressing of NICs
- Optional error recovery
- Optional flow control
- Examples:
  - LAN: 802.2
  - PPP, LAPD, LAPB, HDLC

Network Layer

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- Transports *packets* between networks
- Provides structured addresses to name networks
- Fragmentation and reassembling
- Examples:
  - CLNP
  - IP, IPX
  - Q.931, X.25

Transport Layer



- Reliable transport of *segments* between applications
- Application multiplexing through T-SAPs
- Sequence numbers and Flow control
- Optional QoS Capabilities
- Examples:
  - TCP (UDP)
  - ISO 8073 Transport Protocol

Session Layer

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- Provides a user-oriented connection service
  - *Synchronization Points*
- Little capabilities, usually not implemented or part of application layer
  - Telnet: GA and SYNCH
  - FTP: re-get allows to continue an interrupted download
  - ISO 8327 Session Protocol

Presentation Layer

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

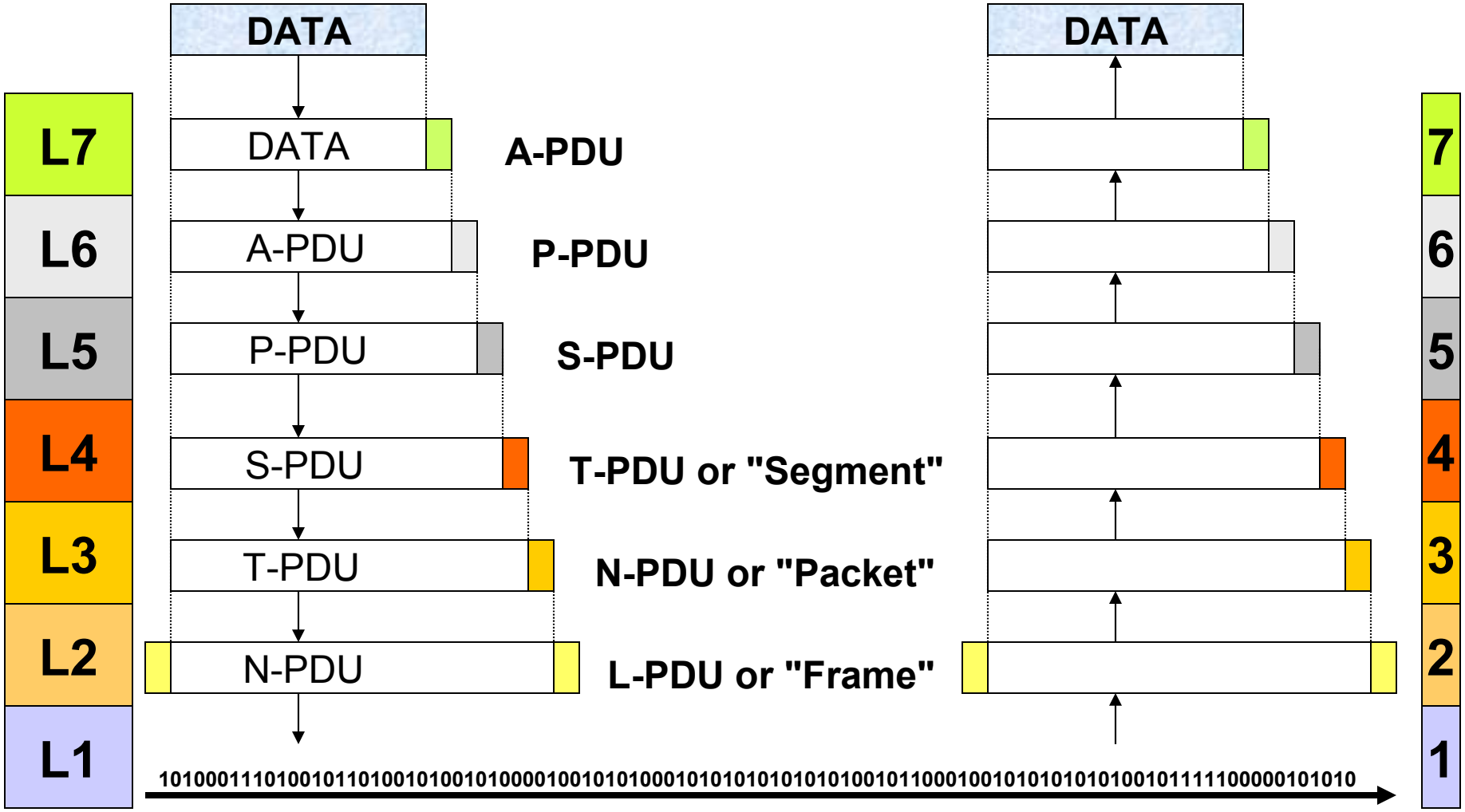
- Specifies the data representation format for the application
- Examples:
  - MIME (part of L7) and UUENCODING (part of L7)
  - ISO: ASN.1 and BER

Application Layer

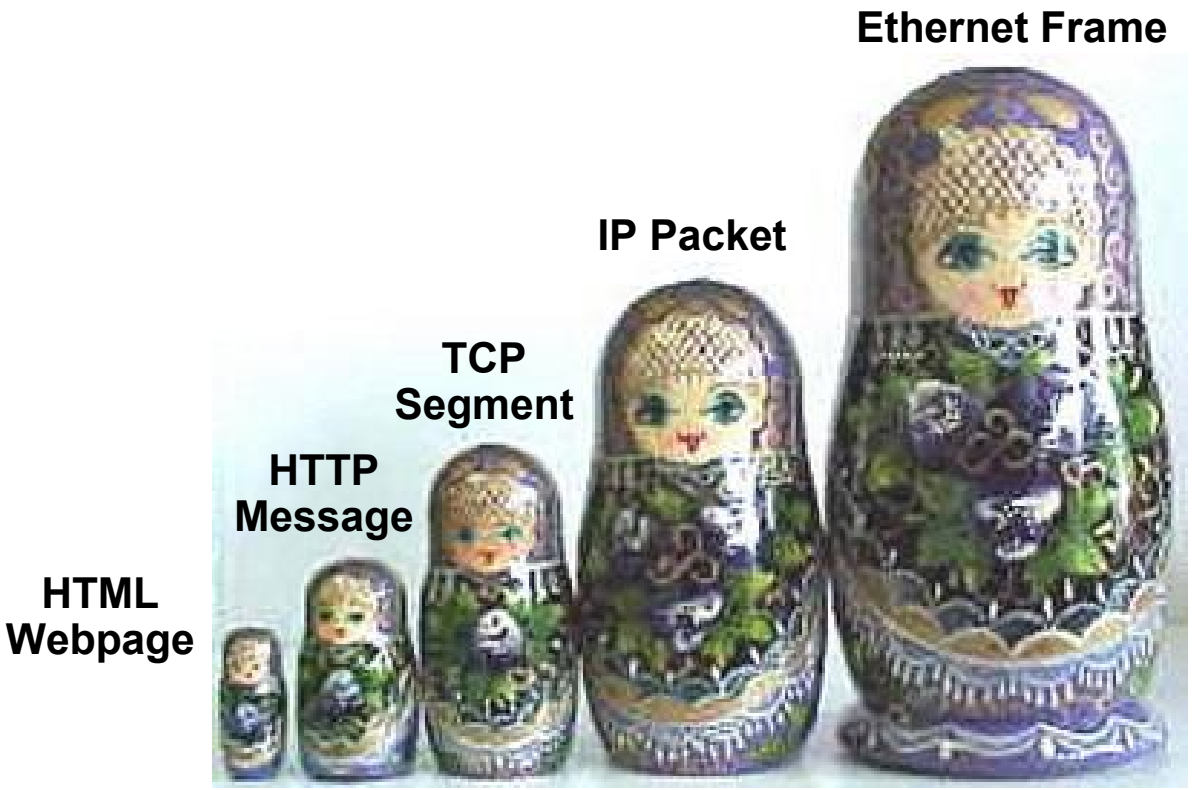
Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

- Provides network-access for applications
- Examples:
  - ISO 8571 FTAM File Transfer Access + Management, X.400 Electronic Mail, CMIP
  - SMTP, FTP, SNMP, HTTP, Telnet, DNS, …

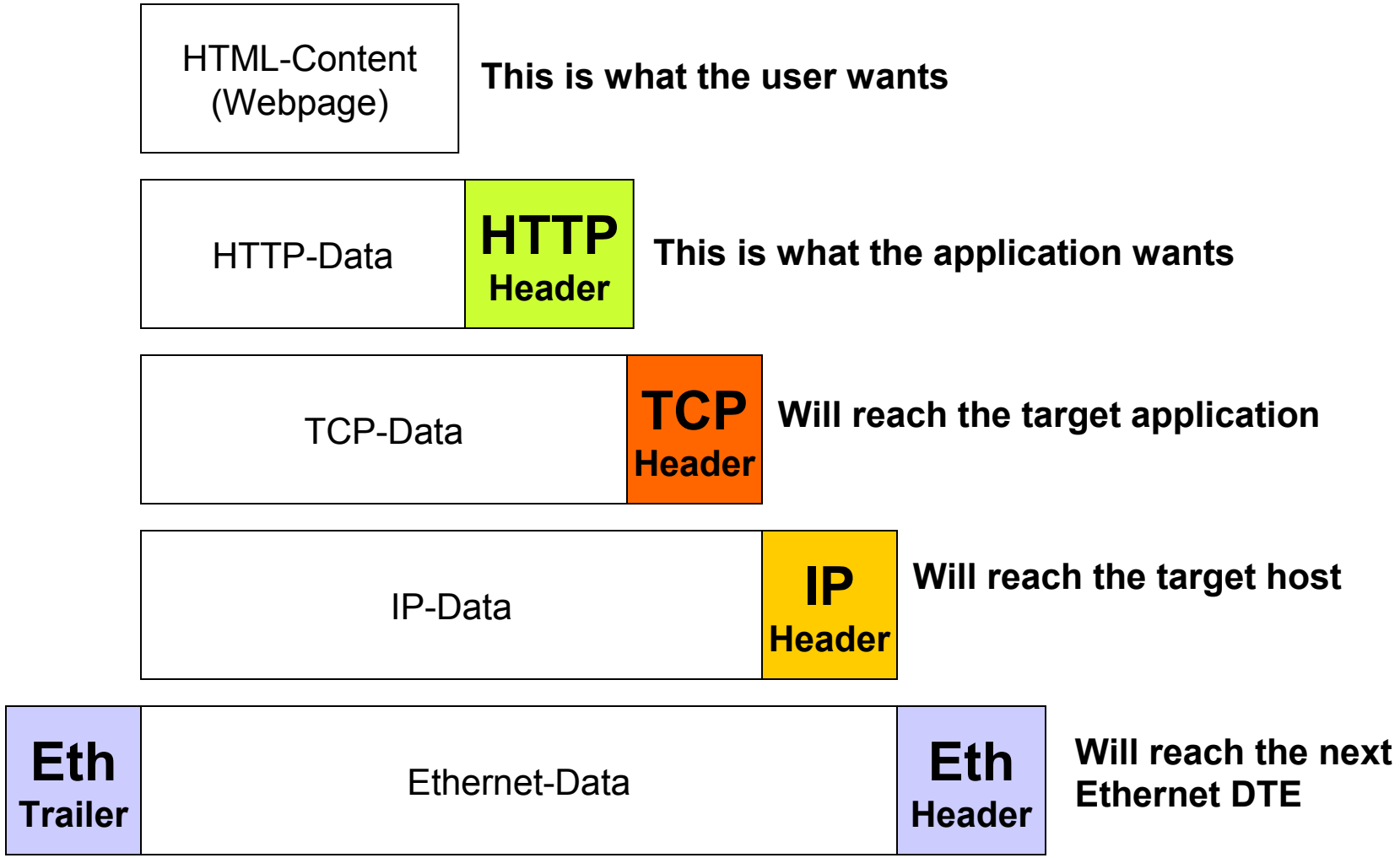
Encapsulation Principle



Practical Encapsulation



Internet Encapsulation



OSI Speak (1)

- Entities
  - Anything capable of sending or receiving information
- System
  - Physically distinct object which contains one or more entities
- Protocol
  - Set of rules governing the exchange of data between two entities

OSI Speak (2)

- Layer
  - A set of entities
- Interface
  - Boundary between two layers
- Service Access Point (SAP)
  - Virtual port where services are passed through

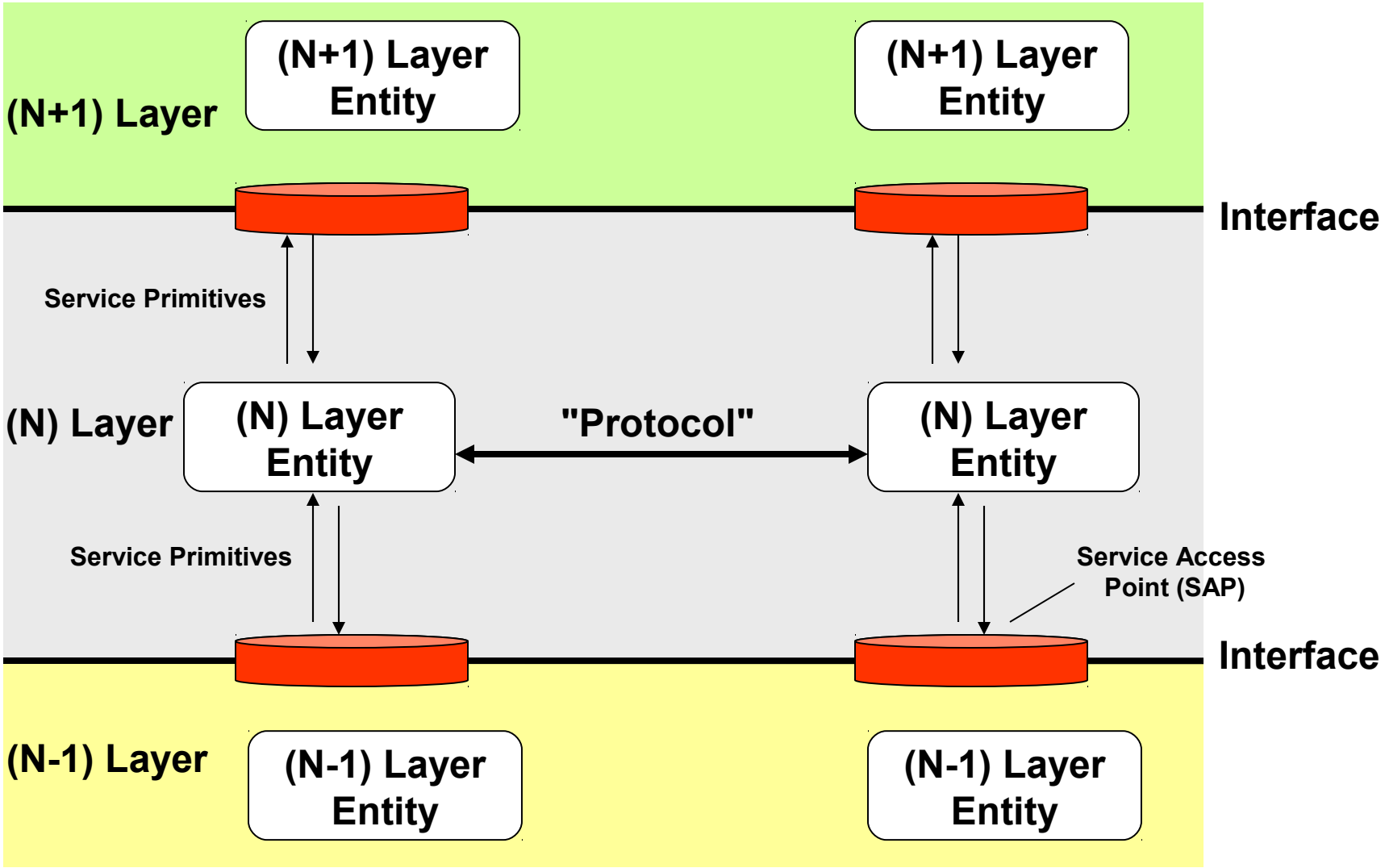
OSI Speak (3)

- Interface Data Unit (IDU)
  - Data unit for vertical communication (between adjacent layers of same system)
- Protocol Data Unit (PDU)
  - Data unit for horizontal communication (between same layers of peering systems)

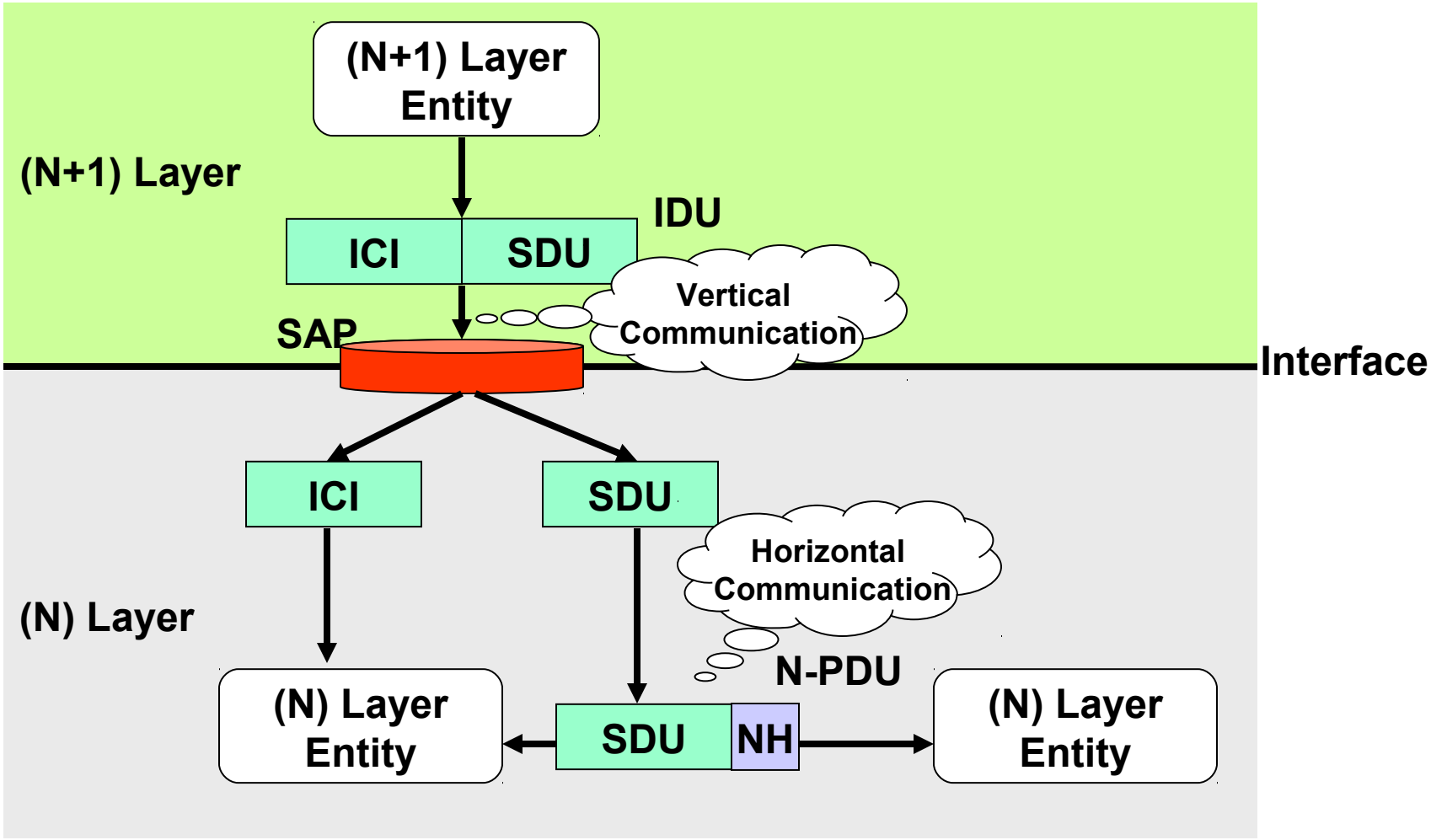
OSI Speak (4)

- Interface Control Information (ICI)
  - Part of IDU
  - Destined for entity in target-layer
- Service Data Unit (SDU)
  - Part of IDU
  - Destined for further communication
  - Contains actual data ;-)

OSI Speak Summary (1)

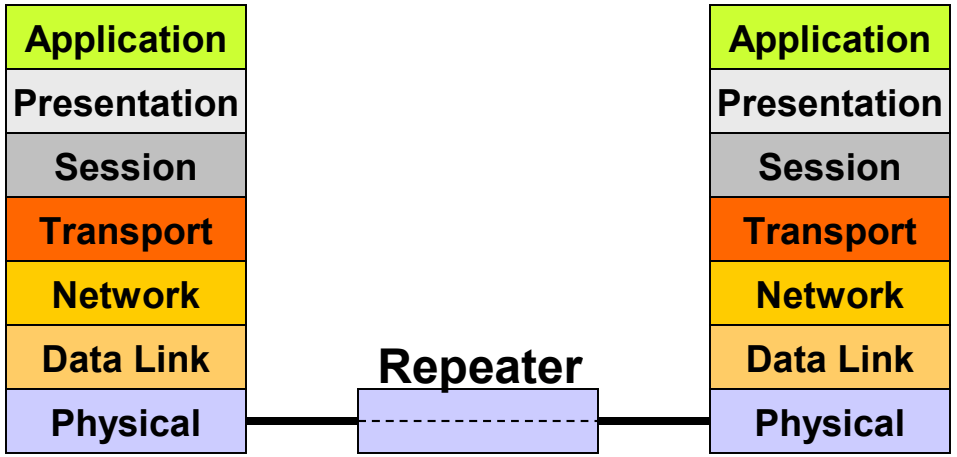


OSI Speak Summary (2)



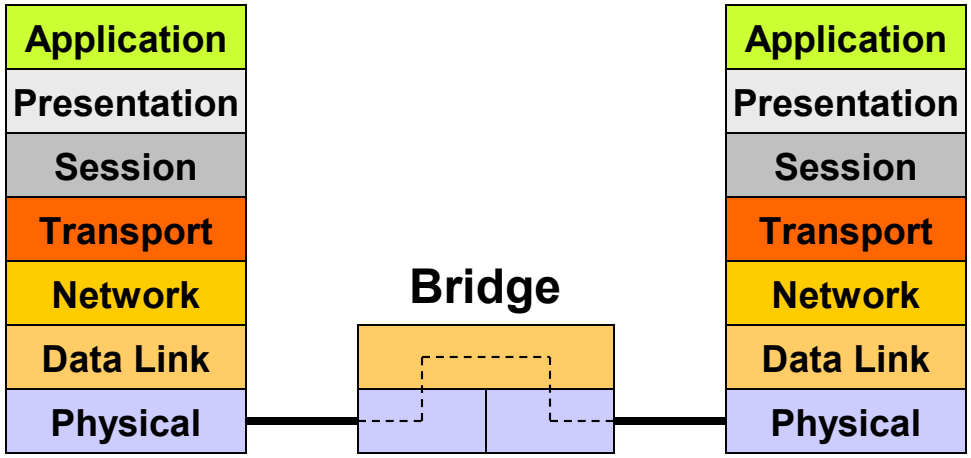
Layer 1 Devices

- Adapts to different physical interfaces
- Amplifies and/or refreshes the physical signal
- No intelligence
- Repeater, Hub, NT1



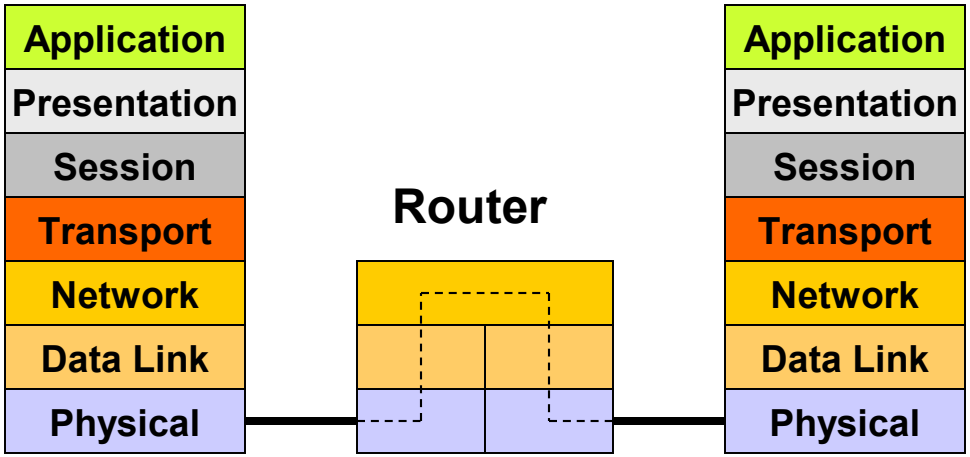
Layer 2 Devices

- Filter/Forwards frames according Link Layer Address
- Incorporates Layer 1-2
- LAN-Bridge ("Switch")

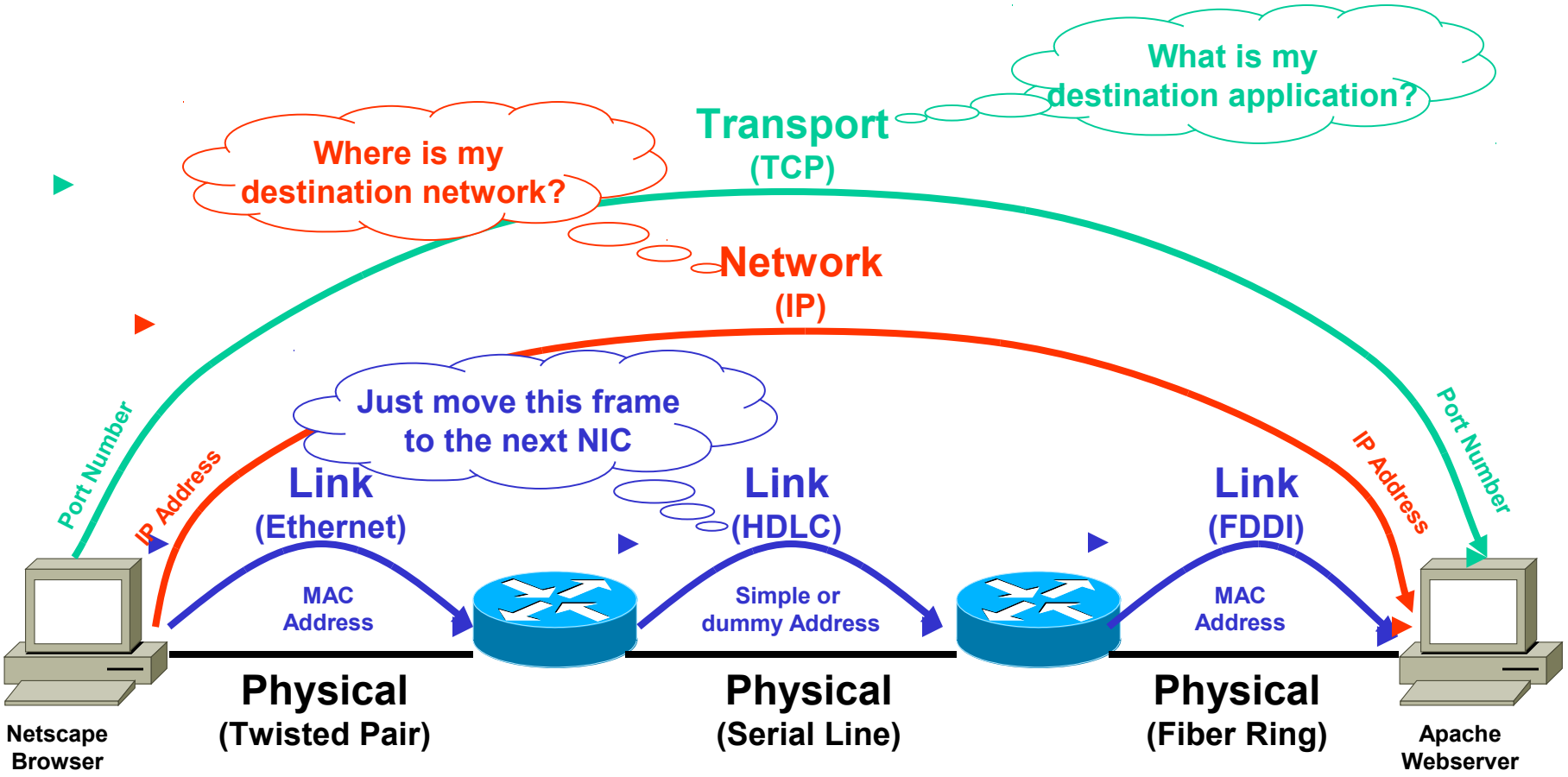


Layer 3 Devices

- "Packet Switch" or "Intermediate System"
- Forwards packets to other *networks* according *structured* address
- Terminates Links
- Router, WAN-Switch



A Practical Example

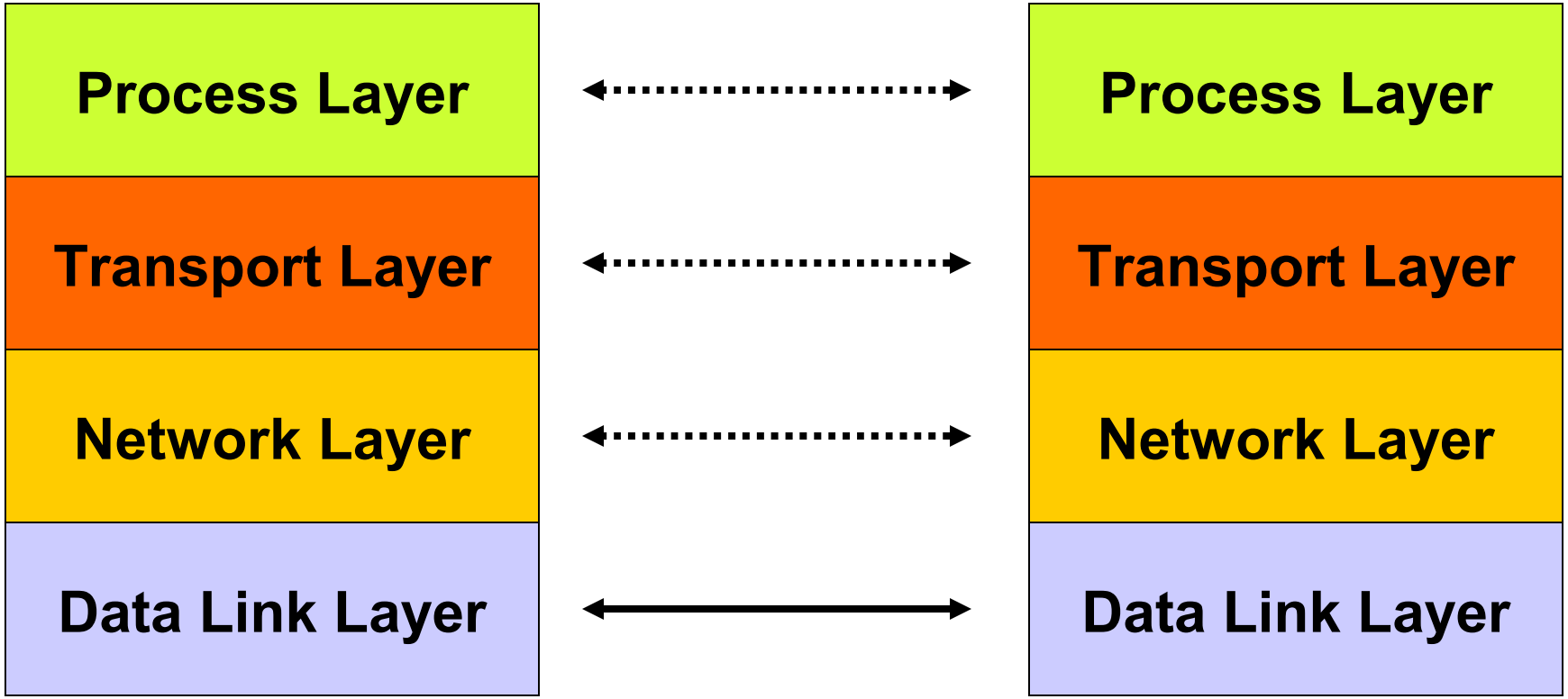


Padlipsky's Rule

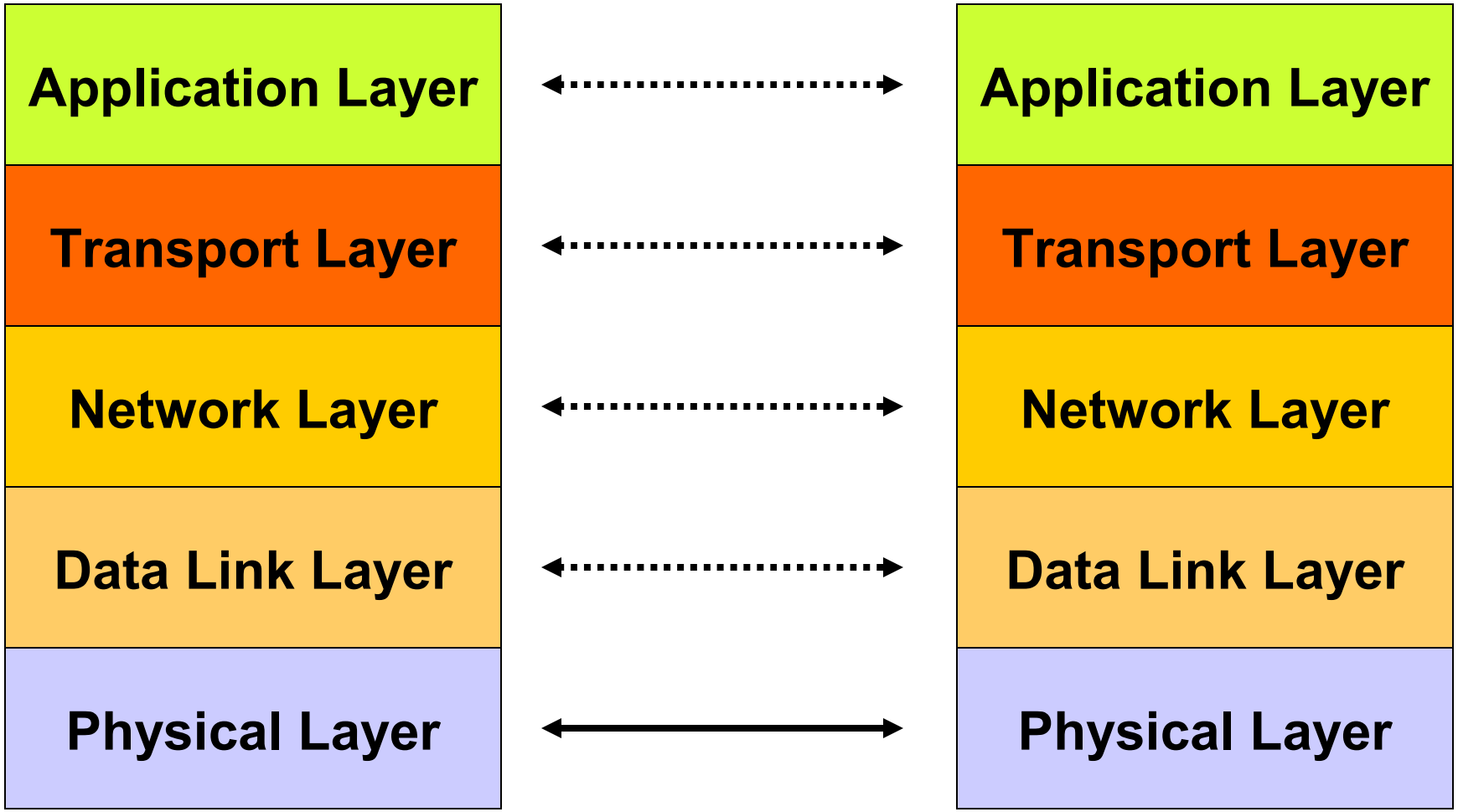
If you know what you're doing, three layers is enough. If you don't, even seventeen won't help.

Stevens 4-Layer Model

Equivalent to the DoD Model (Internet)



Tanenbaum 5-Layer Model



Summary

- Network layers ensures interoperability and eases standardization
- ISO/OSI 7 layer model is an important reference model
- Practical technologies employ a different layer set, but it's always possible to refer to OSI

The Internet perspective is implement it, make it work well, then write it down.

The OSI perspective is to agree on it, write it down, circulate it a lot and now we'll see if anyone can implement it after it's an international standard and every vendor in the world is committed to it.

One of those processes is backwards, and I don't think it takes a Lucasian professor of physics at Oxford to figure out which.

Marshall Rose, "The Pied Piper of OSI"

Quiz

- Explain layer-2 capabilities!
- What could be the task of a layer-4 device ?
- What is a "gateway"?
- How does the (N) layer tell (N+1) layer that it has data to hand over ?
- Why have OSI protocols not been successful on market ?

Hints

- Q1: Framing, Protection, Access,...
- Q2: Layer 4 device might deal with QoS, sequencing and flow control
- Q3: According to OSI a layer 1-7 device, according to IETF a router.
- Q4: Using Service Primitives (Indicate)
- Q5: OSI is too complex and general, several fields in headers might have variable length, sometimes ignores byte- and word-delineation, ...