CSE/PC/B/T/316
Computer Networks
Topic 2- Internet & Network Models

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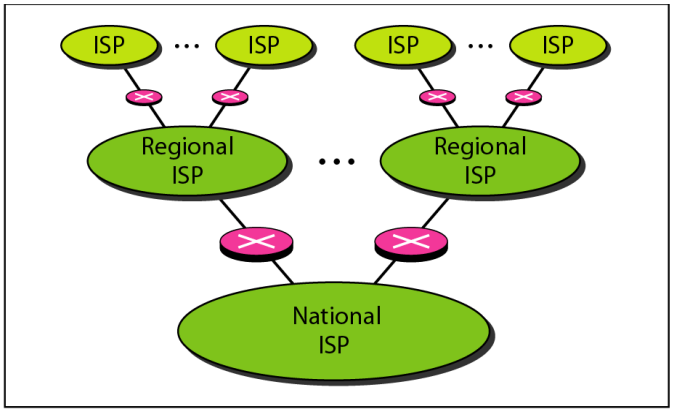
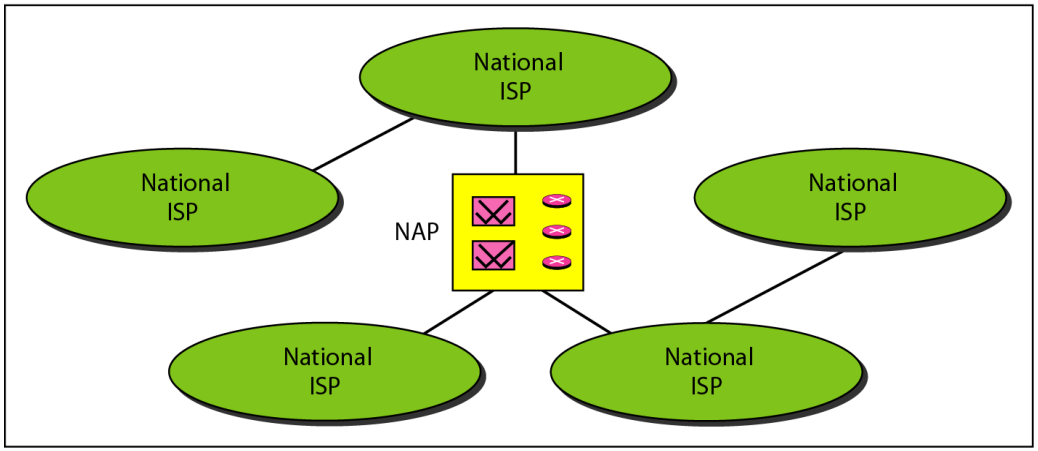
Big and getting bigger….

INTERNET

Hierarchical organization of the Internet

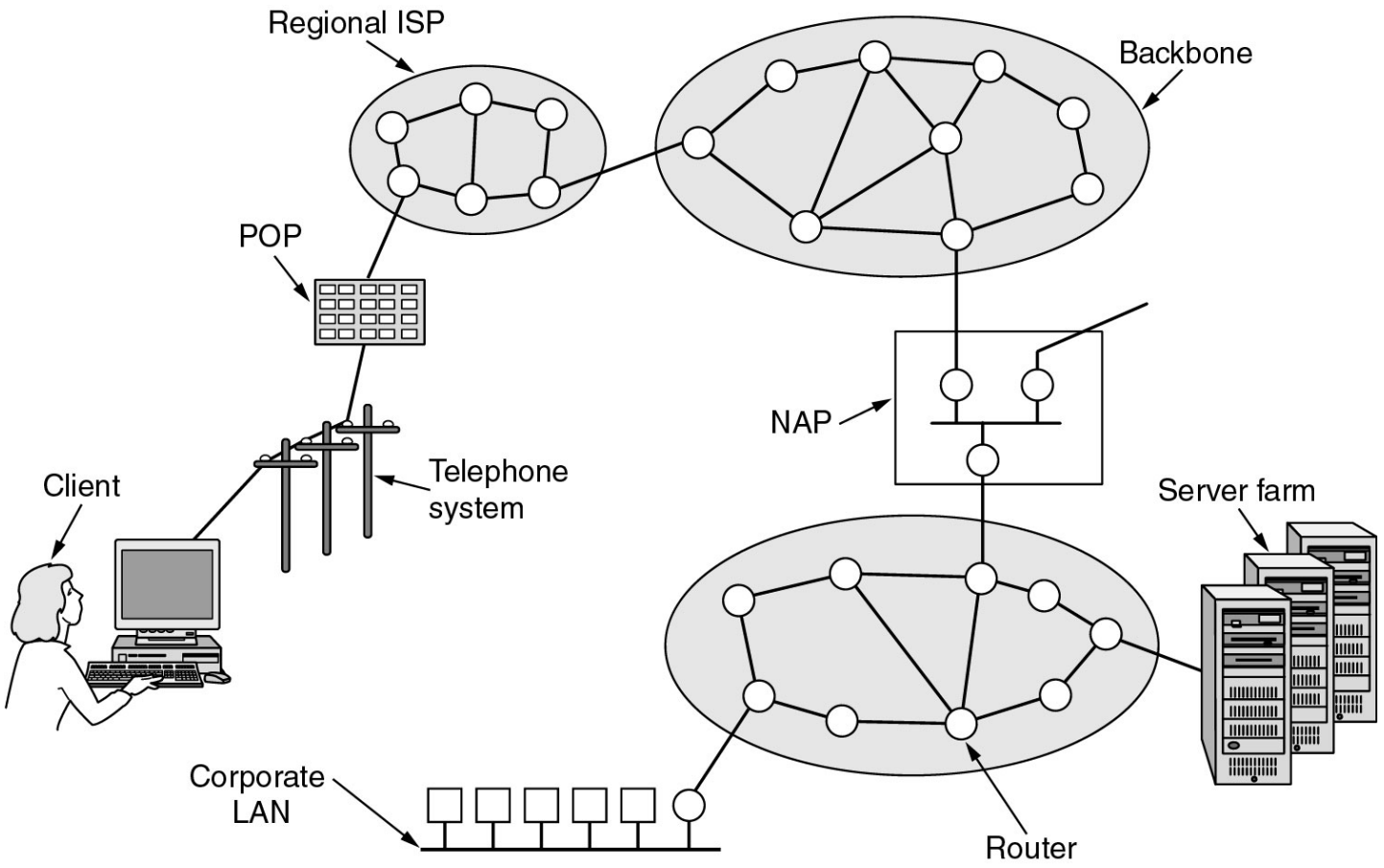


a. Structure of a national ISP

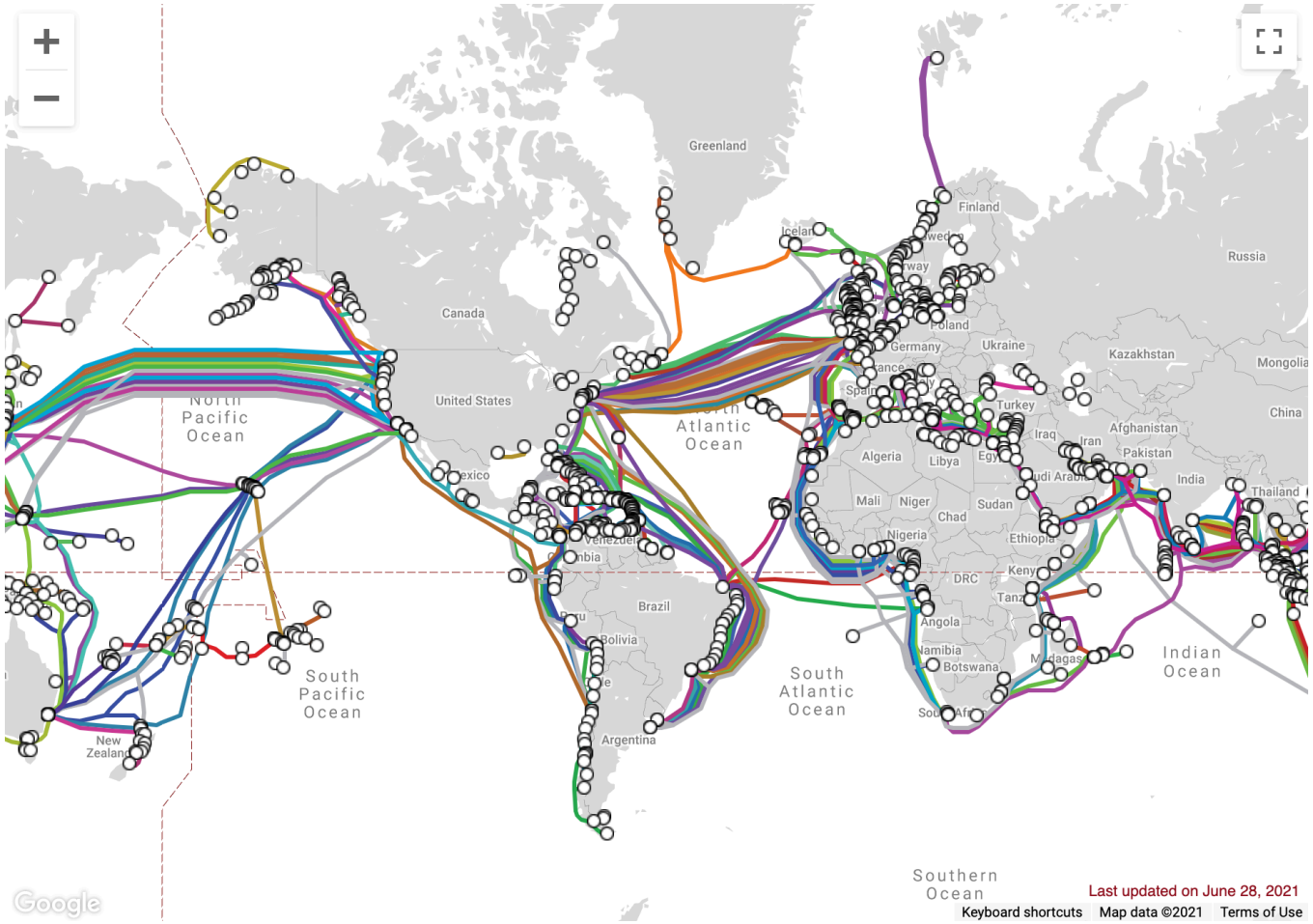


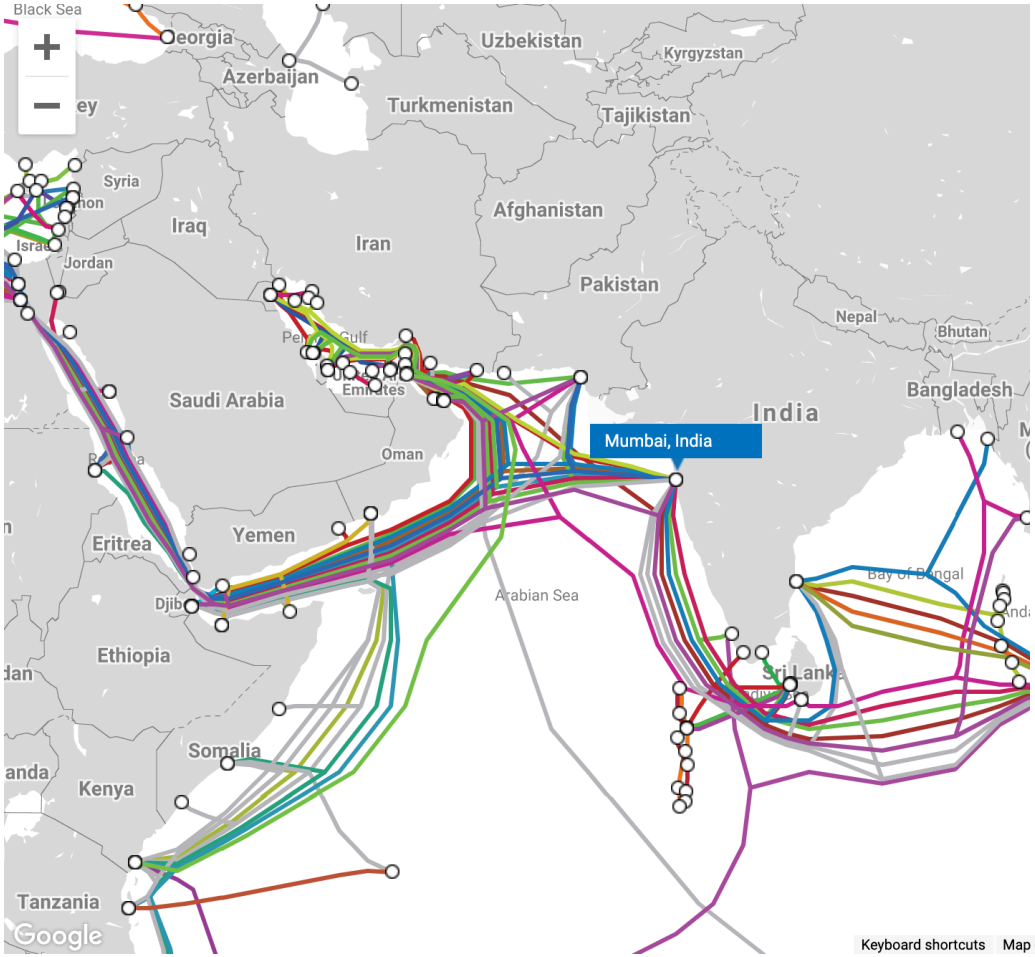
b. Interconnection of national ISPs

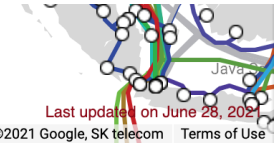
Overview of the Internet: TCP/IP reference model



https://www.submarinecablemap.com/







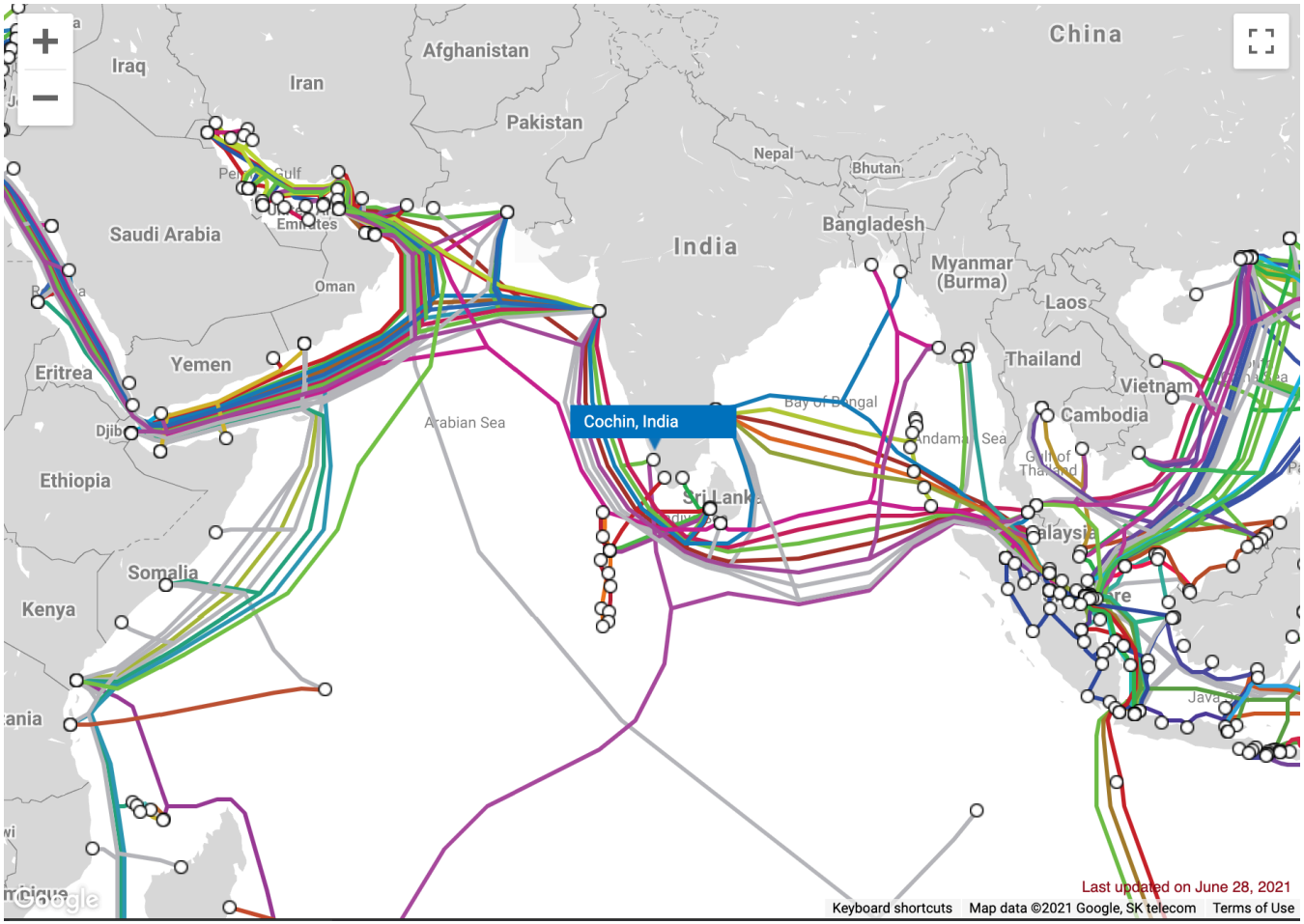
Submarine Cable List

Mumbai, India

Email link

Cables

Asia Africa Europe-1 (AAE-1)
Bay of Bengal Gateway (BBG)
Europe India Gateway (EIG)
FALCON
FLAG Europe-Asia (FEA)
Gulf Bridge International Cable System (GBICS)/Middle East North Africa (MENA) Cable System
IMEWE
India Asia Xpress (IAX)
India Europe Xpress (IEX)
MIST
SEACOM/Tata TGN-Eurasia
SeaMeWe-3
SeaMeWe-4



Submarine Cable List

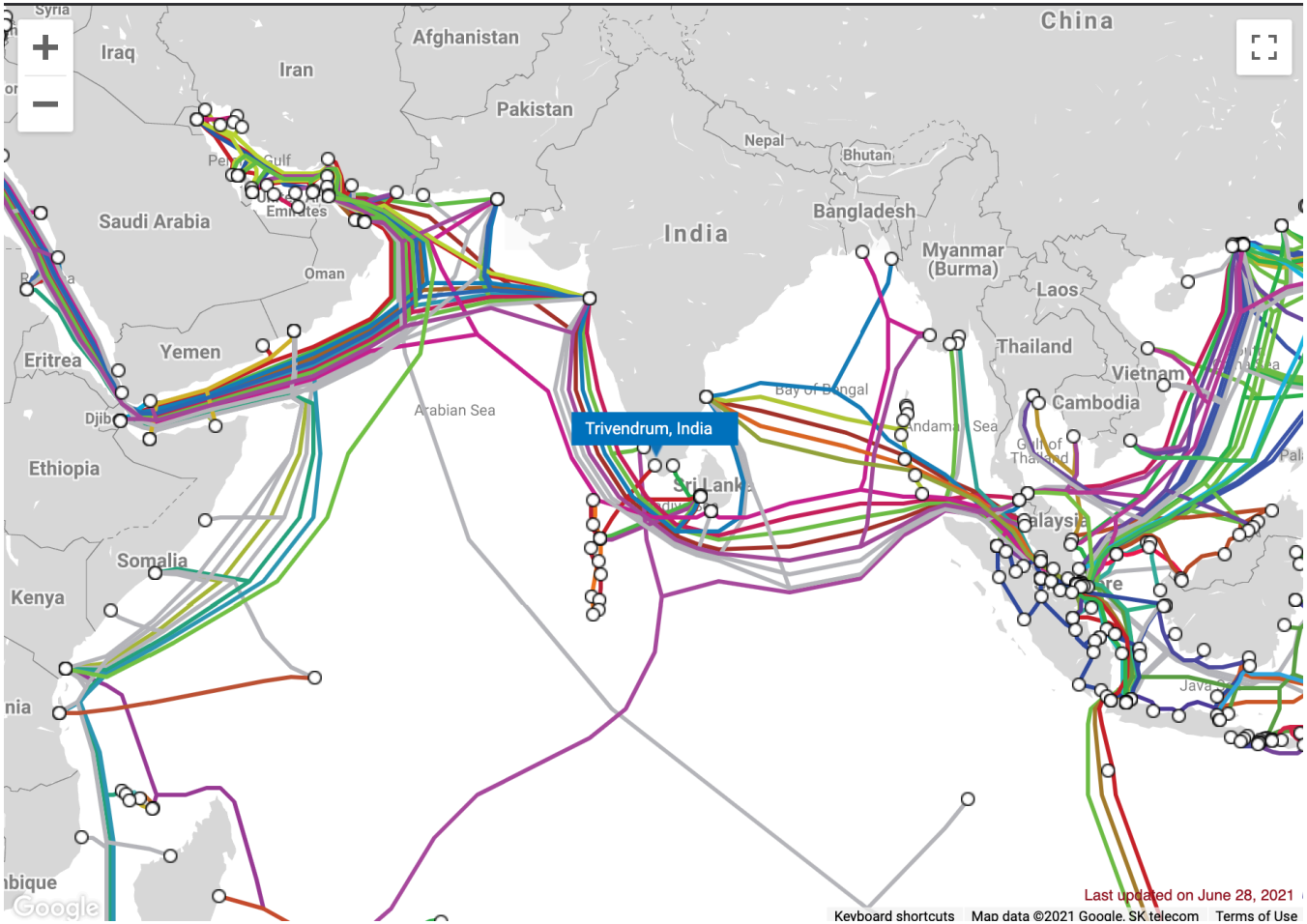
Cochin, India

Email link

Cables

SAFE

SeaMeWe-3



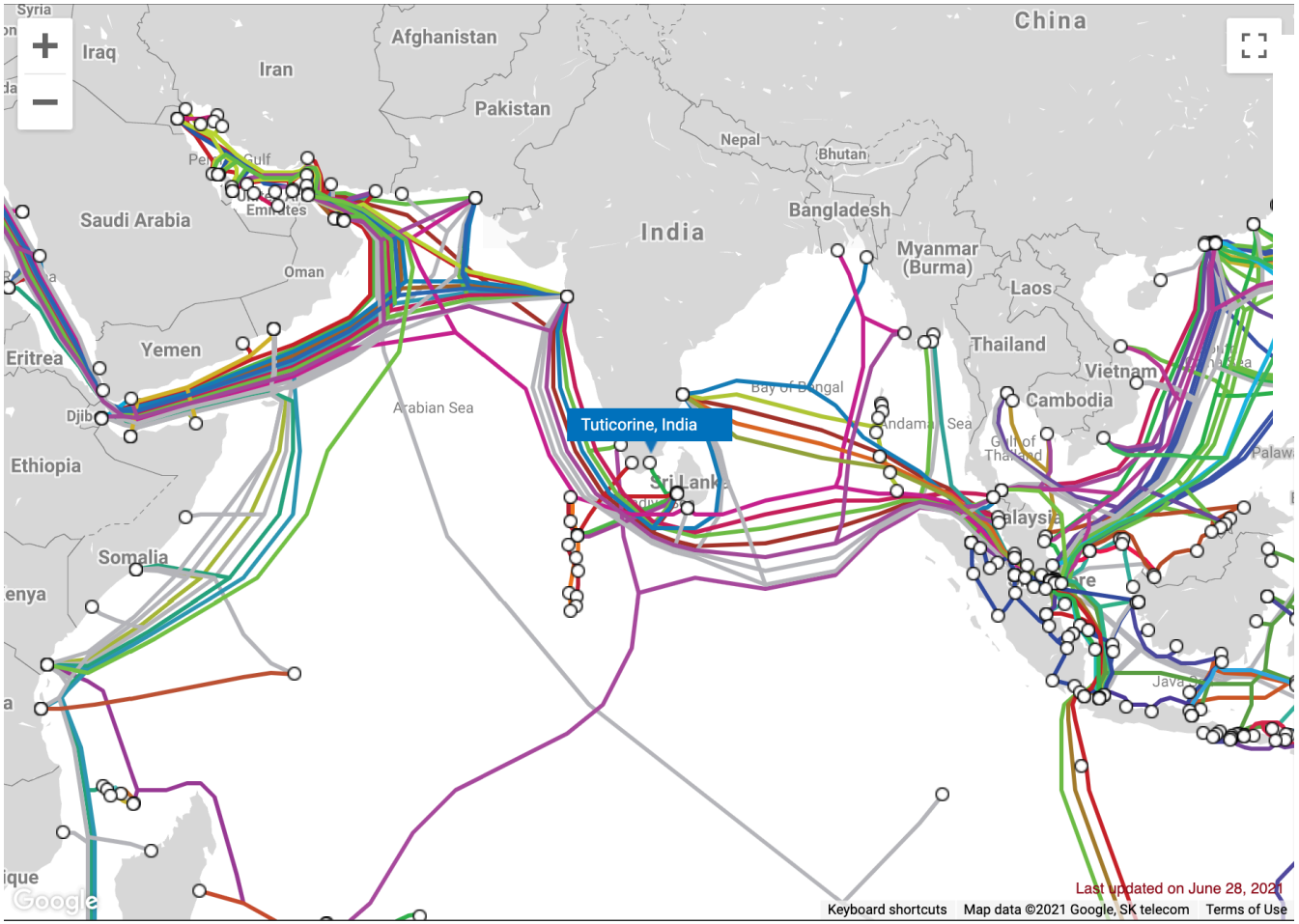
Submarine Cable List

Trivendrum, India

Email link

Cables

FALCON



Submarine Cable List

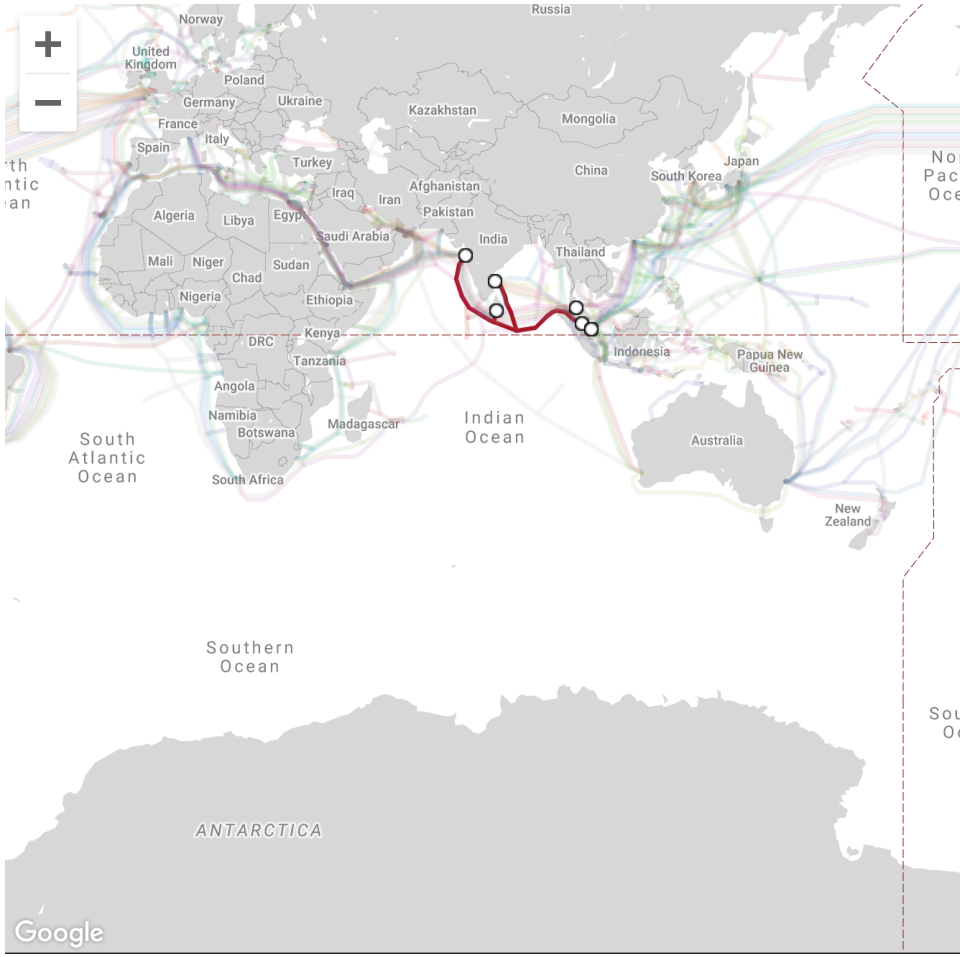
Tuticorine, India

Email link

Cables

Bharat Lanka Cable System

India Asia Xpress



Submarine Cable List

India Asia Xpress (IAX)

Email link

RFS: 2023

Cable Length: n.a.

Owners: Reliance Jio Infocomm

URL: n.a.

Notes: The cable has other owners besides Reliance Jio who have yet to be disclosed.

Landing Points

Chennai, India

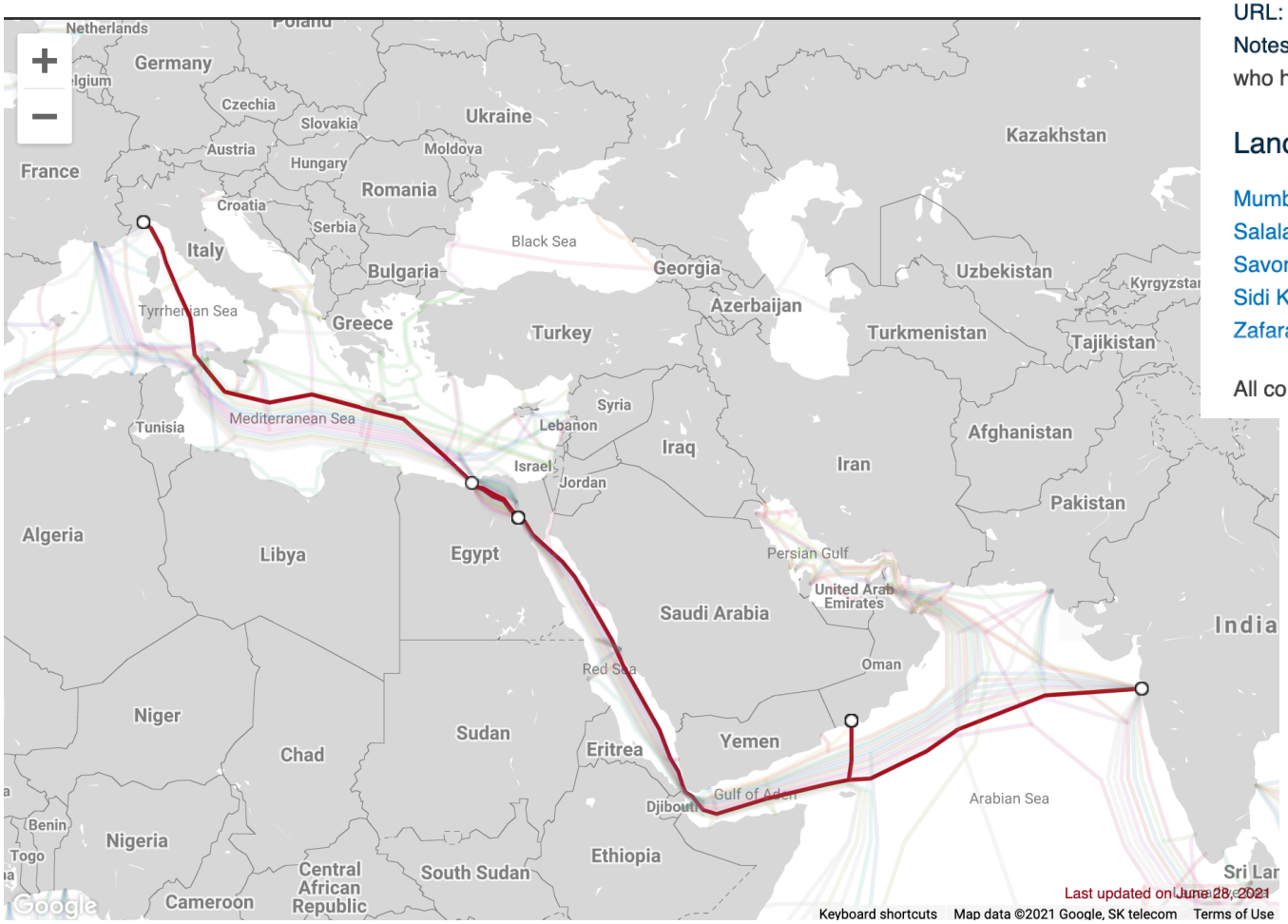
Matara, Sri Lanka

Morib, Malaysia

Mumbai, India

Satun, Thailand

India Europe Xpress



Submarine Cable List

India Europe Xpress (IEX)

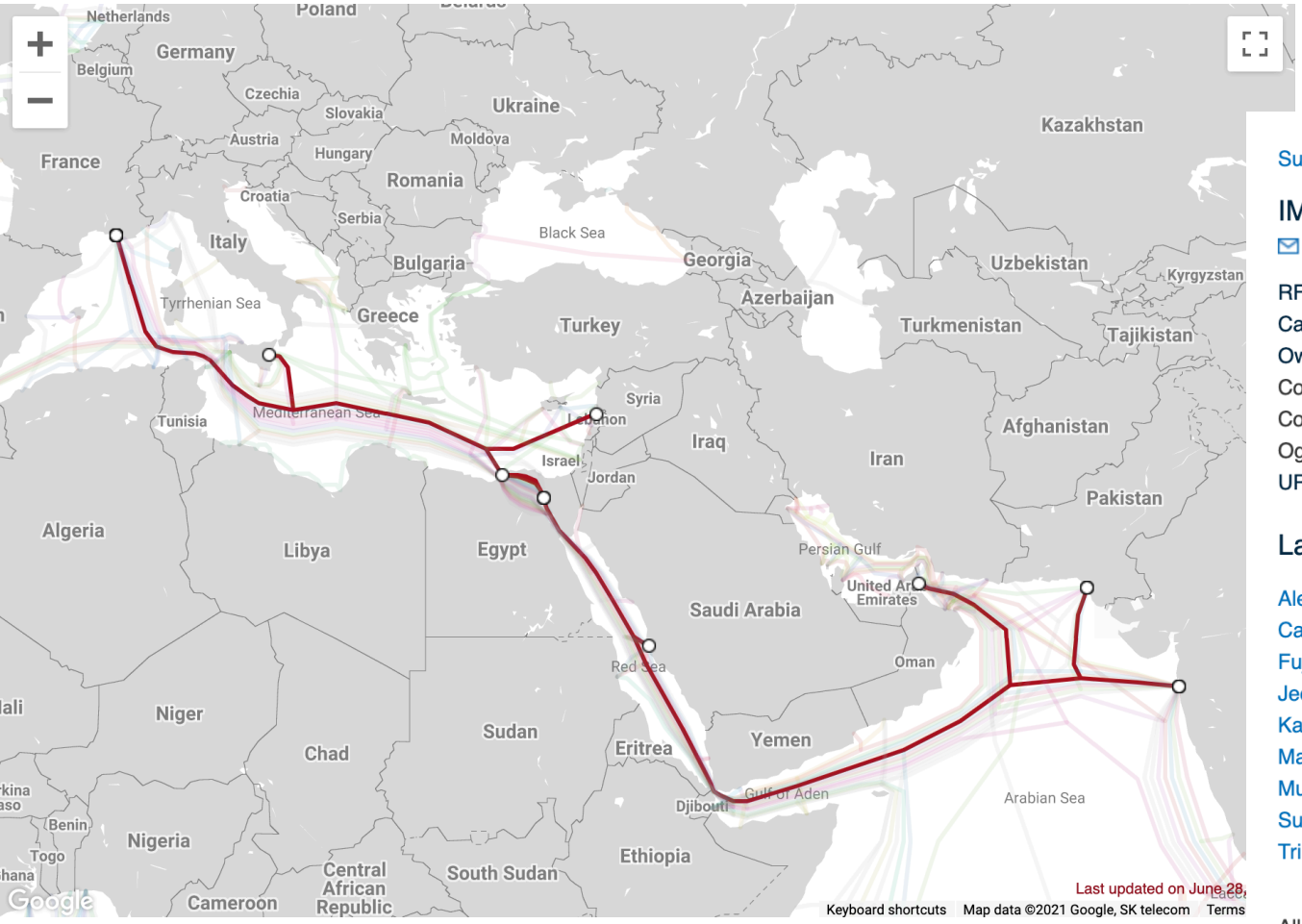
Email link

RFS: 2024
Cable Length: n.a.
Owners: Reliance Jio Infocomm
URL: n.a.
Notes: The cable has other owners besides Reliance Jio who have yet to be disclosed.

Landing Points

Mumbai, India
Salalah, Oman
Savona, Italy
Sidi Kerir, Egypt
Zafarana, Egypt

India Middle East Western Europe



Submarine Cable List

IMEWE

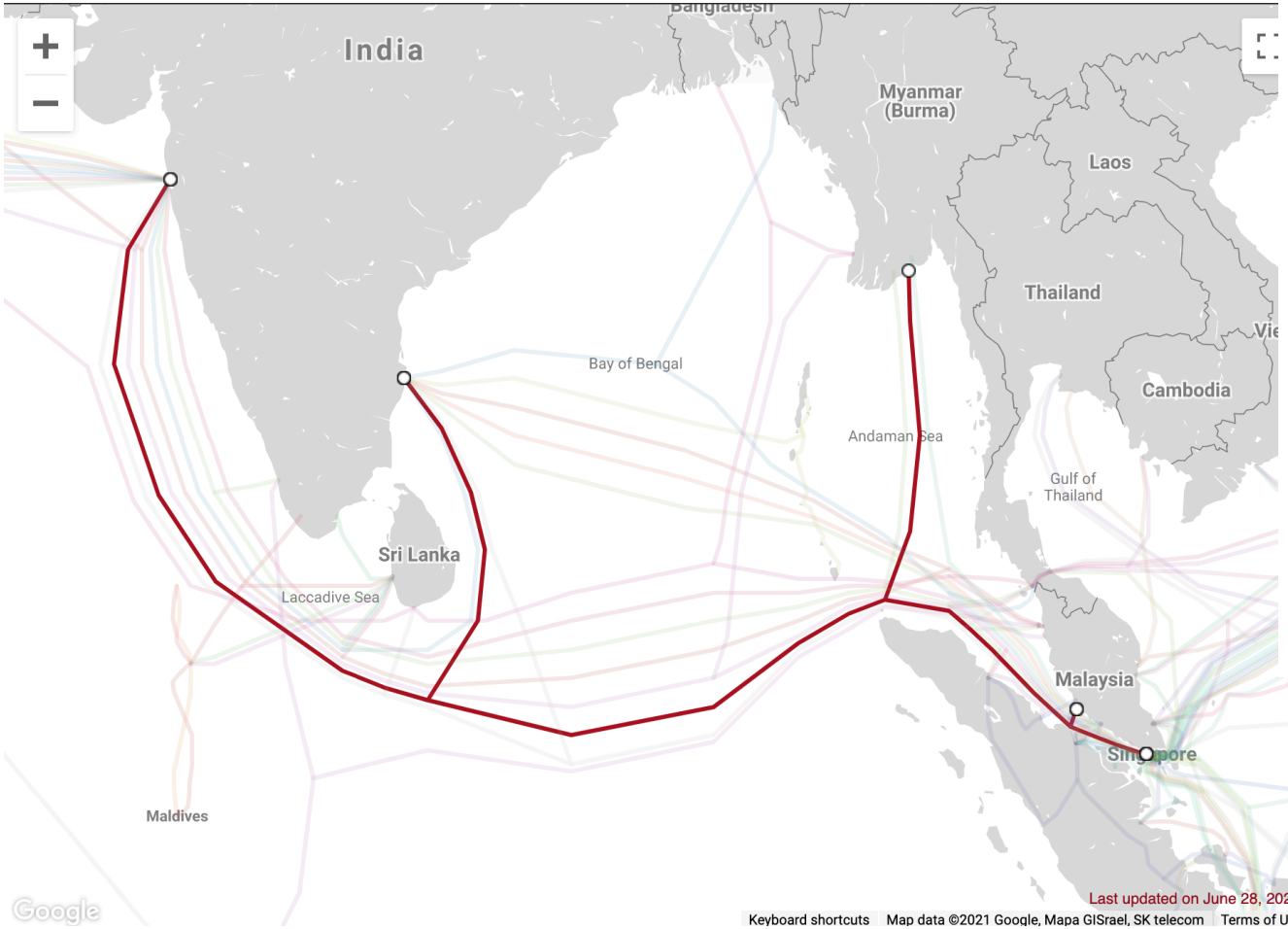
Email link

RFS: 2010 December
Cable Length: 12,091 km
Owners: Telecom Italia Sparkle, Etisalat, Tata Communications, Pakistan Telecommunications Company Ltd., Orange, Airtel (Bharti), Saudi Telecom, Ogero, Telecom Egypt
URL: https://imewecable.com

Landing Points

Alexandria, Egypt
Catania, Italy
Fujairah, United Arab Emirates
Jeddah, Saudi Arabia
Karachi, Pakistan
Marseille, France
Mumbai, India
Suez, Egypt
Tripoli, Lebanon

Mayanmar/Malaysia India Singapore Transit



Submarine Cable List

MIST

Email link

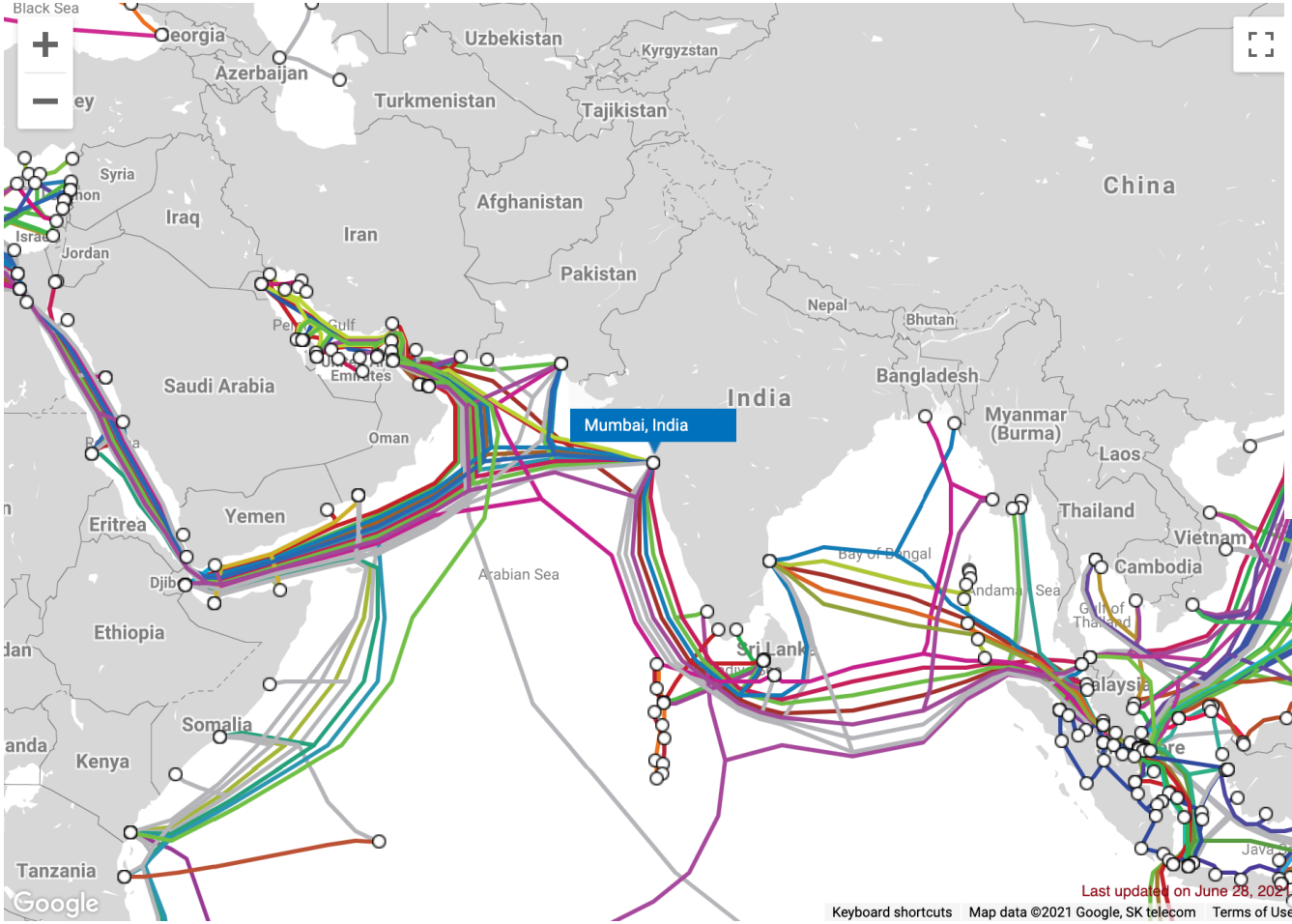
RFS: 2022 Q3
Cable Length: 8,100 km
Owners: Orient Link
URL: https://orient-link.com/home/

Landing Points

Chennai, India
Letkokkon, Myanmar
Morib, Malaysia
Mumbai, India
Tuas, Singapore

Protocols

- A protocol is synonymous with rule. It consists of a set of rules that govern data communications. It determines -
  - what is communicated
  - how it is communicated and
  - when it is communicated.
- The key elements of a protocol are *syntax*, *semantics* and *timing*



Submarine Cable List

Mumbai, India

Email link

Cables

- Asia Africa Europe-1 (AAE-1)
- Bay of Bengal Gateway (BBG)
- Europe India Gateway (EIG)
- FALCON
- FLAG Europe-Asia (FEA)
- Gulf Bridge International Cable System (GBICS)/Middle
- East North Africa (MENA) Cable System
- IMEWE
- India Asia Xpress (IAX)
- India Europe Xpress (IEX)
- MIST
- SEACOM/Tata TGN-Eurasia
- SeaMeWe-3
- SeaMeWe-4

Elements of a Protocol

- Syntax
  - Structure or format of the data
  - Indicates how to read the bits - field delineation
- Semantics
  - Interprets the meaning of the bits
  - Knows which fields define what action
- Timing
  - When data should be sent and
  - What speed at which data should be sent or speed at which it is being received.

NETWORK MODELS

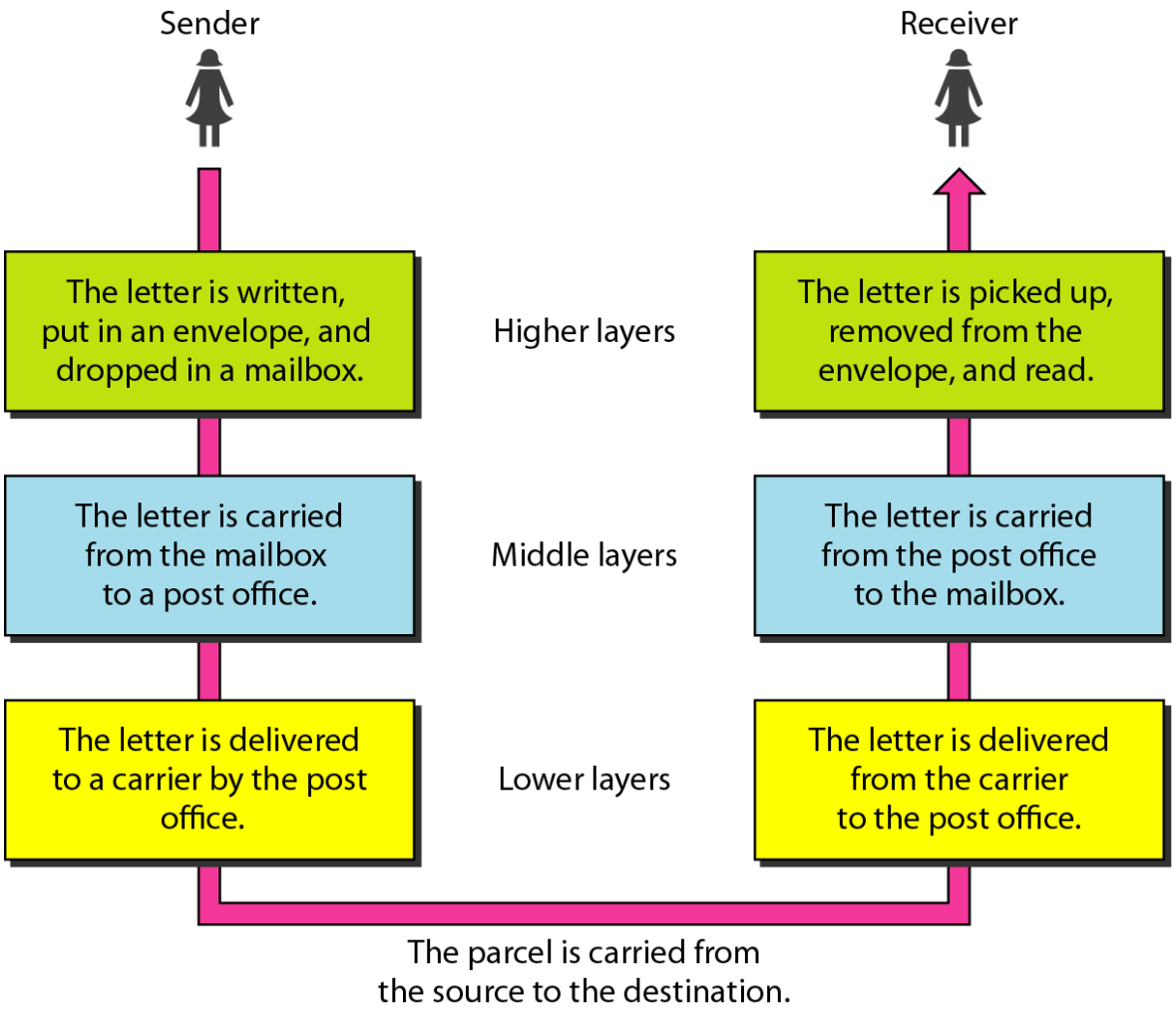
Communication Architecture

- Strategy for connecting host computers and other communicating equipment.
- Defines necessary elements for data communication between devices.
- A communication architecture, therefore, defines a standard for the communicating hosts.
- A programmer formats data in a manner defined by the communication architecture and passes it on to the communication software.
- Separating communication functions adds flexibility, for example, we do not need to modify the entire host software to include more communication devices.

Example

- We use the concept of layers in our daily life. As an example, let us consider two friends who communicate through postal mail. The process of sending a letter to a friend would be complex if there were no services available from the post office.

Tasks involved in sending a letter



Layer Architecture

- Layer architecture simplifies the network design.
- It is easy to debug network applications in a layered architecture network.
- The network management is easier due to the layered architecture.
- Network layers follow a set of rules, called protocol.
- The protocol defines the format of the data being exchanged, and the control and timing for the handshake between layers.

ISO or OSI

- ISO (International Organization for Standardization)
  - is the organization.

- OSI (Open Systems Interconnection)
  - is the model.

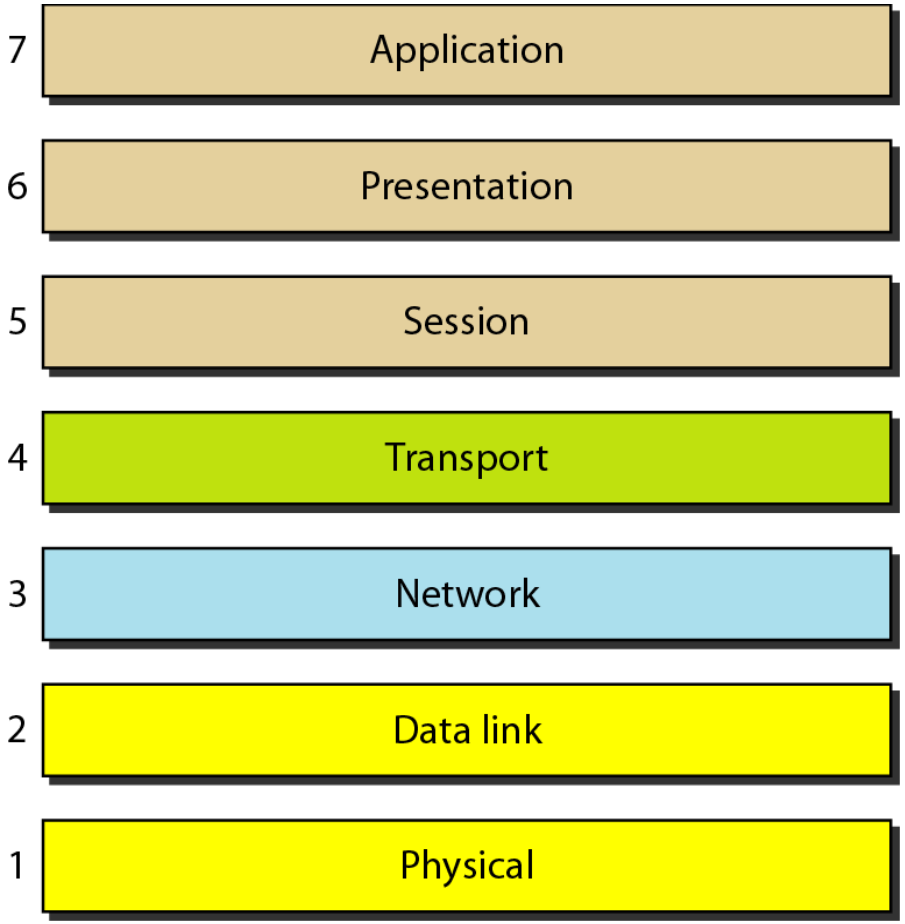
Open Systems Interconnection (OSI) Model

- International standard organization (ISO) established a committee in 1977 to develop an architecture for computer communication.
- Open Systems Interconnection (OSI) reference model is the result of this effort.
- In 1984, the Open Systems Interconnection (OSI) reference model was approved as an international standard for communications architecture.
- Term “open” denotes the ability to connect any two systems which conform to the reference model and associated standards.

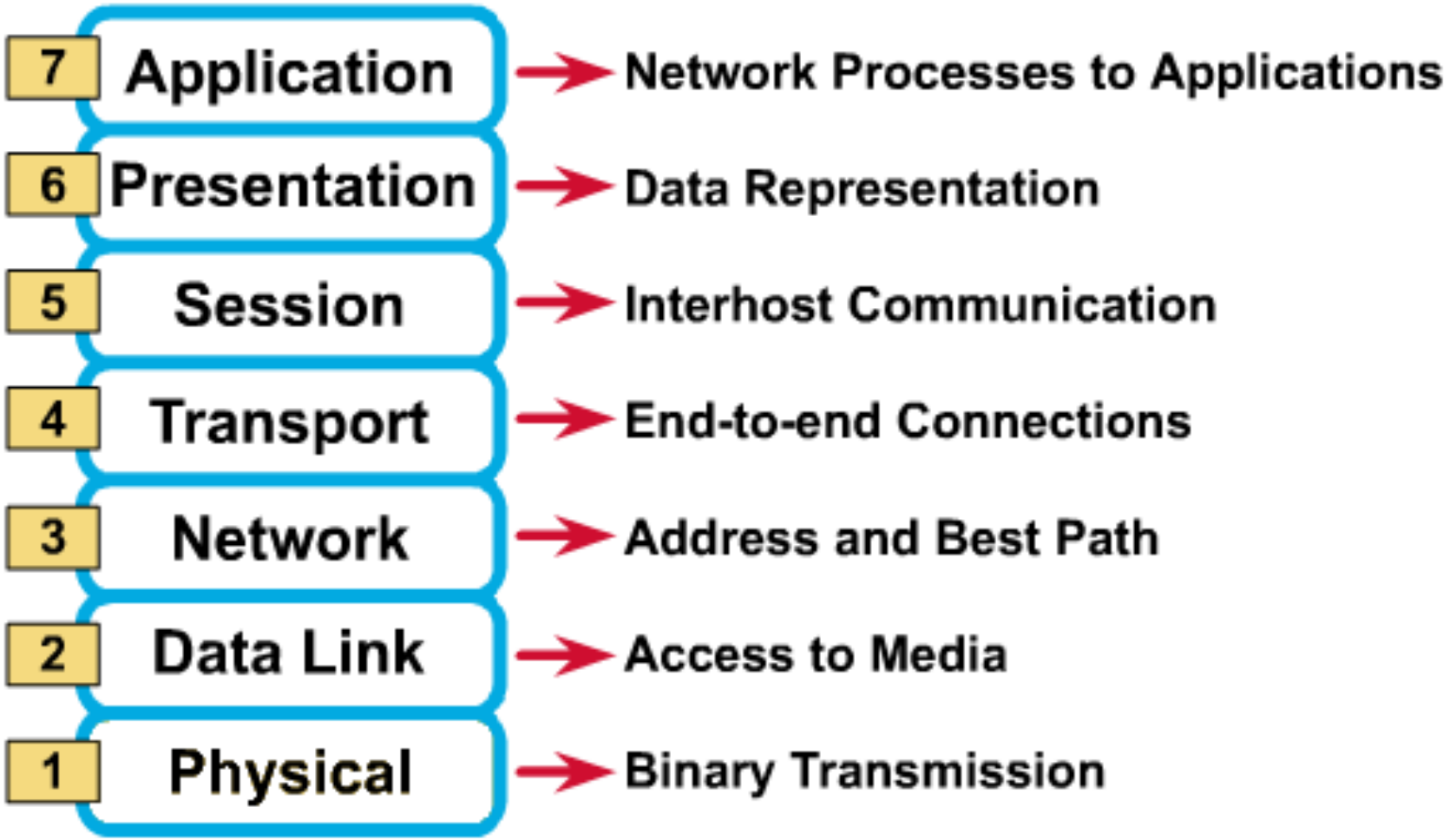
OSI Reference Model

- The OSI model is now considered the primary Architectural model for inter-computer communications.
- The OSI model describes how information or data makes its way from application programmes (such as spreadsheets) through a network medium (such as wire) to another application programme located on another network.
- The OSI reference model divides the problem of moving information between computers over a network medium into SEVEN smaller and more manageable problems .
- This separation into smaller more manageable functions is known as layering.

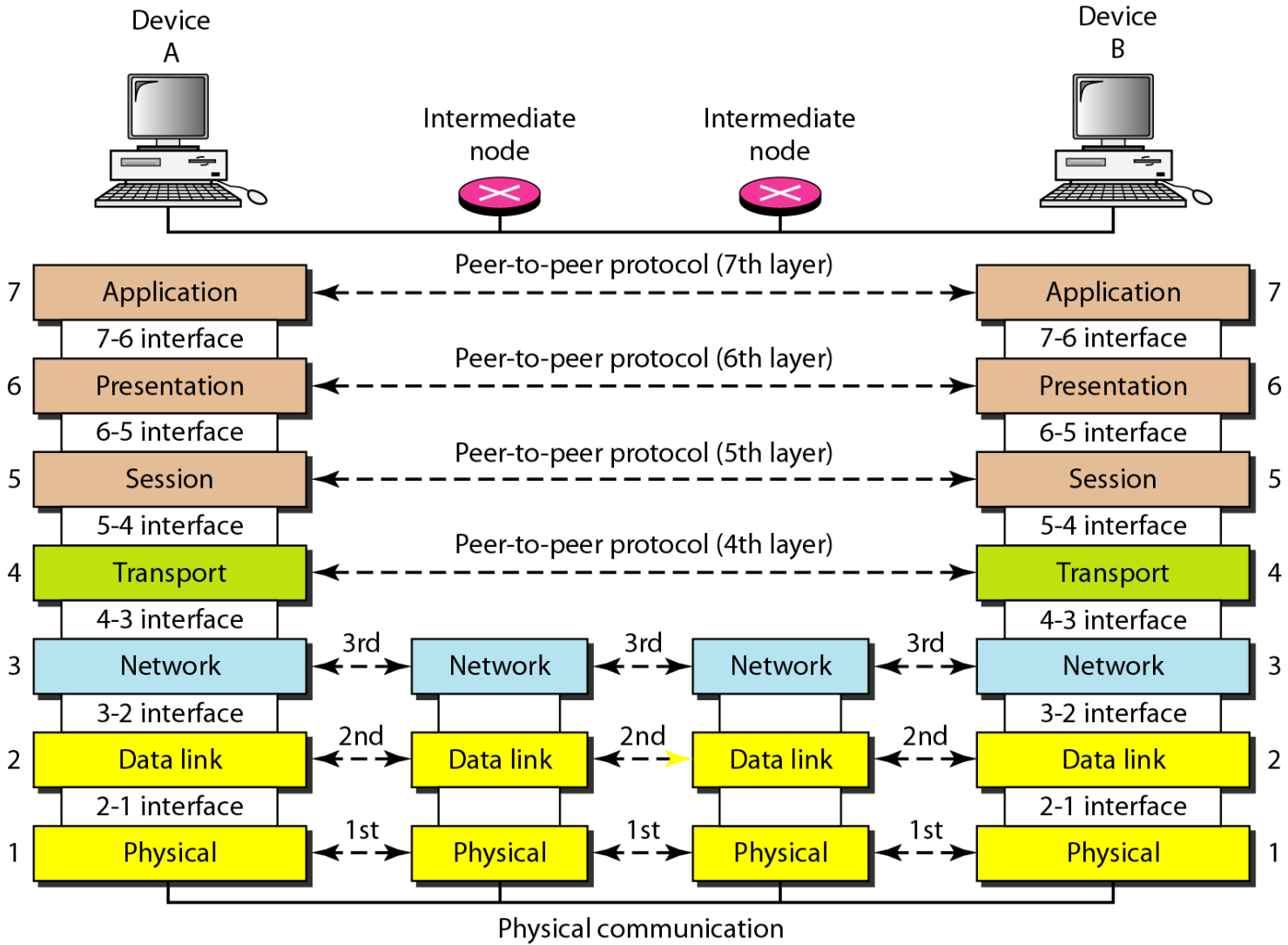
OSI Model


7
Application
6
Presentation
5
Session
4
Transport
3
Network
2
Data link
1
Physical

OSI Reference Model: 7 Layers



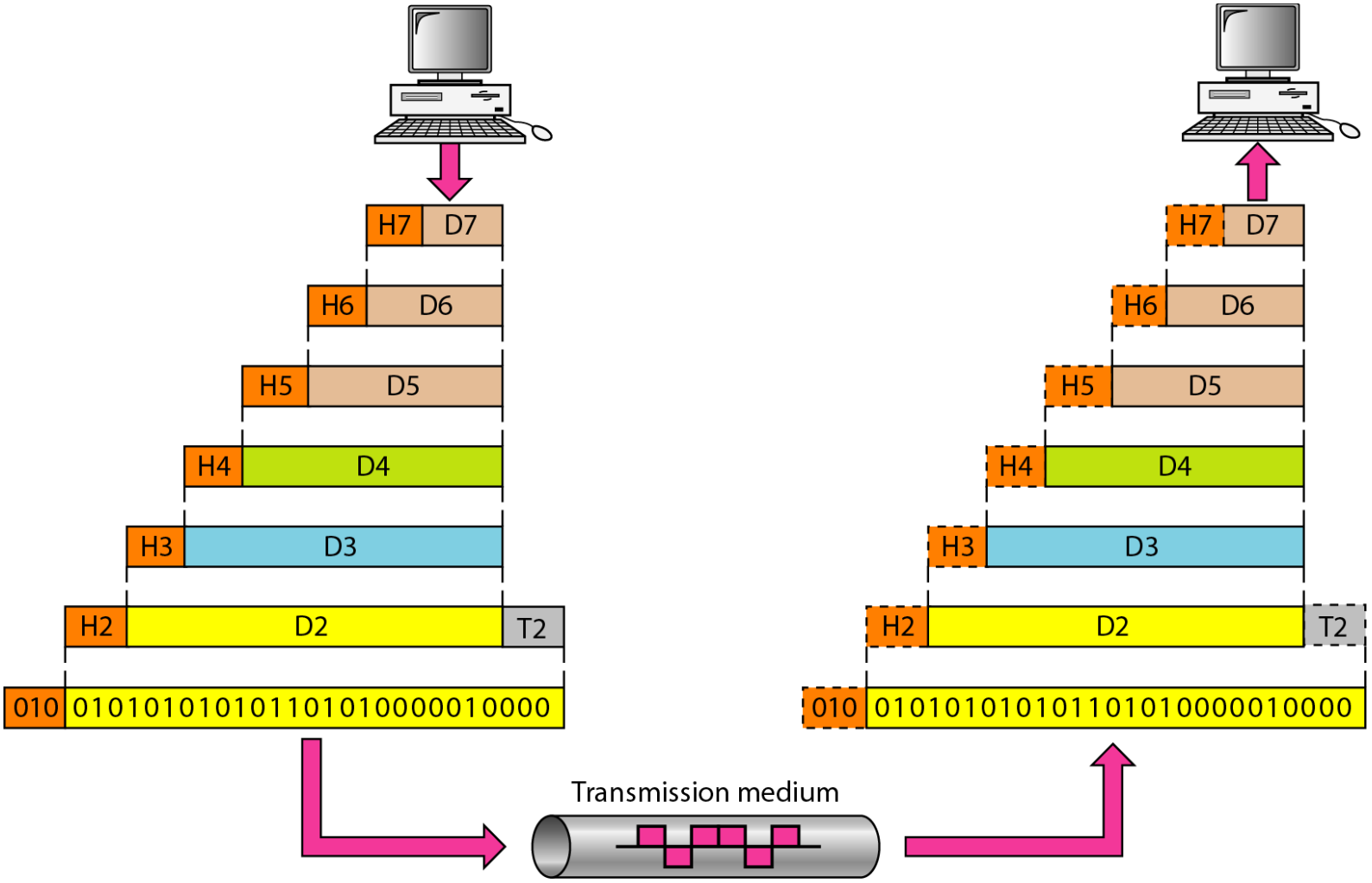
The interaction between layers in the OSI model



OSI: A Layered Network Model

- The process of breaking up the functions or tasks of networking into layers reduces complexity.
- Each layer provides a service to the layer above it in the protocol specification.
- Each layer communicates with the same layer's software or hardware on other computers.
- The lower 4 layers (transport, network, data link and physical —Layers 4, 3, 2, and 1) are concerned with the flow of data from end to end through the network.
- The upper three layers of the OSI model (application, presentation and session—Layers 7, 6 and 5) are orientated more toward services to the applications.
- Data is Encapsulated with the necessary protocol information as it moves down the layers before network transit.

An exchange using the OSI model



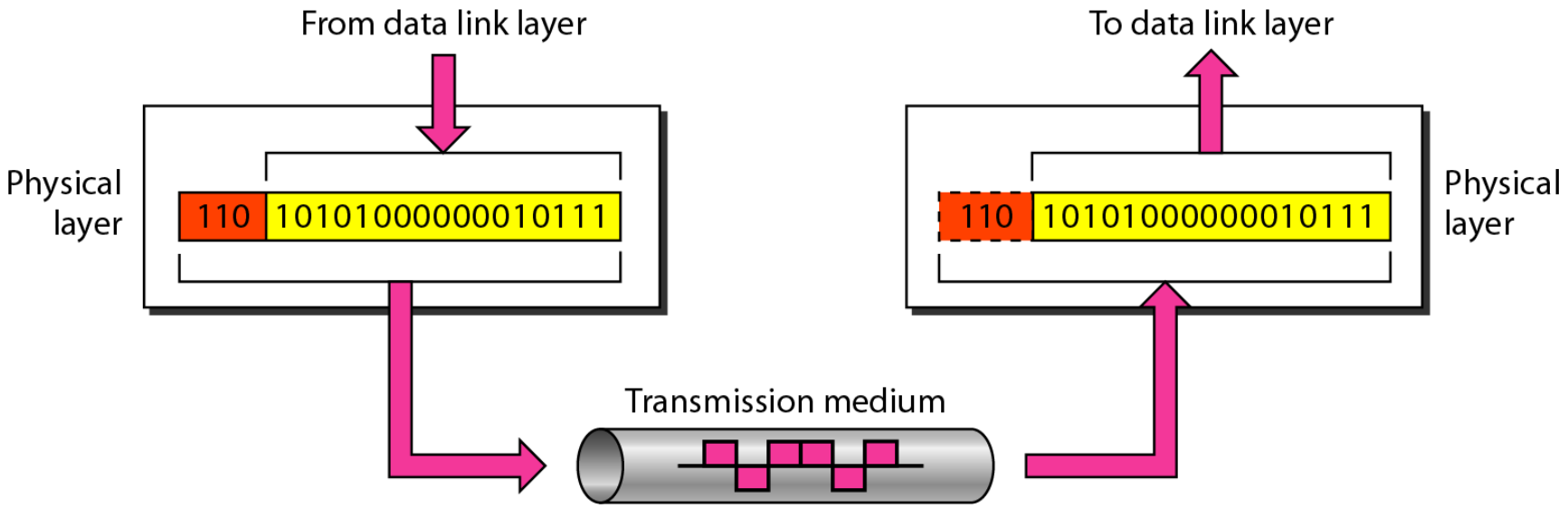
Physical Layer

- Provides physical interface for transmission of information.

- Defines rules by which bits are passed from one system to another on a physical communication medium.
- Covers all - mechanical, electrical, functional and procedural - aspects for physical communication.
- Such characteristics as voltage levels, timing of voltage changes, physical data rates, maximum transmission distances, physical connectors, and other similar attributes are defined by physical layer specifications.

Physical Layer

The physical layer is responsible for movements of individual bits from one hop (node) to the next.



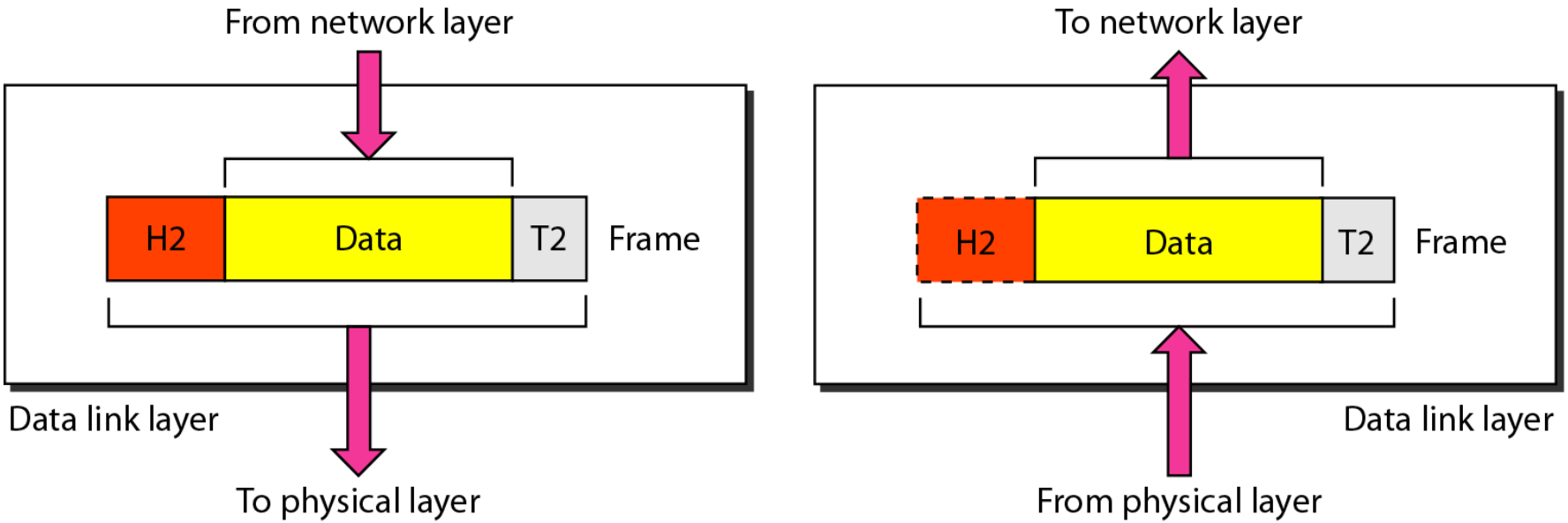
Data Link Layer

- Data link layer attempts to provide reliable communication over the physical layer interface.

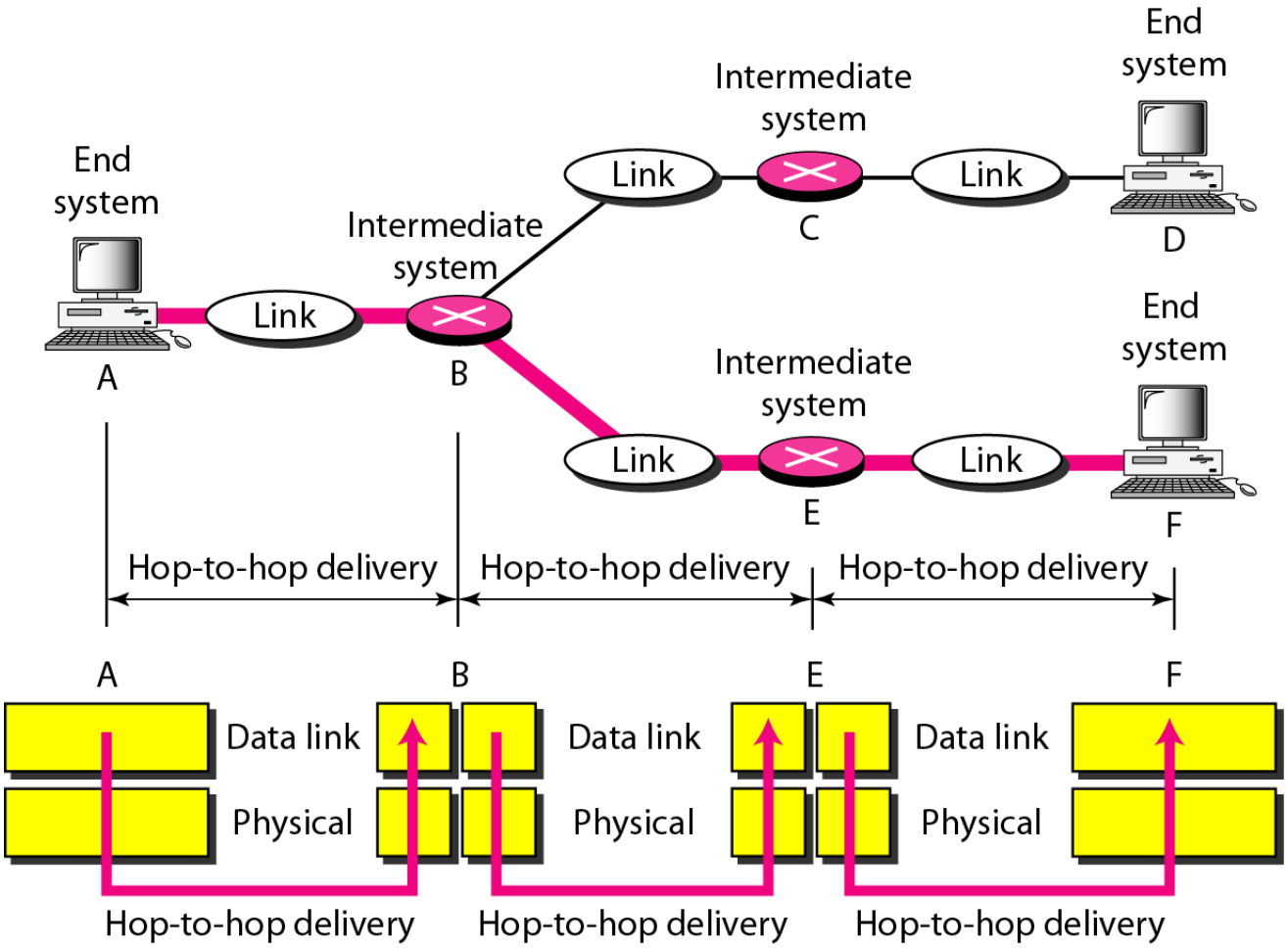
- Breaks the outgoing data into frames and reassemble the received frames.
- Create and detect frame boundaries.
- Handle errors by implementing an acknowledgement and retransmission scheme.
- Implement flow control.
- Supports points-to-point as well as broadcast communication.
- Supports simplex, half-duplex or full-duplex communication.

Data Link Layer

The data link layer is responsible for moving frames from one hop (node) to the next.



Hop to Hop Delivery



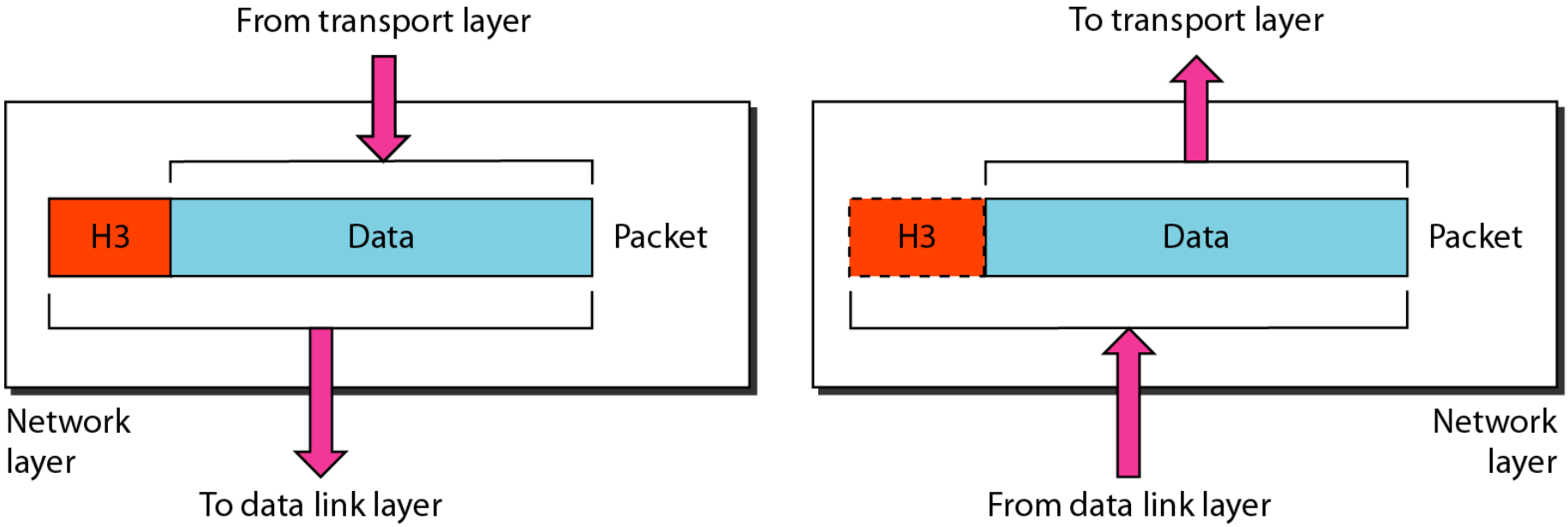
Network Layer

- Implements routing of frames (packets) through the network.

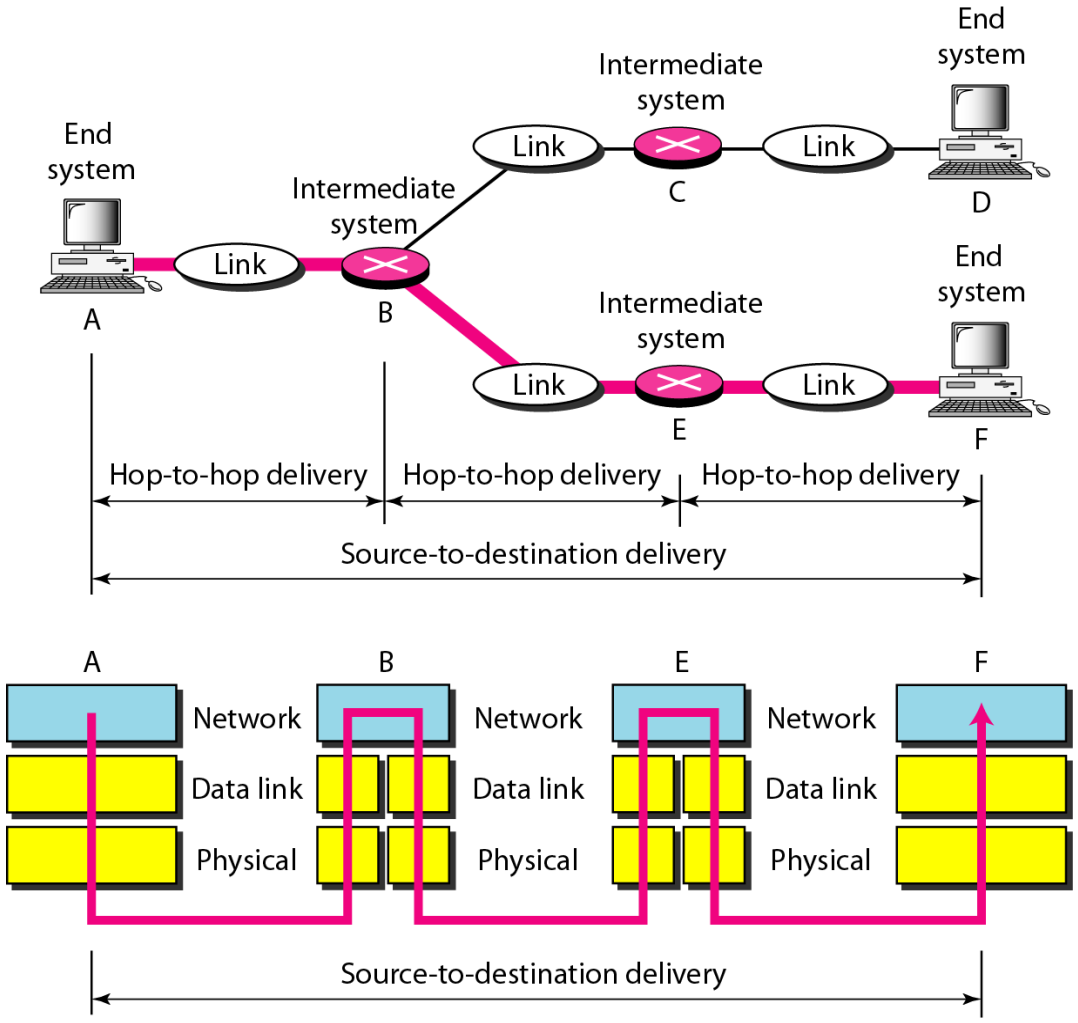
- Defines the most optimum path the packet should take from the source to the destination
- Defines logical addressing so that any endpoint can be identified.
- Handles congestion in the network.
- Facilitates interconnection between heterogeneous networks (Internetworking).
- The network layer also defines how to fragment a packet into smaller packets to accommodate different media.

Network Layer

The network layer is responsible for the delivery of individual packets from the source host to the destination host.



Source to destination delivery



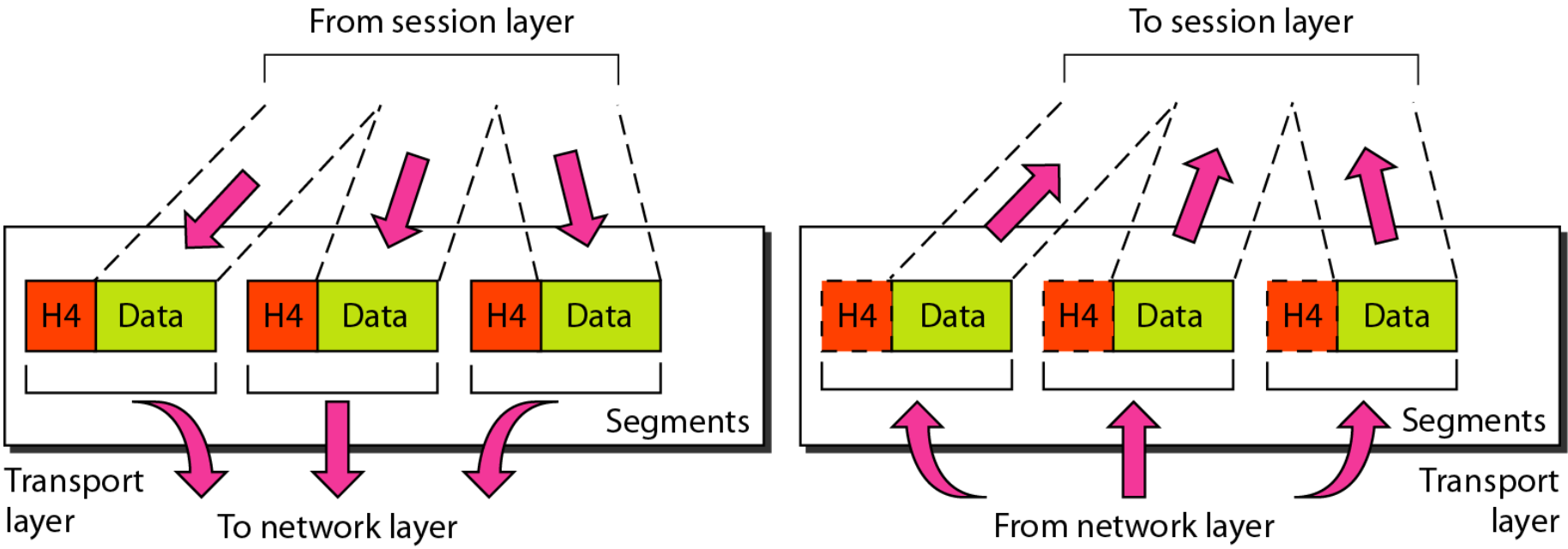
Transport Layer

- Purpose of this layer is to provide a reliable mechanism for the exchange of data between two processes in different computers.

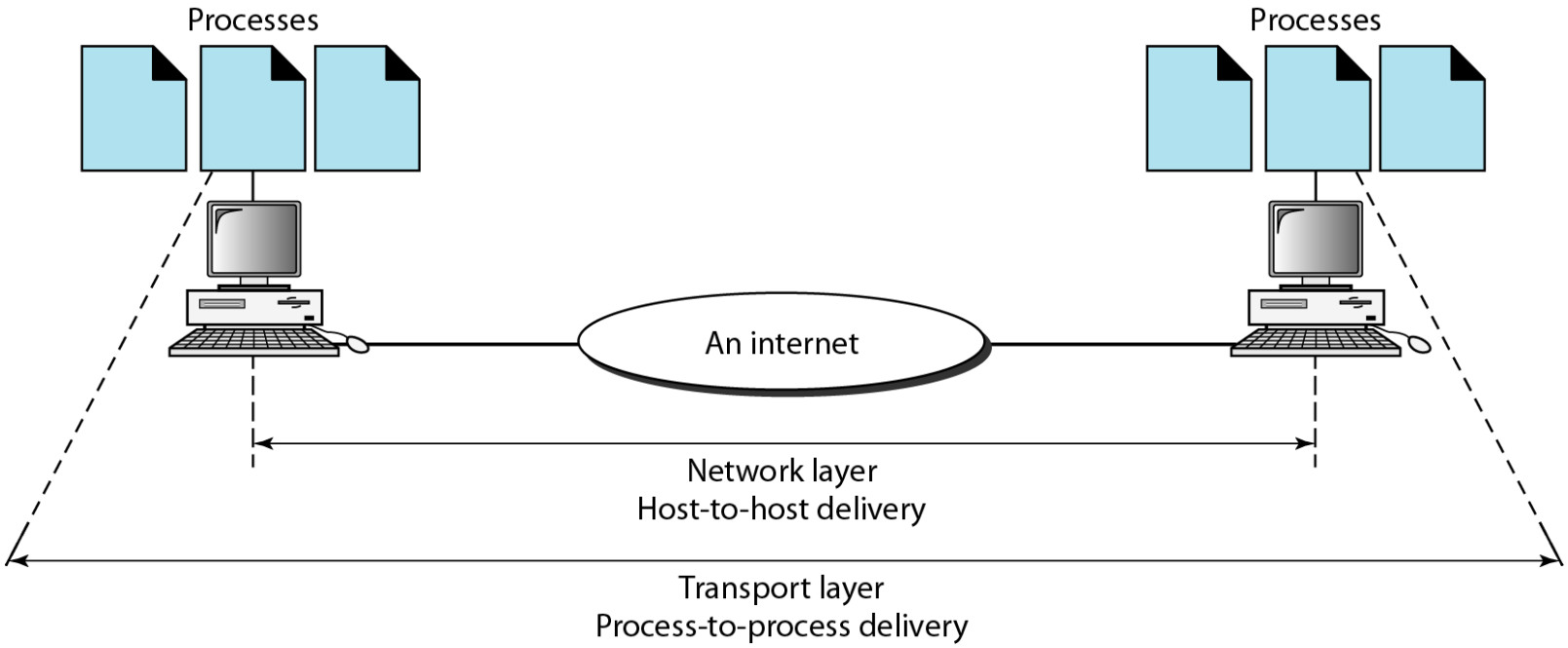
- Ensures that the data units are delivered error free.
- Ensures that data units are delivered in sequence.
- Ensures that there is no loss or duplication of data units.
- Provides connectionless or connection oriented service.
- Provides for the connection management.
- Multiplex multiple connection over a single channel.

Transport Layer

- The transport layer is responsible for the delivery of a message from one process to another.



Reliable process-to-process delivery of a message



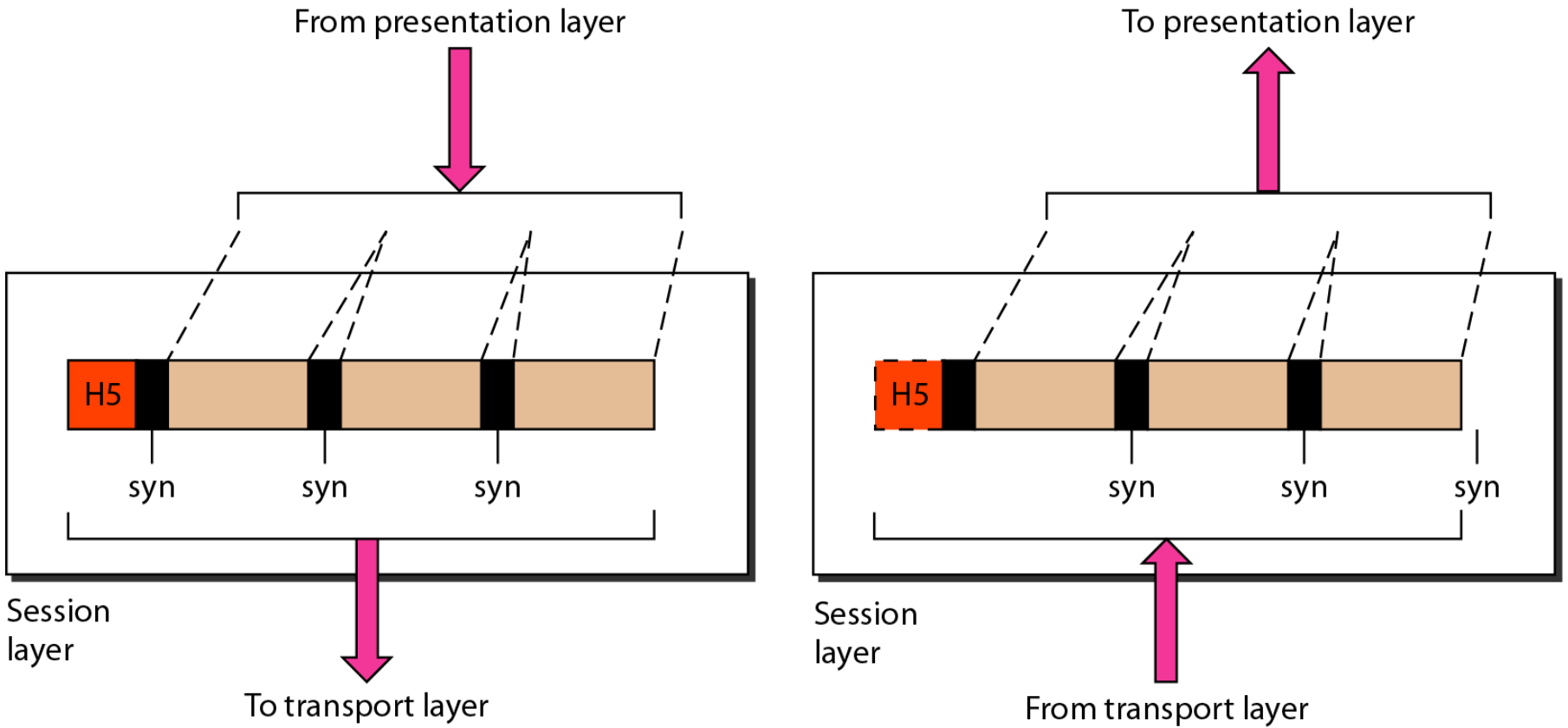
Session Layer

- Session layer provides mechanism for controlling the dialogue between the two end systems. It defines how to start, control and end conversations (called sessions) between applications.

- This layer requests for a logical connection to be established on an end-user's request.
- Any necessary log-on or password validation is also handled by this layer.
- Session layer is also responsible for terminating the connection.
- This layer provides services like dialogue discipline which can be full duplex or half duplex.
- Session layer can also provide check-pointing mechanism such that if a failure of some sort occurs between checkpoints, all data can be retransmitted from the last checkpoint.

Session Layer

- The session layer is responsible for dialog control and synchronization.

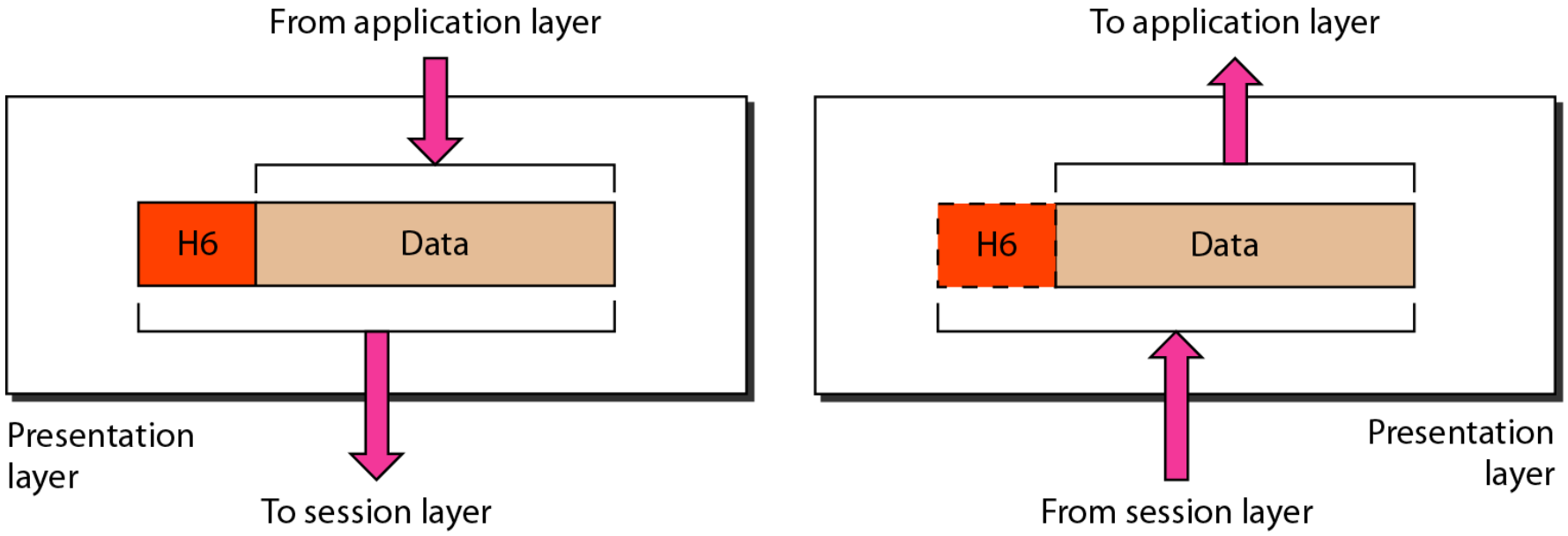


Presentation Layer

- Presentation layer defines the format in which the data is to be exchanged between the two communicating entities.
- Also handles data compression and data encryption (cryptography).

Presentation layer

- The presentation layer is responsible for translation, compression, and encryption.

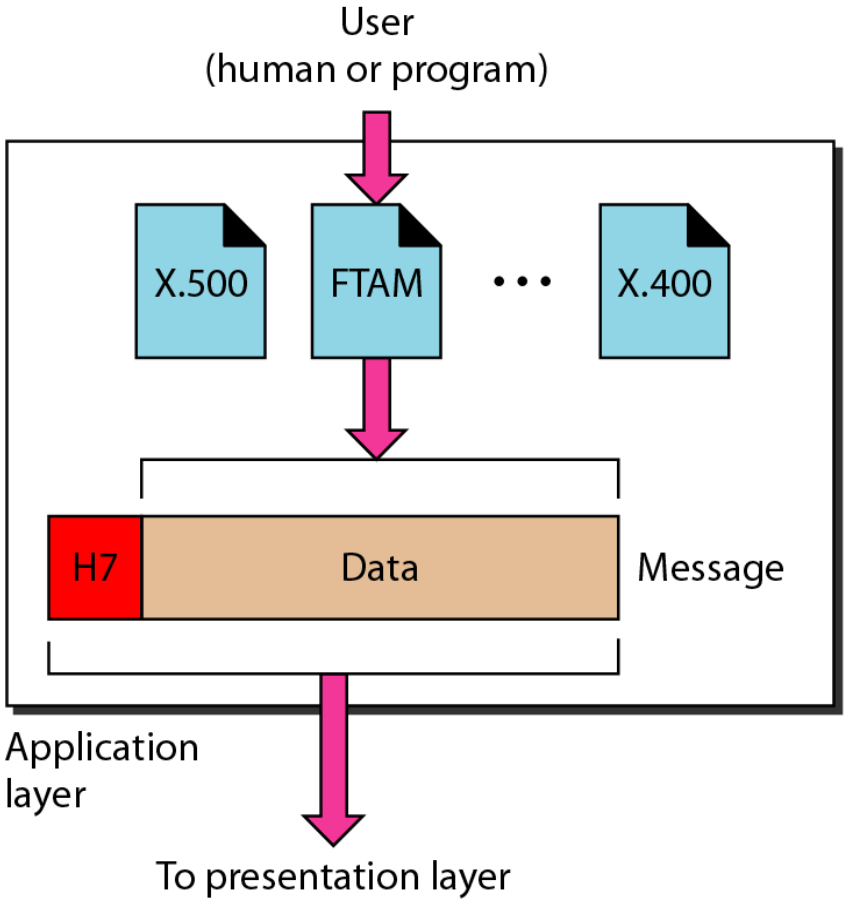


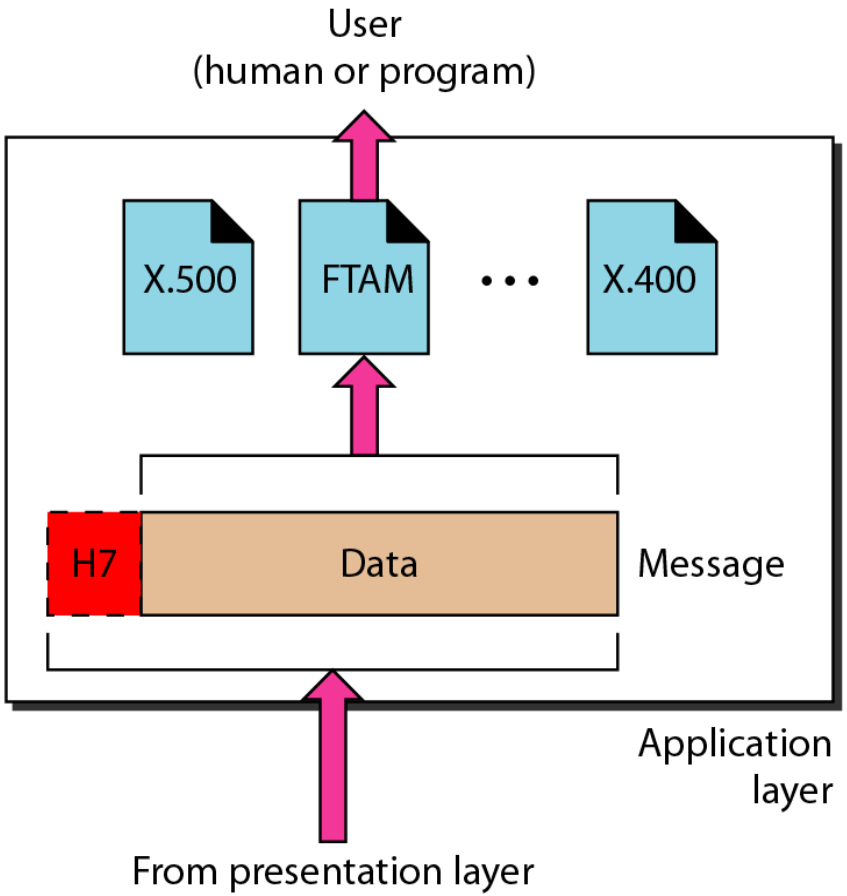
Application Layer

- Application layer interacts with application programs and is the highest level of OSI model.
- Application layer contains management functions to support distributed applications.
- Examples of application layer are applications such as file transfer, electronic mail, remote login etc.

Application layer

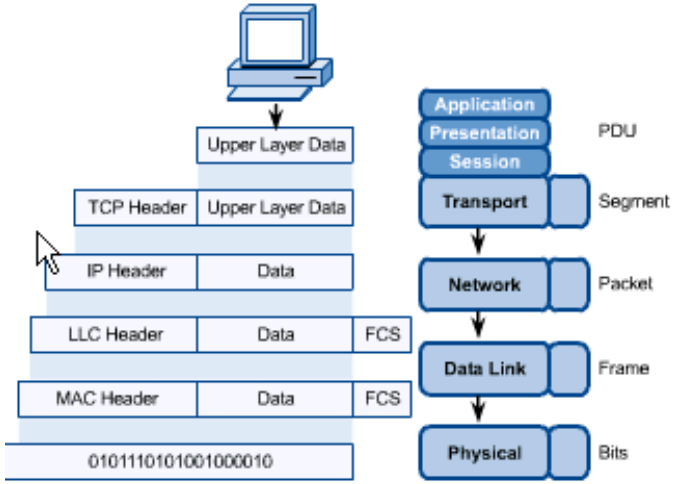
- The application layer is responsible for providing services to the user.

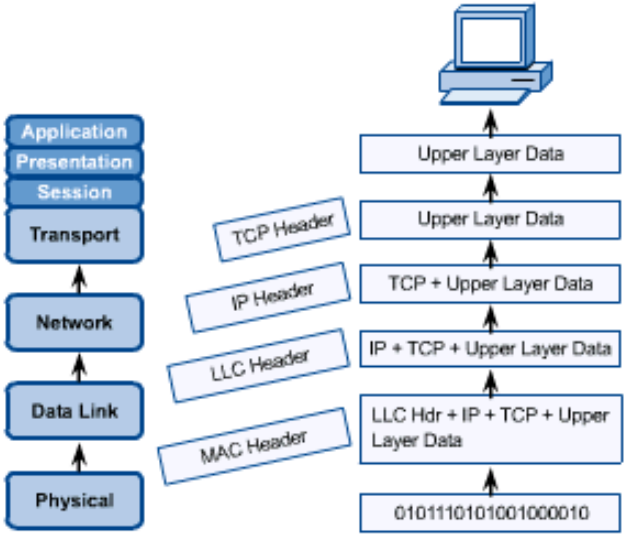




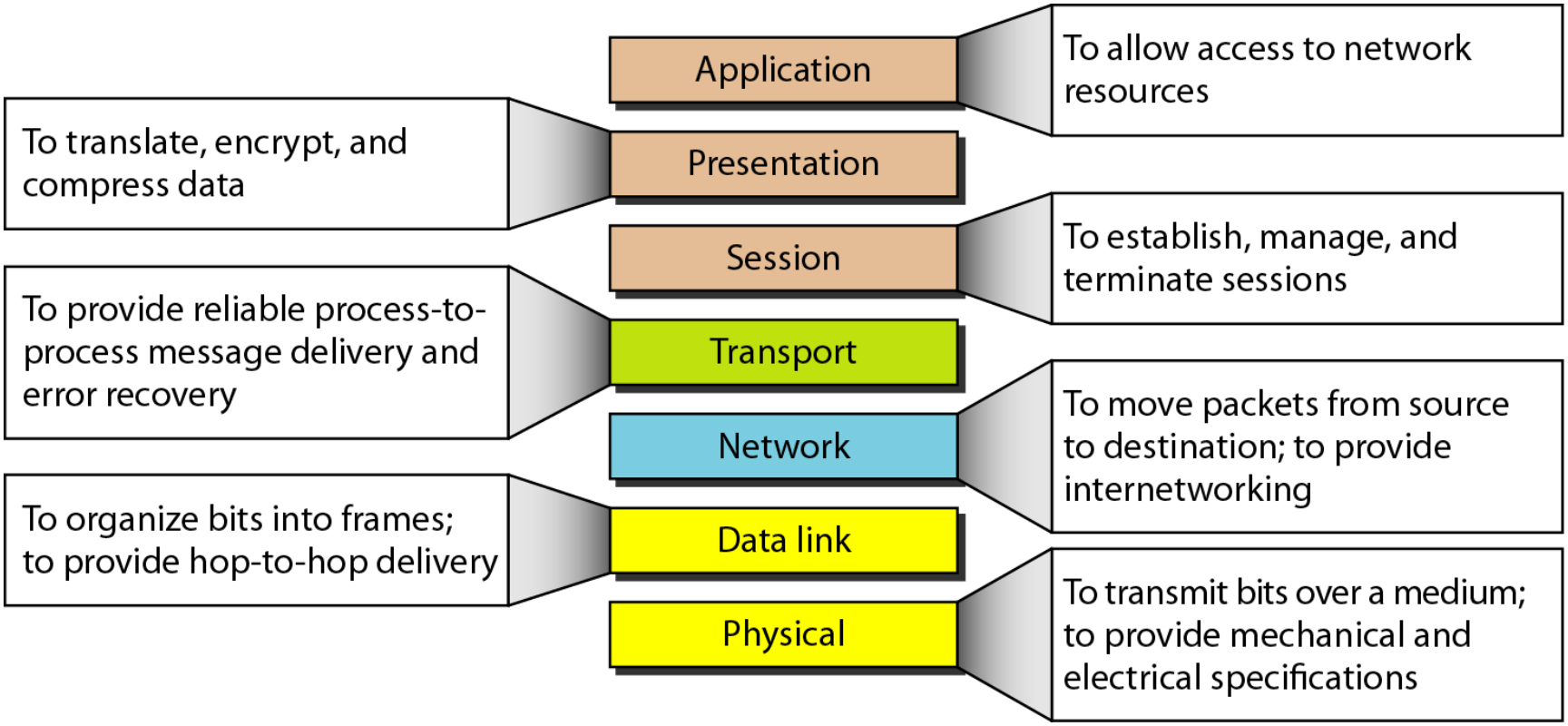
OSI in Action

- A message begins at the top application layer and moves down the OSI layers to the bottom physical layer.
- As the message descends, each successive OSI model layer adds a header to it.
- A header is layer-specific information that basically explains what functions the layer carried out.
- Conversely, at the receiving end, headers are striped from the message as it travels up the corresponding layers.





Summary of layers

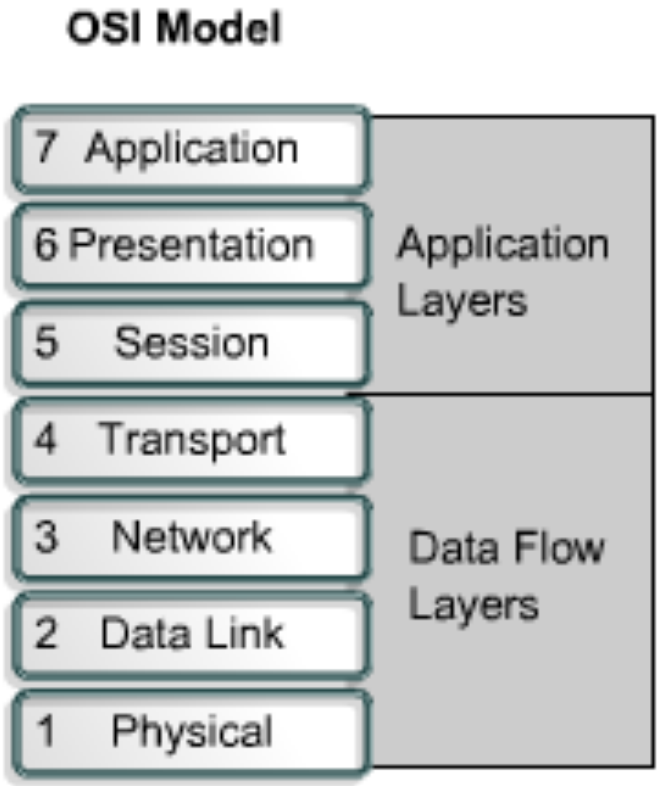


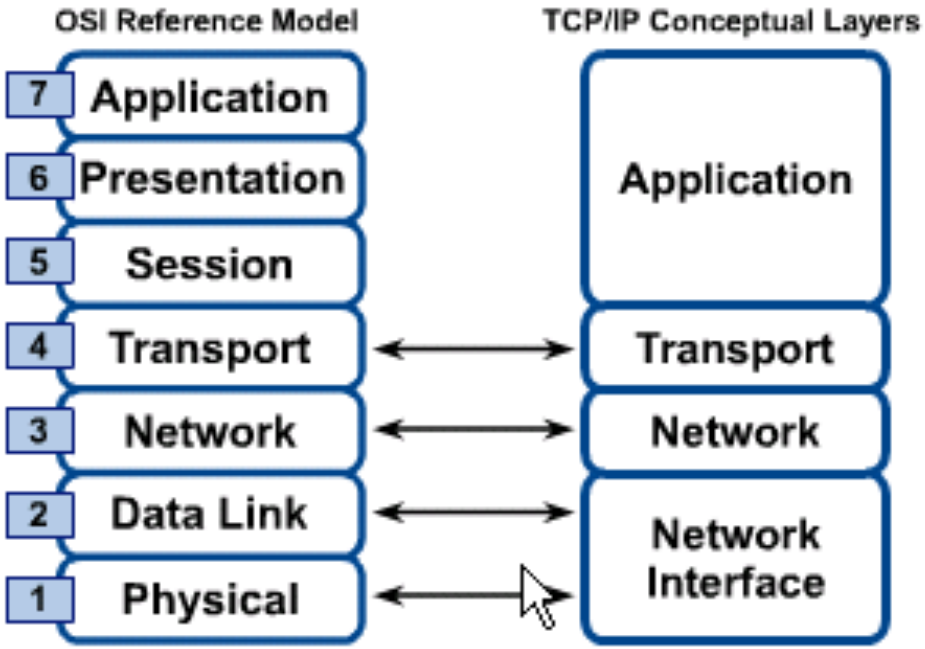
TCP/IP MODEL

TCP/IP protocol suite

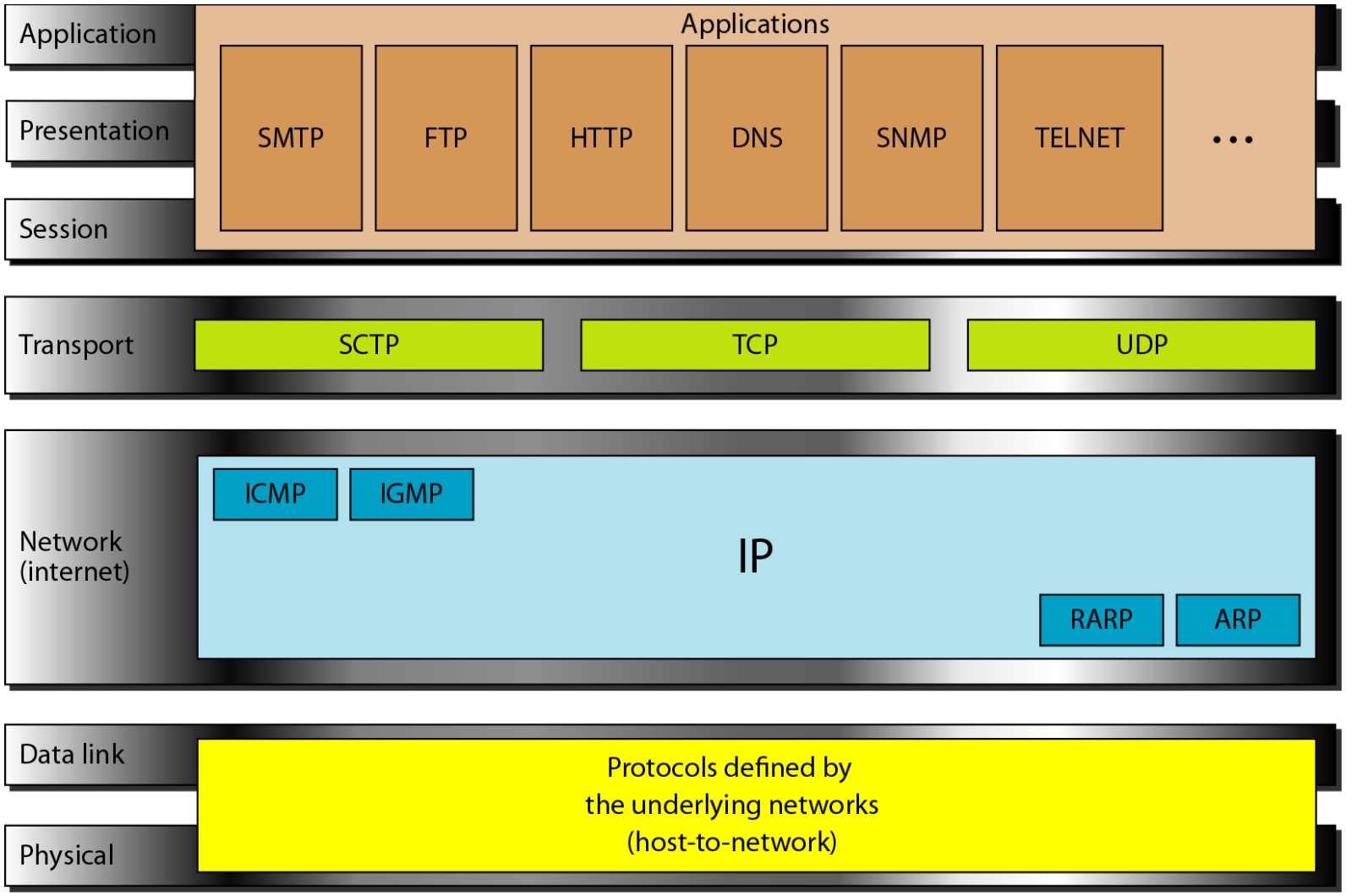
- The layers in the TCP/IP protocol suite do not exactly match those in the OSI model. The original TCP/IP protocol suite was defined as having four layers: host-to-network, internet, transport, and application. However, when TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers: physical, data link, network, transport, and application.

OSI & TCP/IP Models





TCP/IP and OSI model



TCP/IP Model

Application Layer
Application programs using the network

Transport Layer (TCP/UDP)
Management of end-to-end message transmission, error detection and error correction

Network Layer (IP)
Handling of datagrams : routing and congestion

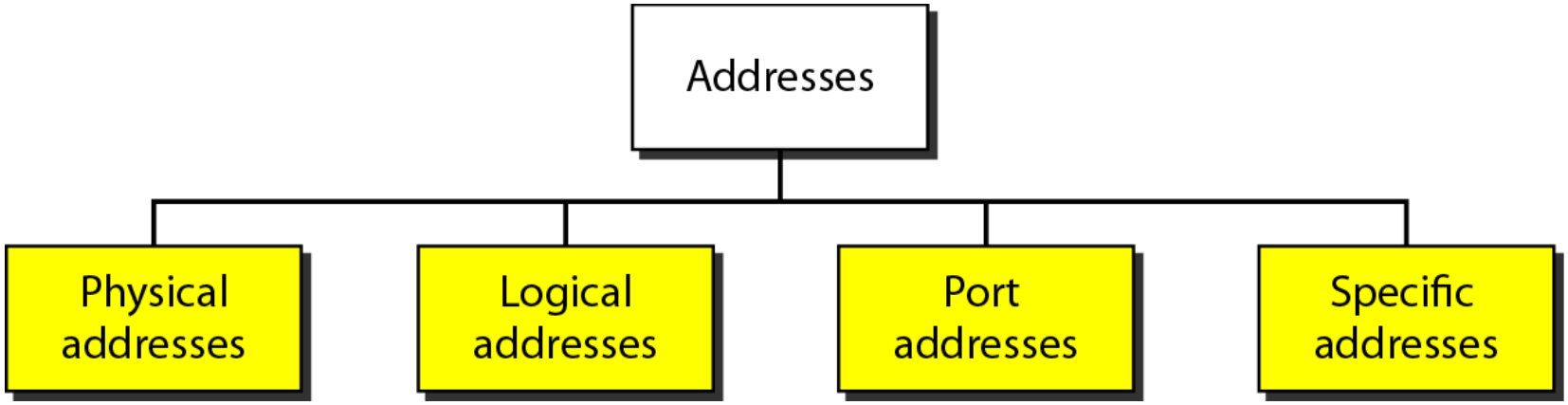
Data Link Layer
Management of cost effective and reliable data delivery, access to physical networks

Physical Layer
Physical Media

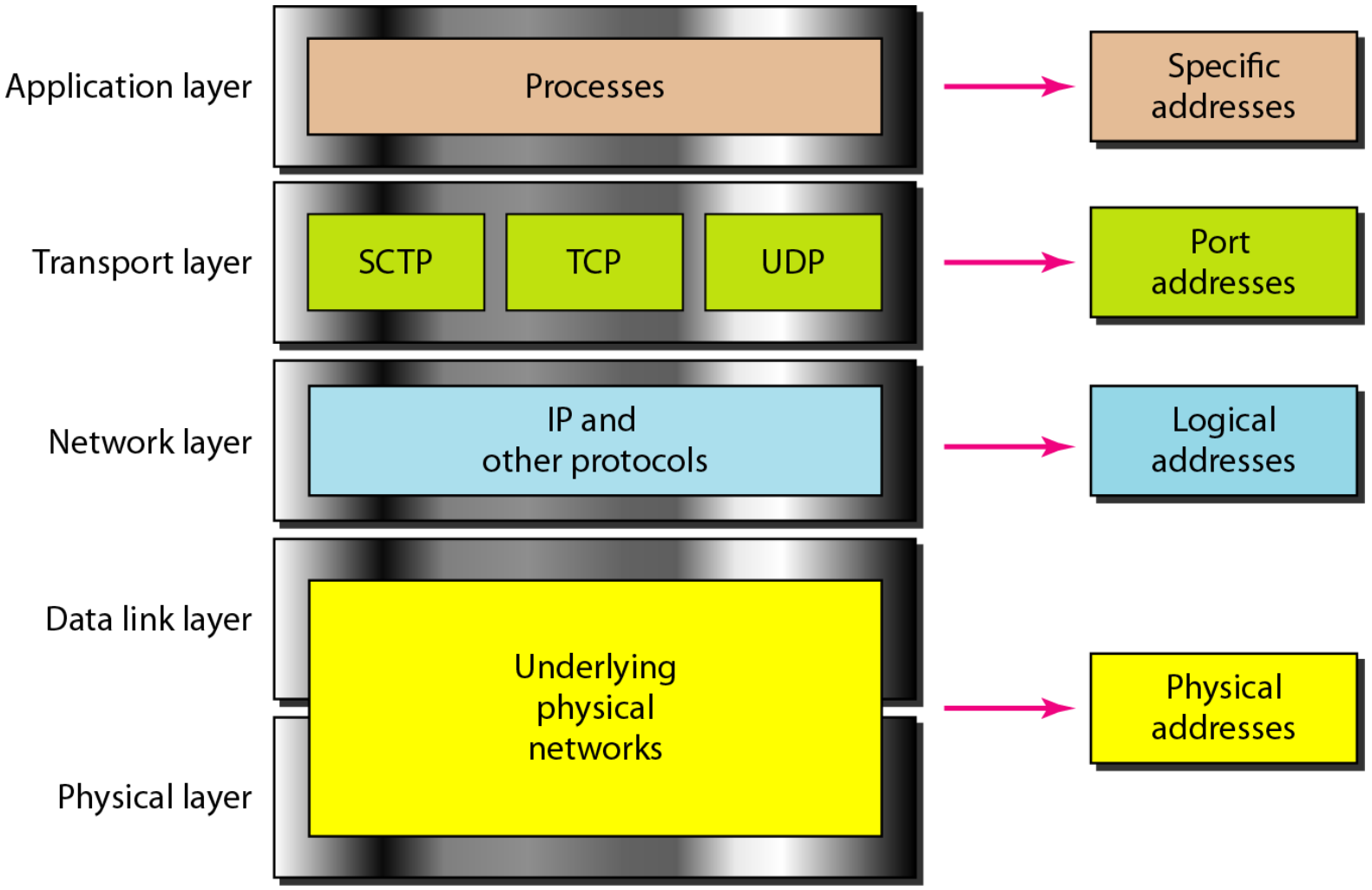
Addressing

- Physical Addresses
- Logical Addresses
- Port Addresses
- Specific Addresses

Addresses in TCP/IP

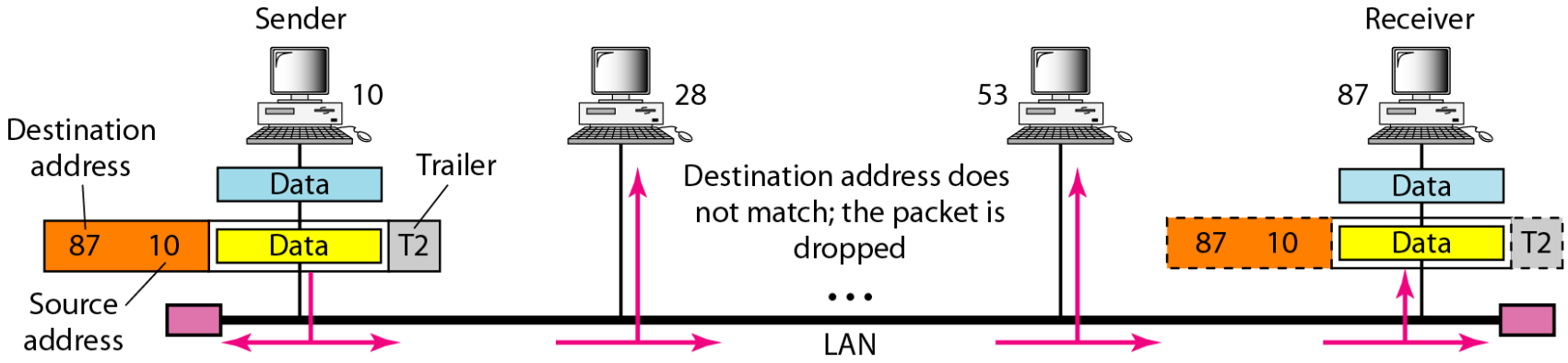


Relationship of layers and addresses in TCP/IP



Physical Addresses

- Here a node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link (bus topology LAN). As the figure shows, the computer with physical address 10 is the sender, and the computer with physical *address 87 is the receiver.*



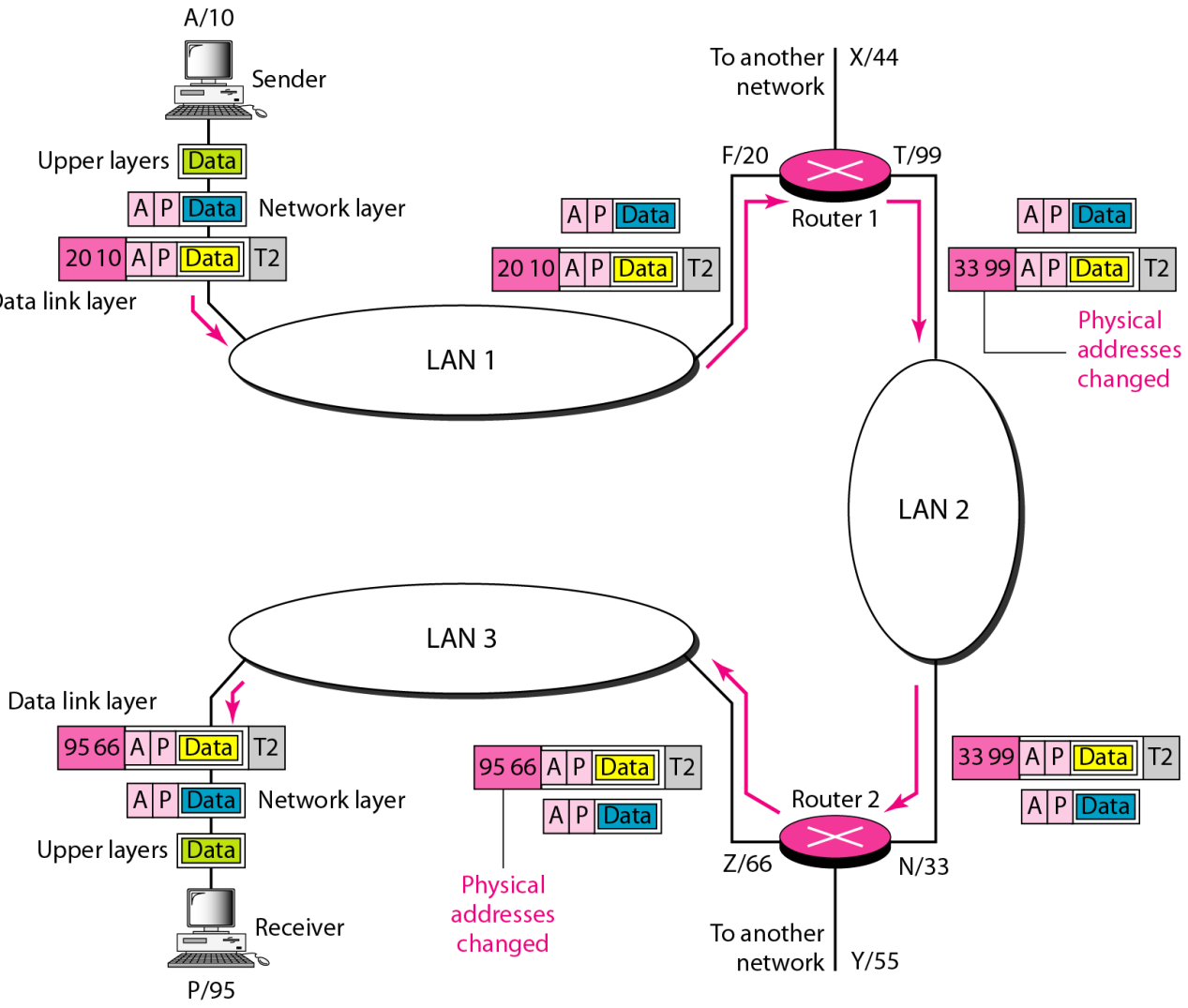
- Most local-area networks use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:

07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address.

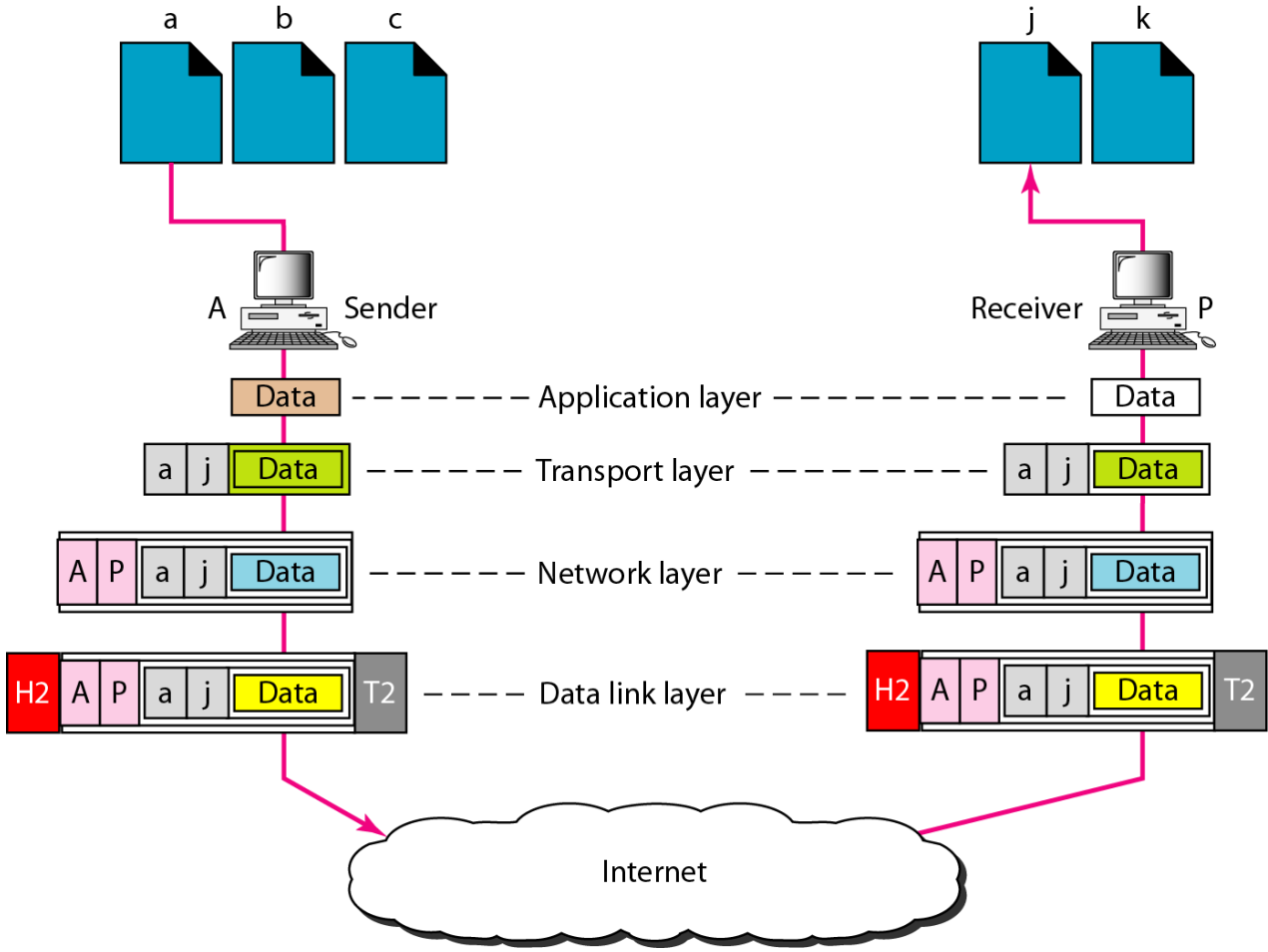
IP Addresses: A part of an internet with two routers connecting three LANs

- Each device (computer or router) has a pair of addresses (logical and physical) for each connection.
- In this case, each computer is connected to only one link and therefore has only one pair of addresses.
- Each router, however, is connected to three networks (only two are shown in the figure).
- So each router has three pairs of addresses, one for each connection.



Port addresses

- *The sending computer is running three processes at this time with port addresses a, b, and c.*
- *The receiving computer is running two processes at this time with port addresses j and k.*
- *Process a in the sending computer needs to communicate with process j in the receiving computer.*
- *Note that although physical addresses change from hop to hop, logical and port addresses remain the same from the source to destination.*



The physical addresses will change from hop to hop, but the logical addresses usually remain the same.

- *A port address is a 16-bit address represented by one decimal number as shown.*

753

- A 16-bit port address represented as one single number.
- Ports 0 through 1023 are defined as well-known ports. Registered ports are from **1024 to 49151**. The remainder of the ports from 49152 to 65535 can be used dynamically by applications.