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| TRƯỜNG ĐẠI HỌC GTVT TP.HCM  Khoa: Công Nghệ Thông Tin  Báo cáo Bài Tập Lớn  Đề tài: The Link Layer and LANs  Giáo viên hướng dẫn: Phan Thị Hồng Nhung  Sinh viên thực hiện:   1. Tên sinh viên: Phạm Đình Khánh Duy\_MSSV: 080205009362 2. Tên sinh viên: Lưu Nhất Huy\_MSSV: 080205003639 3. Tên sinh viên: Đỗ Tiến Đạt\_MSSV: 080205003860 4. Tên sinh viên: Phạm Võ Thành Đạt\_MSSV: 080205008151 |

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# Danh mục các từ viết tắt

ARP: Address Resolution Protocol

CSMA: Carrier Sense Multiple Access

CDMA: Code Division Multiple Access

CMTS: Cable Morden Termination System

DOCSIS: Data Over Cable Service Interface Specification

FDM: Frequency Division Mulplexing

FEC: Forward Error Correction

FDDI: Fiber Distributed Data Interface

LAN: Local Area Networks

MAC: Medium Access Control

NIC: Network Interface Controller

TDM: Time Division Multiplexing

# LỜI MỞ ĐẦU

Trong bài báo cáo này sẽ giới thiệu về tầng liên kết dữ liệu trong mạng máy tính. Bài báo cáo này nhằm giúp chúng ta hiểu thêm về cấu trúc và chức năng của mạng máy tính và hi vọng rằng bài báo cáo này sẽ giúp cho mọi người có thêm nhiều kiến thức bổ ích. Trong thế kỉ XX, thời đại của công nghệ và kỹ thuật số phát triển rất mạnh, chúng ta cần học hỏi thêm nhiều để bắt kịp xu hướng của thời đại

# Nội dung

# Chương 5. Tầng liên kết dữ liệu

## 5.1. Giới thiệu về tầng liên kết dữ liệu

## + In this lesson we will learn about the data link layer (layer 2) in computer network systems. Any device running a link layer (layer 2) protocol is a node. They are include hosts, routers, switches, and WiFi access points.

## + Adjacent nodes along the communication path are links. For a datagram to be transmitted from the source host to the destination host, it must travel over each individual link in the path from start to finish.

## + A WiFi link between the sending host and the WiFi access point, an Ethernet link between the access point and a link layer switch; a link between a link layer switch and a router, a link connecting two routers, an Ethernet connection between a router and a link layer switch, and lastly, an Ethernet connection from the switch to a host. On each link, the transmitting node will encapsulate the datagram in a link layer frame and send the frame over the link

## \* Consider a travel agent planning a trip for a tourist from Princeton to Lausanne. The tourist will travel via three modes of transportation (limousine, plane, and train) corresponding to the links in the network. Each mode of transportation is a link-layer protocol, and the travel agent is the routing protocols.

## 5.1.1 The Services Provided by the Link Layer (các dịch vụ của Tầng Liên Kết)

## + Services provided by the link layer

## - Framing: all link layer protocols encapsulate each network layer datagram in a link layer frame before transmitting it over the link. A frame consists of a data field, into which the network layer datagram is inserted, and several header fields. The link layer protocol defines how the frame is structured.

## - Link access: A medium access control (MAC) protocol defines the rules for transmitting frames over a link. For point-to-point links with one sender and one receiver, the MAC protocol is straightforward—the sender can transmit whenever the link is idle. MAC protocol coordinates frame transmissions among the nodes.

## - Reliable Delivery: When a link layer protocol provides reliable delivery, it guarantees to move each network layer datagram over the link without errors.

## - Error Detection and Correction: Many link-layer protocols provide error detection by adding error detection bits to the frame. When the frame is received, the receiving node checks for errors. Error correction involves detecting and locating errors in the frame for correction.

## 5.1.2 Where Is Link Layer Implemented (nơi triển khai tầng liên kết)

## + This chapter covers the implementation of the link layer and asks where this layer is implemented, whether it is implemented in hardware or software, and how it connects to the rest of the server hardware and operating system.

## + Ethernet capabilities are typically built into the mother board chip set or achieved with an inexpensive dedicated Ethernet chip. The link layer is executed on a chip known as a network adapter (or network interface controller).This controller performs many link-layer services such as framing, link access, and error detection.

## \* On the transmission side, the controller retrieves the datagram created by the upper layers of the protocol stack, stores it in the server’s memory, and then encapsulates it into a link frame by filling in the appropriate fields of the frame. Afterward, this frame is transmitted over the communication link in accordance with the link access protocol.

## On the receiving side, the controller captures the complete frame and extracts the datagram belonging to the network layer. If the link layer provides error detection, the sending controller adds error-checking bits to the frame header, and the receiving controller uses those bits to perform an error verification.

## While the link layer's operations are mostly handled by hardware, some aspects are managed by software running on the server’s CPU. This software takes care of higher-level link layer functions such as handling link-layer addresses and triggering the controller’s hardware components

## 5.2 Error Detection and Correction Techniques (kỹ thuật phát hiện và sửa lổi)

+ In the previous chapter, we mentioned that detecting and correcting bits at the bit level, as well as detecting and correcting bits in the topology that are transmitted between neighboring nodes over a physical connection, are two services typically provided by the topology layer. As discussed in Chapter 3, these detection and remediation services are also commonly available in the shipping layer.

# *5.2.1 Parity Checks (kiểm tra chẵn lẻ)*

+ Detecting errors with parity bits works as follows: In the parity method, the party that sends one more bit to the data string and selects the value of this bit so that the sum of the 1 bits in the entire string (including the original data and the parity bit) is an even number. For the odd method, the value of the parity bit is chosen so that the total number of 1 bits in the string is odd.

### *5.2.2 Cyclic Redundancy Check (phương pháp kiểm tra tổng)*

+ A simple comprehensive test method is to add k-bit integers together, and then use the sumc of the results to detect errors. The Internet General Audit applies this method, treating each byte of data as a 16-bit integer and performing an addition to them.

The Internet Checkup is then generated by offsetting 1 of the sum result, and is contained in the segment header.

## 5.3 Multiple Access Links and Protocols (liên kết và giao thức truy cập đa dạng)

There are two main types of network links: point-to-point links and broadcast links.

- A point-to-point link includes a sender at and a seceiver at either end of the link.

- A broadcast link, in which there may be multiple sending and receiving nodes all connected to the same single, shared broadcast channel. The term broadcast is used here because when any one node transmits a frame, the channel broadcasts the frame and each other node receives a copy.

- An important issue in broadcast links is the multiple access problem, that is, how to coordinate the access of multiple nodes to a common channel. For example, at a party or in a classroom, many people may want to talk at the same time. Multiple access protocols on computer networks act like social rules, dictating when nodes can trasmit data to avoid collisions and wasted bandwidth.

- Multiple access protocols are used in both wired and wireless networks, as well as satellite networks.

Ideal multiple access protocols should meet the following requirements:

1. When only one node wants to transmit data, that node can use the entire bandwidth of the channel.
2. When there are M data transmitting nodes, each node has an average transmission rate of R/M bps.
3. The protocol must be decentralized, without a single control node causing a point of failure.
4. The protocol should be simple and easy to implement.

The three main types of are:

• Channel partitioning protocols: Share bandwidth by dividing channels.

• Random access protocols: Allow nodes to transmit at any time, with collision handling.

• Taking-turns protocols: Nodes transmit data in turns.

### *5.3.1 Channel Partitioning Protocols (giao thức phân vùng kênh)*

+ TDM (Time Division Multiplexing) and FDM (Frequency Division Multiplexing) are two techniques used to divide the bandwidth of a broadcast channel among nodes sharing the channel.

+ TDM divides time into time frames, and each frame is divided into N small time slots. Node is assigned can only transmit data during that time slot.

+ Advantages: Avoid collisions and fairness, each node has a transmission rate of R/N bps.

+ Disadvantages: When a node has a lot of data to send, it is still limited by R/N bps and must wait for its turn to transmit, even if no other node wants to transmit data.

+ FDM divides the channel's R bps bandwidth into different frequency bands (each band has a bandwidth of R/N), each node is assigned a separate frequency band.

+ Advantages and disadvantages similar to TDM: No collisions and fair sharing, but the node is still limited by R/N bps bandwidth even if it is the only node that *wants to transmit data.*

### *5.3.2 Random Access Protocols(Giao thức truy cập ngẫu nhiên)*

+ The second class of diverse access protocols is random access protocols.

In this protocol, the transmitting node always transmits at the full rate of the channel, namely R bps. When a collision occurs, each node involved in the collision repeatedly retransmits its frame (i.e., packet) until its frame is transmitted without a collision. But when a node encounters a collision, it does not necessarily retransmit the frame immediately.

Examples of random access protocols:

1. Slotted ALOHA:

- Time is divided into equal-sized slots (time to transmit 1 frame).

- Nodes only start transmitting at the beginning of the time slot.

Nodes are synchronized.

If there are 2 or more nodes transmitting in the same slot, all nodes detect collisions.

\* Operating:

- When a node receives a new frame, it transmits in the next slot.

- No collision: the node can send frame in the next slot.

- If there is a collision: the node retransmits the frame in each subsequent slot with probability ppp until it succeeds.

\* Advantages:

- Allows the node to transmit at R bps when it is the only node with data.

\* Disadvantages:

- Low efficiency when there are many nodes transmitting data due to collisions and empty slots.

- The maximum efficiency of Slotted ALOHA is 37% when there are many active nodes, meaning that only 37% of the time slots are used effectively.

1. Pure ALOHA:

- No time synchronization required.

- If a collision occurs, the node waits a random amount of time before retransmitting.

Disadvantages:

- Only 50% as efficient as Slotted ALOHA due to higher chance of collision.

- The maximum efficiency of Pure ALOHA is 18%.

1. CSMA (Carrier Sense Multiple Access):

- Before transmitting, each node "listens" to the channel to see if another node is transmitting (carrier sensing). If the channel is empty, the node transmits the data.

- If a collision is detected while transmitting, the node stops transmitting and waits a random amount of time before trying again (collision detection).

- CSMA/CD (CSMA with Collision Detection) is an improved version of CSMA, where nodes stop transmitting as soon as a collision is detected, saving bandwidth.

\*Performance of CSMA/CD:

- Performance depends on propagation delay (dprop) and frame transmission time (dtrans).

- Performance of CSMA/CD

tprop = maximum transmission delay between two nodes in the LAN.

ttrans = time to transmit a frame of maximum size.

- Formula for calculating performance:



Efficiency approaches 1 as:

tprop approaches 0.

ttrans approaches infinity.

Better efficiency than ALOHA, and the system is simple, cheap, distributed!

### *5.3.3 Taking-Turns Protocols(Giao thức luân phiên)*

Taking-Turns protocols are a family of multiple access protocols designed to ensure

that when only one node is active, it has a maximum transmission rate of R bps, and

when M nodes are active, each node has a rate close to R/M bps. This overcomes the

drawback of protocols such as ALOHA and CSMA, which do not achieve equal rates

between nodes.

The two most popular Taking-Turns protocols are:

1. Polling Protocol:

- There is a master node, the master node polls other nodes to allow them to transmit data in rotational order.

- Each node is allowed to transmit a certain number of data frames when it is its turn.

- Advantages:

+ Eliminates collisions and empty time slots, which increases channel utilization.

- Disadvantages:

+ Polling delay: It takes time for the master node to notify each node that it can transmit data.

+ Master node failure: If the master node fails, the entire system will stop working.

Example: Bluetooth protocol.

1. Token-Passing Protocol:

+ There is no control node. A special frame called a token is passed between nodes in a fixed order.

+ The node that receives the token keeps it and transmits any data, if any, then passes the token to the next node.

+ Advantages: Decentralized, highly efficient protocol.

- Disadvantages:

+ If the node fails or does not return the token, a recovery solution is needed to return the token

+ A failure in one node can disrupt the entire system.

1. KẾT LUẬN

+ The data link layer plays an important role in data transmission with functions such as

data framing, link access, error detection and correction, helping to ensure that data

transmission is error-free.

+ In addition, there are various access protocols such as: point-to-point links: (PPP) and

(HDLC), broadcast links: (Ethernet) and (wireless LAN), channel partitioning protocols

contributing to the optimization of data transmission, increasing the efficiency of

bandwidth use and reducing data collisions during data transmission.

+ In summary, the data link layer is crucial for data transmission and guarantees that data

is sent without errors It is necessary to optimize the modern network system

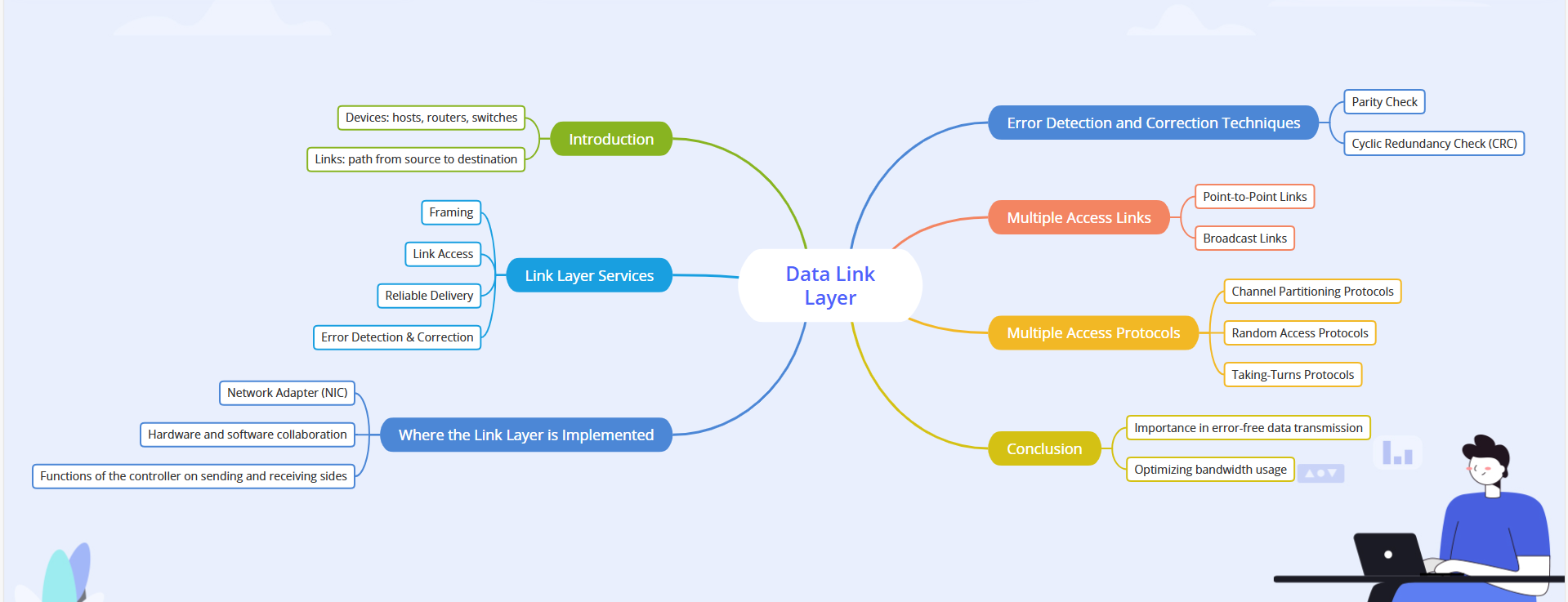
effectively and securely.

\* Tài liệu tham khảo

James F. Kurose || Keith W. Ross , COMPUTER NETWORKING A TOP-DOWN

APPROACH Eighth Edition, năm 2020.

1. MINDMAP:



1. Phụ Lục

\* câu hỏi trắc nghiệm

Câu 1. What services does the link layer provide?

1. 8
2. 6
3. 3
4. 7

Câu 2. Choose the correct answer

What are the two techniques for detecting and correcting errors?

1. Farming, Reliable Deliver
2. Parity Check, Link Access
3. Parity Check, Cyclic Redundancy Check
4. Error detecting and Correcting

Câu 3. How many main types of multiple access protocols are there?

1. 4
2. 3
3. 1
4. 5

Câu 4. What is the main task of random access protocols?

1. Share bandwidth by dividing channels.
2. Nodes transmit data in turns.
3. Allow nodes to transmit at any time, with collision handling.
4. Error detecting and Correcting

Câu 5. Which error detection technique uses parity bits?

1. Cyclic Redundancy Check
2. Farming
3. Reliable Deliver
4. Parity Check

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| Thành viên | Nội dung phân chia |
| Đỗ Tiến Đạt | + Giới thiệu chung về tầng liên kết dữ liệu +The Services Provided by the Link Layer  + Where Is Link Layer Implemented |
| Phạm Đình Khánh Duy | + Error Detection and Correction Techniques  + Parity Check  + Cyclic Redundancy Check  +Câu hỏi trắc nghiệm |
| Lưu Nhất Huy | + Multiple Access Links and Protocols  + Channel Partitioning Protocols  + Vẽ Mindmap |
| Phạm Võ Thành Đạt | + Random Access Protocols  + Taking Turn Protocols  +Kết luận |