Computer Networks and Communication

Isara Anantavrasilp

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Course Description

- Course description from the syllabus:
  - An overview of computer networks, computer network referenced models such as OSI and TCP/IP, wire and wireless digital communication basis, concepts and agreements for peer-to-peer communication, LAN and WAN such as Ethernet and ATM, network layer design issues, routing algorithm, congestion control methodologies, standards and examples of networking, transport layer design issues, quality of services, standards and examples of transport protocols such as TCP and UDP and some computer network applications such as e-mail, WWW and network security.

- Short description:
  - You will learn how the computer networks and the Internet work

Objectives of the Course

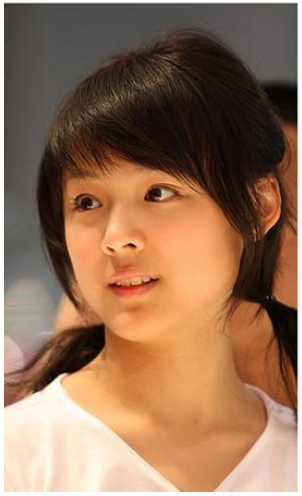
- You should understand
  - How network devices or hosts (such as your computers, iPhones, Galaxy Note and BBs) are connected
  - How network links (such as fiber optics cables and radio signals) works as well as how to use them
  - How can different devices and different links understand each other and interpret the data correctly

Objectives of the Course (2)

- You also should understand
  - How the data are sent and navigated from one host to another.
    - E.g., When you send a Line message from your iPhone, how could your phone know which device the message should go to?
  - How the data correction and error detection work
    - E.g., How can you be sure that **all** your Line messages are **correctly** sent?

Objective of the Course (3)

- How to make sure that your messages are not read by any other individuals
  - E.g., if you send "`Dinner tonight?`" to Pattie, you might not want N'Toey to know
- In other words:
  - How can you be sure that N'Pattie is the only one who can read the message
  - How can N'Pattie knows that it is really you who sent the message



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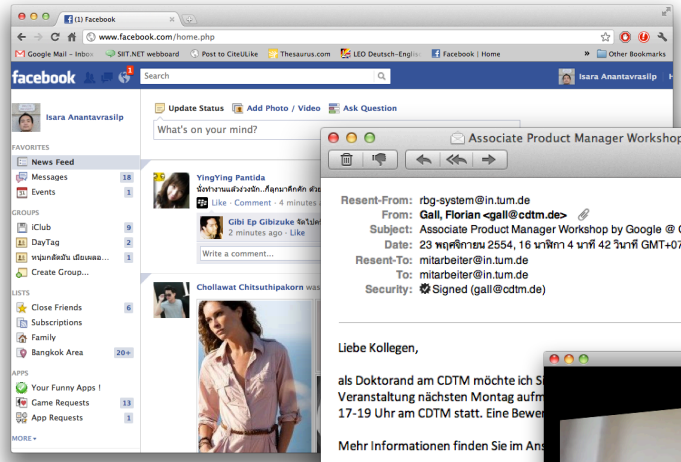
Objective of the Course (4)

- The aforementioned objectives are core concept of computer network field:
  - Connection and communication links
  - Protocols
  - Routing
  - Data Integrity
  - Data Security
- After this course, you should understand these technical concepts

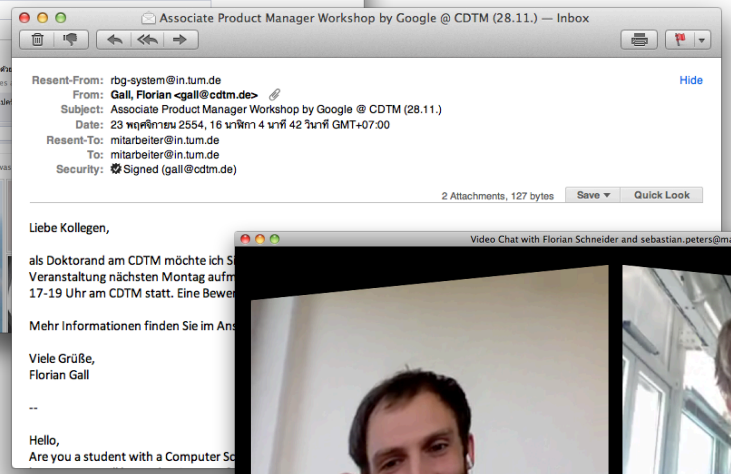
The Internet

- What is the Internet

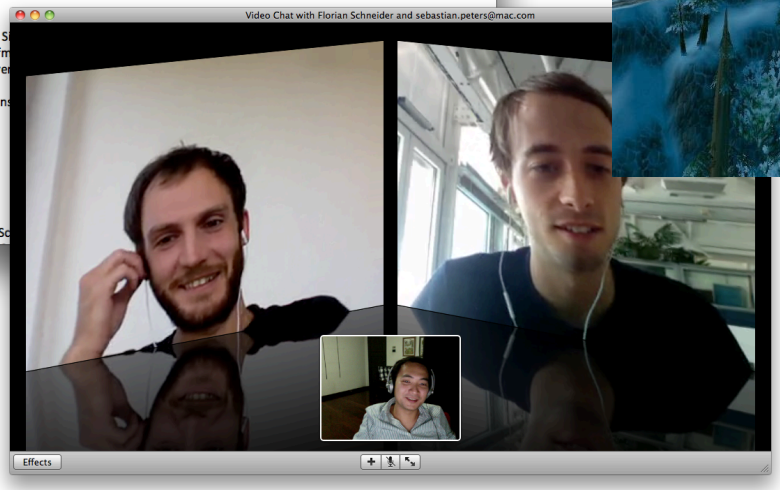
These are **services** on the Internet



Website or World Wide Web



Email

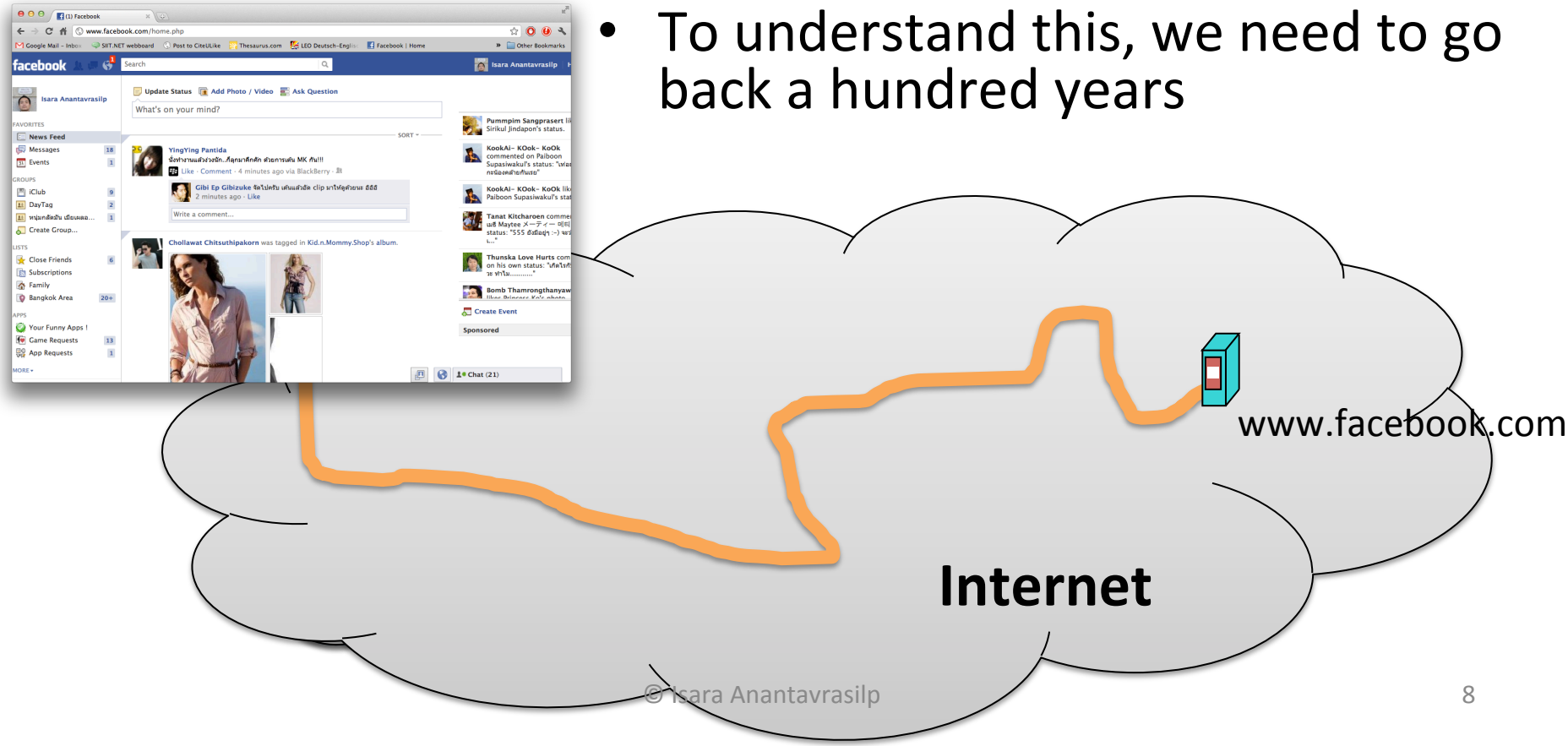


Videoconference

Games

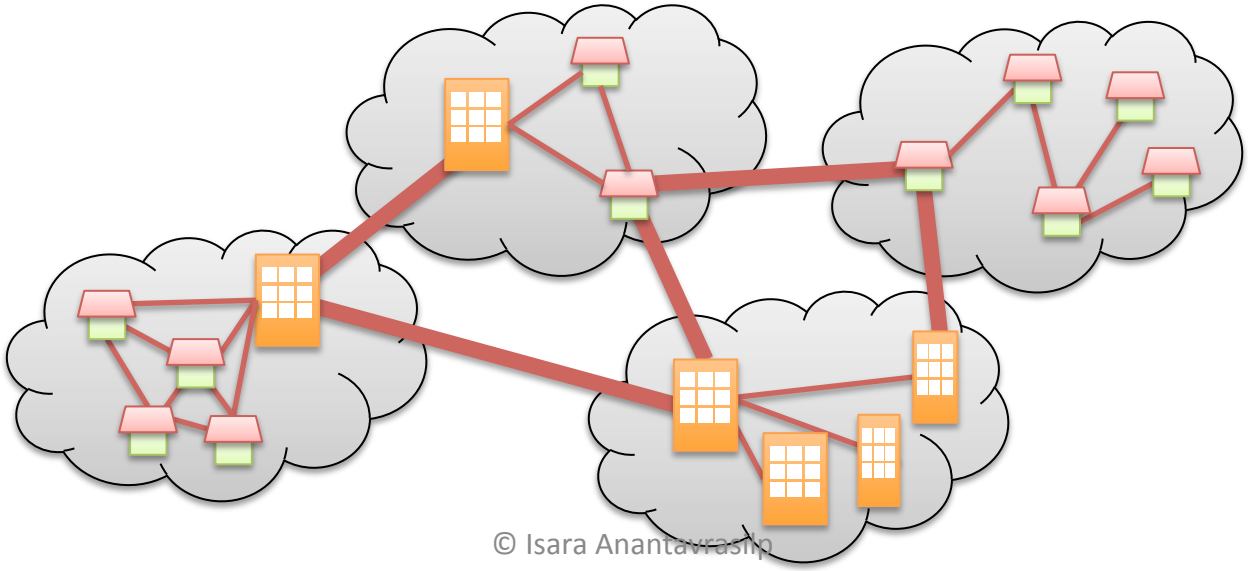
The Internet (2)

- So what exactly is the Internet?
- **Internet**: Inter - networking
  - Network of networks
- To understand this, we need to go back a hundred years



Communication in the Previous Century

- Each town has houses or buildings
- Those structures are connected by roads
- Towns are connected by roads too



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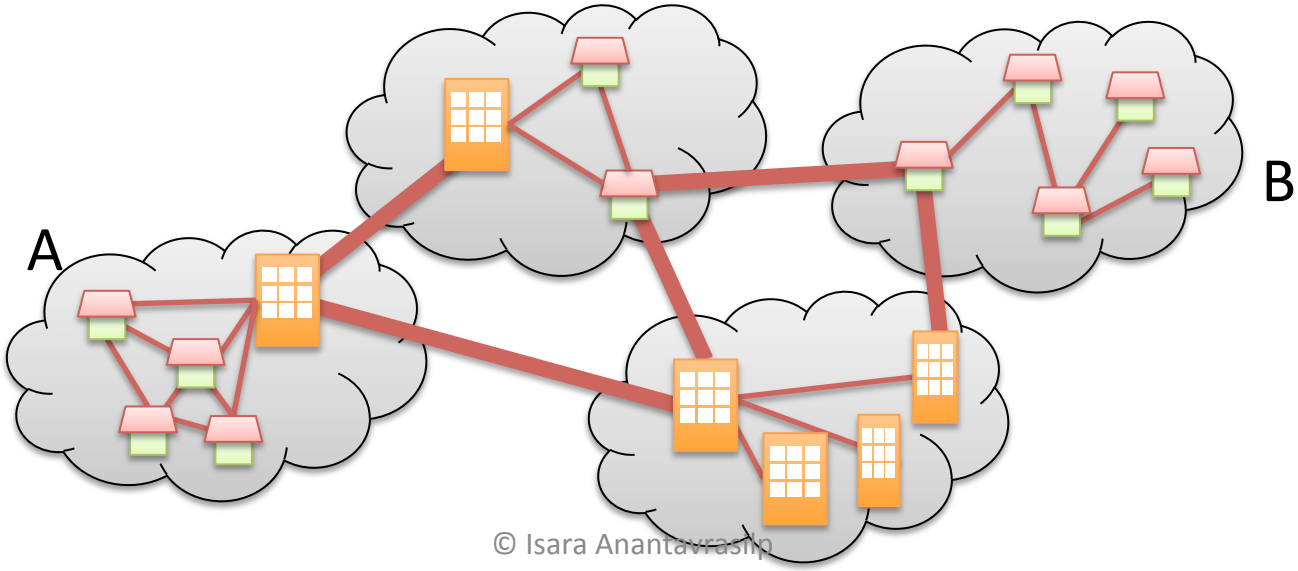
Communication in the Previous Century (2)

- If we want to send a letter from House A to House B, we have to specify
  - Receiver's name and address
  - Sender's name and address
- Thus, effective postal system requires
  - Clear and precise house numbers and road networks
  - Reliable delivery services



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Communication in the Previous Century (3)

- The address of the receiver are getting more specific
  - Country
  - Province and district
  - Street and house number
  - Receiver's name
- The same for sender's address
- Digital messaging works the same way

Image source: http://www.oknation.net/blog/kom/gallery/17932

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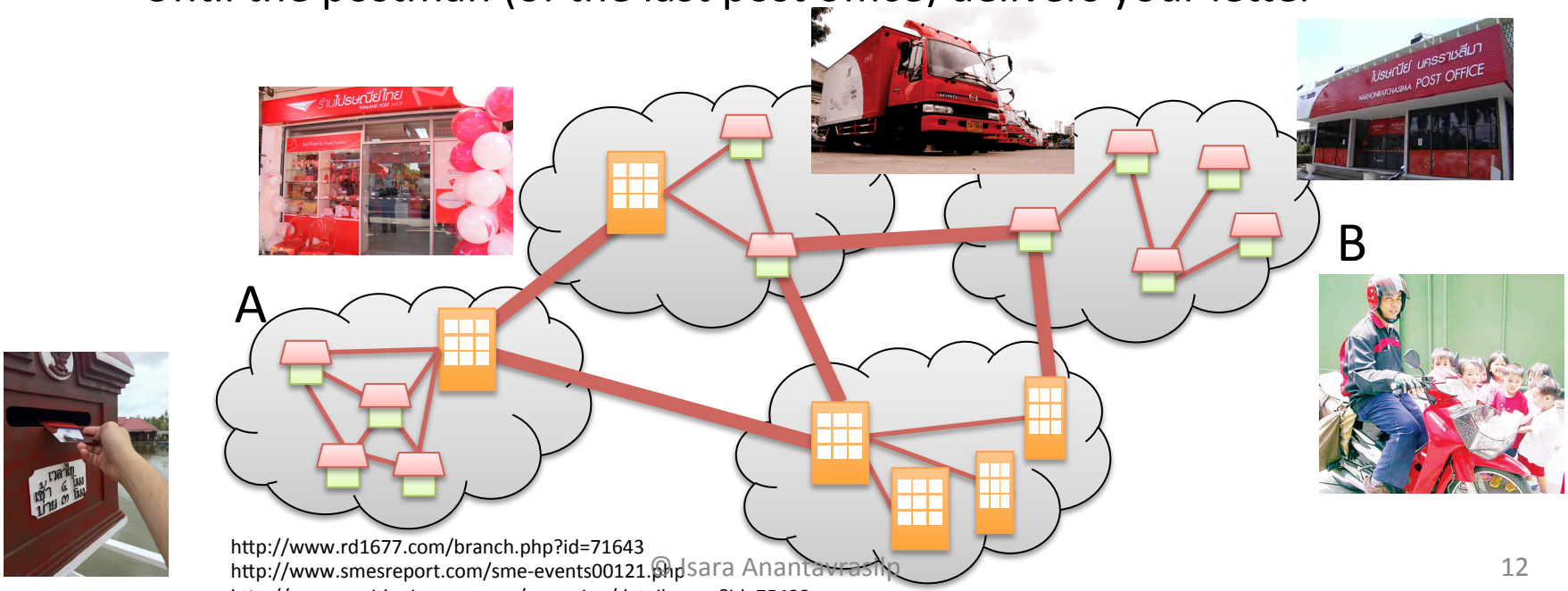
Communication in the Previous Century (4)

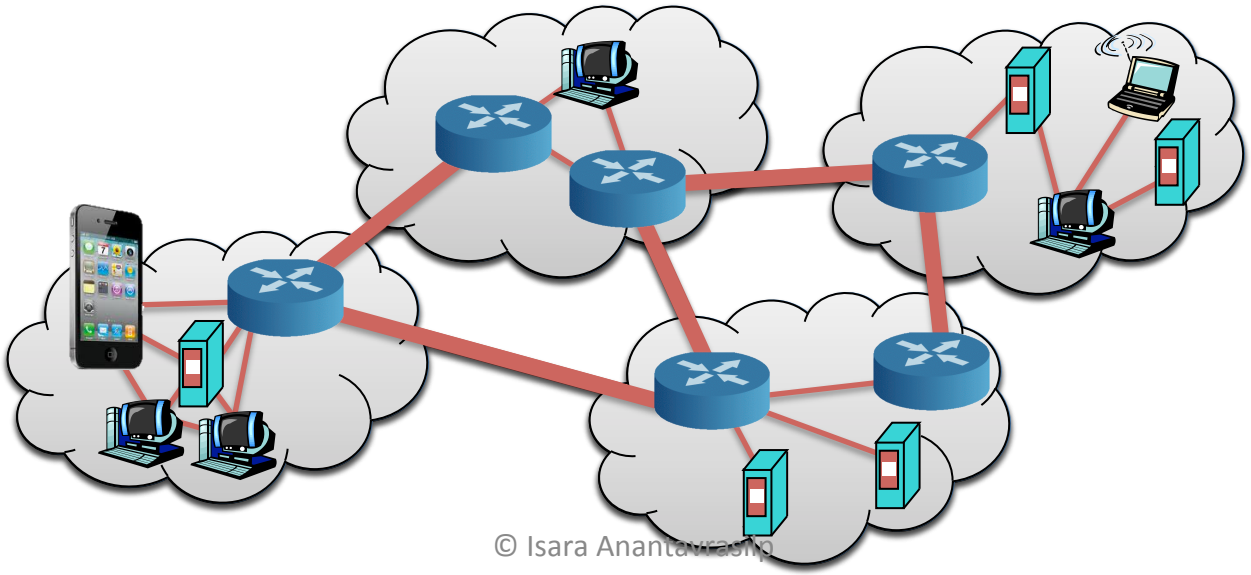
- So, after seeing the address on the letter, how does the post office deliver your message?
  - They check which country should the letter be sent to, follows by province, district, town, etc.
  - The letter will be forwarded to designated post offices
  - Until the postman (of the last post office) delivers your letter



http://www.rd1677.com/branch.php?id=71643
http://www.smesreport.com/sme-events00121.php
http://www.positioningmag.com/magazine/details.aspx?id=75438

Back to the Present

- The main functionality of computer networking is to deliver digital messages from host A to host B
- **Internet**: Inter - networking
  - Network networks
  - Cities, towns, districts, are sub-networks of the Internet
  - Houses and buildings are computers, mobile devices, or **hosts**



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Technical Side of the Internet

- It is network of networks connect together using "**TCP/IP protocol suite**"
- Millions of devices are connected ranging from mainframes, personal computers, mobile phones, cars, to toasters
- The network devices at the end of the network are called "**hosts**" or "**end systems**"

Internet toaster, see: http://www.ohgizmo.com/2008/09/19/scan-toaster-brings-you-internet-on-toast/

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Internet Services and Applications

- Internet services are software functionalities that are available on the Internet such as:
  - Email, videoconferences, WWW, games
- Internet applications are software that implement or use Internet services
  - Usually residing on different host
- Each service has specific "**network protocol**" to communicate among hosts

Human Protocol

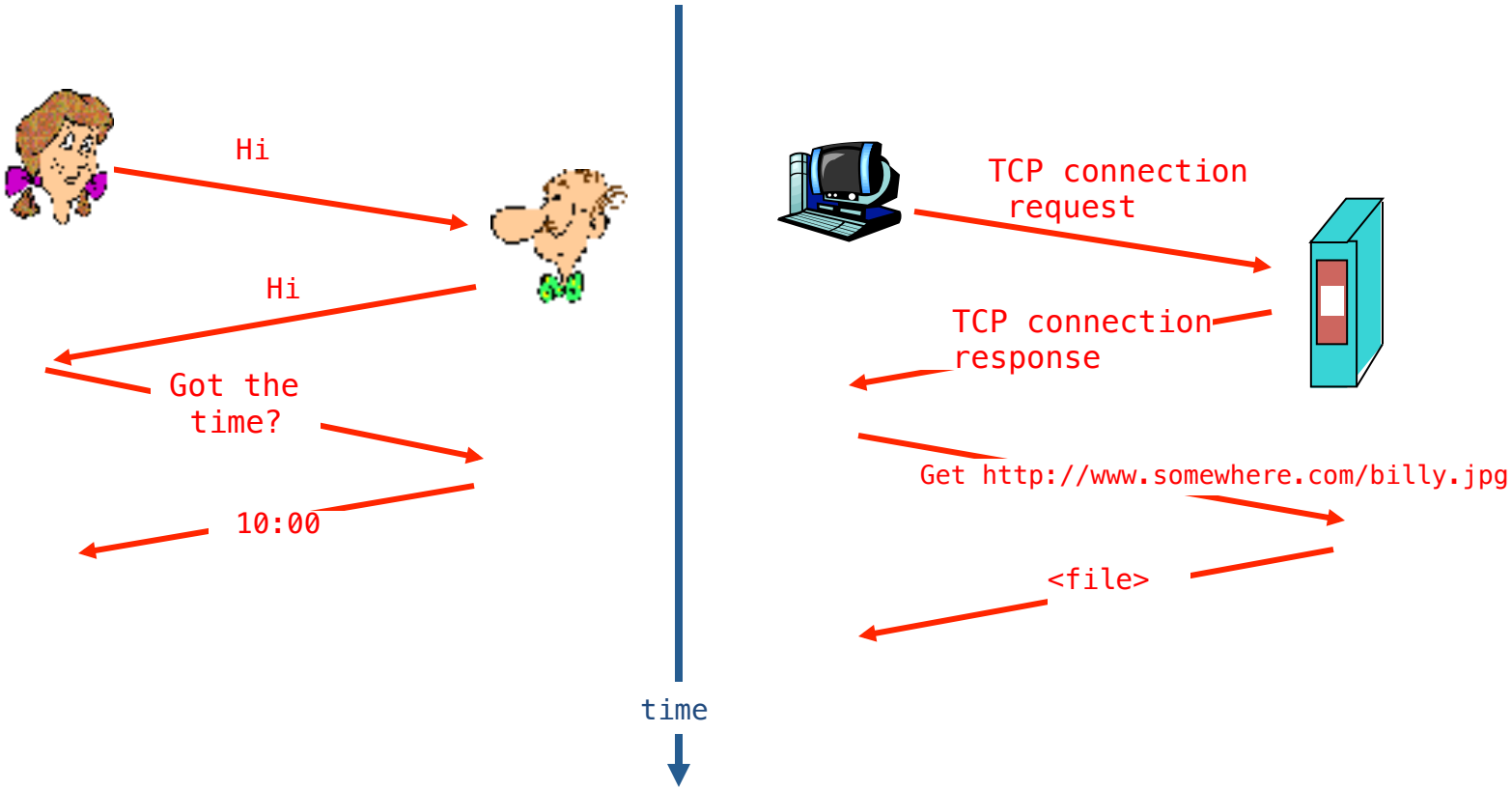
- Let us explain the network protocol with *human protocol*
- Consider the following scenario where Alice wants to ask Bob for the time
  - Alice, being polite, greets Bob, “Hi”
  - Bob replies, “Hi” in return
  - Alice then asks, “What is the time now?”
  - Bob replies, “10:00”
- Alice can communicate with Bob only when Bob understands English and knows how to reply.
- If Alice says “Hi” but Bob does not reply or say “Go away”, Alice would not get what she wants

Network Protocol

- Similar to human protocol, the protocols are rules that define
  - How to exchange information
  - How to react on the information

- **Precisely, network protocols defines**
  - **The format of the message**
  - **The order of messages exchanged between two or more communication entities**
  - **The actions taken on the received message**
  - **The receipt (acknowledgement) of a message or other events**

Network Protocol (2)



Network Protocol (3)

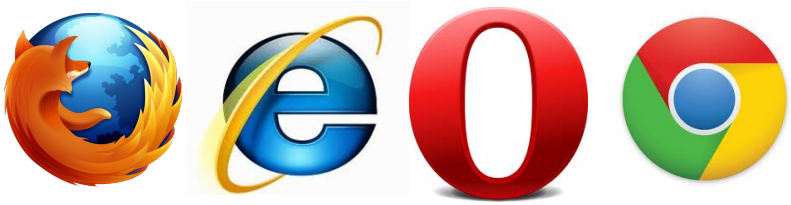
- **Remember**: network devices and applications will understand each other only when they use the same protocol
- When they use the same protocol, it means they are talking the same language and they know how to interact with each other
- Always think about human protocol:
  - If you do not speak the same language as your partner, you will not understand them.
  - If your partner do not know how to react or reply to your message, you will not get what you want.

Network Protocol (4)

- The most important protocols in the Internet are **Transmission Control Protocol (TCP)** and **Internet Protocol (IP)**
  - **TCP** dictates how the data should be sent effectively, correctly and in order
  - **IP** specifies the format of the packets that are sent and received among network components. It is also responsible for message **routing**.
  - We will get back to these protocols soon
- You might also be familiar with the terms **HTTP IRC** or **Ethernet**. Are they protocols?

Internet Services and Protocols

Videoconference



WWW

Instant Messaging

File Sharing

- Different protocols may be designed for the same service
- Some services maybe provided by different applications
- Some applications may provide many services

All icons are courtesy of respective owners

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Other Kinds of Networks

- LAN: Local Area Network
- WAN: Wide Area Network
- MAN: Metropolitan Area Network
- PAN: Personal Area Network

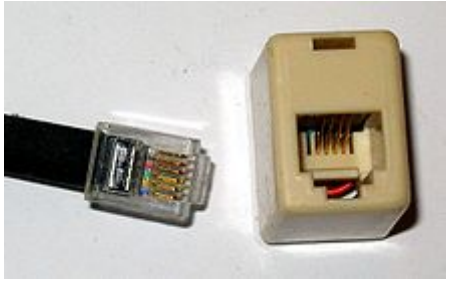
- Homework:
  - NFC: Near-Field Communication

Connecting to the Internet

- **End-users** (e.g. you and me) use end systems to the connect to the Internet through **access networks**
- An access network consists of
  - **Edge router**: First router on a path from the end system to other distant end system
  - **Access links**: physical links that connect the end systems to the edge router
- We collectively call the end systems at end of a network the **network edge**

Connecting to the Internet (2)

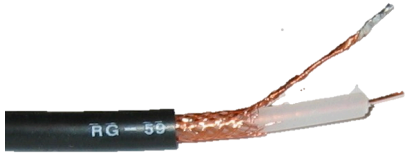
- Example of access links



Telephone line
(DSL, Dial-up)

Ethernet
(LAN cable)

Satellite



Coaxial Cable
(TV cable)

Fiber optic

Terrestrial radio
WiFi, WiMAX,
GPRS (2G),
UMTS (3G), IMT-
Advanced (4G)

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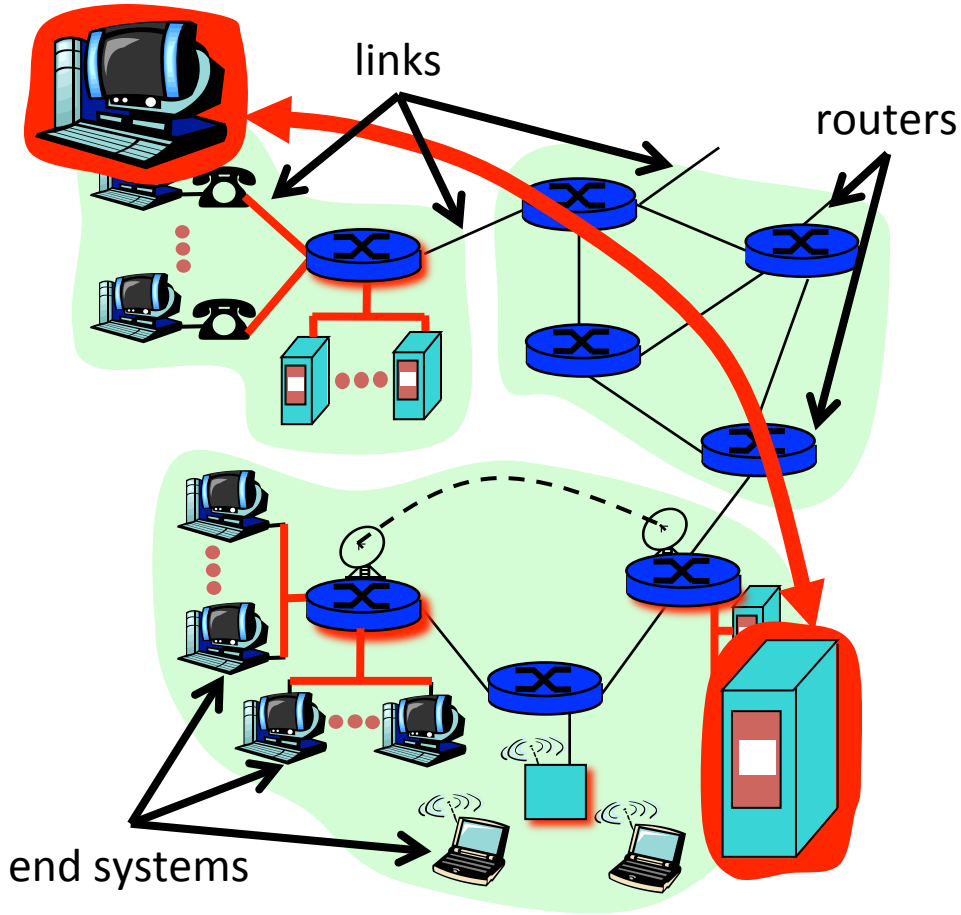
The Network Edge



- The end systems are components at the end of the networks
- Access links and the end routers are highlighted in red
- Communication through the network is about communicating among end systems

Example Scenario

- N' Pattie wants to surf the Internet do videoconference with her friends with Skype. She already has a laptop with a webcam but she needs an Internet access at home. Moreover, she wants to have the Internet access anywhere in the house. She knows you are studying Computer Networks with Dr. Isara, therefore she calls you for help.

- From the scenario above, what would be the best way to get an Internet access at home? Can you help N' Pattie to get her Internet access, so she can skype with her friends?

Example Scenario (2)

- You figure that the best Internet access which is suitable for N'Pattie would be ADSL.
- Therefore, you call an Internet ISP and subscribe for an ADSL service

True Internet true TOT hi-speed 3BB BROADBAND

- A week later the DSL service is *installed* at Pattie's house. The technician plug **splitter** into the telephone jack

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Example Scenario (3)

- Then you go to Pantip Plaza and buy a **wireless modem router**
- At her home, you turn the router on, set the wireless password
- Then, you plug the router into the splitter
- You use Pattie's computer to connect to the wireless network, enter the password
- She can then skype with her friends

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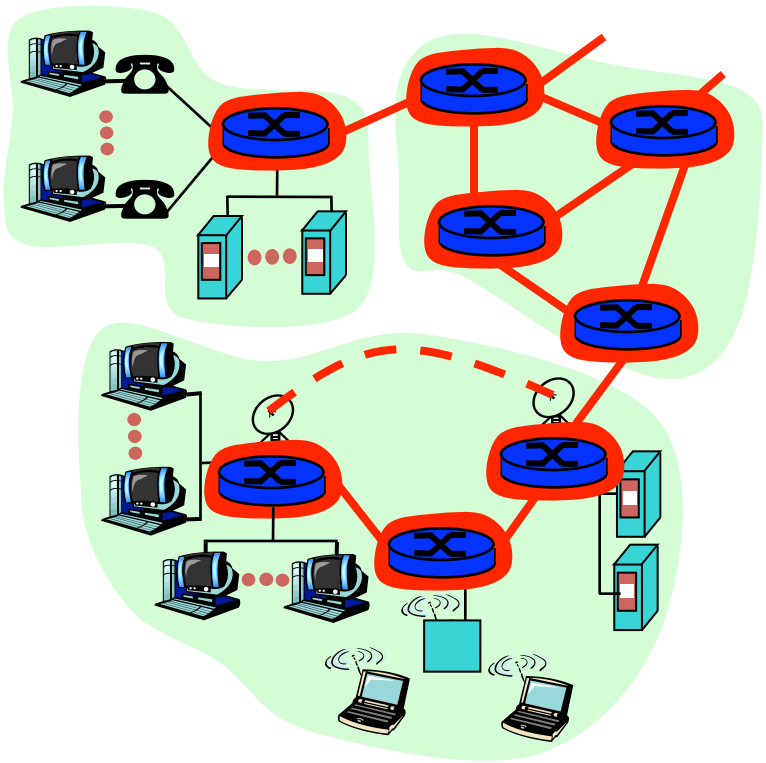
Example Scenario (4)

- Questions:
  - In the scenario, what are the Internet applications?
    Skype and web browser
  - What is/are Skype's service(s)?
    Videoconference and instant messaging
  - Which component is/are the end-system(s)?
    The laptop
  - What is the access network?
    The entire wireless network
  - What is the access link?
    WiFi radio
  - Where do the data go after the splitter?

The Network Core

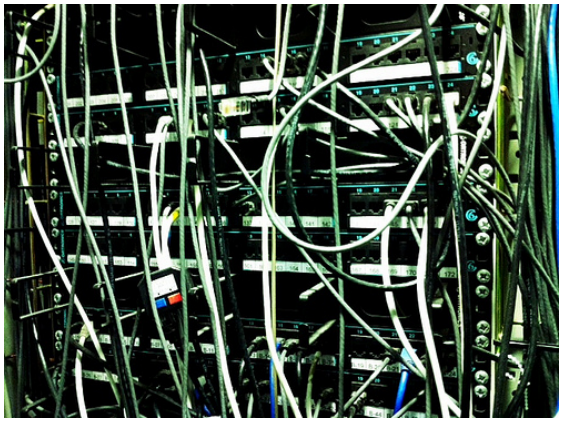
- A **network core** is a mesh of routers, switches that interconnect the Internet's end systems

- The network core components and links are highlighted in red



The Network Core (2)

- At the network core, the main question is:
  - How to transfer the data through the network
  - In other words, how to move the data from one end system to other system(s)
- Routers at the network cores, might not look like what we have seen at home



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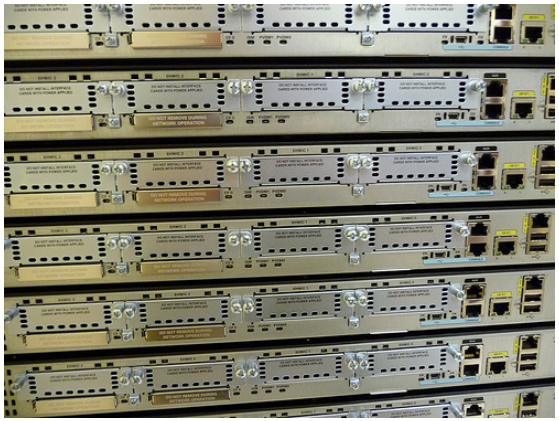

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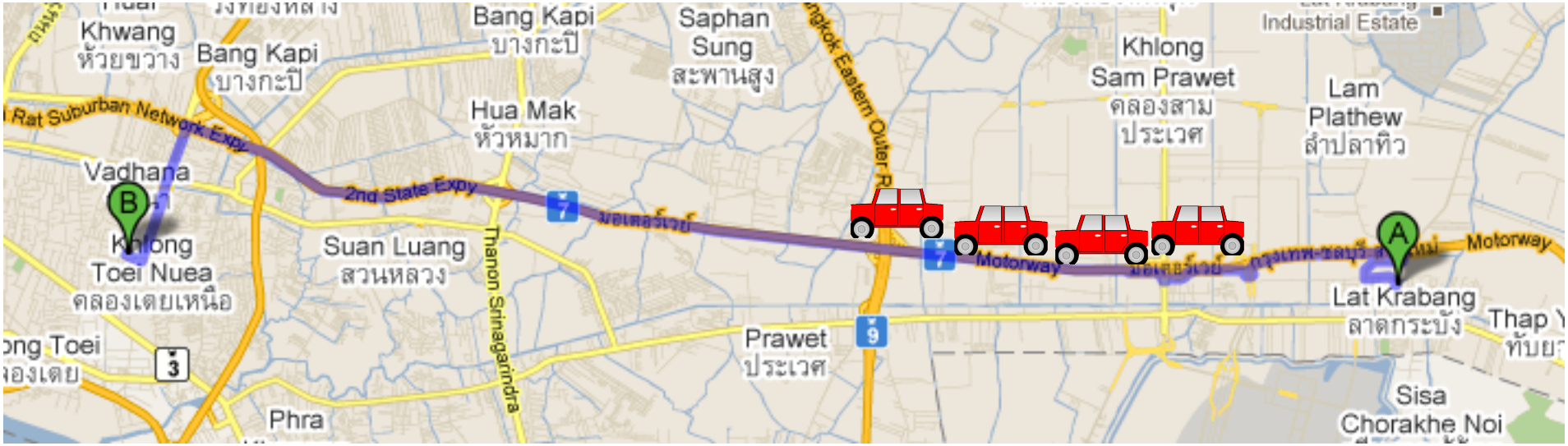
Transferring Data Through the Network

- There are two fundamental approaches to transfer data through the networks
  - **Circuit switching**: The network resources needed along the path from host A to host B are reserved for the duration of the communication session
  - **Packet switching**: The network resources are *not* reserved. The data that are being sent use only the available resources

Circuit Switching Analogy

- We are 20 people and we have 4 cars. If we want to go to Funky pub from the International College, KMITL, how do we get there?



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Funky

Source: Google Maps, of course

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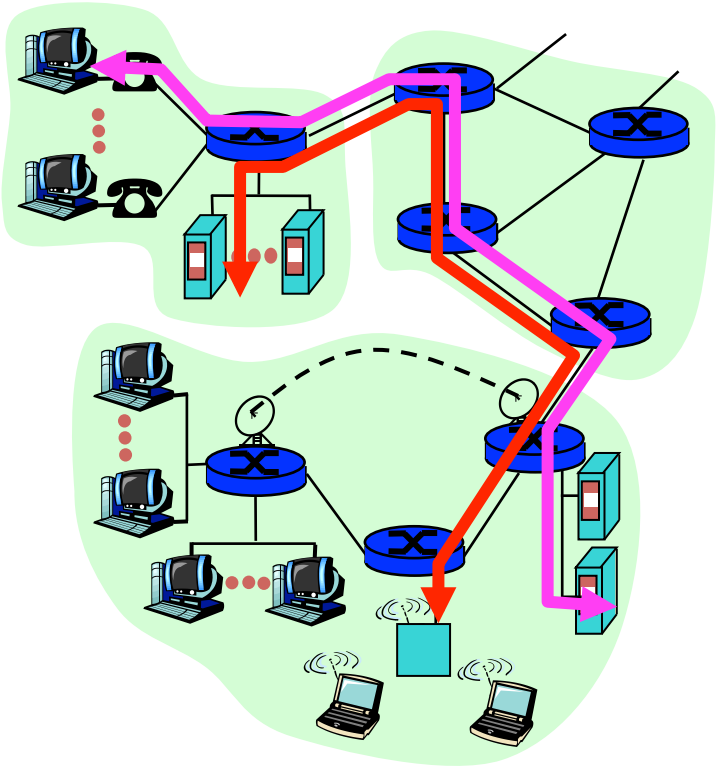
Circuit Switching Analogy (2)

- If we leave at 17:00, it might take us 2-3 hours to get there because there are simply too many cars on the road!
- Now, what if we are all VIPs and the police block all the road all the way from KMITL to Funky for us?
  - That is, the police reserve the road network resources for us
  - All the cars can travel through the same route
  - The traveling time is can be guaranteed
  - However, would it be a good idea to always have the roads reserved for us?
  - What if the others can reserve the road too?

Circuit Switched Networks

- End-to-end resources are reserved for each connection
- A connection is called a **circuit**
- The resources include, e.g. **link bandwidth** and **switch capacity**
- Because the resources are reserved, the network performance is guaranteed
- Circuit setup is required. That is, you have to issue the reservation request to the routers along the route before you can use the link



Circuit Switching Analogy (3)

- Back to the Funky scenario, if other VIPs also reserve the road for themselves too, we have to share the road with them
- How would we do it?

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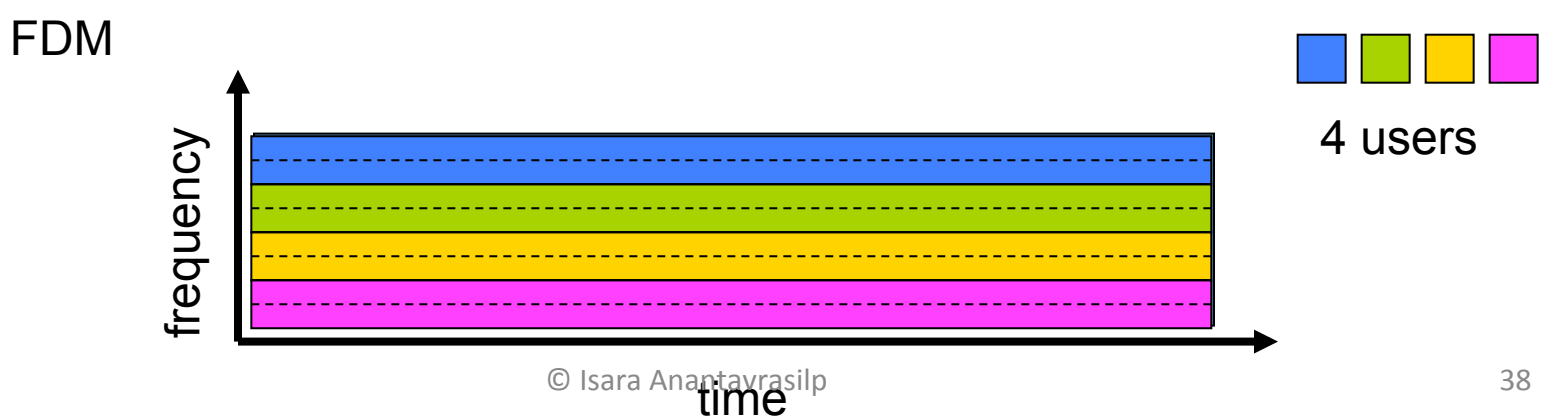
Multiplexing

- If one link can be used only for one connection, it would be too expensive
- Therefore, we have to share the link among the connections
- In other words, we have to combine data from connections to one large connection so that they can be sent using the same link
- A method which is used to combine several connections into to a single connection is called "**multiplexing**"
- Conversely, "**demultiplexing**" is a method which is used to separate a single connection into multiple connections

Multiplexing in Circuit-Switched Networks

- **Frequency-division multiplexing (FDM)**
  - Divide the frequency spectrum of the link among the connections
  - Each link dedicates a frequency band to each connection.
  - The width of the frequency band is called "**bandwidth**"
  - For example, FM radio stations share the frequency spectrum between 88 MHz and 108 MHz.
  - A DSL splitter is also an FDM device!



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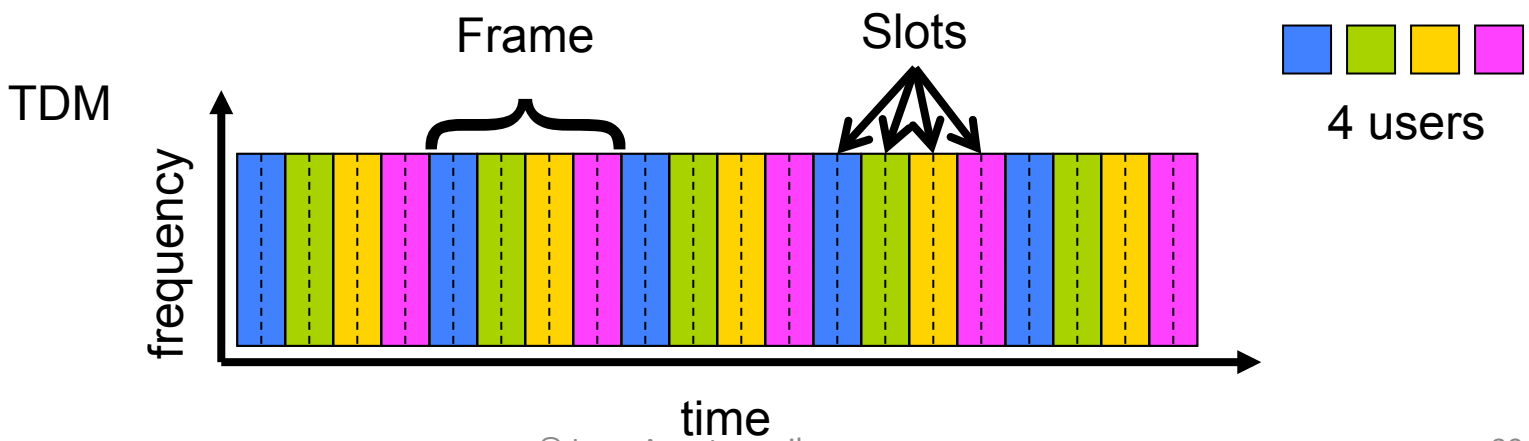
Multiplexing in Circuit-Switched Networks (2)

- **Time-division multiplexing (TDM)**
  - Divide the time into **frames** of fixed duration, each frame is divided into a fixed number of **time slots**
  - Each slot is dedicated to a connection
  - That is, at one time, the link is used only for one connection



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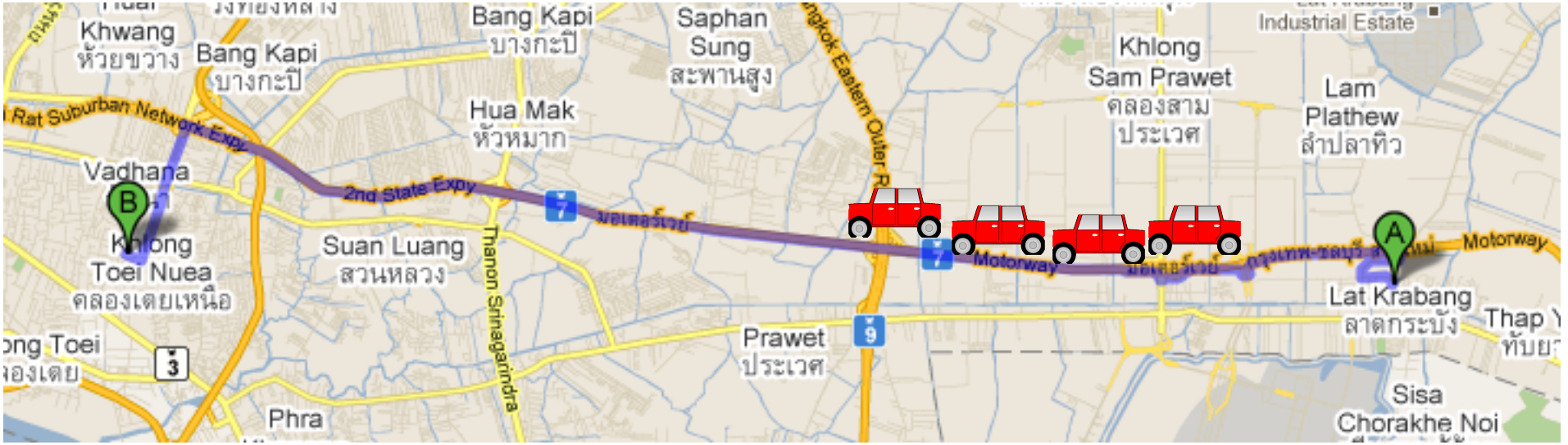
Advantages and Disadvantages of Circuit-Switched Networks

- Advantages
  - Network performances are guaranteed because the network resources are reserved for each connection
  - Network route can be determined beforehand
- Disadvantages
  - Because the resources are reserved, if the link is not used or no data are transferred, the reserved resources cannot be used by other connections
  - In short, circuit-switching is **wasteful** and **underutilized**
  - Resource reservation also introduce additional overhead

Packet Switching Analogy

- Consider the Funky scenario again. Now, we are just (not very important) people and cannot reserve the roads.



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Funky

Source: Google Maps, of course

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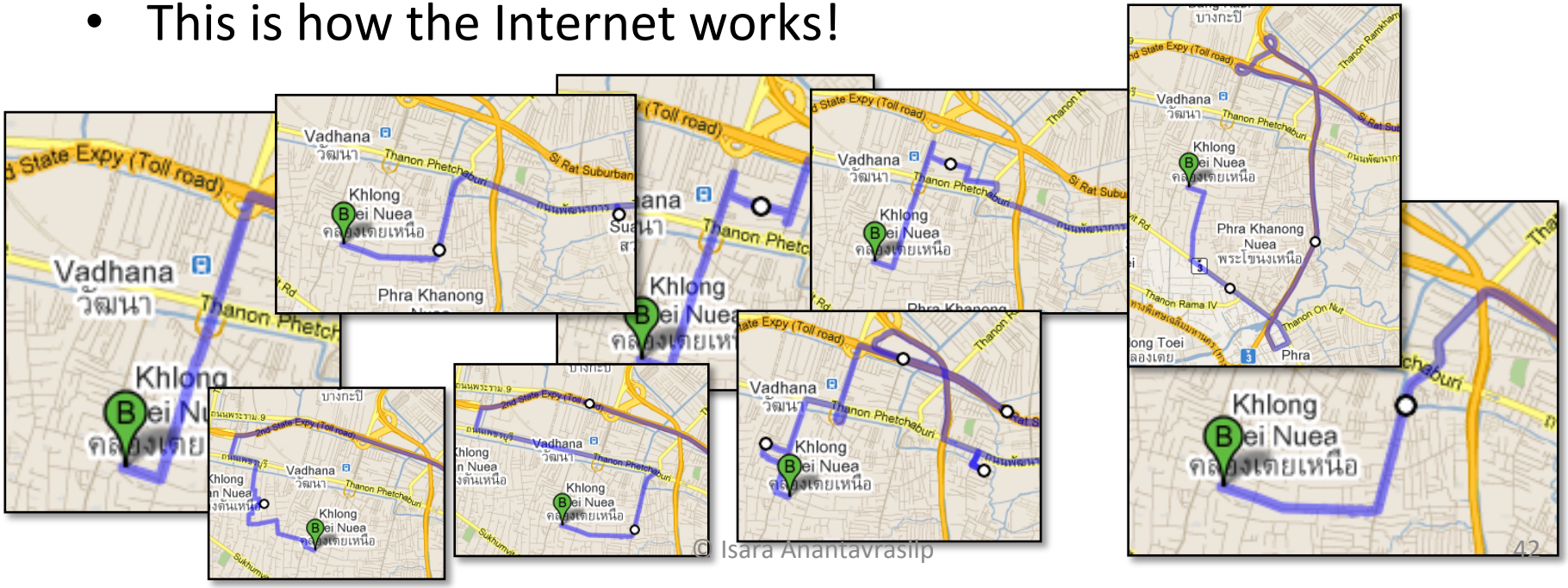
Packet Switching Analogy (2)

- As we do not have any reserved route, our cars might travel in **different** routes
- Also, we might got stuck in bad traffic
- However, the roads are more utilized because the other cars can share the same roads
- This is how the Internet works!



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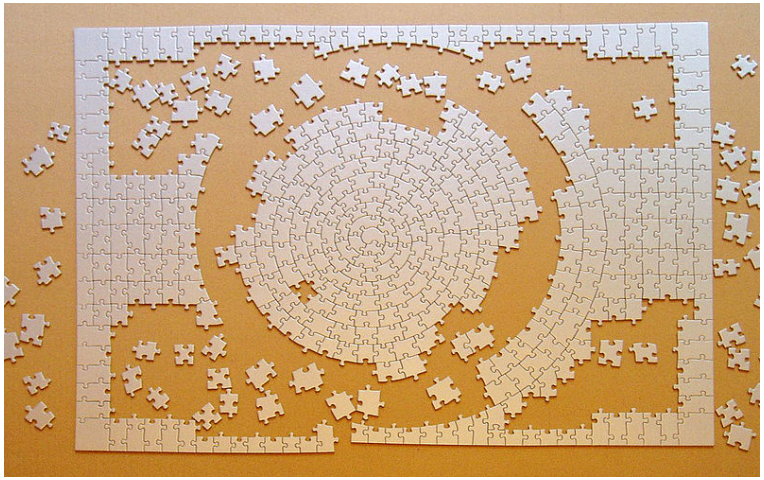
Packets

- The Internet is a **packet-switched network**
- In a packet-switched network, the data are divided into pieces called "**packets**".
- Each piece is sent to the destination independently without resource reservation
- Example:
  - Sending all students in this class to Funky using different cars
  - Sending a jigsaw puzzle piece by piece



Queuing Delay

- As we have discussed, connections on the Inter net do not make any resource reservation
- The Internet tries its **best effort** to deliver the packets in a timely manner, but it does not make any guarantee
- However, if the links are **congested**, the packets might have to wait and suffer a **queuing delay**
- Queuing delay is the time where the packets are waited to be sent from a router to another one
- The network delay is similar to the delay we encounter on the road when we got stuck at the traffic lights

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Advantages and Disadvantages of Packet-Switched Networks

- Advantages
  - The links are more utilized than those in the circuit-switching networks
  - If the links are free (not congested), the on-going connections can enjoy higher performance because no one reserve the resources
  - Simpler and cheaper to implement because it does not need resource reservation functionality. You just have to send the packets away
- Disadvantages
  - Network performance is not guaranteed

Getting Around the Internet

- So far we have discussed the fundamental structure of the Internet including
  - **Service**: What can you do on the network
  - **Protocol**: How the components talk to each other
  - **Communication links**: How the network components (e.g. end systems and routers) are connected
  - **Packets and packet switching**: How the data are sent through the Internet
- Still, how can the routers know which way to correctly send the packets to the destination?

Packet Forwarding

- The packets in the network are not travelling by themselves, they are sent or **forwarded** by the routers
- Each router has a **forwarding table** that maps the destination address or portions of the address to appropriate outbound links
- When the router sees a packet, it examines the destination address in the packet and send the packet through the correct link

Forwarding Analogy

- A forwarding table is similar to a highway sign
- It tells you which way you should go based on your destination

Forwarding Table Analogy (2)

- Another (and more precise) analogy of the forwarding table and the routing process:
  - A driver who does not use a map but always asks for directions
- Example scenario: If I tell you to go to Nimmana Haeminda Soi 11, Mueng District, Chiang Mai, without using a map, a navigator or any traffic sign, what would you do?

Packet Forwarding and Routing

- **Packet forwarding** refers to **router-local** action of transferring a packet from input link to appropriate output link
  - This is similar to asking people for direction at each cross road for appropriate direction
- **Packet routing** refers to the network-wide process that determines end-to-end paths that the packets take from source to destination
  - This is similar to consulting a map and plan the entire trip before you leave home

- Okay, now that we know what routing is, why do we call a router router?

What did we learn today?

- Introduction to the Internet
  - Internet services and applications
  - Network protocols
  - End systems
  - Communication links
  - Circuit and packet-switched networks
  - Packet forwarding and routing

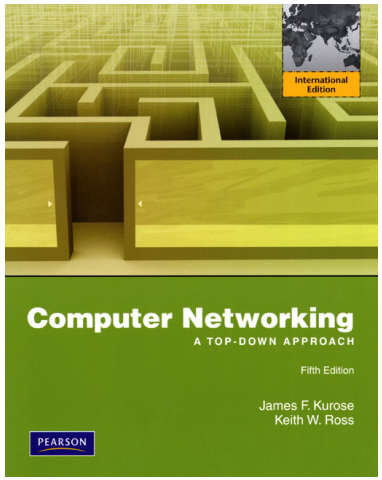
Evaluation

- Midterm exam 40%
- Final exam 50%
- Exercise 10%

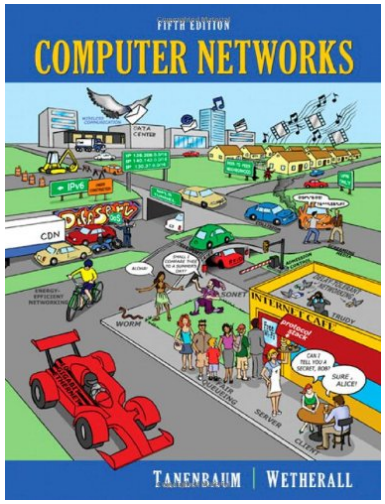
- **Free stuff**: If you come at least **12** classes **ON TIME** (+**5** mins) and **participate** in the lecture, I will give you 10% score for free.

- This means, if your final score is 70%, it will be boosted to 80%

Textbooks



- J. F. Kurose & K. W. Ross, *Computer Networking: A Top-Down Approach*, 5th edition, Addison Wesley, 2010



- Andrew S. Tanenbaum, *Computer Networks,* 5th edition, Prentice-Hall, 2010