Tutorial 4

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1. What is the principal difference between connectionless communication and connection-oriented communication?

Question 1's Answer:

- Connection-oriented communication has three phases. In the establishment phase a request is made to set up a connection. Only after this phase has been successfully completed can the data transfer phase be started and data transported. Then comes the release phase.

- Connectionless communication does not have these phases. It just sends the data.

2. *Packet switched networks route each packet as a separate unit, independent of all others. Virtual-circuit networks do not have to do this, since each data packet follows a predetermined route. Does this observation mean that virtual-circuit networks do not need the capability to route isolated packets from an arbitrary source to an arbitrary destination? Explain your answer.*

Knowledge point:

Packet switched: connectionless (just like postmail)

Virtual circuit: connection-oriented (just like phone communication)

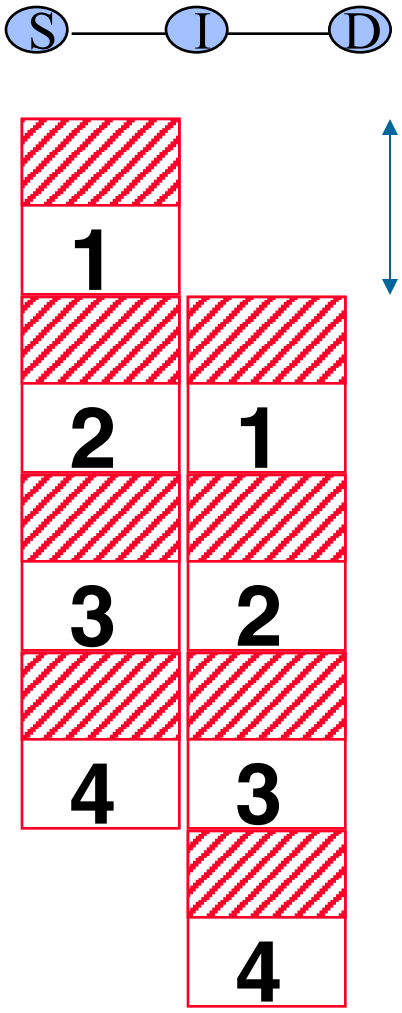
Question 2's Answer:

Virtual circuit subnets most certainly need this capability in order to route **connection setup packets** from an arbitrary source to an arbitrary destination.

Question 3:

Consider a packet switched network. Two nodes, node S and node D, are connected through an intermediate node I. A message of size 1000 bytes is transmitted from node S to node D. The message is fragmented into four packets each with a 50-byte header. All links run the same data rate. If propagation delay is negligible, determine the minimum data rate of the links to achieve 100ms of total transmission delay. (Hint: *pipeline effect*)

Question 3's Answer:



Transmission time, T_f
(frame size = 250 + 50 bytes)

Let:

- ***d***: the link data rate (to determine)
- T_f: transmission time of a packet
- ***T***: The total transmission time

The last bit is sent at time $4T_f$. To get to the destination, the last packet must be retransmitted by the intermediate router I. The retransmission takes time T_f. Then the total delay is $T = 5T_f$
According the question, we know that T<100ms
so, $5T_f$ < 100ms - - - (1)

Since T_f = (250 bytes + 50 bytes) * 8 / d - - - (2)

By (1) & (2), d > 120 kbps

4. A factor in the delay of a store-and-forward packet-switching system is how long it takes to store and forward a packet through a switch.

   If switching time is 10 µsec, is this likely to be a major factor in the response of a client-server system where the client is in New York and the server is in California?

   Assume the propagation speed in copper and fiber to be 2/3 the speed of light in vacuum.

Question 4's Answer:

The speed of propagation is 200,000 km/sec, i.e., 200 meters/μsec. In 10 μsec the signal travels 2 km.

Thus, each switch adds the equivalent of 2 km of extra cable.

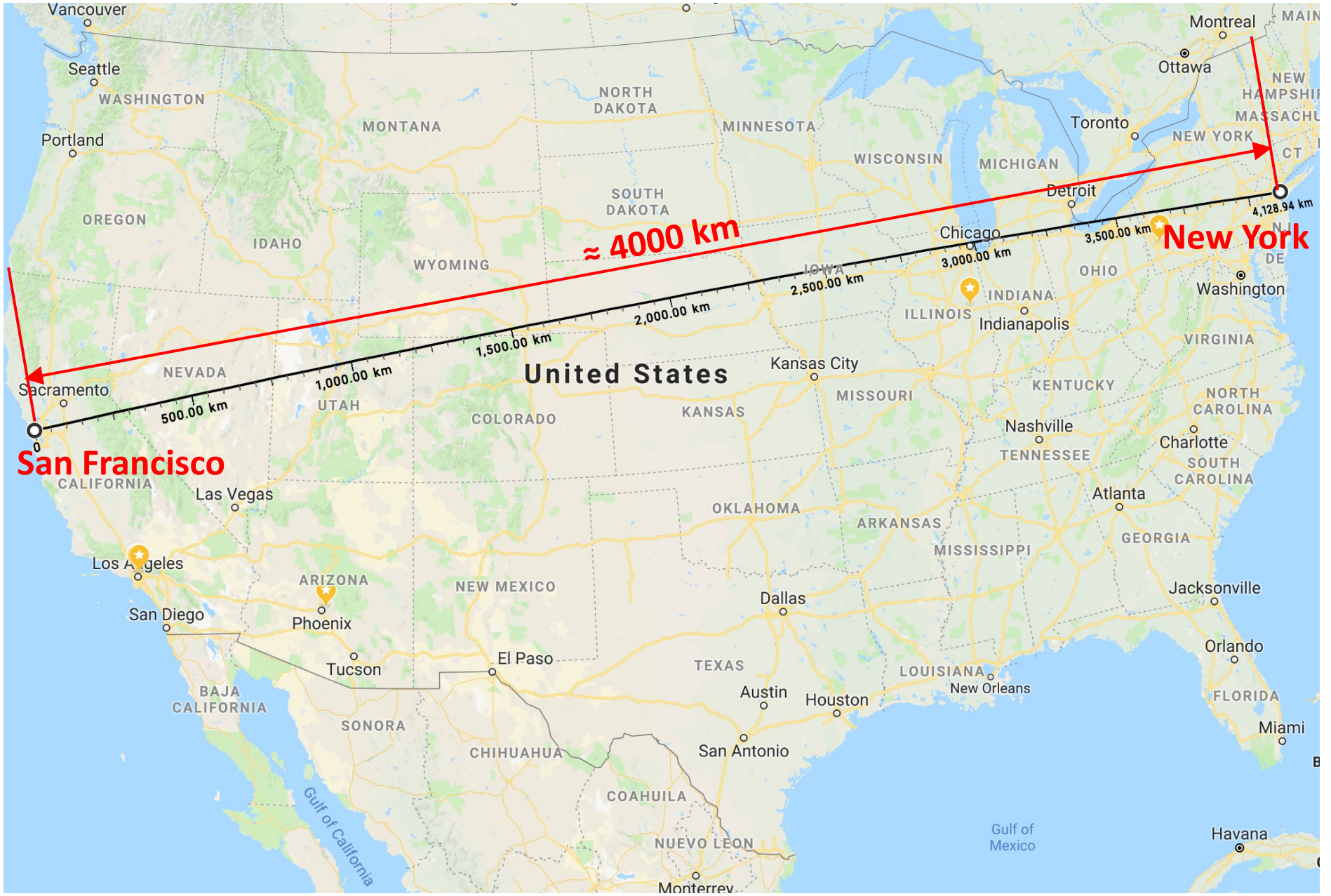
So the questions are:

Where is New York and California?

How many switches the signal have to travel?

If the client and server are separated by 4000 km (e.g., from New York to San Francisco), traversing even 50 switches adds only 100 km to the total path, which is only 2.5%.

Thus, switching delay is not a major factor under this circumstance.


≈ 4000 km
San Francisco
New York
0
500.00 km
1,000.00 km
1,500.00 km
2,000.00 km
2,500.00 km
3,000.00 km
3,500.00 km
4,128.94 km
United States
Vancouver
Seattle
Portland
Montreal
Ottawa
Toronto
Detroit
Chicago
Washington
Indianapolis
Kansas City
Sacramento
Las Vegas
Los Angeles
San Diego
Phoenix
Tucson
El Paso
Dallas
Austin
Houston
San Antonio
New Orleans
Atlanta
Nashville
Charlotte
Jacksonville
Orlando
Miami
Havana
Monterrey
WASHINGTON
OREGON
CALIFORNIA
IDAHO
NEVADA
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
IOWA
KANSAS
MISSOURI
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ARKANSAS
LOUISIANA
TEXAS
OKLAHOMA
NEBRASKA
NEW YORK
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLORIDA
BAJA CALIFORNIA
SONORA
CHIHUAHUA
COAHUILA
NUEVO LEON
Gulf of California
Gulf of Mexico

Why assuming 50 switches for the signal to travel from New York to San Francisco?

- Maximal number of hops allowed:
  64 in MacBook's Operating System (MacOS),
  255 in Windows Operating System.

- Even we assume 100 switches, switching delay is just 5% (i.e., not a major factor) of the path delay.

5. Compare the delay in sending an x-bit message over a k-hop path in a circuit-switched network and in a (lightly loaded) packet-switched network.

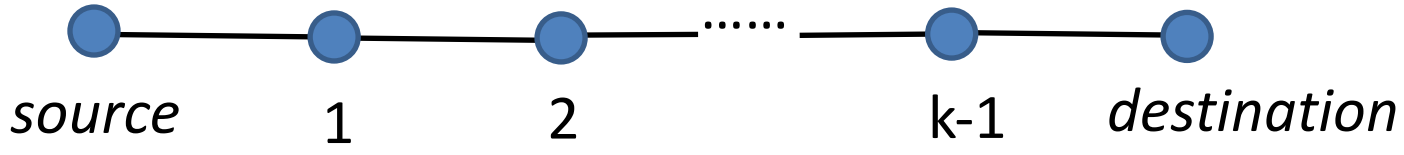
   The circuit set up time is s sec,
   the propagation delay is d sec per hop,
   the packet size is p bits,
   and the data rate is b bps.

   Under what conditions does the packet network have a lower delay?

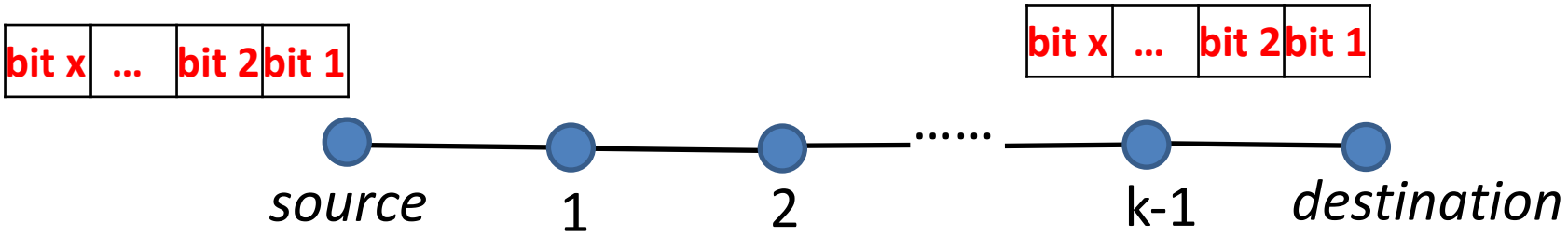
Question 5's Answer —— Slide 1:

With circuit switching,

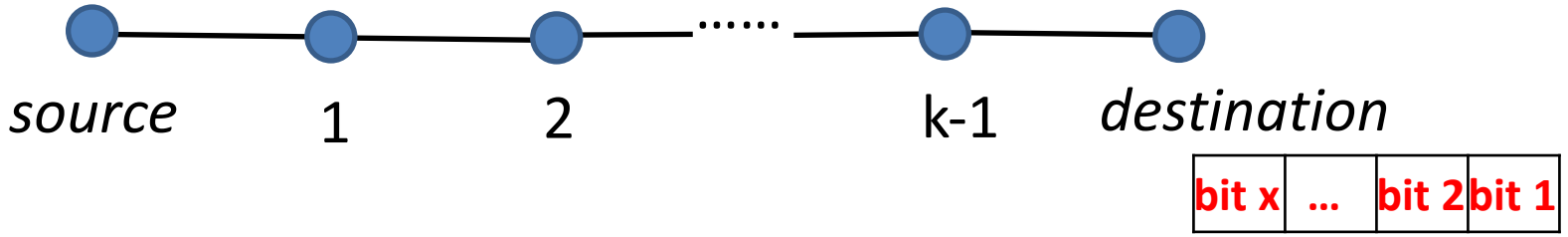
- After *s* time, the circuit is set up.



- After *kd* more time, the first bit is received by destination.



- After *x/b* more time, the last bit is received by destination.

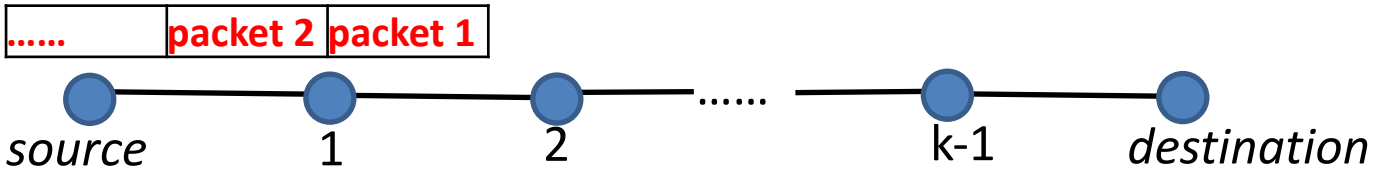


- Total delay: *s* + *x/b* + *kd*

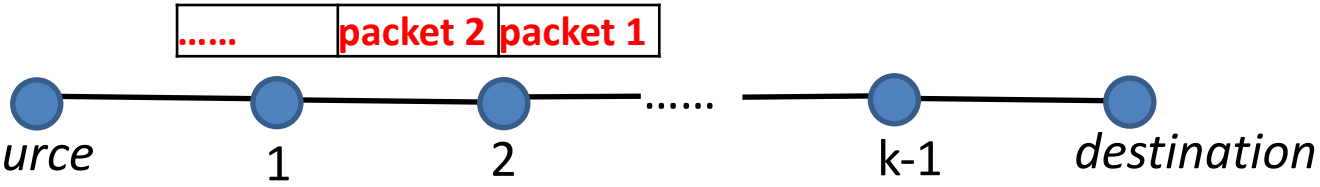
Question 5's Answer —— Slide 2:

With packet switching,

- After *p/b+d* time, the 1st packet is sent to the 1st hop.

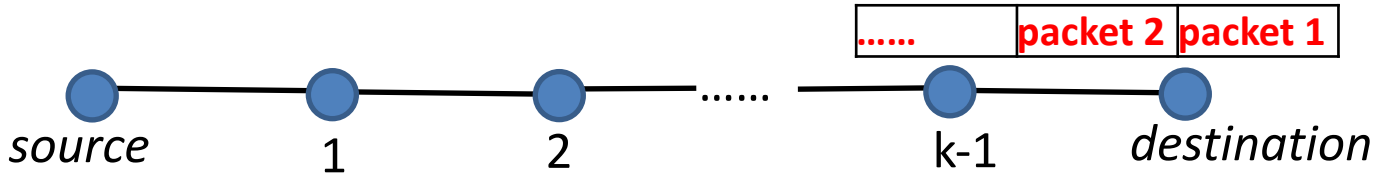


- After *p/b+d* more time, the 1st packet is sent to the 2nd hop.

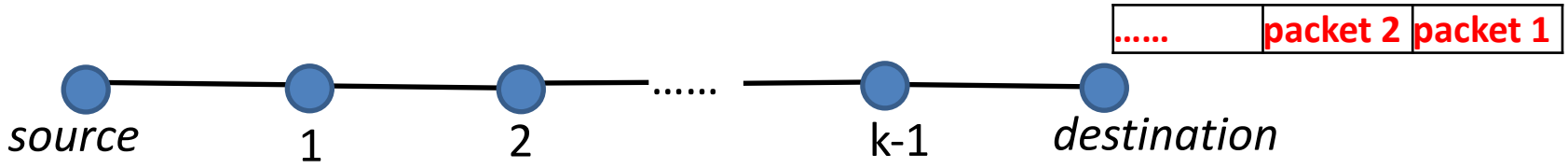


- ……

- Starting from the instant that the 1st packet is sent to the (k-1)th hop, after *p/b+d* more time, the 1st packet is sent to the kth hop (i.e., the destination).



- Starting from the instant that the 1st packet is sent to the destination, after (*x-p*)*/b* more time, the last packet is received by the destination.



- Total delay: k * (*p/b+d*) + (*x-p*)*/b* = *x/b* + (*k* − 1)*p/b* + *kd.*

Question 5's Answer —— Slide 3:

- With circuit switching, the total delay is $s + x/b + kd$.

- With packet switching, the total delay is $x/b + (k - 1)p/b + kd$.

- The total delay with packet switching is smaller if $x/b + (k - 1)p/b + kd < s + x/b + kd$;
  i.e., $(k - 1)p/b < s$.

In addition to the office hours listed in the previous slide, please feel free to contact Assistant Professor Jun ZHAO as follows to schedule appointments to ask questions. Thanks!

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