Chapter 1: Exercises

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EX1: Protocol design

- Design and describe an application-level protocol to be used between an automatic teller machine (ATM) and a bank’s centralized computer (BCC):
  - user’s card and password to be verified
  - the account balance (at BCC) to be queried
  - money disbursed to the user
  - handle all-too-common case in which there is not enough money in the account to cover the withdrawal
Step 1: Specification

- Specify the protocol by listing the msgs exchanged and the action taken by the ATM or the BCC on transmission and receipt of the msgs.

**Msgs from ATM (client) to BCC (server) and ATM actions**

- The user puts the card in the ATM machine.
- The card’s `<userid>` is transmitted to BCC.
- The user types PIN that is sent to BCC.
- The user requests balance.
- User asks to withdrawl money.
- User gets the money or error msg and leaves.

**Msgs from BCC to ATM machine and BCC actions**

- BCC checks the card.
- Asks user for PIN (password).
- BCC checks the PIN.
- PIN in ERROR or PIN OK.
- BCC checks the operation.
- operation in ERROR or operation OK.
- BCC sends the balance.
- User done, display welcome screen at ATM.
**Msgs from ATM machine to Server**

<table>
<thead>
<tr>
<th><strong>Msg name</strong></th>
<th><strong>purpose</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>HELO (&lt;userid&gt;)</td>
<td>Let BCC know there is the card user ID in the ATM</td>
</tr>
<tr>
<td>PASSWD (&lt;passwd&gt;)</td>
<td>User enters PIN, which is sent to server</td>
</tr>
<tr>
<td>BALANCE</td>
<td>User requests balance</td>
</tr>
<tr>
<td>WITHDRAWAL (&lt;amt&gt;)</td>
<td>User asks to withdrawl money</td>
</tr>
<tr>
<td>BYE</td>
<td>User all done</td>
</tr>
</tbody>
</table>
### Msgs from Server to ATM machine

<table>
<thead>
<tr>
<th>Msg name</th>
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</tr>
</thead>
<tbody>
<tr>
<td>PASSWD</td>
<td>Ask user for PIN (password)</td>
</tr>
<tr>
<td>OK</td>
<td>Last requested operation OK</td>
</tr>
<tr>
<td>ERR</td>
<td>Last requested operation in ERROR</td>
</tr>
<tr>
<td>AMOUNT &lt;amt&gt;</td>
<td>Sent in response to BALANCE request</td>
</tr>
<tr>
<td>BYE</td>
<td>User done, display welcome screen at ATM</td>
</tr>
</tbody>
</table>
Step2: Operation example

- Sketch the operation of the protocol for the case of a simple withdrawal with no errors, using a diagram with arrows
Correct operation

client

server

HELO <userid>
PASSWD
PASSWD <passwd>
OK
BALANCE
AMOUNT <amt>
WITHDRAWL <amt>
OK
BYE
BYE

check if valid userid
check password
password is OK
check if enough $ to cover withdrawal
ATM dispenses $
No enough money

client

server

check if valid userid
check password
password is OK
check if enough $ to cover withdrawal

error msg displayed
no $ given out

HELO <userid>
PASSWD
PASSWD <passwd>
OK
BALANCE
AMOUNT <amt>
WITHDRAWL <amt>
ERR
BYE
BYE
Step 3: underlying end-to-end transport service

- Explicitly state the assumptions made by the protocol about the underlying end-to-end transport service
  - **connection-oriented:** secure “connection” required between client (ATM), server (BCC)
  - **reliable transport:** data cannot be loss or received in wrong order
  - **flow control:** the total amount of data transferred is small
  - **congestion control:** this application cannot congest the network
  - **timing:** it is not really time sensitive
  - **minimum bandwidth guarantees:** the msgs sent are few and small
Ex2: packet vs circuit switching

Consider an application that transmits data at a steady rate (for example, the sender generates a N-bit unit of data every k time units, where k is small and fixed). Also, when such an application starts, it will stay on for a relatively long period of time. Answer the following questions, briefly justifying your answer:

a) Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?

b) Suppose that a packet-switching network is used and the only traffic in this network comes from such applications as described above. Furthermore, assume that the sum of the application data rates is less than the capacities of each and every link. Is some form of congestion control needed? Why?
Circuit switched network

- circuit-switched network:
  - the application involves long sessions with predictable smooth bandwidth requirements.
  - transmission rate is known and not bursty, bandwidth can be reserved for each application session circuit with no significant waste.
  - no overhead costs of setting up and tearing down a circuit connection (amortized over the length sessions).

- if packet-switched network:
  - no predictable delay
  - protocol overhead (information in the packet).
  - congestion and flow control needed
Packet switched network

- Large link capacities:
  - the network needs no congestion control mechanism.
  - Even if all the applications simultaneously transmit over the same link with bandwidth $L$, $L$ is sufficient to (greater than) handle the sum of all of the applications' data rates (very little queuing).
Ex3: Delay

Consider two hosts, Host A and B, connected by a single link of rate $R$ bps. Suppose that the two hosts are separated by $m$ meters, and suppose the propagation speed along the link is $s$ meters/sec. Host A is to send a packet of size $L$ bits to B.
Propagation and transmission delay

- Express the propagation delay, $d_{\text{prop}}$, in terms of $m$ and $s$.
  - $d_{\text{prop}} = \text{distance/speed} = \frac{m}{s} \text{ seconds}$.

- Determine the transmission time of the packets, $d_{\text{trans}}$, in terms of $L$ and $R$.
  - $d_{\text{trans}} = \text{packet-length/rate} = \frac{L}{R} \text{ seconds}$.

- Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.
  - $d_{\text{end-to-end}} = d_{\text{prop}} + d_{\text{trans}} = \frac{m}{s} + \frac{L}{R} \text{ seconds}$.
**Bits**

- Suppose Host A begins to transmit the packet at time $t_0 = 0$. At time $t = d_{\text{trans}}$, where is the last bit of the packet?
  - The bit is just leaving Host A.

- Suppose $d_{\text{prop}}$ is greater than $d_{\text{trans}}$. At time $t = d_{\text{trans}}$, where is the first bit of the packet?
  - The first bit is in the link and has not reached Host B.

- Suppose $d_{\text{prop}}$ is less than $d_{\text{trans}}$. At time $t = d_{\text{trans}}$, where is the first bit of the packet?
  - The first bit has reached Host B.
Numerical example

Suppose $s = 2.5 \times 10^8$, $L = 100$ bits, and $R = 28$ kbps. Find the distance $m$ so that $d_{\text{prop}}$ equals $d_{\text{trans}}$.

$m = \frac{L}{R} \times s = \frac{100}{(28 \times 10^8)}(2.5 \times 10^8) = 8.93 \text{ Km}$
Explain in few lines the following concepts (1):

1. functions of the physical layer
2. functions of the link layer
3. functions of the network layer
4. functions of the transport layer
5. circuit switching
6. packet switching
7. connection oriented communication
8. intermediate systems
9. switch
Explain in few lines the following concepts (1):

10. reliable transport
11. congestion avoidance
12. client-server computing
13. router
14. protocol
15. error recovery
16. flow control
17. PDU