Uppsala Universitet

Institutionen för Informationsteknologi

Datakom I, (1TT821,IDT014,1IT070)
13 oktober 2007: kl 9–14
Skrivsal 1, Gimogatan 4

INSTRUCTIONS TO CANDIDATES

- This is a FIVE (5) hour examination
- Answer all questions
- Questions can be answered in Swedish or English.
- Marks total 50.
- Grade ranges, 0–26 = U, 27–34 = 3, 35–42 = 4, 43–50 = 5

Section A : Overview and Applications

Question 1

Discuss how the protocol stack "encapsulates" the data in an application's PDU as it moves down the stack. Draw a picture to illustrate this, and explain what type of extra information is added at each of the underlying protocol levels.

[4]

SOLUTION

- *Relevant picture with appropriate labels 2pt*
- *Mentions IP addresses and ports for routing and application delivery 0.5pt each.*
- *Talks about interface addresses at the Link layer, or CRC 1pt.*

How is this extra information used by the protocols in the different stack layers in their communication? Discuss at each level of the stack.

[2]

SOLUTION

- *Reasonable and relevant discussion of what happens at each level 0.5pt each.*

Question 2

An application level protocol is being designed for a peer to peer overlay based distributed system to maintain consistency between copies of a distributed database. The operations that the peers want to propagate among themselves have the following types.

EXECUTE - Apply the enclosed SQL query to your version of the database.

ACK - An SQL query was successfully applied to the database by the peer.

ROUTES - Route advertisment. The peer/cost vector that the originating peer uses currently to forward transactions.

Not all peers are able to directly communicate with each other, so some peers act as relays, forwarding transactions that are not addressed to them to other peers. This means that the peers need to exchange information about their connections to other peers in order to be able to determine how to forward traffic for each other.

NOTE: You can assume that the SQL syntax used is the same for all participating systems and that all data is transfered reliably, so no transactions can be lost or corrupted in transmission.

Define a common header format for the PDU's to be used by the system. List the fields you think are necessary, and specify how they will be represented.

[4]

Specify how the data section of the packet will be formatted for each of the types of operation listed above (*EXECUTE, ACK, ROUTES*).

[3]

SOLUTION

- *The application protocol header fields needed are at a minimum*
  - *source and destination peer name/ID in the system.*
  - *type of packet, EXEC, ACK, ROUTE.*
  - *payload size.*
- *SQL transactions and ACKS need*
  - *query ID, or transaction ID.*
  - *query data string*

A "good" solution will show packet structure as a diagram or list of fields, and also define the data types and bit sizes for the fields and motivate the choice of data types in a short discussion.

Section B : Transport Layer

Question 3

Describe the process that TCP uses to set up a connection (the three way handshake). Draw a series of time line diagrams showing the packet exchanges used to establish a connection in the following cases.

- No data loss occurs
- The initial SYN packet requesting a connection is lost in transit, later the SYN/ACK packet from the responding machine is also lost.

[3]

SOLUTION

1pt for the no data loss example, and then 2pts for the diagram that should show timeouts and retransmissions resulting from the loss of both the SYN and SYN/ACK. The insight that we are looking for is that the initiator of the connection is the one that times out in both cases.

Question 4

TCP is a complex protocol which provides reliable end to end transport of data to applications. In addition TCP has features that adjust the flow of data. Describe the main features of TCP connection management. In particular describe how the end-points of a TCP connection negotiate the size of the flow window, and what indicators TCP uses when adjusting the congestion window.

[4]

SOLUTION

Main features we expect them to mention are three way handshake for setup, reliable byte stream abstraction, congestion and flow control to react to network load fluctuation and rate management between the endpoints. 1pt

Transmission window $= min(ConWin, FlowWin)$

Congestion window is set in two phases, the startup phase uses one of Direct Start or Slow Start to send data initially. Slow Start extends the window exponentially from 1 MTU until a threshold and then we use linear increase, multiplicative decrease to manage the size in steady state. An annotated diagram is the easiest way to answer the question. 2pts

Flow window uses end to end signalling based on ACKS of received byte sequences in the byte stream to move the window and allow permit more data to be sent. This is subject to capacity in the network or course, see the overall TransWin equation above. 1pt

Explain (with the help of a diagram) the operation of sliding window protocol using selective retransmit.

[3]

SOLUTION

The diagram should show the window area and data that is recieved, not yet transmitted and in transit. The diagram should also show a situation where part of the window has been received but advancing the window is not possible due to missing segments. The description should explain that some non-ack'ed segments need to be transmitted before the window can be moved. Ideally the solution will demonstrate how the window moves when a critical segment is finally received and the window can hop forward quite a distance.

Question 5

Discuss the difference between datagram and circuit switched traffic in communication networks. What are the advantages and disadvantages with each of these approaches to data delivery?

[4]

SOLUTION

Datagram assumes little state in the network and forwards traffic based on local topological information in the nodes. Circuit switching requires connection setup, which also implies increased signaling and state information in the network related to the circuits that are established there. 2pts for this type of basic understanding.

The remaining 2pts are for advantages and disadvantages of each of the approaches. Here we can give 0.5pts for each sensible contribution, this means that we expect at least 1 sensible point for and against each strategy. We should be able to give full marks on this question fairly easily.

Section C : Network Layer

Question 6

Provide a high level overview of the operation of distance vector and link state methods for compiling routing tables from topological information abotu the network. Give details of what types of information are exchanged in each case and how this information is processed in order to generate a routing table.

[4]

SOLUTION

We expect something like

Distance Vector compiles routing tables based on destination/cost vectors received by each node from its immediate neighbours. The algorithm is decentralised and local, it relies only on local information. For each destination in the network each node determines a minimum cost path using min(cost to neighbour + neighbour advertised cost to destination).

Link State collects immediate neighbour information for all nodes in the graph. We need to have complete global information first, we then run dijkstra's algorithm to determine the graph structure and derive routing tables. This algorithm is decentralised, but requires global knowledge and communication to fully converge. Message loss when broadcasting neighbour information may cause problems.

Question 7

What is meant by the "count-to-infinity problem"? Explain how this problem can arise in a network which uses distance vector routing.

[3]

Question 8

IPv4 addresses have a format X.X.X.X, explain the idea of longest prefix routing using IP addresses. For a network with a 16 bit prefix write down the appropriate mask with which to obtain the network number in X.X.X.X format.

[1]

Suppose we have a network with prefix 163.121.0.0. Propose a scheme for allocating the available host addresses in this prefix range to three subnetworks connected via a single accesss router. The networks should be able to host 900 interfaces, 105 interfaces and 3000 interfaces respectively.

[6]

SOLUTION

So the networks need

Net 1: 7 bits host address = 128
Net 2: 10 bits host address = 1024
Net 3: 12 bits host address = 4096

This gives us the 4 high order bits in the lower order 2 bytes for network address for the largest network. Assuming that the addresses don't need to overlap in range we can allocate addresses to networks as follows.

The high order 16 bits are the highest order prefix.

Net 1 can have a max prefix of 25 bits
Net 2 can have a max prefix of 22 bits
Net 3 can have a max prefix of 20 bits

This gives a huge number of alternatives when it comes to allocating network numbers and will mean that this question can be slow to grade.

Section D : Link and Physical Layer

Question 9

Describe how an Ethernet hub and bridge are different. Discuss the advantages of using bridges vs hubs when constructing large Ethernets.

[3]

SOLUTION

The aim here is to get people to recall that a bridge separates traffic, thus the broadcast collision domain is reduced in comparison to using hubs.

There are also security advantages if we want to separate traffic from one network from another.

For one or other of these points above 2pts, then the extra point for if you made both observations.

Question 10

At the link layer we transmit data between two hosts as *frames*. Why is data framing needed at the link layer?

[2]

SOLUTION

We need to be able to divide the data into chunks so that we can check for bit errors in transmission using CRC and or forward error correction techniques. We also need to be able to resynchronise when a bit is lost in signaling.

What features are often provided by link layer services to deal with issues that arise in 1-hop data transmission?

SOLUTION

1pt each for up to two of the following

- *bit error detection via CRC*
- *IP to interface hardware address resolution*
- *media access control in broadcast media such as ethernet*
- *sliding window for flow control to manage buffering over a single hop.*
- *bit or byte stuffing to prevent end-of-frame from appearing in the data stream.*

[2]

Question 11

Optical fiber has replaced copper as a main trunk technology for communications systems. List some advantages with optical fibre compared to its predecessor copper twisted pair cabling.

[2]