University of Uppsala

Department of Computer Systems (DoCS)

Final Examination

IT3 (Datorsystem II : Networks)

Data Communication and Networks

INSTRUCTIONS TO CANDIDATES

- This is a FIVE (5) hour examination
- Answer all questions
- All questions to be answered in English
- Dictionaries are Permitted
- Marks total 180
- This exam contributes 85/100 points to the final mark in this subject.

A: (Short Answer Questions)

Question 1

Name two well known data transport protocols provided by the Internet Transport Layer.

Provide a brief description of each service and indicate what type of application might use that service.

[8]

SOLUTION

TCP and UDP.

TCP is a connection oriented data service that provides a reliable loss free end to end connection. Peer to peer communication between applications is often managed using TCP.

[4]

UDP is an unreliable datagram service which provides end to end packet delivery without recovery and retransmission for applications that might wish to implement their own packet management and error recovery protocols such as streaming applications and NFS. UDP is also often used in Client/Server applications where no special packet handling is required.

[4]

Question 2

Describe the "token bucket" mechanism for congestion control.

With which other technique is token bucket usually combined to achieve complete flow control?

What problems in the simpler approach are addressed by using a "token bucket" mechanism?

[9]

SOLUTION

The token bucket approach to congestion tries to limit the impact of bursts of network packets on routers along the path, while retaining some flexibility in terms of allowing a brief increase in traffic in response to sudden demands/bursts.

The answer should include a picture indicating the burst response pattern that results from the use of token bucket, and show how that feeds into a leaky bucket in order to eliminate packet loss from the leaky bucket and provide overall loss free rate/flow control.

[4]

Token bucket is combined with leaky bucket, which buffers incomming packets and emits them in a constant rate stream.

[1]

The advantage of the combination is that token bucket provides some flexibility in responding to sudden requests for high traffic volume allowing an intial burst of traffic to saturate the link, and then enforcing a constant bandwidth utilisation after the initial free token pool has been exhausted.

[4]

Question 3

For three marks each define the following general terms used when discussing protocols.

Peers

IDU

SDU

PDU

[12]

SOLUTION

Peers - *active elements of a protocol (processes) at the same protocol stack layer level on different hosts.*

IDU - *Interface Data Unit, data to be passed accross an access point. Generally SDU plus control information.*

SDU - *Service Data Unit, data/information to be sent to a peer process.*

PDU - *Protocol Data Unit, packet data to be transmitted. May be a part of an SDU with a header. N-PDU's are the packet format exchanged between peers at layer N of the protocol stack.*

Question 4

Give a definition of a **Service** and a **Protocol**. Use these definitions or any other discussion to illustrate the fundamental difference between a **Service** and a **Protocol**.

[10]

SOLUTION

Defn: A service is an operation or facility provided by protocol layer N to the layer N+1 above it.

[3]

Defn: A protocol is an algorithm operating at protocol layer N that uses services provided by layer N-1 to implement a style of communication.

[3]

A service is a facility that can be used, such as **SendAPacket***. A protocol uses a number of services to manage the exchange of data. Thus a protocol may be compared to an algorithm, and the services to the instructions which are used to express that algorithm.*

[4]

Question 5

Give an overview of the distance vector method of updating routing table information. In particular, explain using an example how information about a node failure propagates using this algorithm.

What problem is encountered in deciding whether a host has become unreachable?

In what circumstances is it impossible to resolve this problem?

[16]

SOLUTION

Distance vector routing uses a distance metric, (round trip time, physical distance, number of network hops) to select the best current path to each reachable destination in the network.

To compute its routing table a host computes the value of the chosen metric with respect to all its neighbours, and also obtains the routing vectors of all its neightbours. It then computes the distance metric to a destination A for each (neighbour, destination) pair. The host then chooses the neighbour with the minimum distance value to be used to forward messages to the destination A. This process is repeated for all destinations in the network.

[8]

When a host fails in the network this information propagates very slowly, since each host updates its vector to be the minimum of its neighbours vector entries plus its delay to that neighbour. How do we decide that the delay vector entry has become high enough to register the host as unreachable? This is called the count to infinity problem.

[4]

The problem can be resolved if the distance metric is related to the number of hops to the destination. Then we can set infinity to be network diameter plus 1. If the metric is time based we need an estimate of the maximum acceptable delay. In this case it is possible that congestion will cause some hosts to be marked as unreachable from time to time. However, since host recovery propagates quite quickly this may not be a problem at least in relatively small networks.

[4]

Question 6

Provide the formal definition of a Petri-Net and describe each of the variables/operators in the 5 entries in the 5-tuple.

[8]

SOLUTION

The formal definition of a Petri-Net C is a 5-tuple as follows.

$$C = (P, T, I, O, \mu) \qquad [1]$$

[1]	P	*The set of places in the net*
[1]	T	*The set of transitions in the net*
[2]	I	*The input mapping function, applied to a transition generates the set of input places to that transition.*
[2]	O	*The output mapping function, applied to a transition generates the set of output places to that transition.*
[1]	μ	*The initial marking, which describes the initial location of tokens.*

Question 7

Discuss the use of formal analysis techniques for protocols. Comment on why such techniques are used in analysing protocols, and give some examples of the types of problems that such an analysis can reveal.

[6]

SOLUTION

Formal analysis of protocols is an important part of establishing confidence in the correctness of proposed communications products. Formal analysis tools such as petri nets and finite state machines represent the logical structure of the protocol and allow designers to investigate the operation of the protocol in all possible situations.

State space expansion can identify failure modes, and deadlock situations that can arise if certain sequences of events occur. In addition, such analysis can reveal redundant states and thus be used to optimise the protocol. Safety properties can also be proposed and verified.

The use of some specification tools can assist in automatic verification using computer analysis which eliminates the possibility of human error, an important factor in many proof techniques.

Question 8

It has been claimed that state machines are a natural tool for protocol analysis since protocol implementations can be derived directly from the state transition tables. Discuss this assertion and argue for or against the implementation of protocols using this approach.

[8]

SOLUTION

Since state/transition diagrams are directly related to table driven programming it can be argued that the type of specification and implementation flow directly from one another.

By deriving the implementation directly from the specification with little need for interpretation the possibility of erroneous implementations is decreased.

In addition it has been argued by Tannenbaum and others that state transition based programming is the natural way to implement protocols, and to visualise their operation. Thus the choice of state machines for the analysis and validation of protocols is both natural and effective. Especially since tools are available that are capable of generating implementation code directly from the specification.

Question 9

Define the role of a **firewall** and draw a diagram that shows where a firewall should be positioned with relation to protecting a local network. In defining the role of a firewall, you should discuss the techniques that a firewall uses at different levels to prevent external attacks on the network and control traffic flow through the firewall.

[6]

SOLUTION

The solution will show a local area network structure and the firewall as the single interface point or gateway to the outside world.

[2]

The characterisation of firewall activity will probably touch on a majority of the following points.

- *denying connection requests to known ports, such as ftp, sendmail on hosts within the local network.*
- *packet filtering based on keywords or encryption status.*
- *suspicious packet traffic patterns that represent denial of service or packet spoofing attacks on local hosts from external IP addresses.*
- *an exceptional answer might note that wireless networking often bypasses firewalls and represents a possible security hole.*

[4]

Question 10

Explain, using an example, how bit stuffing is used to preserve frame boundaries when transmitting binary data at the Data Link level of the protocol stack.

[8]

SOLUTION

Suppose we choose the bit pattern 01111110 to represent the frame boundary in a bit stream that we are transmitting. To prevent the occurence of this bit pattern in the payload (and thus incorrect identification of a frame boundary by the receiver we will modify the payload by inserting a 0 bit into the stream after every consecutive five 1 bits seen in the payload.

Unstuffing at the receiving end will remove these zero bits and restore the format of the original frame payload.

[4]

As an example consider the following payload bit stream.

00**1111111101111110**1111010001110011010

The transmitted stream would be

00**111110111011111010**1111010001110011010

preventing incorrect identification of a frame boundary in the highlighted section of the bit stream.

B: (Topic Questions)

Question 11

Describe the OSI seven layer model. Name each of the layers in the model and draw a diagram that shows the ordering of these layers. Write a paragraph describing the areas of function that each layer is responsible for.

Contrast the OSI model you have just described with the TCP/IP reference model. Using a diagram show the correspondence between relevant protocol layers in the two models.

Discuss the relative merits of each of these models in the context of modern computer networking.

[30]

SOLUTION

Presentation of the OSI diagram and list of the functions carried out in each layer.

[10]

The contrast with the TCP/IP model should note the corespondence between the OSI and TCP layers at the Network and Transport level. The discussion will also indicate that the Host_to_Network layer of TCP/IP corresponds pretty well to the Data Link and Physical layers of the OSI model. Session and Presentation layers are not present in TCP/IP, and really are not needed as has been shown by experience over the last few years.

[8]

A discussion of the merits of TCP/IP vs OSI as a reference model for networking. In terms of discussing relative merits students should touch on the following key ideas.

- *Political influence on the OSI model, thus the OSI protocol stack represents a design philosophy created by committee*
- *OSI failed to gain wide acceptance in the industry and consequently is largely of academic interest.*
- *OSI provides a much better model of layering and clearly defines and separates protocols, interfaces and services. This allows for greater flexibility and allows the layers to be viewed and implemented independently of each other.*
- *TCP/IP describes a protocol, it is not really a standard.*
- *TCP/IP is in very wide use and is well understood.*
- *TCP/IP has proven very robust and well engineered.*

[12]

Question 12

Discuss the hierarchy and addressing issues surrounding the construction of large networks.

[10]

Comment on the current status of IPv4 in this context. Identify the major emerging problems for IPv4 and discuss how they are addressed in IPv6.

[20]

SOLUTION

A good solution to this question should discuss the problems associated with flat address structures in large networks.

In particular the following points:-

- *length of addresses*
- *size of routing tables as a function of number of hosts.*
- *the concept of routing between network clusters on a backbone, and then routing within the destination cluster, so called "hierarchical routing".*

In the context of IPv4 the discussion will center on the issues surrounding the packet header fields, and the current IP address space.

Use of class B networks for small numbers of hosts and the resulting waste in the address space should be discussed, and the the use of CIDR to resolve some of these problems in the near future should be described.

Consideration of IPv6 should touch on the arguments associated with selecting the new address format, and the elimination of the checksum field and other changes to the packet header.

Question 13

Describe the physical construction characteristics of the following transmission media. If there is more than one type of each media then present the choices of type, and identify the differences between them.

- Twisted pair
- Coaxial cable
- Optical fibre cable

[9]

Possible choices for data communication infrastructure for long distance data transfer include microwave, optical fibre and radio transmission.

Discuss the advantages and disadvantages of each of these media, in terms of cost, political impact, ease of installation and adaptability in providing a range of services to clients.

[15]

What problem with data transmission in broadband coaxial cable networks is addressed using frequency splitting? Name two types of frequency splitting strategy, and identify how they are different.

[6]

SOLUTION

The discussion of communication media types should be structured similarly to the following.

- *Twisted pair is the common telecommunications wiring standard for office and domestic buildings throughout the 1970's and 1980's. In the late 1980's UTP, (Uninsulated Twisted Pair)*