Dept. Computer Science **Computer Networks**
Vrije Universiteit **27.08.2004**

Always explain your answers concisely and be sure to be to-the-point.

1a There is one feature that truly distinguishes a home network from an office network. What is it? *5pt*

A home network cannot rely on a network administrator. Therefore, it has to be fully self-organizing and self-managing.

1b "In a connection-oriented service, packets follow the same route." Is this statement correct? Explain your answer. *5pt*

The statement is false: a service specifies nothing about the routing of packets, which is an implementation issue. The canonical example is TCP, which is implemented on top of IP.

2a What is the purpose of modulation, and which three forms are commonly applied? *5pt*

The purpose of modulation is to circumvent the problems of sending a digital signal through a medium. Doing so, may cause the signal to be so heavily corrupted that its correct detection becomes impossible. Instead, analog signals are used to encode bits, and in this way bits can be transmitted. The three types of modulation are: amplitude, frequency, and phase modulation.

2b Explain the difference between frequency-division multiplexing and time-division multiplexing. *5pt*

See book.

3 The reliability of a channel can be increased by applying error-correcting codes. The price to pay for this increased reliability is lower effective bandwidth. Explain this trade off. *5pt*

Error-correcting codes require that more bits are added to each frame in comparison to error-detecting codes. In other words, the ratio between data bits and redundant bits decreases, and thus also the effective bandwidth of a channel.

4a Ethernet follows a CSMA/CD protocol scheme. Explain how this scheme works. *5pt*

CSMA/CD stands for Carrier Sense Multiple Access with Collision Detection. This means that when a node wants to transmit data, it (1) senses the carrier until no transmissions are detected, (2) starts transmission, and (3) continues to check for a collision. If a collision happens, the node stops and waits a random period before starting with step (1) again.

4b How big should the contention period be in a CSMA/CD protocol? *5pt*

The problem that needs to be solved is that a node that started transmission, continues to transmit bits long enough to be able to detect that another node concurrently started a transmission. If τ *is the time it takes for a signal to reach the farthest node in a CSMA/CD network, the contention period should be equal to* 2τ*. Assume A starts transmission at* T_0*. In the worst case, the farthest station begins its transmission just before* $T_0 + \tau$*, which then requires* τ *time units to reach A. As a consequence, only after* 2τ *time units A will detect that some other node started as well.*

4c A 10 Mbps Ethernet segment can be as long as 2500 meters. If frame specifications stay the same, how does an increase in supported bandwidth affect the segment length? *5pt*

The problem is the minimum frame length in relation to the contention period. By increasing the bandwidth support, it takes less time to transmit a 64-byte frame, while the contention period should remain the same. Because the bit propagation time stays the same, the maximum segment size has to drop.

4d The Ethernet specifications are fundamentally unsuited for wireless networks unless it is assumed that all stations are always in each other's range. Explain why. *Hint: think of the way frame collisions are detected in Ethernet.* *5pt*

The problem lies in the fact that Ethernet assumes that any sender can detect a collision caused by any other transmitter. In wireless networks, this need not be the case, unless it is assumed that all stations are in each other's range. If we drop the latter assumption, a sender A may not be able to detect a collision at the receiver by a competing station B, because A is out of B's range.

5a What is an Autonomous System (AS)? *5pt*

An AS is a network that falls under the regime of a single organization and generally runs a single routing protocol.

5b Explain what an exterior gateway routing protocol is, and give an example of such a protocol. *5pt*

BGP is such a protocol. These routing protocols are designed to handle the routing of packets between different autonomous systems, and as such are often manually configured to avoid that packets from source A pass through the networks of organization/country B.

5c Explain what a peer-to-peer overlay network is. *5pt*

Such a network consists of a collection of hosts. Each host has a (limited) list of other hosts called its neighbors. Routing messages is done through routes only between the hosts that part of the overlay network. Any actually routing through lower-level networks is not taken into account. Examples of such networks are special classes of VPNs and structured P2P systems.

5d Consider an IPv6 packet that is being sent from *A* to *B*, but which can reach *B* only by traversing an intermediate network that supports only IPv4. How can this problem be solved? *5pt*

The answer is actually quite simple: when reaching a gateway of the intermediate network, the packet is put into an IPv4 packet and tunneled *to a gateway en route to B. At that point, the original IPv6 packet is removed and sent towards B. Note that in the case of fragmentation (by IPv4), all fragments need to be sent to the outgoing gateway of the intermediate network. On the other hand, IPv6 can tell the sender to pass only small packets.*

6a Below is an excerpt from a DNS response. Explain which DNS query was submitted, and what the returned answer was. *5pt*

```
; <<>> DiG 9.2.1 <<>> mx vu.nl
;; global options:  printcmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 26939
;; flags: qr rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 4, ADDITIONAL: 3

;; QUESTION SECTION:
;vu.nl.                         IN      MX

;; ANSWER SECTION:
vu.nl.                  60      IN      MX      20 mail.it.vu.nl.
vu.nl.                  60      IN      MX      10 mail.vu.nl.

;; AUTHORITY SECTION:
vu.nl.                  86400   IN      NS      star.cs.vu.nl.
vu.nl.                  86400   IN      NS      ns.vu.nl.
vu.nl.                  86400   IN      NS      ns1.surfnet.nl.
vu.nl.                  86400   IN      NS      ns2.vu.nl.

;; ADDITIONAL SECTION:
mail.vu.nl.             86400   IN      A       130.37.129.161
mail.it.vu.nl.          56003   IN      A       130.37.129.165
ns2.vu.nl.              86400   IN      A       130.37.129.5

;; Query time: 85 msec
;; SERVER: 192.168.1.6#53(192.168.1.6)
;; WHEN: Mon Aug 16 12:41:12 2004
;; MSG SIZE  rcvd: 199
```

The DNS query concerned the host name of the mailer for domain vu.nl. There are two mailers: mail.vu.nl with address 130.37.129.161, and a lower priority mailer mail.it.vu.nl with address 130.37.129.161.

6b DNS root servers do not support recursive queries. Why not? *5pt*

Root servers are busy enough. If they are also required to forward queries for further resolution, and to later process a complete answer, they may indeed become a true bottleneck.

7a Explain how mutual authentication with public/private key pairs works. *5pt*

See book.

7b Explain the Diffie-Hellman key exchange protocol. *5pt*

See book.

7c Construct a certificate issued by an authority *CA*, telling that E_A is the public key of *A*. Explain the content of your certificate. *5pt*

So many people got this wrong the last time. Have a look at this: $[E_A, A, CA, K_{CA}(E_A, A)]$*, where* K_{CA} *is the private key of CA.*

Grading: *The final grade is calculated by accumulating the scores per question (maximum: 90 points), and adding 10 bonus points. The maximum total is therefore 100 points.*