DELFT UNIVERSITY OF TECHNOLOGY
Faculty of Electrical Engineering, Mathematics and Computer Science

Exam CS4055 – High-Performance Data Networking (Lecturer: Prof. dr. ir. Fernando Kuipers)
09:00 – 12:00, January 27, 2023

Material: CS4055 slides & reader. During the examination, the use of slides, books, readers, lecture notes, etc., is not allowed. The use of a calculator is also not permitted.

Structure: This exam consists of two parts: (1) 20 multiple-choice questions (each worth 0.3 point) and (2) 5 open questions. The points for the open (sub)questions are listed next to the question.

Part 1 – Multiple choice questions

Answers: Give your answers in the table below (and add your name). Only one answer per question.

Student name:			
Student number:			
1	6	11	16
2	7	12	17
3	8	13	18
4	9	14	19
5	10	15	20

1) BGP chooses the best path to a destination based on:
a. Number of hops
b. Delay
c. Policies
d. Geographical distance

2) Which of the following is not a goal of QUIC:
a. Easier connection migration
b. Better congestion control
c. Multiplexing without head-of-line blocking
d. Faster handshake process

3) Which statement about BBR is true?
a. BBR attempts to react faster to packet loss than Reno or Cubic
b. BBR attempts to achieve fairness among flows by using an AIMD scheme
c. BBR attempts to measure the RTT by regularly raising its sending rate
d. BBR attempts to keep 1 Bandwidth-Delay Product of data inflight

4) How many packets does CoDel drop at the end of an interval?
a. Either 0 or 1
b. Exactly 1
c. At least 1
d. As many packets as the minimum sojourn time in milliseconds

5) In Software-Defined Networking (SDN), which part of the network is programmable?
a. Switches
b. Controller
c. Hosts
d. All of the above

6) An OpenFlow PacketOut message:
a. Installs or removes new forwarding rules on a switch
b. Forwards an unmatched packet from a switch to the controller
c. Instructs a switch to drop a packet
d. None of the above

7) In NFV, network functions are run on:
a. Specialized hardware
b. Commodity servers
c. Traditional switches and routers
d. End-host devices

8) What is Bandhari's algorithm used for?
a. Finding disjoint paths
b. Finding multi-constrained paths
c. Finding critical regions
d. Finding positions for emergency nodes

9) What is the Average Two-Terminal Reliability (ATTR)?
a. The number of links that would cause a graph to become disconnected when removed / total number of links in the graph
b. The number of connected node pairs in a graph / total number of node pairs in the graph
c. The average number of links between any two nodes within a network
d. The average number of disjoint links between two leaf nodes of a graph

10) Which of the following protocols and techniques cannot be used to implement Multicast?
a. IGMP
b. ICMP
c. SDN
d. None of them can be used

11) Which of the following is not a goal of content-centric networking?
a. Reduced latency
b. Encryption of Data packets
c. Encryption of Interest packets
d. In-network content caching

12) Who initiates the reservation process in RSVP?
a. A sender
b. A token bucket
c. A controller
d. A receiver

13) What is the job of a router inside a DiffServ domain (i.e., an interior router)?
a. Classify packets, set DSCP, and forward
b. Shape and limit traffic
c. Reset the DSCP and forward
d. Classify packets and forward

14) Following the SAMCRA algorithm, you want to find a path from node 0 to some destination node. You have computed the lower bound and start to analyze the four neighbors of node 0. There are three constraints: (50, 40, 25). The weights of the paths to the neighboring nodes of 0 and the lower bounds computed for these nodes are:
Neighbor 1: path weights: 1, 2, 3. Lower bounds: [4, 8, 2]
Neighbor 2: path weights: 4, 1, 2. Lower bounds: [11, 7, 3]
Neighbor 3: path weights: 3, 2, 1. Lower bounds: [7, 4, 3]
Neighbor 4: path weights: 2, 1, 4. Lower bounds: [8, 5, 6]
Which node will the SAMCRA algorithm analyze in the next step?
a. Neighbor 1
b. Neighbor 2
c. Neighbor 3
d. Neighbor 4

15) Which of these features does the P4 language support?
a. "for" loops
b. Vector instructions
c. Custom type declarations
d. Multiplication and division

16) If you want to use P4 to add a custom header to a packet, which part of your P4 program would be responsible for adding the header to the packet?
a. Parser
b. Ingress control block
c. Egress control block
d. Deparser

17) Which of the following is true?
a. 4G has the concept of network slicing but 5G does not
b. 5G has the concept of network slicing as well as 4G
c. 5G has the concept of network slicing but 4G does not
d. Both 4G and 5G do not have the concept of network slicing

18) What is the network slice requirement for an eMBB slice?
a. Delay tolerance
b. High data rates
c. High reliability
d. High connection density

19) What is not a tier of RAN Disaggregation?
a. CU-DU-RU disaggregation
b. CUPS of CU
c. CUPS of DU
d. Software Defined RAN Control

20) In tier 2 disaggregation, what part of the cellular stack does the CU-C contain?
a. RRC
b. RLC
c. MAC
d. PHY

[*Part 2 of the questions on the following page*]

Part 2 – Open questions (Write your answers clearly in the boxes)

21) Imagine you want to emulate an SDN using Mininet, Ryu, and OpenFlow. You have written two scripts:
`my_ryu_app.py`: a Ryu controller application that uses OpenFlow 1.3.
`my_topology.py`: a mininet topology file that contains a topology class MyTopo that is mapped to the name 'mytopo'.
You try to start up your SDN using the following two commands in separate windows:

```
$ PYTHONPATH=. ./bin/ryu-manager my_ryu_app.py --ofp-tcp-listen-port 1337
$ sudo mn --topo my_topology.py --controller=remote --switch
ovs,protocols=OpenFlow3 --observe-links
```

Assume that your environment is set up correctly and the paths to executables and script are correct. There are four issues with these commands. Explain each one. [1pt]

22) In an SDN that uses OpenFlow, you try to ping one host from another. No flow entries have been installed thus far. Your controller triggers three PacketIn events, for which it logs the Ethernet source address (eth_src) and the Ethernet destination address (eth_dst):
(1) `PacketIn: eth_src=12:23:34:45:56:67 eth_dst=ff:ff:ff:ff:ff:ff`
(2) `PacketIn: eth_src=98:de:ad:be:ef:87 eth_dst=12:23:34:45:56:67`
(3) `PacketIn: eth_src=12:23:34:45:56:67 eth_dst=98:de:ad:be:ef:87`
a. Explain what packets these messages correspond to. [0.5pt]
b. In this scenario, there is a fourth packet, but it triggers no PacketIn event at the controller. Why? [0.5pt]

23) An OpenFlow controller (app) installed the following flow entry on switch s3:

```
cookie=0x0, duration=345.733s, table=0, n_packets=71434, n_bytes=97007372,
priority=2,ip,nw_dst=224.0.0.14 actions=group:1
```

And the following group entry on the same switch:

```
OFPST_GROUP_DESC reply (OF1.3) (xid=0x2): group_id=1, type=all,
bucket=actions=output:"s3-eth1", bucket=actions=output:"s3-eth2"
```

a. What do this flow entry and this group entry do? [0.5pt]

b. What would change in the behavior of this switch if port s3-eth2 goes down? Would packets still arrive at their destination? [0.5pt]

24) Write the egress processing logic of a P4 program that marks packets with explicit congestion notification (ECN). Your program has defined an IPv4 header that contains an ECN field, uses the v1model, and the ECN threshold is 50. (For the 2-bit ECN field, 00 means ECN is not supported, 01 and 10 stand for ECN support and 11 means congestion experienced.) [1pt]

```
control MyEgress(inout headers hdr,
      inout metadata meta,
      inout standard_metadata_t standard_metadata) {
```

```
}
```

End of examination – Please return the exam + answers