UNIVERSITY
OF SKÖVDE

School of Information Technology

WRITTEN EXAMINATION

Course Distributed Systems G1F

Sub-course

Course code IT413G

Credits for written examination: 4 HP

Date 2023-10-25

Examination time 14.15-19.30

Examination responsible Erik Billing
Examiner Simon Butler

Aid at the exam/appendices Swedish-English / English-Swedish dictionary

Other

Enter answers directly in the exam, where applicable.
Enter your name and number on every page of the exam.
Use clear handwriting, unreadable answers will be ignored.

Instructions

- ☒ Take a new sheet of paper when starting a new question.
- ☒ Write only on one side of the paper.
- ☒ Write your name and personal ID No. on all pages you hand in.
- ☒ Use page numbering.
- ☒ Don´t use a red pen.
- ☒ Mark answered questions with a cross on the cover sheet.

Examination results will be made public within 18 working days

Good luck!

Total number of pages: 12

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Note:

The examination includes multiple selection and multiple-choice questions. You can choose only one correct option for multiple-choice questions, which use circle icons. To pass a multiple-choice question, you should have selected only one correct option. For multiple selection questions, which use square icons, you may select several options. To pass a multiple-selection question, you must select all correct options, and you should not have selected any wrong options. Enter your answers to multiple choice/selection questions directly into the exam paper. Answers given otherwise do not count. Select an option by drawing a cross in the box/circle. If you change your mind, fill-in the whole box/circle, as illustrated below.

Properly completed multiple-**selection** responses:		Properly completed multiple-**choice** responses:	
Amended multiple-**selection** response:		Amended multiple-**choice** response:	

Rating:

- The maximum number of points is indicated to the right of each question. Note that most questions have sub-questions (a, b, c, ...) and the indicated points refer to the total maximum score for that question, given perfect answers to all sub-questions.

    - Multiple choice questions are awarded with full points for a correct answer or zero points otherwise.
    - Unless otherwise specified, multiple selection questions are awarded with 1 point for each correct selection and -1 point for each incorrect selection. The maximum number of points may be higher than the number of correct selections and is awarded to completely correct answers. There are no multiple selection questions will zero correct options. The total score cannot be less than zero.
    - Questions where you are asked to match items in two lists are awarded with 1p for each correct match. The maximum number of points may be higher than the number of correct matches and is awarded to completely correct answers.

- The total number of points on the exam is 90. After assessment, the points will be translated to a grade as follows: 81→A, 72→B, 63→C, 54→D, 45→E.
- The above grade is awarded for the course under the assumption that you have passed the Laboratory and Project assignments of the course.

Name: _____ Personnummer: _____

QUESTION 1 – Distributed vs centralized systems

6 p

List three characteristics of distributed systems and describe briefly how each characteristic differ from a typical centralized system.

Name: _____ Personnummer: _____

QUESTION 2 – Security

9 p

Five security services that can be implemented using encryption have been discussed in the course: non-repudiation, confidentiality, authentication, authorization and integrity.

Alice sends a message (m) to Bob in plaintext that she has signed with her digital signature. Assume that Bob has a copy of a security certificate from a trustworthy source, such as a certificate authority, that confirms Alice's identity. Alice has a public key K^{+}_{A} and a private key K^{-}_{A}.

a) Explain the operations Alice uses to create a digital signature for the message m?

b) Which security services does Alice implement by creating a digital signature?

c) Explain the operations (or steps) that Bob needs to perform to confirm the message m and Alice's digital signature?

Name: _____ Personnummer: _____

QUESTION 3 – Cloud services

9 p

There is a privacy awareness campaign that uses the slogan: "There is no cloud, just other people's computers". This is largely true for private Internet users using SaaS. Business users have greater choice about the extent to which they use public cloud services and the type of service (IaaS, PaaS and SaaS) used. Motivate, with examples, a company's reasons for choosing to use:

a) public cloud services;

b) a private cloud service; and

c) a hybrid cloud.

Name: _____ Personnummer: _____

QUESTION 4 – Elasticity in cloud computing

7 p

One property of cloud computing is "elasticity", meaning that customers are able to access and purchase cloud computing resources when needed.

a) From the perspective of a cloud computing provider, describe the challenges and implications of providing 'on demand' or elastic computing services.

b) Describe briefly how your answer to (a) relates to Goal 7.3 of the UN 2030 Sustainable Development Goals, which states "By 2030, double the global rate of improvement in energy efficiency".

Name: _____ Personnummer: _____

QUESTION 5 – Networking

10 p

Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP) are application layer protocols that both use the Internet Protocol (IP) in the transport layer, which is responsible for end-to-end transmission of packets.

a) Describe the characteristics of TCP and UDP.

b) HTTPS is usually implemented using TCP and voice over IP (VoIP) uses UDP. Explain at least one consequence each of implementing HTTPS using UDP and VoIP using TCP.

Name: _____ Personnummer: _____

QUESTION 6 – Replication

10 p

a) Describe the *generic replication scheme* so that it is clear what components it comprise, how they relate, and how coordination and agreement are solved. *You are encouraged to visualize your answer with a drawing.*

b) Four different motivations for using replication have been discussed in the course. Select two motivations and describe in detail, with examples, how replication is used with each selected motivation.

Name: _____ Personnummer: _____

QUESTION 7 – Logical clocks

6 p

Assume you have two processes P1 and P2 that execute 5 events each. Events are indexed 1 to 5 in the order of execution within each process. You know that event 3 is message being sent by P1 and received by P2 as event 1. Event 2 of P2 is a reply which is received by P1 as event 5.

a) Show how a Lamport's logical clock can be used to achieve a global notion of order over the two processes. The Lamport timestamp should be indicated for each event.

b) Lamport's clock is exploiting a specific relation when calculating global order. Name this relation.

Name: _____ Personnummer: _____

QUESTION 8 – Concurrency

6 p

Parallel, concurrent, and asynchronous programming have been discussed extensively through the course. Describe these three concepts so that it is clear both how they relate and what their differences are.

Name: _____ Personnummer: _____

QUESTION 9 – Design challenges

9 p

a) Describe what *Quality of services (QoS)* means and discuss how it pose a design challenge to distributed systems.

b) Describe what *transparency* means and discuss why it is an attractive attribute in the design of distributed systems.

c) Describe what *openness* means and discuss why it is an attractive attribute in the design of distributed systems.

Name: _____ Personnummer: _____

QUESTION 10 – System models

7 p

Several system models have been discussed in the course and one of the most prominent is the layered architecture.

a) Describe the generic layered architecture.

b) Give a concrete example of the layered architecture from the course. Make sure to include the number and names of all layers and how the layers relate and communicate in the specific example.

Name: _____ Personnummer: _____

QUESTION 11 – Interprocess communication

9 p

a) One of the most prominent design patterns in distributed systems is called Remote Procedure Call (RPC). Describe how RPC works so that it is clear how it relates to a local procedure call.

b) The middleware ZeroMQ has been discussed extensively through the course. Describe in principle how ZeroMQ can be used to implement RPC, so that it is clear which parts is provided by the middleware and which is handled in application code. *Programming code is not requested, but include the names of socket types and the principal steps that the RPC implementation goes through.*

c) A more modern design pattern for distributed system is the *pipeline pattern*. Describe the pipeline pattern, including a specification of its different nodes and how ZeroMQ sockets may be used to implement this pattern. *Programming code is not requested, only the name of the correct socket types and their respective place within the pipeline. Illustrations are welcome.*

Name: _____ Personnummer: _____

QUESTION 12 – Multicast

3 p

Describe how multicast works so that it is clear how it differentiate from unicast and broadcast.