

This is a “closed book” exam.

No printed materials or electronic devices are admitted for use during the exam.

You are supposed to answer the questions **in English**.

Wishing you lots of success with the exam!

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. To pass the exam, it is sufficient to get at least 55 points.

1. Scalability

Using the example of Grid computing systems, explain which techniques can be used to deal with size scalability, geographical scalability, and administrative scalability. (be brief, one technique each!) 6pt

2. Architecture

2.a: Sketch a middleware organization in which communicating processes are decoupled in space. 5pt

2.b: In a shared data space, processes are also decoupled in time. What does this mean and why is it so difficult to find scalable solutions for communication for shared data spaces? 7pt

3. Stream Communication

3.a: Give the definitions for synchronous and isochronous transmission. 4pt

3.b: Which technique can be implemented to reduce the effects of jitter on streaming applications? 4pt

3.c: How can multiple, related streams (e.g., two audio and a video channel of a movie) be synchronized with each other for replay at the receiver side? 3pt

4. Gossiping

4.a: Explain the basics how gossiping algorithms work. 4pt

4.b: How can gossiping be used to estimate the number of nodes involved in the gossiping algorithm? 6pt

5. Logical clocks

5.a: Explain how Lamport’s logical clocks work. 6pt

5.b: Explain how totally ordered multicast can be implemented with Lamport’s logical clocks. 8pt

5.c: Provide an alternative implementation that realizes totally ordered multicasting. 6pt

6. Consistency

6.a: Why is the following data store not sequentially consistent? Is it causally consistent? Explain your answer.

6pt

P1:	W(x)a	
P2:	W(x)b	
P3:	R(x)b	R(x)a
P4:	R(x)a	R(x)b

6.b: Consider a system that combines read-your-writes consistency with writes-follow-reads consistency. Is this system also sequentially consistent? Explain your answer.

6pt

7. Two-phase commit (2PC)

7.a: Explain the two-phase commit (2PC) protocol and draw the state diagrams for coordinator and participants.

8pt

7.b: What happens in 2PC when the coordinator fails and all participants are ready to commit?

5pt

7.c: If you were to implement 2PC, what would you do in the case that the coordinator does not receive an answer from a participant?

6pt