Department of Computer Science	Exam **Distributed Systems**
Vrije Universiteit	Exam code: X_400130
Dr. T. Kielmann	17 – 12 – 2014

Please make sure that your handwriting is readable!

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. Scaling and Distribution Transparency

1.a: Name five out of the seven forms of distribution transparency. 3pt

1.b: Give a compelling reason why full distribution transparency can not be achieved (be brief!) 3pt

1.c: Using the example of a Web-based information system, explain which techniques can be used to deal with size scalability, geographical scalability, and administrative scalability. (be brief, one technique each!) 4pt

2. Replication

2.a: Explain the difference between active replication and passive replication. 2pt

2.b: For pushing updates and pulling updates, compare both the necessary state at the server and the response time at the client. In which cases would you prefer pushing or pulling updates, respectively? 4pt

2.c: How can *leases* help with the trade-off from question 2.b? 3pt

2.d: On which system properties can adaptive leases be based upon? 6pt

3. Two-phase commit (2PC)

3.a: Explain the two-phase commit (2PC) protocol and draw the state diagrams for coordinator and participants. 8pt

3.b: What happens in 2PC when the coordinator fails and all participants are ready to commit? 5pt

3.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

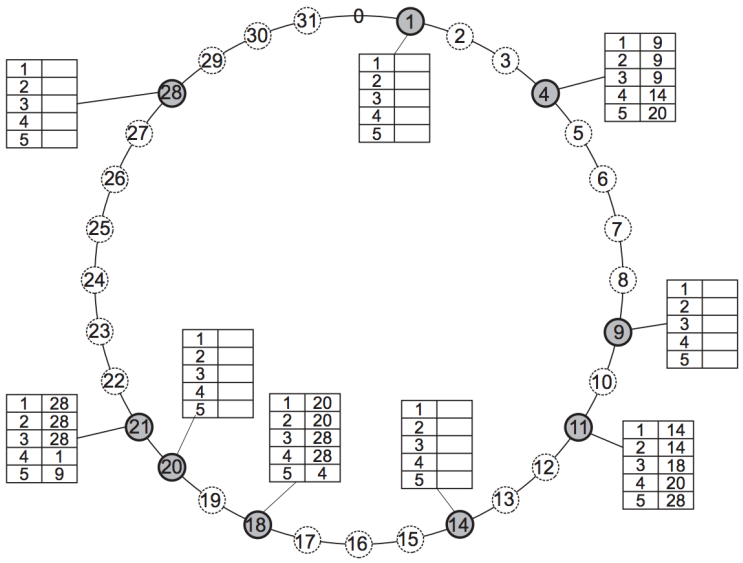
4. Logical clocks

4.a: Explain Lamport's happened-before relationship and provide a distributed implementation of the associated logical clocks. 5pt

4.b: Give an example of how Lamport's logical clocks can be used to realize distributed mutual exclusion. 5pt

5. Chord

Consider the following Chord ring:



5.a: Fill in the missing Chord finger table for nodes 1, 9, 14, 20, 28. 5pt

5.b: Show all hops for the following key lookups for the shown Chord-based P2P system: 5pt

source	key
1	12
9	3
14	20
14	31
20	18

5.c: Which problem might occur when deploying a Chord DHT across the Internet? 4pt

6. Gossiping

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

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

7. Consistency

7.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

7.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