TU Delft

Examination TPM

Delft University of Technology - Faculty of Technology, Policy and Management

Course name:	**Simulation Masterclass**	**Course code:**	**SEN9110**
Date:	**Friday 26 January 2024**	**Time:**	**09:00 – 12:00**
Module manager:	**Prof.dr.ir. A. Verbraeck**		

Examination questions:

Number of open questions: **4 (*)** questions
Number of multiple choice questions: **0** questions
Max. number of points: **90** points

☐ **all questions have the same weight**
☒ **the questions have different weights** (indicated per question)

Total number of pages (incl. cover page): **2** pages

Use of tools and information sources:
During the examination, the use of any tools or information sources (this includes mobile phones, smartphones or any devices with similar functions) is strictly forbidden unless stated below.

Permitted tools and information sources:
☒ **books** ☒ **notes** ☒ **dictionaries** ☒ **readers** ☐ **formulae sheets**
☒ **calculator** ☒ **computer** ☒ **slides, papers, course materials, USB-stick**

Additional instructions: *(optional)*
(*) Students have to choose 3 out of 4 questions to answer (30 points each, total 90 points + 10 points = 100 points). Indicate clearly on your answer sheet which question you are answering. Don't answer all 4 questions.
This mark contributes for 50% to your final mark, and has to get a mark ≥ 5.8 to be averaged with the term paper (30%, including presentation) and simulation package (20%) for the overall mark.

Final marking date:
(the maximum marking period is 10 working days)
15 February 2024

To be handed to the examiner or invigilator:
☒ Examination work with name and student number on each page.
☐ Examination documents

Any suspicion of fraud or any breach of the exam rules will be immediately reported to the Board of Examiners

For more information about fraud: TU Delft Student portal> TPM> Rules and Guidelines

Don't forget to write your name, student number, and question number clearly on every page you hand in. Also indicate on the first page how many separate sheets you have handed in in total. Write using pen only: officially anything written in pencil should be ignored for grading. Only use the computer in the computer room; use of your own electronic devices is prohibited, with the exception of a USB stick, which is allowed.

CHOOSE 3 OUT OF 4 QUESTIONS TO ANSWER. CLEARLY INDICATE WHICH QUESTIONS YOU CHOSE.

1. **Systems Theory and Systems Specification** (30 points)
   a. In Lecture 2, we discussed, based on the cybernetics theory of Ashby, that simulation can be viewed as a closed, single valued transformation. Explain how a DEVS simulation model uses transformations, explain why it is closed, and explain why it is single-valued. (10 points)
   b. Activity scanning is known as a more time consuming worldview for the implementation of simulation models than event scheduling. Explain what makes activity scanning (locality of state) so "slow" compared to event scheduling (locality of time). (10 points)
   c. The data system in Klir's levels of system specification / Zeigler's system specification hierarchy (Lecture 3 and 4) contain the data system with time-indexed data. Explain what that time-indexed data is, why it is needed to build a simulation model, and give an example. (10 points)

2. **DEVS** (30 points)
   a. DEVS models are discrete-event models and in that sense, they match the inner working of DES software (Schriber & Brunner, reader). Explain precisely how the time-delayed state and how the condition-delayed state are implemented in the Atomic DEVS formalism. (10 points)
   b. It is possible to combine a DESS-submodel (differential equation submodel) with an (atomic) DEVS-submodel in a Hierarchical DEVS model? How would the *select* function work in such a case, and how often would it need to evaluate the priorities of the submodels? (10 points)
   c. The *ta* function in Atomic DEVS (Reader p.73) describes the time till the next event. Often, in examples, this value is infinite under certain conditions (Figure 12 on page 79 of the reader has an example of this). What does this mean? Would the atomic model stop functioning as a result? Can the atomic model start working again after *ta* got the value ∞ ? (10 points)

3. **Distributed Simulation** (30 points)
   a. Optimistic distributed simulation has many ways of dealing with an event that took place out-of-order. Clearly describe three different 'repair' methods and compare them by providing advantages and disadvantages of each of the repair methods. (10 points)
   b. Explain as clearly as possible how relaxed time synchronization for distributed simulation works, and what problem it tries to solve. Give a clear example where it is a great idea to use this form of time synchronization. (10 points)
   c. Explain as clearly as possible why we need an RTI in distributed simulation, and why 'peer-to-peer' communication in distributed simulation would have much more difficulty to solve the main issues that distributed simulation is faced with. (10 points)

4. **Object-oriented Simulation** (30 points)
   a. Object-oriented simulation uses information hiding and encapsulation as two of its main principles. Give two main reasons why these principles are so helpful when creating simulation models. (10 points)
   b. Do simulations that use 'locality of object' (process interaction) need an object-oriented simulation model? Explain clearly why, or why this is not the case. (10 points)
   c. In the Object-Oriented Simulation lecture (and in the Real-Time Simulation lecture) we discussed the importance of 'asynchronous communication'. Explain what it is, why it is important, and what problem it tries to solve. (10 points)