UNIVERSITY OF OSLO

Faculty of Mathematics and Natural Sciences

Exam in TEK5010 Multiagent systems
Day of exam: Tuesday 3rd of December 2019
Exam hours: 09.15-13.15 (4 hours)
This examination paper consists of 6 page(s).
Appendices: Non
Permitted materials: Non

Make sure that your copy of this examination paper is complete before answering.

Question 1 [30 marks]

The concept of agency is vital to multiagent systems modelling. We want you to elaborate on the concept of agency and describe the different aspects of agency as applied to game theory and swarm intelligence. Be careful to explain and comment on your answers.

a) What is a common definition of an agent?

b) And what is a multiagent system?

c) Define swarm intelligence?

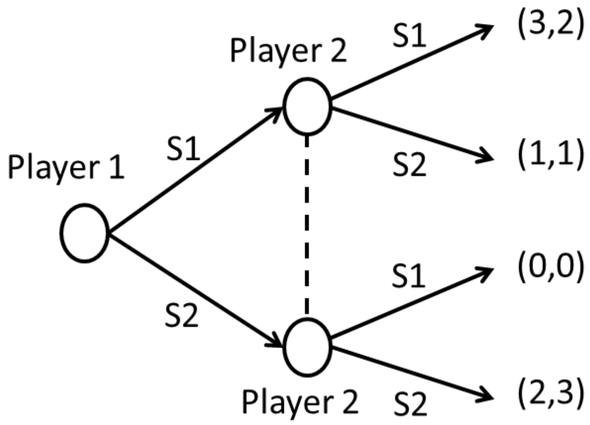
d) Name a few key properties of swarm intelligence.

e) What do we mean by emergence in swarm intelligence?

f) What is stigmergy?

Question 2 [30 marks]

Two agents, Player 1 and Player 2, have strategies S1 and S2 available to them. The resulting payoffs are given in the following extensive form game:



a) Explain why this is a strategic game. Could you write the game in strategic or normal form?

b) In relation to this game, could you define and identify:

i. Nash equilibrium (pure strategy)
ii. Pareto optimal outcomes
iii. outcomes that maximize social welfare

c) What is Nash's theorem?

d) What is the mixed strategy Nash equilibrium in this game?

Question 3 [30 marks]

Given the voters $Ag = \{1, 2, 3\}$ and their possible outcomes $\Omega = \{\omega_1, \omega_2, \omega_3, \omega_4\}$, the preference ordering of the different voters are as follows:

$$\varpi_1 = (\omega_1, \omega_2, \omega_3, \omega_4)$$
$$\varpi_2 = (\omega_2, \omega_3, \omega_4, \omega_1)$$
$$\varpi_3 = (\omega_3, \omega_4, \omega_1, \omega_2)$$

a) Define plurality voting. What outcome is winner if voting procedure is plurality? Do we have a Condorcet's paradox here?

b) What is Borda count? Apply the Borda rule to select an outcome, given the voter preference as shown above.

c) Write up all winners in pairwise elections. Explain what a majority graph is and draw the corresponding majority graph from the pairwise elections. Discuss what would be the preferred social ordering based on this graph?

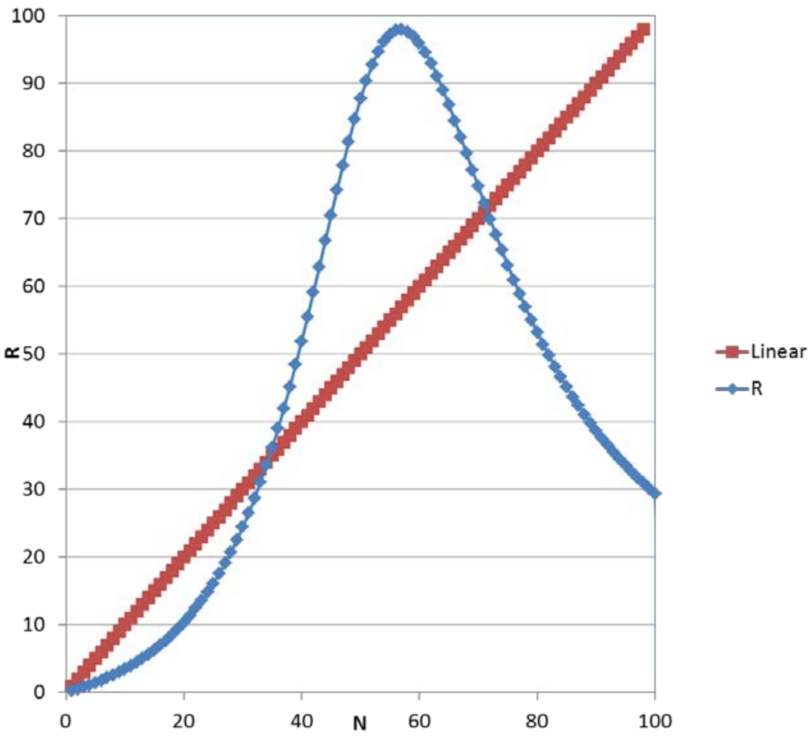
d) What is Slater ranking? What is the best outcome in terms of the Slater rule? Why is the Slater rule problematic to use in the general case?

Question 4 [30 marks]

The Universal Scalability Law (USL) [Gunther, 1993] is given by the following equation:

$$R(N) = C\frac{N}{1 + \alpha(N-1) + \beta N(N-1)}$$

And in the following graph the *R* value as a function of *N* is plotted (blue) using parameters $C = 0.25$, $\alpha = -0.0335$ and $\beta = 0.00032$. For reference a linear line is also plotted (red):



a) In terms of using USL for modelling the performance of swarm systems, could you explain the variables in the model?

b) In the above graph, how would you characterize the performance of this swarm system? What is the optimal performance in this case? You can assume that the benchmark linear speedup is 1.

c) Would the optimal performance level change if a constant loss per operating agent would have to be replaced by a limited pool of available agents? Explain your answer.

Question 5 [30 marks]

It has been claimed that Beeclust [Schmickl & Hamann, 2011] is one of the most important algorithms developed in terms of swarm research progress.

a) Discuss the validity of such a claim and elaborate on what type of problems it would be appropriate to apply Beeclust.

b) Could you describe the Beeclust algorithm and explain how it works?

c) Based on the equations given below, could you explain how one could mathematically connect the micro level modelling with the macro level performance of the Beeclust?

Equation 1: $\dot{\boldsymbol{R}}(t) = \alpha \nabla P(\boldsymbol{R}(t)) + B\boldsymbol{F}(t)$

Equation 2: $\frac{\partial \rho_m(\boldsymbol{r},t)}{\partial t} = B^2 \nabla^2 \rho_m(\boldsymbol{r},t) - \rho_m(\boldsymbol{r},t)\varphi + \rho_m(\boldsymbol{r}, t - w(\boldsymbol{r}))$