Part 1 (45 pts)

In this assignment the following case is analyzed:

Agent Piet possesses an outdated phone model, which he desires to replace by a modern one. A trendy phone model appeared at the market. Piet is interested in this model. During one month Piet collects opinions of his friends concerning the new phone. If, during the evaluation period, no negative opinions and at least one positive opinion are obtained by Piet, then he intends to buy the new model. Otherwise the agent does not consider the purchasing of the new model. To realize his intention, Piet waits till the holiday season starts, when prices for many products are reduced, and purchases the new model.

Assume that the process of generation of any internal state takes one time unit (given that all pre-conditions for the state are satisfied) and that a month is equal to 100 time units. Furthermore, assume the following relevant state properties in your model:

Input state properties

obs(own_phone_outdated)	Piet observed that his phone is outdated
obs(negative_opinion)	Piet observed a negative opinion of a friend concerning the new phone model
obs(positive_opinion)	Piet observed a positive opinion of a friend concerning the new phone model
obs(holiday_season_started)	Piet observed that the holiday season has started

Output state properties

performed(purchase_new_model)	Piet purchased the new phone model

Internal state properties

belief(own_phone_outdated)	Piet believes that his phone is outdated
belief(negative_opinion)	Piet believes that a friend has a negative opinion concerning the new phone model
belief(positive_opinion)	Piet believes that a friend has a positive opinion concerning the new phone model
belief(holiday_season_started)	Piet believes that the holiday season has started
d	Piet desires to buy a modern phone
i	Piet intends to buy the new phone model

a) Give an example of a trace (showing input, output and internal state properties), which describes the behaviour of agent Piet which results into the purchasing of the phone, and a trace, in which Piet does not purchase the phone. (6)

b) Show the dynamics of the example in graphical form. Do not forget to indicate which state properties are persistent. (7)

c) Write down at least 3 executable dynamic properties in the semi-formal form that characterise these dynamics. (6)

d) For the properties you defined in c), indicates which ones are *step properties* and which ones are *persistence properties*. (4)

e) For the intention state property i indicate by which of the dynamic properties its *functional role* is defined. (4)

f) Give a set of dynamic properties that specifies the input-output correlation from an external perspective. (6)

The following two questions are independent from the case study:

g) Give examples of dynamic properties (in semi-formal or formal form) that describe three types of behavior in a system of your choice: stimulus-response, delayed-response, and adaptive. (6)

h) Explain what *requirements refinement* is, and how this can be used in the analysis of a multi-agent system. (6)

Part 2 (45 pts)

One of the ways for the European Union to maintain its competitive advantage in the world economy is by means of innovation. As a result, the European Union is investing a substantial amount of money in funding research projects in which parties of different countries collaborate. A total budget of 9.1 billion is available for this purpose. The research projects funded tend to involve large consortia, for instance projects with 15 or even 30 partners are no exception. To still have a coherent research program, a management structure is put into place. An example of the organization of an EU project with a management structure and a very limited number of partners (2 in this case) is described below.

Within the organization, there are essentially three groups, namely the Management Team (MT), and the two partner organizations (in this case the VU and the University of Krakow). Within the Management Team, three roles are present that can all communicate, namely the Project Coordinator, and representatives of both partners (i.e. a representative VU and a representative of the University of Krakow). These representatives have a group interaction with the role Partner Project Manager which is a role present in both the group VU as well as the group University of Krakow (so both the group VU and the University of Krakow contain a role Partner Project Manager). Finally, in each of these groups (VU and University of Krakow) one Researcher role is also present with which the Partner Project Manager interacts.

The process now works as follows. Within the Management Team the Project Coordinator starts the process with communicating a task division among the members to the representative VU and the representative of the University of Krakow. They respond with a modified task division according to their own ideas. Based upon the two modified task divisions (i.e. from the representative VU and the representative Krakow) the Project Coordinator outputs a compromised task division which the partners should follow to the Representative of the VU and the representative of the University of Krakow. As a consequence of this input for the representative VU, an output is generated by the role Partner Project Manager within the VU group containing the compromised task division, which is eventually received by the Researcher that should conduct the actual research. For the Krakow part the same holds, so a compromised task division received by the representative of the University of Krakow results in an output of the Partner Project Manager within the University of Krakow group of the task division to the Researcher who eventually receives it. Finally, the Researcher works the same in both groups. As a response to the compromised task division a planning of the research is generated.

a) Express the AGR-specification of this organization in graphical format. (15)

b) Express the behavior of the organization in terms of semi-formal dynamic properties. Try to limit yourself to the behavior described in the text above. (15)

c) Provide a proof tree for the organizational property "if the Project Coordinator outputs a task division, then the Researcher within both the VU as well as the University of Krakow group outputs a planning of the research" (15)