AUTONOMOUS SYSTEMS
ASSIGNMENT OF THE SEMINAR PROJECT

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Information for the analysis and the design of the multi-agent system

Name of the topic	Social Insects as the Multi-Agent Systems

PART 01: Analysis of the multi-agent system

Create the conceptual design of the multi-agent system (MAS). The MAS has to be designed for a particular task. The assignment should be meaningful. The system should have rational purpose. The MAS should not be too complex, but on the other hand it should not have trivial structure or solve trivial problem(s). The MAS is not going to be directly programmed during the subject aAUTS. It is going to be deeply designed and described. The implementation of the MAS will be realised during the next related subjects, e. g. Complex Systems.

1. Literature research – the state of the art preparation

Preparation of the review of the literature is the first part of the analysis of the MAS. Review of the literature should offer the aggregate overview of the actual state (state-of-the-art) of the application domain. For more information about the review of the literature, please see the following sources: http://library.bcu.ac.uk/learner/writingguides/1.04.htm, http://writing.wisc.edu/Handbook/ReviewofLiterature.html. Five citations (information sources) should be mentioned at least. Use the following scientific libraries as the information sources for your projects (Only these ones are acceptable.):

- www.springerlink.com
- www.sciencedirect.com
- Any information source that can be received from the university web page: https://www.uhk.cz/cs-CZ/UHK/Centralni-pracoviste/Univerzitni-knihovna/Databaze#UHK-Article
- The sources have to actual (2010 or later).
- Personal webpages, comments, discussions are not acceptable as the information sources for the project.

Length of the review should be 2 pages (A4) at least. Use the Harvard style of citations formatting in the end of the review of the literature (examples: https://www.staffs.ac.uk/assets/harvard_quick_guide_tcm44-47797.pdf). All used information sources (citations) have to be mentioned directly in the review of the literature and in the table below the text. Include 5 research studies in your literature research at least.

SOCIAL INSECTS AS THE MULTI-AGENT SYSTEMS

1) General introduction into application domain

Colonies of social insects – ants, bees, wasps, and termites – can be viewed as highly parallel, distributed systems for solving the problems intrinsic to colony survival and reproduction. Colonies are highly parallel in that large numbers of individual colony members are interchangeable: the system is composed of redundant individuals behav- ing according to a stereotyped set of rules. Although the workers of many species exhibit a behavioral flexibility that allows them to perform more than one job in the course of their lives, all of the individuals engaged in any one job, such as foraging for food or feeding the brood, seem to follow essentially the same set of behavioral rules. Further- more, all workers follow the same set of rules governing when they perform a given job, and when they switch to another one. In those species in which workers are morphologi- cally and behaviorally specialized to the performance of a single task, workers of a given specialization behave in the same way, making the colony as a whole highly parallel. Colonies are distributed in that they function without hierarchical organization. Information is not integrated in a command center that directs the colony's activities. Instead, information remains dispersed throughout the colony, distributed across all workers and their immediate environments. Individual workers respond to local environmental cues and to interactions with each other – not to signals from central command – and this distributed process achieves the colony's coordination and execution of work. (Hirsh 2001, p.1)

Multiagent systems used in the AI community are typically knowledge based, consisting of heterogeneous unembodied agents carrying out explicitly assigned tasks, and communicating via symbols. In contrast, many extremely competent natural collective systems of multiple agents (e.g. social insects) are not knowledge based, and are predominantly homogeneous and embodied; agents have no explicit task assignment, and do not communicate symbolically. A common method of control used in such collective systems is stigmergy, the production of a certain behaviour in agents as a consequence of the effects produced in the local environment by previous behaviour. The stigmergy is used successfully in a collective robot system modelled on ants. (O.E Holland 2016, p.57)

2) Research papers about your application domain and the multi-agent systems

2.1) Concept of stigmergy

The subject of stigmergy is best approached by considering the ways in which embodied agents (call them robots) can interact. At any instant, a robot can affect another robot directly and immediately in three main ways:

- by affecting the other robot's sensors: for example, by being sensed as an obstacle
- by applying force to the other robot, actively or passively (possibly through the environment): for example, by colliding with it
- by communicating with the other robot

A robot can also affect another robot indirectly, and with a delay, by changing a part of the environment which the other robot may subsequently encounter. The changes may influence the other robot in the following ways when it arrives at the altered location:

- by affecting its sensors, and consequently its choice of behaviour
- by altering the effect of its actions (for example, if the environmental change is the laying down of a film of oil, the effect may be to cause the robot to lose traction and therefore to follow a different trajectory than it would have without the change)

The effects of these indirect interactions constitute stigmergy (Grass6, 1959). Active stigmergy (Holland Beckers 1996) occurs when the effect is to influence the choice of behaviour of the second robot through sensory input.

(O.E Holland 2016, p.58)

2.2) Swarm Intelligence and wasp behavior

Swarm Intelligence,

a term coined by Beni and Wang in 1989, describes the collective emergent behavior resulting from

decentralized and self-organized systems. Its roots are the studies of self-organized social insects, such as ants, wasps or termites. In a colony of such insects, there is no central entity or mechanism controlling or even defining objectives, yet these creatures with strict sensory and cognitive limitations manage to perform complex tasks such as food foraging, brood clustering, nest maintenance and nest construction. As a result, the mechanisms underlying their complex behavior as a whole became subject of great interest and study, resulting in a great wealth of models inspired by Nature.
The particular relevance of such models for our work is based from the fact that most problems dealt within a colony, particularly in the case of wasps, are analogous to the scheduling and logistic engineering problems raised when considering unit production for real-time strategy games.

Wasp Behavior,
From their studies of the wasps, Theraulaz and colleagues created a model of dynamic task allocation that successfully emulates the self-organized behavior of wasps.
The model consists in a wasp hive in which there are two possible tasks: foraging and brood care. Individuals decide which task to do according to their response threshold and stimulus emitted by the brood. The system has the following main features:
– Tasks have the capacity of emitting stimuli that affects the individuals task selection decisions (stimulus);
– Individuals possess response thresholds that represent their predisposition to perform certain tasks (response thresholds);
– Each individual has a force that is taken into account during dominance contests to determine the winner. Dominance contests form a hierarchy within the colony (force);
– When an individual performs a task, the respective response threshold is decreased while the other response thresholds associated with other tasks are increased. This means that the more an individual performs a task the more likely he is to do it again, creating task specialists in the society (specialization).
These four features guide the model towards both performance and flexibility. The capacity of specialization of each individual leads self-organization towards optimal performance, allowing the whole work force to dynamically adapt to the constantly changing external environment as well as the intrinsic needs of the colony resulting, for instance, from loss of individual, etc. Such characteristics are of importance when considering the production scheduling in RTS games. (Antunes, Pinto 2011, p.72)

2.3) The computationality complete ant colony
When McCulloch and Pitts introduced neural networks as models for studying the central nervous system, their first analytical step was to investigate the máximum potential sophistication of information processing by such networks. They were able to show that neural networks are, in principle, computationally complete. That is, such a network can be constructed to solve any problem accessible to a finite digital computer. Lachmann and Sella have recently applied the same methodology to information processing in social insects, addressing the following question. Is the parallel distributed organization of an ant colony capable, in principle, of processing information with the same sophistication as any computer, or is the ant colony limited in its maximum potential sophistication?
The specific aspect of colony organization investigated by Lachmann and Sella is task allocation, the colony’s distribution of workers to different jobs in dynamic response to the shifting state of the environment and the needs of the colony. For a schematic mathematical depiction of this process, they adopt a generalization of a model originally set forth by Pacala.
Based upon this very schematic description of colony dynamics, Lachmann and Sella build a constructive proof of computational completeness.
(Hirsh 2001, p.3)

2.4) Foraging concept

Foraging consists in searching and collecting items in an environment and move them to storage point(s). Ostergaard et al. (2001) define the foraging as a two-step task known as searching and homing, where robots have to find as quick as posible items in the environment and return them to a goal region. While Winfield (2009) defines the foraging with a four state machine (searching, grabbing, homing and depositing), many variations can be derived from this basic point of view to define some special cases like dealing with energy limitations. However, most of the literature that works on foraging consider the two tasks searching and homing, since the two others are more related to robot design. As scalability is an important factor in nowadays applications, we believe that cooperation (over communication) is an important factor to consider in the conception of a foraging system. Therefore, we define foraging as the conjunction of the two tasks (searching and homing) with consideration of communication:

- Searching Robots inspect the search space for targets (or food). While the random walk is the most adopted strategy of search in unknown environments, several other search strategies can be used according to the environment structure and the amount of information provided to robots.
- Homing Robots have to return home with the collected food by using prior information and/or onboard sensors, following a pheromone trail or even exploiting specific tools (e.g. compass).
- Communication The cooperation between robots either in searching or in homing tasks can improve the group performance by accelerating the search when avoiding already visited regions or in homing when exploiting together found food. In several other problems cooperation can be achieved without communication, as in Feinerman et al. (2012). However, communication routine is necessary to share and receive information between agents in the swarm directly via transmitting messages or indirectly via the environment.

(Zedadra et al. Complex Adapts Syst Model 2017, p.3)

<u>3) Projects or research teams which are interested in the same application domain and their results</u>

3.1) RTS games. WAIST: R-Wasp (Warcraft III)

Based on the properties of the natural model created by Theraulaz and colleagues, Cicirello and colleagues proposed an algorithm for dynamic task allocation that later was adapted to Morley's factory problem from General Motors, denominated as Routing-Wasp or R-Wasp.
(Cicirello 2001, p.473) (Morley 1996, p.53)

WAIST, an algorithm inspired in the social intelligence of wasps for scheduling unit production in real-time strategy games and evaluated its performance with a set of five scenario variants developed as a modification of the game Warcraft III The Frozen Throne. The variants accounted for factors such as: the rate and distribution of the requests issued over the scenario, the number of available factories, and environment changes such as the destruction and construction of factories during the scenario.
The performance of WAIST in each scenario variants was compared to three other approaches: random attribution; distance-based attribution, and global attribution, which considers all the information available at the moment from the game environment.
Overall, WAIST performed comparably to the global attribution algorithm (and better than the other), an encouraging result considering WAIST is a decentralized algorithm that relies on local information while the latter has full global knowledge. As such, we believe WAIST to be an efficient and reliable alternative for real time scheduling in real time strategy games.
While WAIST experiences some limitations when dealing with low amounts of requests, it demonstrated good performance in situations of higher congestion of requests, and when setting up from one production type to another has a cost that cannot be ignored.

(Antunes, Pinto 2011, p.81)

3.2) A robotic model of a social insect system "Cementeries"

In order to study the possible use of social insect control techniques in collective robotics, a system was designed around a very simple ant behaviour - corpse gathering. The dead ants from a colony are sometimes found placed together in heaps ('cemeteries') some distance from the nest. The development of these heaps was studied by Deneubourg and his colleagues (Deneubourg et al. 1991) who showered 4000 dead ants onto a nest, and recorded the outcome. Ants from the nest would occasionally pick up a dead ant, carry it for a while, apparently aimlessly, and then drop it, apparently at random. However, after a few hours, the dead ants were seen to be arranged in many small piles. As time went by, these small piles were succeeded by a smaller number of much larger piles, and eventually the characteristic cemetery arrangement appeared. In a computer simulation, Deneubourg showed that the qualitative aspects of this sequence of events could be reproduced by a very simple model in which individual ants wandered at random, picking up dead ants with a probability that decreased, and dropping them with a probability that increased, with the sensed local density of dead ants. The stigmergic links were thus the change in the probability of picking up or dropping a dead ant as a function of the number of dead ants having been picked up or dropped in that area previously.
(O.E Holland 2016, p.59)

4)Research directions into the future

Even if there exists a collection of foraging algorithms evaluated with real robots, the need for using them on real applications or outdoor environments is important to validate them. The most challenging issue right now, is how to implement real foraging robots. Future directions or issues might include:

- The design of the robot should inspire from the real individuals (e.g. ants). If we imitate the collective intelligent behavior of ants for example, we need to deeply study the design of ants in order to produce an Ant-like-Robot (material, shape, actuator,...) that could produce the same behavior in real world.
- For Brooks (Brooks 1990), interactions over the real world are more difficult tan reasoning in the symbolic world. Thus, it is time to start deploying the proposed foraging robots in real world in order to test their applicability and efficiency.
- In designing micro-robots, energy and transport efficiency are of paramount importance.
- Decentralized lightweight data mining algorithms could be fruitfully exploited to support the MAF system.

(Zedadra et al. Complex Adapts Syst Model 2017, p.21)

Mention the used literature sources in the Harvard style into the table below. Book chapters or journals can be cited in the same way. For simplicity, these citations will not be distinguished:

#	Examples
1	SURNAME, J. (year). Name of the paper. Place of publishing: Publisher. ISBN.
2	Neumann, J. (2013). Information ethics: syllabus for bachelor study of information science. Brno: Masaryk University. ISBN 80-2102-981-1.

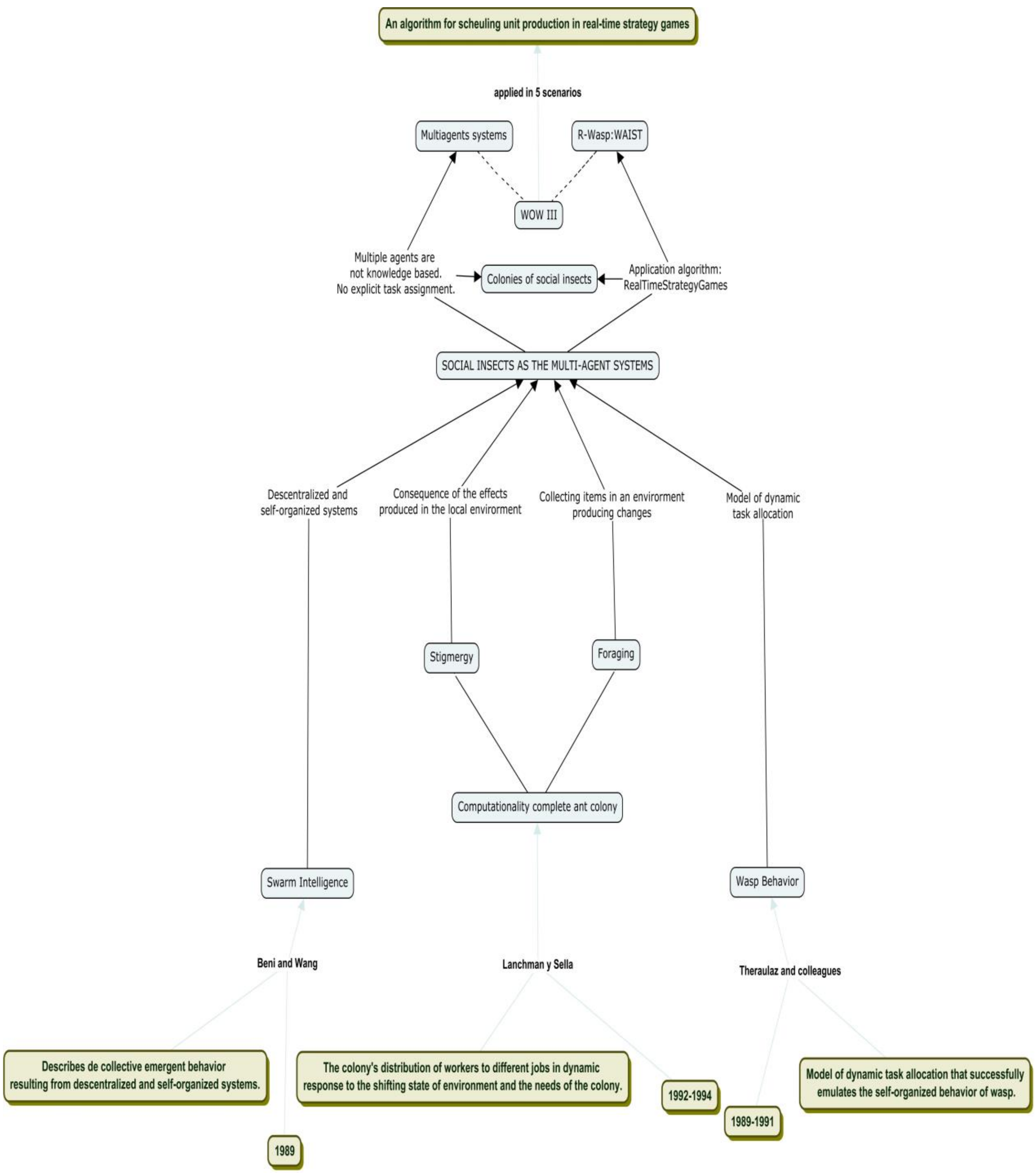
Input your own citation (information sources) into the table below.

#	Citations
1	A.E. Hirsh, D.M Gordon : Distributed Problem Solving in Social Insects. Department of Biological Sciences, Stanford University, Stanford, USA. Kluver Academic Publishers. Printed in Netherlands (2001)
2	Cicirello, V., Smith, S.F.: Wasp nests for self-configurable factories. In: M˙uller, J.P.,Andre, E., Sen, S., Frasson, C. (eds.) Proceedings of the Fifth International Conference on Autonomous Agents, pp. 473–480. ACM Press (2001)
3	Luis Antunes, H.Sofia Pinto (Eds) : Progress in Artificial Intelligence. 15h Portuguese Conference on Artificial Intelligence, EPIA 2011, Lisbon, Portugal, October 2011. Proceedings. Ed Springer
4	Morley, D.: Painting trucks at general motors: The effectiveness of a complexity based approach. In: Embracing Complexity: Exploring the Application of Complex Adaptive Systems to Business, The Ernst and Young Center for Business Innovation, pp. 53–58 (1996)
5	O.E. Holland: Multiagent systems: Lessons from social insects and collective robotics. Intelligent Autonomous Systems Laboratory, Faculty of Engineering, University of the West England, Bristol (2016)
6	Zedrada et al. Complex Adapt Syst Model : Multi-Agent Foraging Review (2017)

2. Mind mapping

Create the mind map in the Cmap tool. Map will graphically visualise structure of your state of the art (literature research). Follow the guidelines for mind mapping preparation, see the seminar 3. Main facts of the research papers (books) which should occur in the mind map: authors, year of publication, place of publication (e. g. journal), number of pages, name of the paper (book), summarisation of its content. Additional parameters can be added, e. g. ISBN, etc.

(Input the structure of your map that you created in the Cmap tool.)



3. PEAS specification

The abbreviation PEAS represents the four key words: Performance, Environment, Actuators, Sensors. It is the basic determination of the application domain – task environment of the MAS. Describe briefly the particular attributes below into the blank spaces.

Performance – mention the textual description how the performance of the MAS will be measured. It should be obvious which main tasks will be solved by the MAS (max. 10 rows).

A colony of ants forages for food. Though each ant follows a set of simple rules, the colony as a whole acts in a sophisticated way. Their behavior consists in the search and collection of food by individual agents who carry out intelligent behavior in group.

Environment – mention the brief description of the environment where the intelligent agents will be located. Focus on the key characteristics and what is the most important. Description cannot be exhaustive, but it should be possible to make clear notation of the environment in which the MAS will work (max. 10 rows).

The MAS works in a simple environment that consists of a nest of ants and food clusters. When an ant eats a piece of food, the cluster lowers until it ends and disappears.

Actuators – describe the actions that the intelligent agents will realise and actuators that will be used by these agents. If you design more intelligent agents, mention the actions and actuators for all of them. 5 rows of description for each of the agent (max.).

The ants look for food and when they find it they leave pheromones on the way to the nest. This action makes it easier for other MAS ants to find food clusters. The actuators are in ants, equipped with a pheromone secretion system that leaves a temporary trace.

Sensors – describe the perceptions that the agents will be able to perceive and sensors that will be used by these agents for perception. . If you design more intelligent agents, mention the perceptions and sensors for all of them. 5 rows of description for each of the agent (max.).

The ants are equipped with a pheromone tracking system, when they find the trail of pheromones left by other ants, it reacts by following the trail to the food.

4. Annotation of the multi-agent system

Mention the brief framework of working of the designed MAS. Description should answer on the following questions: “What will be a part of the MAS and what will not be a part of the MAS, i. e. where you will use the abstraction? What will be the purpose of the system? What is going to be solved by the MAS? For which target group of people the MAS will be used?

Annotation of the project – a brief description of the MAS behaviour (max. 15 rows)

When an ant finds a piece of food, it carries the food back to the nest, dropping a pheromone trail as it moves. When other ants smell the pheromone, they follow the trail toward the food. As more ants carry food to the nest, they reinforce the trail.

Characterise the organisation or the user that will use the MAS (max. 10 rows) (note: Fill only, if the MAS is intended for particular organisation or a group of people).

Notes – You can add some additional notes (comments) that specify the part 2 and 3 of the project (max. 10 rows)

5. ODD+D protocol

Fill the particular parts of the ODD+D protocol, see table below. The protocol is quite general. If some part of the protocol cannot be filled, explain why it is not possible. Use the new line (below the filed/question) for description because of the clarity.

ITEM		QUESTION
1 Overview	1.1	1.1.1 What is the purpose of the study? The behaviour of social insects as a MAS
		1.1.2 For whom is the model designed? For developers of applications based in social behavior.
	1.2	1.2.1 What kinds of entities (resources, agents, environments) are in the model? Ants, nest of ants, clusters of food and pheromones.
		1.2.2 By what attributes (i.e., state variables and parameters) are these entities characterised? Population, diffusion-rate, evaporation-rate, speed.
		1.2.3 What are the exogenous factors / drivers of the model? (Note: Exogenous factor – external influence that has the influence on the behaviour of the model) Food in each pile.
		1.2.4 If applicable, how is space included in the model? The space consists of a plot dimensioned by a coordinate axis in which you can choose the points of origin of the various resources.
		1.2.5 What are the temporal and spatial resolutions and extents of the model? Collect the food from the clusters in a reasonable amount of time. The trail of pheromones during a shorter period of time.
	1.3	1.3.1 What entity does what, and in what order? - Ants come out of the nest. - They move around looking for food (they look for the trail of pheromones) - When they find food, they segregate a trail of pheromones from the cluster to the nest. - If the ants find the trail, they follow it. - If the ants lose the trace, they move by a random search algorithm.
2 Design Concepts	2.1	2.1.2 On what assumptions is/are the agents' decision model(s) based (What is necessary for decisions realisation)? The ants must find the trail of pheromones released by another ant to meet the goal of collecting more fast food.
		2.1.4 If the model / submodel (e.g., the decision model) is based on empirical data, where do the data come from? The empirical data comes from various tests with the simulator.
	2.2	2.2.1 What are the subjects and objects of the decision-making? Follow the trail of pheromones to find the food and take it to the nest.
		2.2.2 What is the basic rationality behind agent decision-making in the model? Do agents pursue an explicit objective or have other success criteria? The main purpose of ants is to collect food. This goal is achieved more quickly by the sub-objective of

ITEM		QUESTION
		finding a trail of pheromones.
		2.2.3 How do agents make their decisions? They react following the trail of pheromones when they find it. They react by leaving a trail of pheromones when they find the food.
		2.2.4 Do the agents adapt their behaviour to changing endogenous and exogenous state variables? And if yes, how? Yes, in the case of the trail of pheromones (exogenous variable) the agents adapt their behavior following the trail. In the other hand, agents change their behavior when they find food (carrying it to the nest) until the food cluster being empty (exogenous variable).
		2.2.5 Do social norms or cultural values play a role in the decision-making process? The main social norm among our agents is that they must release pheromones when they bring food to the nest.
		2.2.6 Do spatial aspects play a role in the decision process? Yes, when the agents find the wall he changes his direction and when a cluster runs out of food it disappears from the plot.
		2.2.7 Do temporal aspects play a role in the decision process? Yes, when an ant releases the pheromones they disappear in a short period of time and the trace can't be traced.
		2.2.8 To which extent and how is uncertainty included in the agents' decision rules? The uncertainty of our system is that we do not know if bunches of food will exist. Then the ants move with a random movement until they find these clusters. In the same way, we can't be sure that one ant finds the pheromone trace of another.
	2.3	2.3.1 Is individual learning included in the decision process? How do individuals change their decision rules over time as consequence of their experience? They do not change their decisions over time.
		2.3.2 Is collective learning implemented in the model? No.
	2.4	2.4.1 What endogenous and exogenous state variables are individuals assumed to sense and consider in their decisions? Is the sensing process erroneous? Endogenous variables - Pheromone trace Exogenous variable - Amount of food in each pile
		2.4.2 What state variables of which other individuals can an individual perceive? Is the sensing process erroneous? Whether he is secreting pheromones or not, only if he is next to another agent.
		2.4.3 What is the spatial scale of sensing? The trail of pheromones (small radio)
		2.4.4 Are the mechanisms by which agents obtain information modelled explicitly, or are individuals simply assumed to know these variables? The mechanisms are explicitly modelled.

ITEM		QUESTION
	2.5	2.5.1 Which data do the agents use to predict future conditions? Nothing.
		2.5.3 Might agents be erroneous in the prediction process, and how is it implemented? No.
	2.6	2.6.1 Are interactions among agents and entities assumed as direct or indirect? Direct.
		2.6.2 On what do the interactions depend? Of the pheromones and the amount of a cluster.
		2.6.3 If the interactions involve communication, how are such communications represented? It is a basic communication between agents represented by a trail of pheromones.
		2.6.4 If a coordination network exists, how does it affect the agent behaviour? Is the structure of the network imposed or emergent? If the agent finds food, it secretes pheromones until it leaves it in the nest. Emergent.
	2.7	2.7.1 Do the individuals form or belong to aggregations that affect and are affected by the individuals? Are these aggregations imposed by the modeller or do they emerge during the simulation? They emerge during the simulation.
		2.7.2 How are collectives represented? Like an ant colony where you can set the population.
	2.8	2.8.1 Are the agents heterogeneous? If yes, which state variables and/or processes differ between the agents? The agents are homogeneous.
		2.8.2 Are the agents heterogeneous in their decision-making? If yes, which decision models or decision objects differ between the agents? The agents in their decision making are homogeneous too.
	2.9	2.9.1 What processes (including initialisation) are modelled by assuming they are random or partly random? While the agents do not find any trace of pheromones or food, the search process is carried out randomly.
	2.10	2.10.1 What data are collected from the ABM for testing, understanding and analysing it, and how and when are they collected? The data is shown in a plot for each execution of the model. In the plot is represented “food in each pile” and “time”
		2.10.2 What key results, outputs or characteristics of the model are emerging from the individuals? (Emergence) The trail of pheromones on the path from the cluster to the nest

ITEM		QUESTION
3 Details	3.1	3.1.1 How has the model been implemented? Implements a simple logic.
		3.1.2 Is the model accessible, and if so where? In netLogo
	3.2	3.2.1 What is the initial state of the model world, i.e. at time t = 0 of a simulation run? All the ants are in the nest and all the clusters are full of food.
		3.2.2 Is the initialisation always the same, or is it allowed to vary among simulations? It's allowed to vary among simulations.
		3.2.3 Are the initial values chosen arbitrarily or based on data? The initial values are based on a data.
	3.3	3.3.1 Does the model use input from external sources such as data files or other models to represent processes that change over time? No

PART 02: Design of the multi-agent system with AML

6. Entity diagram

Mention the entity types into the following table together with the explanation of their roles in the MAS in the "Comment" part. Use the following minimum counts of entity types:

- the environment type (1x),
- the agent type[1] (2x),
- the resource type (1x).

Entity type	Name of the entity type	Comment
Environment type	2DSpace	First layer that dimensions the environment
Environment type	Land	Second layer where the objects are
Agent type	AntColony	Ants as a collective (a unique collective for the model)
Agent type	Ant	Individual agent who will form with his behavior the collective behavior of the model
Resource type	FoodCluster	Stack of food consisting of a specific number of pieces
Resource type	Piece	Unit of food that an ant can carry
Resource type	Trace	Pheromones trail

Input the brief description of the AML-based diagram in the view of relations between entity types into the following blank field. If you create more diagrams, each one has to have a comment.

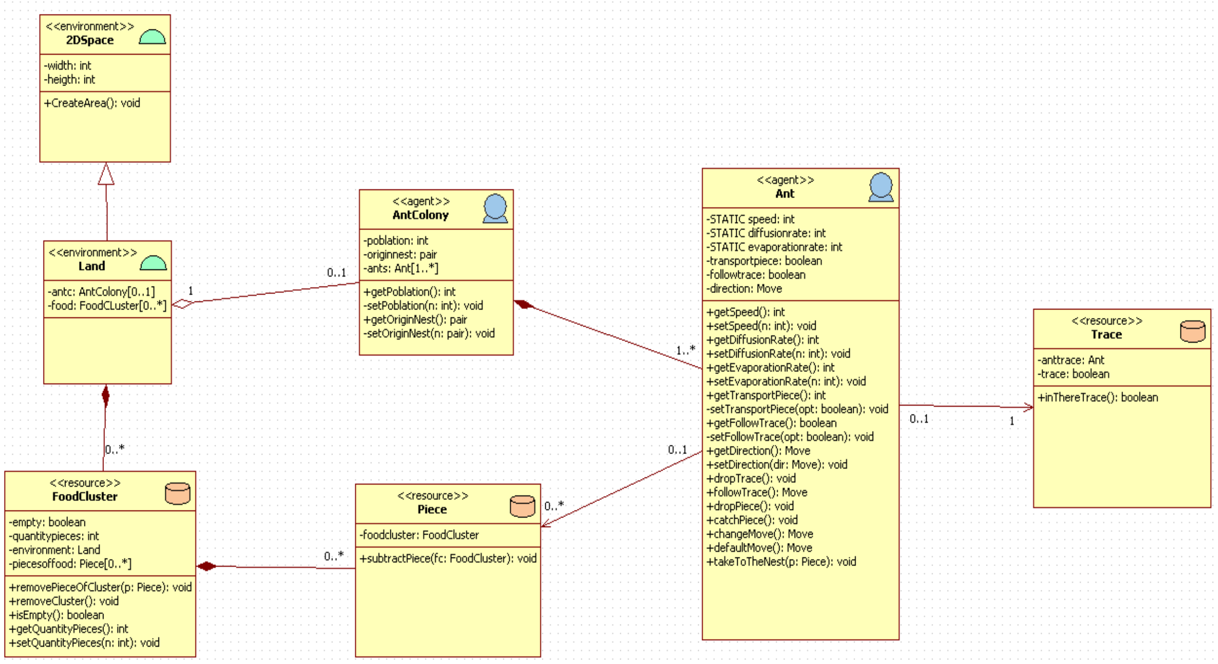
(input the description of the AML-based diagram – ENTITY DIAGRAM; if you have more entity diagrams, copy this box several times accounting to the amount of diagrams)

In the entity diagram is represented the collective of ants and each individual ant with enough operations to implement their tasks. I opted for an option without inheritance to avoid modifying variables such as "poblacion", although it could also have been implemented with it. In this way, making certain variables static, the modifications on them will not have repercussions according to their implementation.

Input the AML-based diagram – ENTITY DIAGRAM into the following blank field. If you need to separate the diagram into several parts, input these several divided parts under each other. Diagram has to be readable in the protocol.

[1] Not instances!

(input the AML-based diagram – ENTITY DIAGRAM)



7. Society diagram / Service diagram / Perceptor-effector diagram

Choose two of the following AML-based diagrams:

- Society Diagram
- Services Diagram
- Perceptor-effector Diagram

Input the used elements into the table below according to the chosen AML-based diagram. Do not forget to include the description (purpose) of these elements in the section Comments.

Society diagram should include the following types of elements with the minimal amount:

- organisation type (1x),
- role type (2x),
- social associations (4x),
- play association (optional element).

Service diagram should include the following types of elements with the minimal amount:

- service specification (2x),
- service provision (dependency relationship) (2x),
- service usage (dependency relationship) (2x).

Perceptor-effector diagram should include the following types of elements with the minimal amount:

- perceptor type (1x),
- effector type (1x),
- the sensor (1x),
- the actuator (1x),
- perceives (2x),
- effects (2x).

Diagram 1

Type of the element	Name of the element	Comments
Organization unit	AntColony	
Entity role	Explorer	
Entity role	TrailFollower	
Entity role	FoodCarrier	
Agent	Ant	
Play association		Between Explorer-Ant
Play association		Between TrailFollower-Ant
Play association		Between FoodCarrier-Ant
Social associations	Lost trace	Between Explorer-TrailFollower
Social associations	Drop trace	Between TrailFollower-FoodCarrier

Input the brief description of the selected AML-based diagram in the view of relations between types of elements into the following blank field. If you create more diagrams, each one has to have a comment.

(input the description(s) of the selected AML-based diagram(s))

Society diagram of ant colony

In this society diagram the 3 different roles that an ant can adopt within the colony are shown:
-Explorer: If you do not bring food to the nest or are following a trail, you will have a default movement to explore.
-TrailFollower: in this case is following a trail of pheromones left by another ant with role "FoodCarrier".
-FoodCarrier: This ant leaves the pheromone while carrying the piece of food to the nest (drop trace)

Input the selected AML-based diagram(s) into the following blank field. If you need to separate the diagram into several parts, input these several divided parts under each other. Diagram has to be readable in the protocol.

(input the selected AML-based diagram(s))

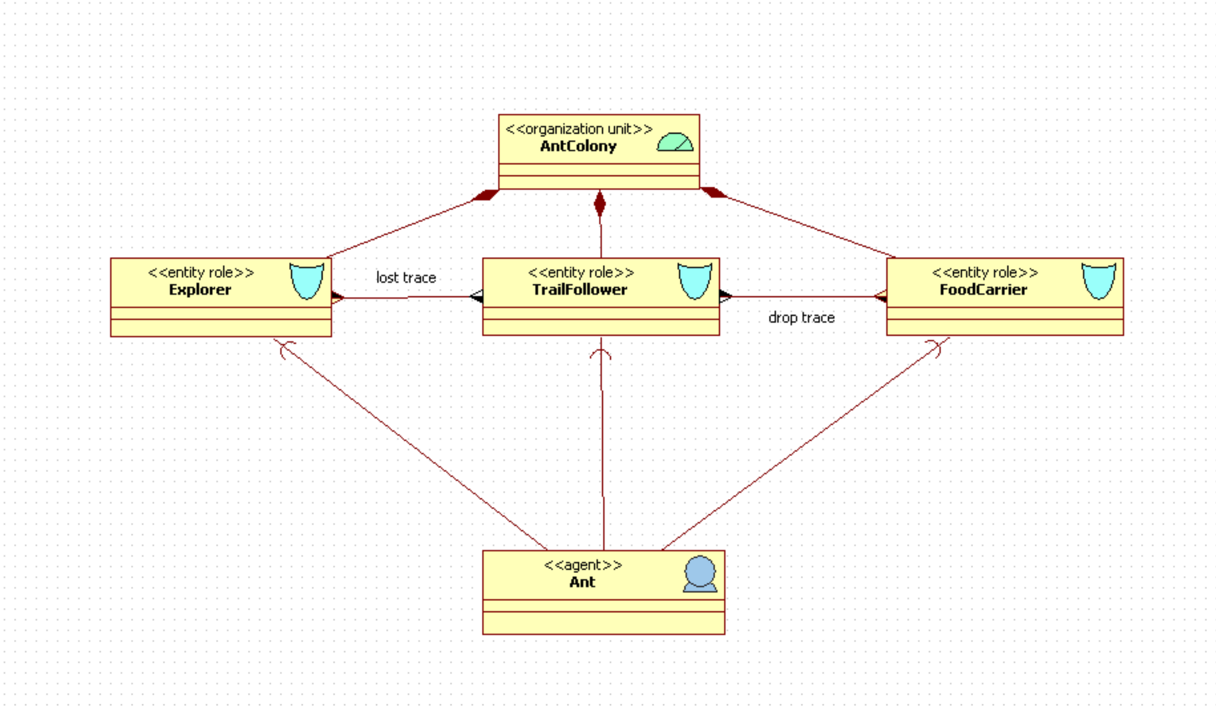


Diagram 2

Type of the element	Name of the element	Comments
Perceptor type	Antennas	Two antennas to feel the land
Perceptor type	Nouse	To smell the trail
Effector type	Gland	To leave the trace of pheromones
Effector type	Arms	To take the piece of food from the cluster

Effector type	Legs	To move around the environment and carry out its objectives
Environment	2DSpace	
Resource	Trace	
Resource	Piece	

Input the brief description of the selected AML-based diagram in the view of relations between types of elements into the following blank field. If you create more diagrams, each one has to have a comment.

(input the description(s) of the selected AML-based diagram(s))

Perceptors and effectors of agents

In this diagram, the functioning of the effectors and perceptors is simply represented:

1-an ant feels a piece of food with its antennae

2-take that piece with your arms

3-leave the trace of pheromones through your gland as you move with your legs around the nest back to the nest.

4-leave the piece and while it progresses it smells if there is a trace to change its direction

Input the selected AML-based diagram(s) into the following blank field. If you need to separate the diagram into several parts, input these several divided parts under each other. Diagram has to be readable in the protocol.

(input the selected AML-based diagram(s))