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Preface

Research on Agents and Multi-Agent Systems has matured during the last decade and many effective applications of this technology are now deployed. An international forum to present and discuss the latest scientific developments and their effective applications, to assess the impact of the approach, and to facilitate technology transfer, has become a necessity.

PAAMS, the International Conference on Practical Applications of Agents and Multi-Agent Systems is the international yearly tribune to present, to discuss, and to disseminate the latest developments and the most important outcomes related to real-world applications. It provides a unique opportunity to bring multi-disciplinary experts, academics and practitioners together to exchange their experience in the development of Agents and Multi-Agent Systems.

This volume presents the papers that have been accepted for the 2011 edition. These articles capture the most innovative results and this year's trends: Finance and Trading, Information Systems and Organisations, Leisure Culture and Interactions, Medicine and Cloud Computing, Platforms and Adaptation, Robotics and Manufacturing, Security and Privacy, Transports and Optimisation paper has been reviewed by three different reviewers, from an international committee composed of 75 members from 24 different countries. From the 81 submissions received, 15 were selected for full presentation at the conference, and 24 were accepted for short presentation at the conference.

We would like to thank all the contributing authors, as well as the members of the Program Committee and the Organizing Committee for their hard and highly valuable work. Their work has helped to contribute to the success of the PAAMS'11 event. Thanks for your help, PAAMS'11 wouldn't exist without your contribution.

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A J-MADeM Agent-Based Social Simulation to Model Urban Mobility

Francisco Grimaldo, Miguel Lozano, Fernando Barber,
and Alejandro Guerra-Hernández

Abstract. The mobility models followed within metropolitan areas, mainly based on the massive use of the car instead of the public transportation, will soon become unsustainable unless there is a change of citizens' minds and transport policies. The main challenge related to urban mobility is that of getting free-flowing greener cities, which are provided with a smarter and accessible urban transport system. In this paper, we present an agent-based social simulation approach to tackle this kind of social-ecological systems. The Jason Multi-modal Agent Decision Making (J-MADeM) library enable us to model and implement the social decisions made by each habitant about how to get to work every day, e.g., by train, by car, sharing a car, etc. In this way, we focus on the decision making aspects of this problem at a micro level, instead of focussing on spatial or other macro issues. The first results show the different outcomes produced by societies of individualist and egalitarian agents, in terms of the average travel time, the use of the urban transportation and the amount of CO_2 emitted to the environment.

1 Introduction and Related Work

The mobility models followed within metropolitan areas, mainly based on the massive use of the car instead of the public transportation, will soon become unsustainable unless there is a change of citizens' minds and transport policies. This fact

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has been highlighted, for instance, by the European Commission through the Green Paper on Urban Mobility [3]. Cities all over the world face similar problems, e.g., congestion, road safety, security, pollution, climate change due to CO_2 emissions, etc. Since these problems are increasing constantly, humankind pays a high price both in economic and environmental terms, as well as for the health and quality of life of citizens. This money would be better spent for developing more efficient transport systems.

The main challenge related to urban mobility is that of getting free-flowing greener cities, which are provided with a smarter and accessible urban transport system. Agent-based social simulation (ABSS) has been proposed as a suitable manner to tackle this kind of Social-Ecological systems and Environmental Management [14], as well as in Economics [19], Anthropology [15], and Ecology [11]. ABSS provides a framework for implementing techniques that fulfill the requirements of environmental modelling. First, ABSS allows to couple the model of the environment to the social entities that it includes. For example, it makes possible to model aspects such as the roles of social interaction and the disaggregated adaptative human decision-making; and second, it enables the study the relationships between the micro-macro levels of decision making, and the emergence of collective behavior as the response to changes in the environment or in the environmental management policies.

Social and organizational models are being studied under the scope of multi-agent systems (MAS) in order to regulate the autonomy of self-interested agents. Nowadays, the performance of a MAS is determined not only by the degree of deliberativeness but also by the degree of sociability. In this sense, sociability points to the ability to communicate, cooperate, collaborate, form alliances, coalitions and teams. The assignment of individuals to an organization generally occurs in Human Societies [16], where the organization can be considered as a set of behavioural constraints that agents adopt, e.g., by the role they play [6].

The definition of a proper MAS organization is not an easy task, since it involves dealing with three dimensions: functioning, structure, and norms [13]. From the functioning perspective, systems focus on achieving the best plans and cover aspects such as: the specification of global plans, the policies to allocate tasks to agents, the coordination of plans, etc. [5]. From the structural perspective, systems focus on defining the organizational structures (roles, relations among roles, groups of roles, etc.) that establishes the obligations/permissions of their agents [8]. Very few models deal with both previous dimensions to support agent decision making about organizations, e.g., MOISE+ [13]. For the sake of simplicity, the third dimension is not discussed here.

Social reasoning has been extensively studied in MAS in order to incorporate social actions to cognitive agents [4]. As a result of these works, agent interaction models have evolved to social networks that try to imitate the social structures found in real life [12]. Social dependence networks allow agents to cooperate or to perform social exchanges attending to their dependence relations [18]. Trust networks can define different delegation strategies by means of representating the attitude towards the others through the use of some kind of trust model, e.g., reputation

[7]. Agents in preference networks express their preferences normally using utility functions so that personal attitudes can be represented by the differential utilitarian importance they place on the others' utilities. Following this preferential approach, the MADeM (Multi-modal Agent Decision Making) model [9] is a market-based mechanism for social decision making, capable of simulating different kinds of social welfares (e.g. elitist, utilitarian), as well as social attitudes of their members (e.g. egoism, altruism).

In this paper we present an ABSS approach to model the mobility within a metropolitan area. Other platforms have face this problem following a similar approach (e.g. UrbanSim [20]) but they usually focus on spatial issues to simulate large-scale urban areas, using gridcell, zonal, or parcel geographies. Instead, we propose focusing on the agent's decision making. At this micro level, the J-MADeM library has been used to model and implement the social decisions made by each habitant about how to get to work every day, e.g., by train, by car, sharing a car, etc. Although there is still work in progress, the main goal of the proposed system is to be used for research and as a decision support platform for metropolitan planning.

The rest of the paper is organized as follows: The next section reviews the J-MADeM library, which allows programming MADeM decisions at the agent level. In section 3 we introduce the urban mobility simulation framework as well as the definition of a simple "travel to work" scenario. Section 4 shows the different outcomes produced by a society of individualist and a society of egalitarian agents in terms of the average travel time, the use of the urban transportation and the amount of CO_2 emitted to the environment. Finally, in section 5 we state the conclusions and discuss about future work.

2 The J-MADeM Library

J-MADeM [10] is a full-fledge AgentSpeak(L) [17] library that implements the Multi-modal Agent Decision Making (MADeM) [9] model in *Jason* [1], the well known extended java based interpreter for this agent oriented programming language. The MADeM model provides agents with a general mechanism to make socially acceptable decisions. In this kind of decisions, the members of an organization are required to express their preferences with regard to the different solutions for a specific decision problem. The whole model is based on the MARA (Multi-Agent Resource Allocation) theory [2], therefore, it represents each one of these solutions as a set of resource allocations. MADeM can consider both tasks and objects as plausible resources to be allocated, which it generalizes under the term *task-slots*. MADeM uses first-sealed one-round auctions as the allocation procedure and a multi-criteria winner determination problem to merge the different preferences being collected according to the kind of agent or society simulated.

The J-MADeM library provides an agent architecture that *Jason* agents can use to carry out their own MADeM decisions; an ontology to express MADeM data as beliefs and rules; and a plan library to execute MADeM processes. The agent architecture `jmadem.MADeMAgArch`, implements in Java a set of actions (Table 1) performing the basic operations of the model. As usual in *Jason*, actions are prefixed by the name of the library, e.g., to set the welfare of the society as a nash equilibrium, the action `jmadem.set_welfare(nash)` is executed in a plan. Other MADeM parameters are defined in the same way. Although this Java based actions are often more efficient than the AgentSpeak(L) plans and rules, they hide information to the agents. For instance, the action $construct\_allocations/4$ basically computes the cartesian product of the slots domains, so that some kind of filtering at the Java level is required to obtain "legal" allocations; but the agents do not know what a "legal" allocation is, to the detriment of the agent metaphor, e.g., they can not reason about legal allocations, nor communicate about them.

Table 1 Actions defined in the J-MADeM library.

Action	Description
`add_utility_function("P.U")`	P is a Java package name and U the utility function name.
`add_utility_function(U,N)`	U is a utility name and N is fully qualified name of the function Java class.
`construct_allocations(T,S,E,Al)`	$T = t(S_1,\ldots,S_n)$ is a function denoting a task t of n slots, $S \subseteq \{S_1,\ldots,S_n\}$ is a set of task slots to be allocated, $E = [[e_1,\ldots,e_j],\ldots]$ elements in the domain of each slot, Al is the computed list of allocations
`launch_decision(A,AL,U,DId)`	A is a set of agents, AL is a set of allocations, U is a list of utilify functions, and DId is the output parameter.
`launch_decision1(A,AL,U,DId)`	As above, but it returns only 1 solution.
`remove_utility_function(U,N)`	U and N are as above.
`reset_personal_weights(PW)`	$PW = [jmadem\_personal\_weight(A,\_),\ldots]$.
`reset_utility_weights(UW)`	$UW = [jmadem\_utility\_weight(U,\_),\ldots]$.
`set_list_of_personal_weights(PW)`	$PW = [jmadem\_personal\_weight(A,W),\ldots]$, where A is an agent and $W \in \Re$ his personal weight.
`set_list_of_utility_weights(UW)`	$UW = [jmadem\_utility\_weight(U,W),\ldots]]$, where U is an utility name and $W \in \Re$ its weight.
`set_personal_weight(A,W)`	A is an agent and $W \in \Re$ is his weight.
`set_remove_MADeM_data(V)`	If V is *true* MADeM data is deleted at the Java level, once the decision is done.
`set_timeout(T)`	T is a numerical value in milliseconds (1000 by default).
`set_utility_weight(U,W)`	U is a utility name and $W \in \Re$ is its weight.
`set_welfare(W)`	$W \in \{utilitarian, egalitarian, elitist, nash\}$ is the welfare.

In order to provide a full-fledge AgentSpeak(L) layer in the library, J-MADeM agents use an ontology (Table 2) to define the data of a decision process declaratively, as beliefs and rules. In this way, data is accessible to Test Goals and Speech Acts with *Ask*-like performatives. Utilities and filters can also be defined as beliefs or rules. For instance, considering allocations of the form showed below in equation 1, the rule:

```
jmadem_utility(dummyUF,_,Alloc,0) :-
    .my_name(Myself) &
    owns(Myself,Vehicle) &
    .member(travel_by(_,Vehicle), Alloc) &
    not .member(travel_by(Myself,Vehicle),Alloc).
```

Table 2 The ontology used by J-MADeM agents.

Belief formula	Description
`jmadem_list_of_personal_weights(PW)`	*PW* is a list of personal weight, as defined below.
`jmadem_list_of_utility_weights(UW)`	*UW* is a list of utility weights, as defined below.
`jmadem_filter(F,Al)`	*F* is the name of the filter *Al* is an allocation to be filtered.
`jmadem_personal_weight(A,W)`	*A* is an agent and $W \in \Re$ his weight.
`jmadem_timeout(T)`	*T* is the timeout in millisecond (1000 by default).
`jmadem_utility(U,N)`	*U* is the utility function name and *N* is the name of the java class.
`jmadem_utility(U,A,Al,V)`	*U* is the utility function name, *A* is the auctioneer agent, *Al* is an allocation, and *V* is the utility value assigned to *Al* according to *U*.
`jmadem_utility_weight(U,W)`	*U* is an utility name and $W \in \Re$ is its weight.
`jmadem_welfare(W)`	$W \in \{utilitarian, egalitarian, elitist, nash\}$.

expresses that an agent is not interested in sharing his vehicle if he is not travelling by too, following the utility function `dummyUF`. And:

```
jmadem_filter(dummyFilter,Alloc) :-
    .my_name(Myself) &
    owns(Myself,Vehicle) &
    .member(travel_by(_,Vehicle), Alloc) &
    not .member(travel_by(Myself,Vehicle),Alloc).
```

defines a filter to delete such instances from the set of allocations computed by the agent. In addition, J-MADeM provides a library of plans `jmadem.asl` to call MADeM processes as Achieve Goals. The trigger events recognized by these plans are listed in Table 3. Utilities and filters can also be defined as plans. For instance, the utility function in the previous example would be defined as a plan as follow:

```
+!jmadem_utility(dummyUF,_,Alloc,0) :
    .my_name(Myself)&
    owns(Myself,Vehicle) &
    .member(travel_by(_,Vehicle), Alloc) &
    not .member(travel_by(Myself,Vehicle),Alloc).
```

Table 3 Trigger Events used by J-MADeM agents.

Trigger Event	Description
`+!jmadem_get_utility_function_names(U)`	*U* is a list of utility names.
`+!jmadem_construct_allocations(T,E,Al)`	*T* is a set of task slots, *E* is a logic formula to compute the elements of the allocation, and *Al* is the resulting set of allocations.
`+!jmadem_filter_allocations(F,Al,FAls)`	*F* is a filter, *Al* is a set of allocations, *FAls* is a set of filtered allocations.
`+!jmadem_launch_decision(A,Al,U,DId)`	*A* is a set of agents, *Al* is a set of allocations, *U* is a list of utility function names, *DId* is a decision identifier.
`+!jmadem_launch_decision1(A,Al,U,DId)`	As above, but for 1 solution.

Then, Speech Acts with *AskHow*-like performatives can be used to exchange utilities and filters defined as plans. Interestingly, there is a plan for constructing allocations after the beliefs of an agent, finding all the allocations that satisfies a logical query E defined by the programmer. Thus “legal” allocations are computed directly. Alternatively, allocations can be further filtered by means of the achieve goal `!jmadem_filter_allocations`.

3 Urban Mobility Simulation Framework

In this section we introduce an urban mobility simulation framework developed over Jason that allows to model the mobility within a metropolitan area. This multi-agent system is highly configurable through XML configuration files, thus, it can be applied to different scenarios. For instance, the user can specify how many towns surround the city as well as the roads that interconnect them. For each of these entities, concrete parameters can be set such as: the number of habitants, the income per capita distribution, the transports available (e.g. car, train, bus), the length and flow of the roads, etc. The environment is based on a very simple traffic simulator that returns the real times and consumptions of each vehicle. On the other hand, each citizen is represented by an agent that uses the J-MADeM library to make decisions that balance individual and social preferences.

As a proof of concept, in this paper we present the “travelling to work” scenario. This scenario represents a 20 Km long road connecting a residential town to a city. Every morning, the habitants of this town must travel to the city to reach their workplaces. Each habitant owning a car can drive alone to work but he/she can also share the car with other habitants, thus lowering the expenses and the CO_2 emissions. Besides, there is the possibility to travel by train, which in the experiments is considered to emit no CO_2 and to cost 1 €/trip. Cars travel at an average speed of 100 Km/h and the train does at 60 Km/h, including all possible stops. However, as the road has a limited flow, when too many cars try to enter the city at the same time they will create a traffic jam, which may produce long delays. We have also set to 5 minutes the delay associated with both catching the train and picking-up each extra passenger in a shared car.

J-MADeM has been used in this scenario to model the main decision that habitants make every morning. That is, which transport to use for travelling to work: alone in their own car, sharing a car or by train. Citizens are randomly organized in decision groups meaning their family, friends, neighbors, etc. As we have fixed the maximum capacity of cars to 4 people, this is also the size of the decision groups. Therefore, the allocations used to represent each travel alternative for each group in this scenario are as follows:

$$alloc_i = [travel\_by(agent_1, vehicle_1), ..., travel\_by(agent_4, vehicle_4)] \qquad (1)$$

where $agent_i$ are the group members and $vehicle_i \in \{car_1, ..., car_4, train\}$ is the transport chosen by each member (logically, car_i belongs to $agent_i$). It should be noticed that, even though every habitant can travel in any car, it is a must that the owner of a car also travels in the car to be a valid allocation.

J-MADeM then collects the preferences of the group about every possible alternative. To express their personal preferences according to different points of view, habitants compute the utility functions defined in equation 2. Function UF_{eco} represents economy and it calculates the monetary cost of each allocation. Function UF_{tmp} informs about the travel time associated to the allocation and, finally, function UF_{CO_2} models its ecological impact in terms of the kilograms of CO_2 emitted to the environment. Consumption and travel times are estimated by remembering previous travel experiences with a similar vehicle-partners configuration. Utility functions represent costs in euros to be able to properly combine them in the J-MADeM process. Finally, J-MADeM selects the winner allocation, which is passed to the traffic simulator in the environment. For the winner determination, we use the Utilitarian collective utility function as an appropiated social welfare to reflect the aggregate impact of the kind of allocations considered.

$$\begin{aligned} UF_{eco}(alloc_i) &= (Consumption(alloc_i) * PricePerLitre)/Partners(alloc_i) \\ UF_{tmp}(alloc_i) &= Time(alloc_i) + Partners(alloc_i) * PickUpTime \\ UF_{CO_2}(alloc_i) &= (Consumption(alloc_i) * CO2PerLitre)/Partners(alloc_i) \end{aligned} \tag{2}$$

Other works [14] have assumed that agents use different world views to interpret the climate change and, consequently, they have distinguished different types of policies based on cultural perspectives:

- *Hierarchical*: It assumes that nature is stable in most cases but it can collapse if we go beyond the limits of its capacity.
- *Egalitarians*: It assumes that the nature is highly unstable and the least human intervention may lead to a collapse.
- *Individualist*: It assumes that the nature provides plenty of resources and it will remain stable under human interventions. Essentially, it encourages strategies that maximize the economic growth.

In order to model the individualist and the egalitarian perspectives in the "travelling to work" scenario, we use the weights that J-MADeM allows to associate to each utility function. Thus, we can simulate the behavior of an individualist and an egalitarian society by using the utility weights in table 4

Table 4 Utility weights used for defining the Individualist and the Egalitarian societies

Type	UF_{eco}	UF_{tmp}	UF_{CO_2}
Individualist	1	0.1	0.1
Egalitarian	1	0.5	0.4

4 Results

This section shows the first results obtained when running the “travelling to work” scenario with 32 habitants for a period of 100 cycles or days. Following table 4, we have simulated the behavior of two types of habitants: a society of individualist and a society of egalitarian agents.

Figure 1 shows the outcomes produced by these societies in terms of the average travel time, the use of the urban transportation and the amount of CO_2 emitted to the environment. In the top left-hand corner, figure 1.a shows the average car/train travel time (in seconds) for both egalitarian and individualist populations. In the top right-hand corner, figure 1.b shows the total amount of kilograms of CO_2 emitted to the environment each day (cycle). In the bottom left-hand corner, figure 1.c shows the average number of passengers per car and, finally, figure 1.d shows the number of habitants travelling by each type of vehicle.

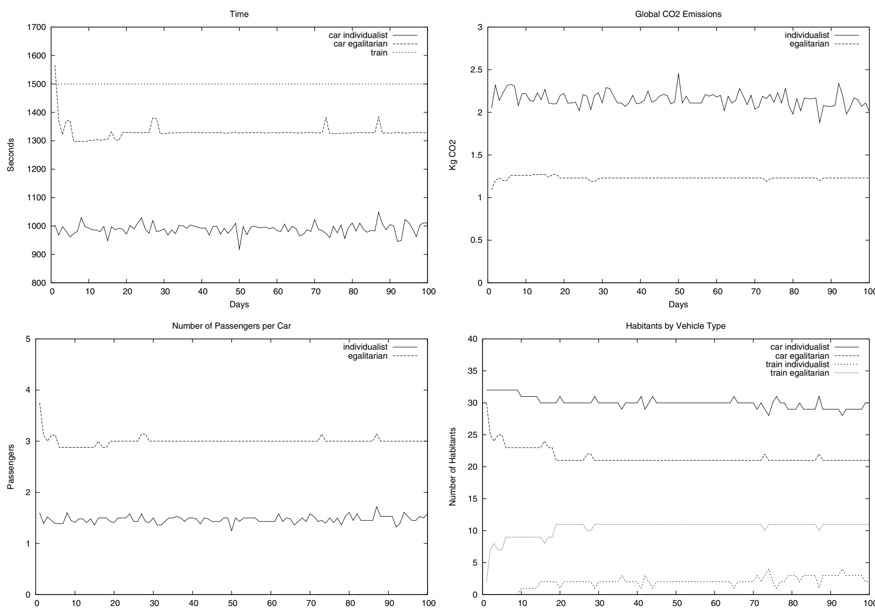

Fig. 1 a)Average travel time; b)CO_2 Emissions; c)Average passengers per car; d)Habitants per type of vehicle.

As shown in figure 1.a, individualist habitants are mainly interested in reducing the travel time. Hence, they usually prefer to travel by car (see the high number of agents using this type of vehicle in figure 1.d). Besides, they rarely share it with another partner as demonstrated by the low values in figure 1.c. Thus, this behavior is eventually reflected in the amount of CO_2 emitted by individualists which is higher than the pollution derived from the egalitarian society.

On the other hand, the average travel time of egalitarian citizens is logically higher (see figure 1.a) since they are also interested in balancing the $C0_2$ emissions and the monetary cost derived from their actions (see table 4). They manage to do this by increasing the degree of car sharing. For instance, when travelling by car, they normally share it with 2 other passengers (see figure 1.c). Additionally, a 30% of the habitants decides to travel by train (see figure 1.d). As a consequence of this behavior, the kilograms of $C0_2$ finally emitted by the egalitarian society is considerably reduced (see figure 1.b).

Although not included in this paper, we have also computed the delay incurred by both societies to verify that the simulation framework has been properly adjusted. The delay is calculated (for each day and agent) as the difference between the desired time to be at work and the arrival time coming from the simulator. The experiments carried out produce an average delay that converges quickly to a small negative value (around 1 minute), which indicates that the habitants are arriving just before they planned. This situation reveals that the scenario has been properly parameterized as different behavior emerge from the societies and both of them arrive on time.

5 Conclusions and Future Work

In this paper we have presented an urban mobility simulation framework developed over Jason that allows to model the mobility within a metropolitan area. The system uses the Jason Multi-modal Agent Decision Making (J-MADeM) library to model and implement the social decisions made by each habitant about how to get to work every day, e.g., by train, by car, sharing a car, etc. Therefore, the proposed approach focuses on the decision making aspects of this problem at a micro level, instead of focusing on the classical spatial or other macro level issues. The first results show the behavior of two societies of individualist and egalitarian citizens, which affect the average travel time, the use of the urban transportation and the amount of CO_2 emitted to the environment.

There is still work in progress to achieve the goal of developing a decision support platform for metropolitan planning. First, we are analyzing more complex scenarios that involve the use of new transports such as the bus or the bike. Second, we plan to extend the configuration files to include features such as the use of tolls or high-occupancy vehicle lanes. Regarding the infrastructure, we are currently studying the scalability of multi-agent systems in Jason so that we can run large-scale simulations.

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References

1. Bordini, R.H., Hübner, J.F., Wooldrige, M.: Programming Multi-Agent Systems in Agent Speak using Jason. Wiley, Chichester (2007)
2. Chevaleyre, Y., Dunne, P.E., Endriss, U., Lang, J., Lemaitre, M., Maudet, N., Padget, J., Phelps, S., Rodriguez-Aguilar, J.A., Sousa, P.: Issues in multiagent resource allocation. Informatica 30, 3–31 (2006)
3. E. Commission Towards a new culture for urban mobility (September 2007), http://ec.europa.eu/transport/urban/index_en.htm
4. Conte, R., Castelfranchi, C.: Cognitive and Social Action. UCL Press, London (1995)
5. Decker, K.S.: Task environment centered simulation. In: Simulating Organizations: Computational Models of Institutions and Groups, pp. 105–128. AAAI Press / MIT Press, Menlo Park (1998)
6. Dignum, V., Dignum, F.: Modelling agent societies: Co-ordination frameworks and institutions. In: Brazdil, P.B., Jorge, A.M. (eds.) EPIA 2001. LNCS (LNAI), vol. 2258, pp. 191–204. Springer, Heidelberg (2001)
7. Falcone, R., Pezzulo, G., Castelfranchi, C., Calvi, G.: Why a cognitive trustier performs better: Simulating trust-based contract nets. In: Proc. of AAMAS 2004: Autonomous Agents and Multi-Agent Systems, pp. 1392–1393. ACM, New York (2004)
8. Ferber, J., Gutknecht, O.: A meta-model for the analysis and design of organizations in multi-agents systems. In: Proc. of the 3rd International Conference on Multi-Agent Systems (ICMAS 1998), pp. 128–135. IEEE Press, Los Alamitos (1998)
9. Grimaldo, F., Lozano, M., Barber, F.: MADeM: a multi-modal decision making for social MAS. In: Proc. of AAMAS 2008: Autonomous Agents and Multi-Agent Systems, pp. 183–190. ACM, New York (2008)
10. Grimaldo, F., Lozano, M., Barber, F.: J-MADeM, an open-source library for social decision-making. In: Proc. of CCIA 2009: International Conference of the Catalan Association for Artificial Intelligence, pp. 207–214. IOS Press, Amsterdam (2009)
11. Grimm, V.: Ten years of individual-based modelling in ecology: what have we learned and what could we learn in the future? Ecological Modelling 115(2-3), 129–148 (1999)
12. Hexmoor, H.: From inter-agents to groups. In: Proc. of ISAI 2001: International Symposium on Artificial Intelligence (2001)
13. Hübner, J.F., Sichman, J.S., Boissier, O.: Developing organised multi-agent systems using the Moise+ model: Programming issues at the system and agent levels. International Journal of Agent-Oriented Software Engineering 1(3/4), 370–395 (2007)
14. Janssen, M.A., Ostrom, E.: Governing social-ecological systems. In: Tesfatsion, L., Judd, K.L. (eds.) Handbook of Computational Economics, 1st edn., vol. 2, ch. 30, pp. 1465–1509. Elsevier, Amsterdam (2006)
15. Kohler, T., Gumerman, G., Reynolds, R.: Simulating ancient societies. Scientific American 293(2), 76–83 (2005)
16. Prietula, M., Carley, K., Gasser, L. (eds.): Simulating Organizations: Computational Models of Institutions and Groups. AAAI Press / MIT press (1998)
17. Rao, A.S.: AgentSpeak(L): BDI agents speak out in a logical computable language. In: Perram, J., Van de Velde, W. (eds.) MAAMAW 1996. LNCS, vol. 1038, pp. 42–55. Springer, Heidelberg (1996)

18. Sichman, J., Demazeau, Y.: On social reasoning in multi-agent systems. Revista Ibero-Americana de Inteligencia Artificial 13, 68–84 (2001)
19. Tesfatsion, L.: Agent-based computational economics: A constructive approach to economic theory. In: Tesfatsion, L., Judd, K.L. (eds.) Handbook of Computational Economics, vol. 2, ch. 16, pp. 831–880. Elsevier, Amsterdam (2006)
20. Waddell, P.: Urbansim: Modeling urban development for land use, transportation and environmental planning. Journal of the American Planning Association 68, 297–314 (2002)

Diversity of the Knowledge Base in Organizations: Results of an Agent-Based Simulation

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Abstract. The knowledge base used in organizations for decision-making usually is diverse due to various information systems or differing expertise of decision-makers. By an agent-based simulation the paper analyzes the question which level of diversity in the knowledge base in an organization is beneficial. The findings indicate that the preferable level of diversity subtly depends on the need and the mode to coordinate decisions in organizations. However, the findings provide support to rather unify the knowledge base on a medium level of quality than fragmenting and specializing the knowledge base. Furthermore, it appears that learning and adjustment capabilities in decentralized structures are more promising than the investment in a knowledge base as perfect as possible.

1 Introduction

An enduring challenge in organizations is to coordinate decisions of organizational units so that the organization's objective is achieved best possible. Among the problems is that decentral decision-makers usually dispose of diverse knowledge. This addresses the two sides of the same coin: Decisions are delegated to benefit from the expertise of specialists (e.g. [17, 3, 4]) while, at the same time, at least two problems emerge. Firstly, if knowledge differs among subunits there is no guarantee that these units estimate the same strategies to be preferable with respect to the organization's objective and, so, the decentral decisions might be unaligned. Secondly, asymmetrically allocated information may be used by self-interested decision-makers for their own best interest without that the headquarters or other decision-makers have the opportunity to detect this so-called opportunistic behavior. Powerful means to deal with these problems are, for example, *incentive systems* as well as *integrated information systems (IS)*. With incentive systems individual interests can be aligned to

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the organization's objective and, so, opportunism is mitigated [13]. Integration of IS (e.g. [5, 15]) to a certain extent can unify the knowledge base of departmental decision-makers and contributes to mitigate opportunistic behavior as it most likely reduces information asymmetries. However, integration runs the risk to standardize what better should be distinct [6, 10]. Furthermore, different mental models and personal expertise are likely to exist regardless of the IS.

So, the very core of the problem remains: *Which level of diversity of the knowledge base in an organization is beneficial given the trade-off among specialization and coordination?* This represents the research question of the paper and can be put more into concrete for IS design in terms of *"What is the appropriate level of integration?"* [6, 5, 10] or might be related to the rather abstract issue of *"homogeneity or heterogeneity of resources"* in organizations (e.g. [7, 1]).

In order to investigate the research question an agent-based simulation is applied. Artificial organizations are sent to fitness landscapes and observed while searching for higher levels of performance. The agents of the model represent departments and the headquarters. Each agent is characterized by an information-level according to the particular expertise, decisional competencies, behavior and preferences. According to the three-dimensional framework of *agent-mediated knowledge management* elaborated by van Elst, Dignum and Abecker [2] our work

- relates to the stage of *analysis* in systems development
- allows to examine *homogeneous* as well as *heterogenous* multi-agent systems
- concentrates on the *utilization* of knowledge for decision-making.

So, we use an agent-based approach as a means to improve the understanding of the effects of diverse knowledge on organizational performance. For a more practical perspective the findings, for example, could contribute to identifying an appropriate level of IS integration and of personel expertise for various coordination needs.

2 Model

The interactions between the decisions that departmental managers are in charge of affects the need for coordination and, thus, reasonably represent an essential point for the effects of a diverse knowledge base. In order to deal with decisional interactions in a controllable way Kauffman's NK model [9, 8] is an appropriate framework. On this basis and similar to Siggelkow and Rivkin [19] we model organizations with self-interested departmental managers and coordination mechanisms. Though we use an advanced version of the NK model with adaptive walks on noisy fitness landscapes as introduced by Levitan and Kauffman [14] our model substantially is distinct as the knowledge base is diversified across the organization.

Our organizations face a ten-dimensional binary decision problem, i.e. have to make decisions $d_i \in \{0,1\}$ with $i = 1,..10$ (so $N = 10$). Each single state of decision d_i provides a uniformly distributed contribution C_i with $0 \leq C_i \leq 1$ to the overall performance $V(\mathbf{d})$ of the organization. In order to map interactions among decisions, C_i does not only depend on the decision d_i but also on K_i other decisions

$d_{j,j\in\{1,\ldots K_i\},j\neq i}$ so that $C_i = f_i(d_i; d_{j=1},\ldots,d_{j=K_i})$. The overall performance $V(\mathbf{d})$ of an organization is given as normalized sum of performance contributions C_i with

$$V(\mathbf{d}) = \frac{1}{N}\sum_{i=1}^{N} C_i = \frac{1}{N}\sum_{i=1}^{N} f_i(d_i; d_{j=1},\ldots,d_{j=K_i}) \tag{1}$$

where $j \neq i$. In our model the agents are the headquarters and $r \in \{1,2,3\}$ departments. Each department is responsible for a partial decision problem (i.e. some of the ten single decisions). In each period a department searches for the best configuration for its "private" partial decision problem and, while doing so, assumes that the other departments do not alter their prior choices.

The evaluation of configurations clearly depends on the incentives. For simplicity the departmental decision-makers are given firmwide incentives so that no conflicts of interest occur, i.e., departments seek to decide in the organization's best interest (thus, we can ignore issue 2 as mentioned in the beginning of the paper and concentrate on the diverse knowledge base). In particular, the compensation in a linear incentive scheme depends on two components, (1) the "own" performance P_r^{own} which is the sum of those C_i related to the subset of i decisions a department head is in charge of and (2) the "residual" performance P_r^{res}, i.e., the performance contributions of those decisions other departments are responsible for . As the head of department r seeks to maximize compensation that configuration $\mathbf{d}$ is preferred that maximizes the value base B_r for compensation. With cross-departmental interactions among decisions a departmental manager r might affect P_r^{res}, and also P_r^{own} might be affected by decisions of other departments.

Our organizations can operate under two alternative *coordination modes* [19]: either the departments propose configurations $\mathbf{d}$ according to their preferences to the headquarters which chooses that one with the highest overall performance ("central") or each department autonomously decides on the "own" partial decision problem ("decentral"). In the latter case the overall configuration $\mathbf{d}$ results as a combination of these departmental decisions without any central intervention.

Our agents use information for identifying superior solutions according to the known contribution to compensation or overall performance, respectively. To be more precise on the *diversity of knowledge base* the model distinguishes three dimensions of diversity:

- *Spread of specialized and general knowledge of a single decision-maker:* Each decision-maker is informed about the decisions he/she is responsible for and the resulting consequences for the own area of competence. Additionally, a decision-maker disposes of information related to the rest of the organization. In this dimension diversity depends on whether, for example, the decision-maker's knowledge is more specialized for the own area of competence or rather generalized with respect to the whole organization.
- *Number of different views within the organization:* According to the aforementioned dimension each decision-maker has a different view (or knowledge) of the organization's decisional problems due to specialization. So, the knowledge base that is applied is the more diverse the more the decision-problem is fragmented

and the higher the number of decision-makers (or departments) that these "partial" decisions are delegated to.

- *Diversity of information-processing capabilities among decision-makers:* Some decision-makers might be very well informed whereas others work on a very noisy basis of information; some might act on a specialized knowledge base according to the first dimension whereas others have no certain expertise.

We assume that departments decide on basis of the *perceived* value base B_r^* for compensation rather than the true value base. Therefore, we "distort" the true performance contributions of the single decisions d_i according to the dimensions of diversity as introduced above. In particular, the performances a department r *perceives* result as sum of true performances and an error term like

$$P_r^{*own} = P_r^{own} + e_r^{own} \tag{2}$$

and

$$P_r^{*res} = P_r^{res} + e_r^{res} \tag{3}$$

Accordingly, in case of coordination mode "central" the headquarters' makes the choice of the proposals on basis of the *perceived* overall performance $V^*(\mathbf{d})$ given as sum of the true overall performance $V(\mathbf{d})$ and an error term e_{head}. At least, with respect to accounting systems [12], it is reasonable that high (low) true values of performance come along with high (low) distortions. So, we reflect distortions as *relative* errors imputed to the true performance (for other functions [14]), and, for simplicity, the errors follow a Gaussian distribution $N(\mu;\sigma)$ with expected value $\mu = 0$ and standard deviation σ.

Furthermore, the organizations might have learning capabilities. To incorporate "learning" the errors related to a certain configuration $\mathbf{d}$ are reduced (with decreasing rates) whenever this configuration is realized (again) by the organization [21].

3 Results and Interpretation

The simulated organizations are thrown randomly somewhere in the fitness landscape in order to search for configurations $\mathbf{d}$ with superior levels of performance $V(\mathbf{d})$. As familiar for adaptive walks we use a hill-climbing algorithm: In the neighborhood of the status-quo-configuration our departments find two alternatives so that each department knows three options. Four scenarios of diversity in the knowledge base are simulated (table 1):

In scenario "Perfect" all decision-makers have perfect knowledge and, in consequence, there exists only one view of the decision-problem. This rather theoretical scenario serves as a kind of "benchmark". In scenario "Special" departmental managers are well informed about their own task but with quite vague knowledge about the cross-departmental effects. In scenario "General" the expertise is lower, but the organization-wide knowledge is better. Thus, among these two scenarios a "trade-off" between expertise and general knowledge is incorporated. In scenario "Nescient" one of the three departments has very vague knowledge. With "central"

Table 1 Scenarios of knowledge base in organizations

Dimension of diversity	Scenario "PERFECT"	Scenario "SPECIAL"	Scenario "GENERAL"	Scenario "NESCIENT"
Spread of knowledge on departments' site	$\sigma_r^{own} = 0$ $\sigma_r^{res} = 0$ ($\sigma_{head} = 0$)	$\sigma_r^{own} = 0.05$ $\sigma_r^{res} = 0.2$ ($\sigma_{head} = 0.12$)	$\sigma_r^{own} = 0.1$ $\sigma_r^{res} = 0.15$ ($\sigma_{head} = 0.12$)	like SPECIAL but dpmt. 3: $\sigma_3^{own} = 0.15$ $\sigma_3^{res} = 0.3$
No. diff. views	1	3 (4)	3 (4)	3 (4)
Differences in info.-processing capabilities	no	no	no	yes

coordination the headquarters' knowledge which is adjusted to a medium level of noise is involved in decision-making and, by that, a fourth perception is involved. The order of magnitude of the error terms was based on insights from organizational theory (e.g. [17, 3, 4, 7]) and calibrated due to findings on the information quality in organizations (e.g. [12, 16, 20]). With incorporating learning the diversity of the knowledge base diminishes in the course of the adaptive walk as the error terms are reduced according to the experience with the area in the fitness landscape.

The simulations were conducted for various interaction structures of decisions (i.e. coordination needs). Tables 2 and 3 report results for two exemplary *intensities of interactions* among decisions (for these and other interaction structures see [18]) which in a way represent two extremes: In the "low" case intra-departmental interactions among decisions are maximal intense while no cross-departmental interdependencies exist. In contrast, in the "high" case all decisions affect the performance contributions of all other decisions, i.e., the intensity of interactions and the coordination need is raised to maximum. While Speed 1 in the tables represents the performance improvement achieved in the first period, Speed 2 is able to reflect in the purest way possible the effect of learning because in period 2 for the first learning might affect decision-making. The average performance over 200 periods as well as the level of performance achieved in the end of the observation time might be regarded as condensed measures for the effectiveness of the search process.

In order to go more into the details and interpretation of the results, we begin with comparing the "Perfect" scenario to the others, then discuss the effect of learning and, subsequently, address the effect of the coordination mode.

So, comparing the "Perfect" scenario to the other scenarios the results provide broad, but no general support for conventional wisdom whereby decision-making based on perfect knowledge leads to higher speed and level of performance than achievable with imperfect knowledge. Two reasons support conventional wisdom [14]: (1) a *false positive* option appears favorable to decision-makers, whereas, in fact, it reduces performance compared to the status-quo level; (2) a *false negative* option appears not beneficial and is rejected while the current configuration of decisions **d** is perpetuated. Interestingly, the results show some exceptions to conventional wisdom and we return to that issue below.