Framework for Evaluation of Networked Mobile Games

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ABSTRACT

In this position paper we propose an evaluation framework for networked mobile gaming, consisting of user, group, communication, and environment models. Each of these components acts as a detailed representation of real-world characteristics. The combination of these models allows a realistic modeling of mobile gaming scenarios. The main contribution of our approaches is a new class of mobility models, which are purely based on strategies derived from real-world scenarios. This allows us to simulate the behavior and the movement of users and groups, and the communication aspects, and thus, it facilitates a creation of test beds for mobile applications. These simulated users interact, e.g. communicate, with each other and are able to move purposeful as well as to build groups spontaneously depending on the similarity of their goals or individual strategies. The paper presents an analytic discussion of the framework, its architecture, and the current state of its implementation.

Keywords

Evaluation of Games, Mobile Gaming, Mobility Models, Simulation.

1. INTRODUCTION

For the evaluation of networked mobile games, especially within mobile ad hoc networks, there is an increasing need for sufficiently realistic models for user and group mobility, communication and environment. For example, currently existing mobility models are highly dynamic, particular in terms of stochastic movement patterns, but they do not consider the individual behavior of a moving object. Thus, they are not suitable for real world scenarios.

An example of the typical scenario we want to evaluate can be described as follows:

- An urban agglomeration, subway, in the morning, hundreds of users are interested in mobile gaming during their trip to work
- Spontaneously, the players form virtual groups to play based on various parameters such as genre of the game, player skills, trip destination, types of gaming devices, etc.
- Ad hoc network: due to the spontaneous character of mobile gaming no infrastructure is available for such a scenario

To realistic evaluation of this application scenario it is important to have a adequate model of all components involved, such as user and group mobility, communication aspects, and the surroundings.

In this position paper we propose an evaluation framework for networked mobile gaming with a new class of mobility models based on the above described features. The environment model represents objects such as buildings, roads, hills, and access points. These objects can be placed by hand at designated positions or, if required, automatically at random positions. At the start of the simulation, players are either assigned to certain positions or randomly located along their movement paths. At this stage there are not yet any groups involved. The associated communication model, based on the well-known free space propagation model, has been extended with terms describing the impact of obstacles, and the heterogeneity of communication devices like types of antennas or transmission power, on propagation characteristics. The single-user mobility model is based on user/player strategies mapped from the real world to virtual agents interacting with each other or with groups of users. These strategies reflect single-user goals as well as group ambitions. All the functionalities mentioned above are available, or deliverable, to other associated models via predefined interfaces (Fig.1) leading to a high degree of modularity. The whole framework determines the behaviors of users located on the map and the movement patterns of single users and groups.

Current mobility models, such as Random Walk or Random Waypoint are lightweight and focus on a simple and quick implementation due to the lack of appropriate validation methods and to the absence of real movement traces. This leads to difficulties in the evaluation of new communication aspects, for example in mobile ad-hoc networks. However, such stochastic and simplified models are not capable of accurate modeling of realistic scenarios; for such tasks we need a real-world environment as well as models for natural behaviors of participating players.

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Generally, in the real world, each movement takes place individually or within groups [2, 3]. Within simulated communication scenarios, the movement of hosts follows certain well-defined global rules, specified within so-called user mobility models. The main aspect of the rising demand for realistic mobility models is the increasing importance of ad hoc technology, i.e., the topology form where the network does not include any kind of fixed infrastructure for packet forwarding such as access points, etc. This leads to several problems with regard to setting up of appropriate test beds, especially in the generation movement patterns and models of player behaviors. Additionally, the communication connections between players are of a self-organizing nature: an individual host's movement depends on the movements of the nearby hosts, and their data and control paths often change abruptly. Within simulation environments, typical mobile users/players should move independently of each other. According to their flexibility, mobile ad hoc networks can emerge spontaneously as soon as several devices are located close to each other. Understandably, they have to support similar types of communication technology. Therefore, the mobility models become more important due to the new perspective on investigation of quality of service, security, and the performance. Simulations with new types of devices have to be executed under more and more realistic conditions. For this reason, we do not always have the opportunity to consider real test data for research issues. Often, this type of data is not available at all due to the newness of the technology. On the other hand, multiple simulation runs with equal parameters do not conform to realistic situations.

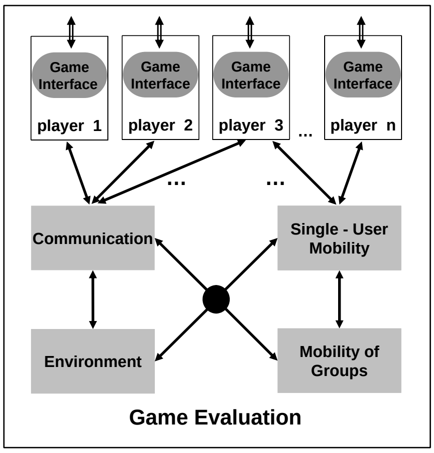

Figure 1: Framework for Game Evaluation.

Today's models are highly dynamic, particularly in terms of stochastic movement patterns. They are based on statistical or deterministic assumptions, and sometimes on heuristic specifications, but they do not consider individual behaviors of moving objects and create movement patterns poorly representative of real movements, as we describe in more detail in Sections 2 and 3.

This paper is organized as follows: First we describe the related work dedicated to the different movement patterns resulting from currently used mobility models. Following which, we present our approach for Strategy-Based Mobility Model in Section 3. In Section 4, we discuss its implementation, and conclude in Section 5 with a description of the ongoing work as well as our future intentions.

2. RELATED WORK

To our best knowledge there are currently no solutions for the evaluation of mobile gaming. Furthermore, existing solutions for evaluation of wireless ad hoc communication protocols lack the desired degree of realism as we discus in this section.

Random Walk [2] and Random Waypoint [5] are the most frequently employed mobility models. However, their movement patterns are abstract, simplified, not realistic, or realistic only under certain conditions and extensions. The Random Walk algorithm implements many abrupt, unrealistic changes of direction. Random Waypoint, similar to Random Direction [2], does not consider any geographic restrictions located between start and end points of particular movements. Additionally, the use of nearly all these models raises questions about the sense of equal distribution of movement targets and about the 'time of rest' and unrealistic behaviors of simulated users on the border of the investigated area.

The Boundless Simulation Area [6], Gauss-Markow [12], and Probabilistic Random Walk [2] models all consider the previous speed as well as the previous direction in estimating new targets and the resulting speed values. Thus, such approaches are more realistic. Some of the already proposed models, in accordance with their special rules, can be used only for certain scenarios with dedicated characteristics (e.g., highways, streets, military formations, etc.) because they more closely model these scenarios. Invariably, knowledge of the scenario under investigation is an important factor for the choice of a mobility model [11, 3], e.g., for tests of communication protocols in such scenarios. The more detailed the mobility model is, the more accurate and useful are the obtained results. Similar to the models mentioned above, the latest models consider neither any kind of geographic restrictions nor the individual preferences of users.

Lately, Jardosh et all [8] introduced with their Obstacle Mobility Model (OMM) an abstract map including buildings with gates linked via ways. This model includes a map of real-world topographical terrain as well as a simple model for communication. The obstacles are objects characterized by their arbitrary positions and by their sizes. They are represented by polygonal shapes and are located randomly on a virtual map of the observed region. This allows the description of different environments with a much closer resemblance to reality. The most significant part of this model is the movement graph, which represents a set of all possible pathways for participating users. The Voronoi Diagram method, based on obstacle corners, is used for computing and fixing possible pathways. In this method, pathways lie halfway between obstacles in the surroundings (Fig.2). The route selection is based on shortest path routing policy and allows the movement of users between two arbitrary points lying somewhere on the movement graph. Generally, the user can go through the obstacles (e.g., buildings) if the shortest path policy requires and/or allows it. Thus, the model takes a big step forward towards reality; on the other hand it remains simple and abstract enough.

But all these models do not regard the user as an impor-

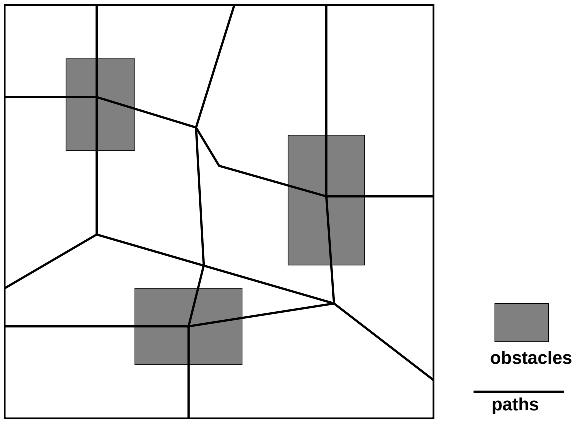

Figure 2: Obstacle Mobility Model.

tant part of the simulation: neither his preferences nor his abilities are taken into account.

Nearly all the mobility models proposed up till now create movement patterns which are not comparable to real movements [10],[8]. Also, they [3],[4] do not really describe the investigated scenarios, rather they are based on statistical or deterministic assumptions, but seldom on heuristic specifications. Typical crowd scenes like pedestrian zones, shopping areas, exhibitions, fairs, campuses etc., can not be well-described by patterns of random direction or random destination. In real-world scenarios, people prefer to walk on self-defined paths towards self-selected destinations. Thereby, the people often take into consideration existing obstacles or visible or assumed crowds, composition of ways, and subjective attraction of surrounding environments, for their decisions about new targets. The majority of people usually follow provided paths, though some of them cross the areas for potential way reduction or due to instinctive change of mind. Additionally, obstacles in the real world are typically not randomly located, and in no case buildings, roads, clump of trees, etc. The correct choice of a mobility model has a significant impact on the simulation results. For example, an investigation of communication aspects in mobile scenarios requires realistic assumptions about the topology, delays, heterogeneity of devices, user characteristics and so on.

Recently, some interesting new approaches have been proposed; one tries to extract mobility patterns of users using traces of wireless network activities [9] and to create adequate mobility models based on such observations. The study from Ilyas at al. [7] proposes a new idea of an influence model, which can be categorized as a graph-based hybrid mobility model. This model bases on the work of Asavathiratham [1] and extends it by considering restrictions of movement due to obstacles in the environment.

3. STRATEGY BASED MOBILITY

The movement of each agent/player located on the structured map in our model consists of three significant subproblems that have to be solved. Firstly, appropriate methods for finding the next logical *target*, usually a building or a way, should be specified and established; secondly, the possible, often multiple *paths* within a movement graph have to be calculated; and thirdly, the virtual *movement* on the current element of path must be executed.

In the Obstacle Mobility Model (OMM) the next target is randomly chosen from the available buildings, and the shortest path is taken. The virtual movement is equivalent to a point-to-point movement between two adjacent elements of map.

For the first two subproblems, those of target and path, we use realistic models. We do not just want to execute randomly chosen movements as in OMM, but consider the individual player preferences, so-called *colors* for coming to a decision about the next target and the movement pattern (Fig.5). All elements of the map are distinguished not only by their size and location, but also by specified individual *attractiveness*. Our approach is based on the interchangeability of weighting functions for evaluation of single strategies and the corresponding selection mechanisms for the resulting strategy; we called it "evaluate - select" mechanism (Fig.4).

3.1 Consideration of Surrounding Environment

Taking into account information about the surrounding environment allows a more realistic examination of investigated scenarios. In our approach we consider landscape aspects as well as obstacles in the form of buildings and potential routes. Our approach models the surrounding environment as objects and organizes it as a graph structure (Fig.3). The objects are characterized by position and size, as well as by particular attributes like the material properties of walls. The map exists as an XML structure and supports other parts of the framework with a predefined data exchange interface. It acts as a logical channel for other models, i.e., for the single-user model in which the distances between significant points within a map are pre-estimated and remain unchanged, or for the communication model in which the quality of transmissions is described. As of now, the surroundings are generated by hand (fixed on designated positions or, if required, even randomly located), but in the future, they could be imported from the evaluated game or even from a real-world map.

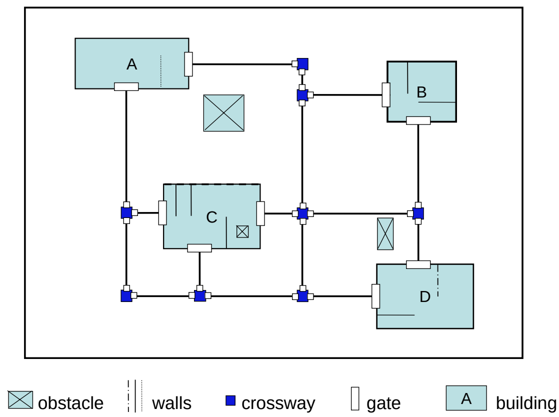

Figure 3: Abstraction of Environment.

3.2 Single User Movement

Currently used mobility models rarely take into account individual behaviors of users. Characteristics like target-changes or path-changes are mostly deterministic or randomly distributed. Other parameters, for example, individual strategies, path and location preferences, spontaneous changes of mind regarding the destination or current situation, willingness to build groups, time dependency of actions, and the different specifications of communication aspects, which significantly influence the player behaviors, are not implemented or even recognized. Until now, mobility models have assumed the statistical homogeneity of users, indeed, without realistic individual character.

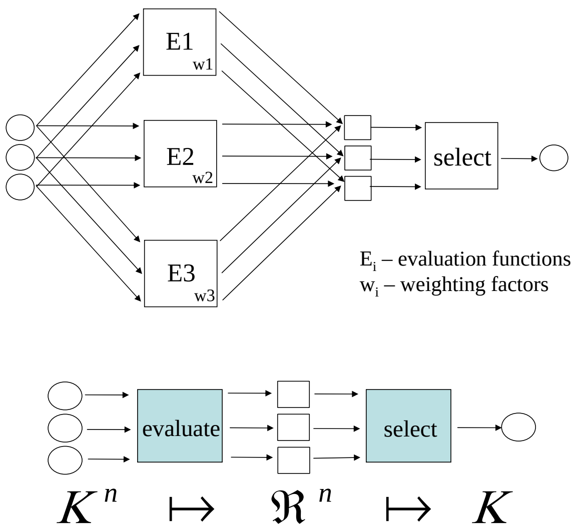

Figure 4: Evaluate-Select Mechanism.

All the criteria mentioned above depict a typical problem from the decision theory: from all available targets, adjacent elements included, the next logical target has to be chosen considering the order of importance. The resulting global strategy, represented by a function, solves such a problem by the mapping of all targets to a single element of the surroundings. In the real world, the people weigh up various criteria to make a decision. These criteria have different importance to each of them and thus, they reflect their individual preferences. The analytic discussion is often difficult because we do not always have the opportunity to consider real test data for research issues. Often, this type of data is not available at all due to the newness of the technology, for example within mobile ad hoc networks, sensor based networks, etc. Strategies that cover more criteria should be of a modular design. Each coexisting criterium may work cumulatively and without loss of significant information. It is more than a typical problem of choice; the individual importance of each strategy, the dynamical attractiveness of targets, and the interactions between players.

Decisions are often of diffuse character such as in the fuzzy-logic science. We split the decision in two separate parts: a step of evaluation (EVALUATE) in which each decision obtains a numerical value representing its current importance and a step of selection (SELECT) in which the resulting element is chosen under consideration of global relevance (Fig.4). We call this mechanism as "evaluate-select" approach.

We define some relevant terms of our approach as follows:

- **Evaluation function** (short **Evaluator**) represents a function of an set of objects (elements of a map) which returns a numerical value to each object. It is time-dependent and considers strategies, preferences, attributes, and history of objects.

- **Selection function** chooses a one numerical value from a set of numerical values. It can act deterministically or probabilistically. The resulting value represents the probability of use of the selected target.

- **Combination of evaluation functions** (short **CEvaluator**) describes a family of evaluation functions working on the same set of objects, whose results can be linearly combined over weighting factors. This leads to uniform and consistent evaluation results. CEvaluator is consequently an evaluation function which can be nested.

- **Strategy** is a decision function which maps a set of objects to a single object. In our approach each strategy consists of an evaluation function and selection function.

The evaluation function can be simple, like assigning a random value to each element of the map as in the Obstacle Mobility Model, or inherently complex, if it considers specified behaviors of players and elements of the environment. Additionally, different evaluation functions can be combined with each other using weighting factors.

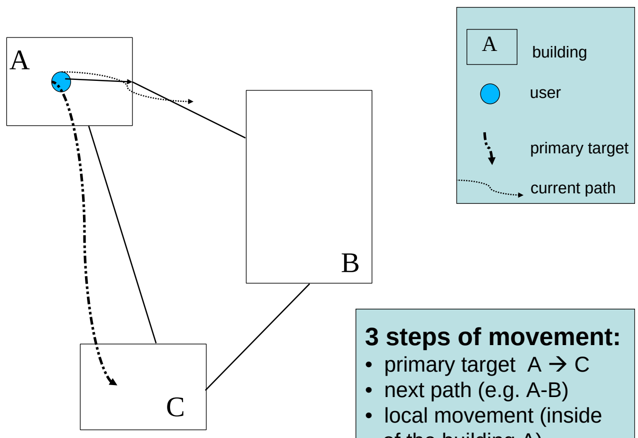

Figure 5: Movement of Single User.

The concept of coexisting strategies is used for the realization of mobility models within a virtual map. The movement can be divided in three independent hierarchical levels (Fig.5):

- **Choice of the target**: the next logical target of the movement is identified

- **Choice of the way**: a path within a movement graph is calculated

- **Local movement**: the virtual movement on the current element of path is executed

There are two ways to solve this problems: the player opts either for the fixed paths to the destination or for the next neighbor (temporary destination) which will hopefully lead to the final target. In second case, the player must repeat this decision on each new temporary destination until the end point is reached. The second method seems to be more acceptable because it does not need a global knowledge for the decision making and is more dynamic, i.e., the determination of the next neighbor can happen independently of time. In principle, the criteria for the next target and the next way can be completely different from each other, but they are usually alike.

3.3 Group Awareness

Lately, some research has identified the need for considering group movement patterns for gaming test beds. But none of the currently used mobility models consider the relevance of group awareness aspects. In nearly all models, users act independently of each other and are not able to build groups spontaneously, not to mention being unable to share group strategies, or negotiate common or separate goals or perspectives. In some closed mobility scenarios resembling the military, an individual user follows another, often a virtual leader [4].

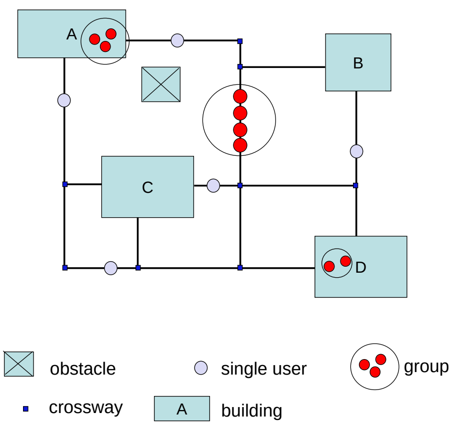

Figure 6: Group Building Mechanism.

Primarily, we concentrate our efforts on the modeling of social aspects of the group-building process. Through the detection of target-similarities, individual preferences and strategies, we classify users in order to develop group-building mechanisms. Each of them is characterized by several attributes such as the numerical similarity of targets, companionability, factor of predominance, etc. The attributes are represented by heuristic functions and equipped with predefined threshold values for the estimation of appropriate ranges of behaviors. Group behaviors vary depending on the location (e.g., outside or inside of buildings) and the time at which places are visited (e.g., the train station is more attractive for passengers in the daytime than at night) (Fig.6).

3.4 Combination with Transmission Model

The use of mobility models for simulation of game scenarios only makes sense if they are coupled with transmission models accordingly. We already implemented the free-space propagation model that delivers enough meaningful information for the prediction of transmission characteristics. In our approach we consider various landscape aspects and obstacles for their influence on transmission characteristics. Also, we distinguish between outdoor and indoor transmission and model this fact accordingly. Consideration of other aspects, such as weather influences (e.g., humidity, temperature, etc.) which affect the transmission quality, will be implemented soon. Furthermore, we act on the assumption of heterogeneous communication devices. Generally, our transmission model generates a family of maps, which represents the communication capability of each participating device (Fig.7) or of each player at a given moment and location. The generation of the maps is based on the Quad-Tree approach [14], well-known from computer graphic science. The leaves of the tree consist of values of signal strength taking into consideration the influence of obstacles on the way from the sender to the receiver. In this way we can realize different communication mechanisms, based both on pure technologies as also on non-technology-driven methods (e.g. visual communication methods). For these reasons obstacles could be penetrable for some kind of communication techniques and the transmission model would not consider the distances between the participating users, etc.

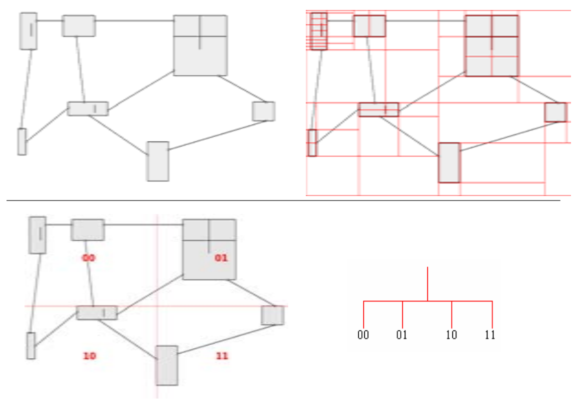

Figure 7: Communication Model.

4. SIMULATION

For the implementation of our approach we use the Discrete Event Simulation System OmNet++ [13]. We have designed and implemented a general model of mobile interaction including user and group mobility, communication model as well as the surrounding environment (Fig.1).

In comparison with other research solutions our model differs in some significant respects:

- Behaviors of user and groups are taken into consideration
- Strategies represent user and group activities
- Activities are functions of time and location

- Various kinds of obstacles (buildings, topographical, variation of communication devices, etc.) are taken into account

The concatenation of models relies on equal rights for coexistent participating models. Each of the models used can act as a simulation model separately, but equipped with a suitable interface it can interact with other models. Based on such an assumption, tasks like synchronization and data exchange can be carried out simply. Representations of obstacles and possible paths are results generated from the environment model which is always aware of the current situation and responds to external requests. Each user consults the environment model for obstacles, possible paths, and location of other players. After acquiring the knowledge about required parameters, the player performs movements according to the currently dominant strategy.

The single user from the real world is represented by an individual mobile agent. The agent moves on the map consulting the environment model for obstacles as well as the model for communication possibilities. Each mobile agent tries to manage its own individual strategies to achieve its particular targets. These strategies consider previous knowledge about past experience within the entered area, and individual, time-dependent action lines. Also, each agent is equipped with a set of additional, dynamic parameters which describes its individual ability for group building, such as "willingness for" and "bonding" in case of group creation, individual preferences within groups, the coupling mechanism, etc. According to these parameters, the users interact with each other and build temporary groups, go towards common targets, communicate in local and global manner, etc. All these participating models communicate and interact with each other using predefined interfaces and messages. /

5. CONCLUSION AND FUTURE WORK

With our approach we are able to map various highly dynamic scenarios to the simulation environment in a realistic manner. Not just campus scenarios, shopping areas, fairs, exhibitions, etc. but also maps from real game environments can be simulated and the user interactions there can be intensively investigated. Also, this approach makes it easier to equip users with any kind of realistically simulated transmission devices (mobile phones, visual communication methods, etc.). According to the currently used mobility scenario, it also allows the investigation of various aspects of communication, like performance of protocols used, communication services, service discovery issues, and desired/required parameters for quality of service. For technology-driven communication, the implementation of popular ad hoc routing protocols (AODV, DSR) will be finished soon to enable a detailed analysis and evaluation of the proposed mobility model within ad hoc mobile networks.

We have started connecting a networked mobile game to our framework and generating user traces for designed scenarios. We would compare these simulated traces with traces collected from real games. We also face some challenges such as synchronization of tasks between the simulator and the game, efficient data exchange, etc. and will present appropriate solutions to these problems soon.

Furthermore, we plan to implement more realistic strategies for individual users as well as for groups. More detailed observations are still necessary to discover the typical behaviors of users according to the various scenarios under consideration. For example, in the campus scenario, more detailed information about inter-dependencies of students' activities is needed. It will allow us to realistically map the group-building mechanism to the simulated objects.

Additionally, we are looking for appropriate models and methods which can describe the learning process for each user. Situations involving casual contact, the knowledge of formerly visited places, and previously chosen paths can influence user strategies in the future and should additionally be considered. The history of each agent which represents its learning aptitude and its ability to retain facts in memory are significant factors which may affect its behavior. Situations within new and unknown regions, physical changes of map elements, results of interactions with other participants or elements of surroundings are of significant importance for our further research efforts. Generally, all effects resulting from the changes of states of each agent/element involved may be understood as a memory effect. It can cause stimulus satiation effects and lead to temporary modification of user behaviors.

We believe that such a framework of single concatenated models (environment, communication, individual user strategies, group-building mechanisms) permits accurate simulation results and adequate approximation of realistic scenarios. This will allow us a successful evaluation of networked mobile games in the near future. /

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