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Large-scale Agent-based Modeling and Simulation

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ABSTRACT

This research presents a method to build large-scale agent-based modeling and simulation on PC for large-scale social systems with complex social networks. The novelty of this method is reflected in both designing of individual agent and organizing a group of agents for interactions on a large scale. As a case study, we constructed a large-scale artificial city Beijing, on which to test policies for controlling the spread of disease among full population (19.6 million) in Beijing.

1 INTRODUCTION

With the development of computing resource and computational theory in recent decades, large-scale agent-based modeling and simulation is getting more attention in many research areas, such as Epidemic Model(Rakowski et al., Bisset et al., Stroud and Valle, Parker and Epstein). Since using a single computing core may be inadequate(Hawe et al.) to deal with the scalability issue, some of the implementations are based on distributed architectures, which increases the number of communication messages. Thus, to balance between performance and accuracy, reducing interactions among distributed agents by simplifying the network model becomes a compromise. For example, random contact is used to replace social interaction in a global-Scale model(Parker and Epstein).

In this research, we constructed a large-scale artificial city Beijing with 19.6 million population and 8 million geo-referenced locations(like households, schools, offices, hospitals, stations, etc.), in which 200 million activities are executed per simulation day. In addition to general contacts in locations like home and schools, agents can interact with each other based on dynamic formation of social networks. Furthermore, we include a microscopic public transportation system in this city model to implement random travel contacts. Based on this model, we studied the effect of intervention (school closure) for controlling spread of pandemic influenza.

2 LARGE-SCALE AGENT-BASED MODELING AND SIMULATION FOR ARTIFICIAL CITY

The typical way of implementing agents in artificial cities is initializing an activity list for each agent. Instead, agents in this implementation are activity pattern based. Every agent is assigned with an reconfigurable index pointing to a week pattern which include seven day patterns. A day pattern constitutes of a linked list of executable activities which can repeatedly be executed. Agents can be referenced to the same week pattern if they have similar schedules, but distinct information is provided to them during simulation run, such as duration and location. With sequenced execution of the activities in the referenced pattern, the attributes of agents update with the simulation time increases. A overview of the class diagram of the system is shown in Figure1.

We modeled a transportation system to execute travel activities, which helps traveling agents to determine a route and give out the travel duration. The public transportation system in the model is microscopic, where we modeled all lines and stops of metro and bus system in Beijing. Modeled buses and metro trains will execute their schedules on these routes based certain timetables. The geographic information and

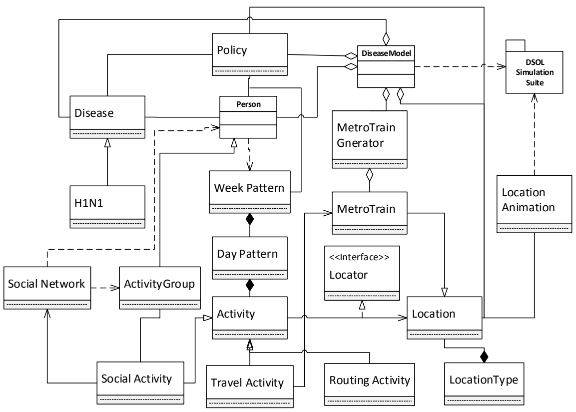

Figure 1: Class diagram of the artificial city

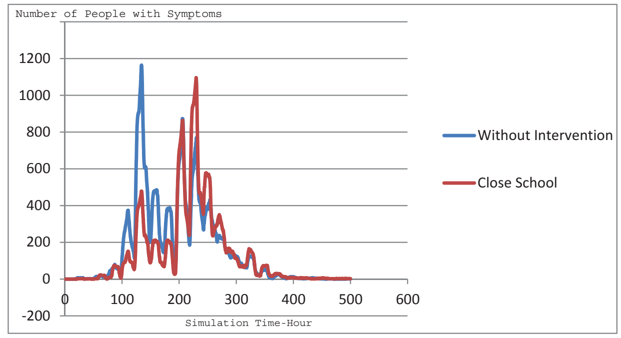

Figure 2: Number of Symptomatic People

routing data of the transportation infrastructure network are acquired from open source based OpenStreetMap (http://www.openstreetmap.org) by using a java library osmosis. To show the topologies of the whole public transportation network in Beijing, a big graph is built in this model by a java library jgrapht(http://jgrapht.org). It models stops as nodes and routes as links. For commuting vehicles(cars and taxis) on the road networks, we don't model the real road networks, but present estimated travel duration according to the distance and historical statistical data on congestion.

Besides, the agents in our model are able to communicate in joint social activities. This feature is realized through a dynamic construction of social networks and execution of social activities. When executing joint social activities, a representative agent called 'activity group' is generated to organize and manage the participants and social contact network emerges from the execution.

3 SIMULATION RESULT

Based on this artificial city, we implemented a pandemic influenza disease progression model and tested several interventions. The whole model is implemented on DSOL package, and we run this simulation on a PC(Intel Core i7-2620M CPU, 16.0 GB RAM) for a simulation period of 30 days. Figure 2 compares the number of symptomatic people between no interventions involved and school closed.

The results are considered as a proof of concept that large-scale artificial city with complex social networks can be constructed by large-scale agent-based method. Besides epidemic modeling, it demonstrates potential in the areas such as intelligent transportation system and online social network.

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