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Connectors and mavens in social networking - an agent-based approach

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Abstract

The article presents an agent-based model in which artificial users choose a service they use at each iteration. Its aim was to study the role of mavens and connectors in social networking. The received results show that this role is nontrivial and ambiguous.

1. Introduction

Social networking services are becoming an integral part of our lives. With the use of web 2.0 technologies [13] and relying on network effect [18] they are examples of new models of business activities. However, although services like Twitter or Facebook exist for a few years, during last several months their popularity has grown much faster than earlier [19, 22].

One explanation of these phenomena is given by Malcolm Gladwell [5]. He explains that the ability of an idea or product to "tip" can depend on a very small group of people with some special abilities (he calls them connectors, mavens and salesmen). He provides some very convincing examples such as rapid popularity growth of Hush Puppies shoes in the middle of 1990s or Paul Revere's ride at the beginning of the American Revolution. The idea seems especially intriguing when comparing dates of the information about famous sportsmen [20] or other celebrities [21] starting using Twitter with graph of Twitter's popularity.

In this article an agent-based approach to study the role of mavens and connectors in social networking is presented. Model was constructed in which artificial users choose a service they use at the moment. Motivation for their choices is the number of their neighbors (in the social network graph) using the service, but there is also a lot of place for chance and randomness, representing all other unexpected factors. The aim is to test the two hypothesis. First, that mavens and connectors can speed up the moment when one service gains advantage over others. Second, that the circumstances when mavens and connectors all use the same service at some moment result in its more popularity in the long term. The basic assumption made in the model is that services are substitute goods and user can only use one of them at the same time. And following the network effect, the more friends choose the service, the more incentives a user has to choose the same one.

The article is organized as follow. Sections 2 and 3 provide theoretical background. Roles in social networks are discussed and conception of agent-based modeling and simulation is presented. Sections 4 and 5 contain model description and the results. In section 6 some ideas for further research are proposed.

2. Roles in social networks

When social networks are considered the deliberations almost always start with Stanley Milgram and his experiment [10] which initialized debates about so called “small world phenomena” and the concept of “six degrees of separation”. Mathematical properties of this concept were studied by Watts and Strogatz [15]. They gave an algorithm for creating small world graphs (Figure 1) which can be treated as a representation of real-life social networks. Graph theory is widely used in social networks researches (see e.g. [7]). Vertices (nodes) of a graph represent people and connections between them are edges (if there is an edge between two nodes it means that the people know each other).

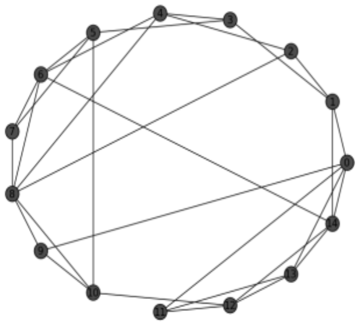

Figure 1. Small world graph

In a small world graph there can be distinguished regular edges (linking nearest nodes), but there are also some irregular, “shortcuts”, which connect distant nodes. These shortcuts lowers the number of intermediaries between any two nodes.

In Gladwell’s “law of the few” concept [5] *connectors* are people with many contacts. In social network graph nodes which represent them have degree (i.e. number of connections to other nodes) above the average. But it is not only the number of people they know that matters. Connectors work as intermediaries between different groups, they link different circles of interest and are the channels for message and opinions passing between “different worlds”.

Gladwell’s *mavens* are people who know a lot and they are eager to share their knowledge. They are often obsessed with looking for occasions (e.g. finding a bakery where cheaper bread can be bought), but their knowledge is useful and they are often asked for advices. Others know that a maven person usually spends much more time before choosing a product or a service and their decisions are taken after long deliberations. So they must be accurate.

Gladwell mentions also about *salesmen*. They are “persuaders” (which mavens are not), they are very convincing and can get you to act like they want.

In the article only connectors and mavens are dealt with, but it should be remarked that the latter are considered as having also the features of salesmen. Connectors are people with many contacts. Mavens in this perspective are simply people whose opinions are more important.

3. Agent-based modeling and simulation

A simplest definition of agent-based simulation can be found in [12] where it is defined as *a simulation made up of agents, objects or entities that behave autonomously*. The agent's definition varies and different features are emphasized depending on authors [11, 17]. But they all agree that an agent is situated in some environment and able to make autonomous decisions [8]. If there are more than one agent then we deal with multi-agent system and some kind of communication between agents is also required [17].

As it is claimed by North and Macal, *agent-based modeling and simulation (ABMS) is a new modeling paradigm* [8]. It became used in social science with the publication of SugarScape model [4]. Axtell and Epstein called their approach "generative social science" as its aim was to generate artificial society of agents in which some macro-level similarities to the real-world situations could be observed. In this context ABMS can be treated as a computer research laboratory in which assumptions about real-world phenomena can be tested and explored [9]. And they gain more and more attention, especially when it comes to model networks of social interactions [1, 14].

There are many ABMS tools and environments [9]. For the purpose of this article the simulations were created and performed with NetLogo 4.04 [16].

4. Model description

Simulation starts with initializing users. Each of n_u users is randomly placed in a 2-d world with a torus topology (see Figure 3). In the beginning users have equal probabilities of choosing one of n_s services. In the initial phase connections between users are also made (see subsection 4.1).

During each iteration users check which services were chosen by their neighbors and update their own preferences (it is described in subsection 4.2). After that they make their choices.

Simulation ends when all users use the same service. General overview of a simulation is presented below. The simulation is available at www.roz6.polsl.pl/pl/strona/zmi/owczarek/sym/sym-users.html.

```
//initial phase
randomly place n_c users
make connections
for each user
    choose service
//iteration
repeat
    for each user
        check neighbors' choice
    for each user
        update preferences
    for each user
        choose service
//stop condition
until all users choose the same service
```

Figure 2 presents sample services' ratings during one simulation. There were two services and simulation lasted 530 iterations.

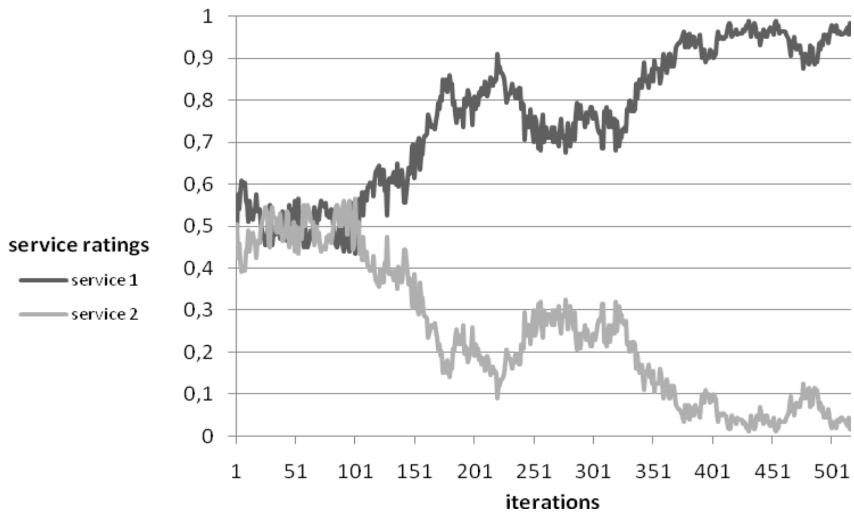

Figure 2. Example of services' ratings during simulation

4.1. Connections making

The algorithm which adds connections between neighbors is a modified version of model proposed by Watts and Strogatz [15]. The modifications were made because of agents' random arrangement on a 2-dimensional plane. The algorithm consists of two main steps.

In the first step each agent makes connections to n_l (global variable which represents the basic connections number for each user) nearest users. If there are more than n_l users in the same distance then links are added to all of them. Notice that some users may have more connections than others.

In the second step *r* (global variable) fraction of all links are 'rewired', i.e. one end of link is exchanged for a randomly chosen node from the other users. There is a condition that this changed node cannot be a connector. Although there is no guarantee that the network graph will be connected, the probability that it is disconnected is very low when parameters n_u, n_l and *r* are chosen carefully.

A network example is shown in Figure 3. Notice that the world used in simulation has a torus topology, i.e. its opposite edges are connected.

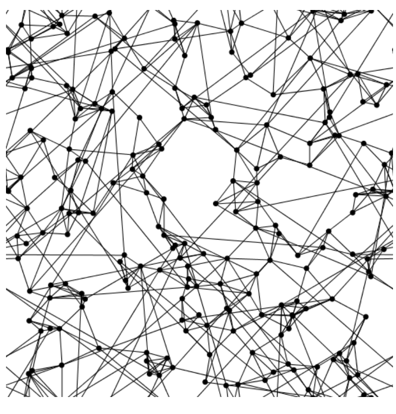

Figure 3. Example of connections between users

4.2. Service choosing

The process of service choosing is based on a roulette wheel known from genetic algorithms reproduction mechanism [6]. Each user has preferences represented by a table with n_s elements. Values of this table sum up to one and the *i*-th element of the table represents probability that user will choose *i*-th service. Preferences of each user are updated during each iteration and they are combination of users past preferences and choices of its neighbors. The more friends using some services, the better chances that a user will choose this service during next iteration.

Let p_j^i be the probability that user chooses *i*-th service in *j*-th iteration, let n be the number of users neighbors and let n_j^i be the number of user's neighbors choosing *i*-th service in *j*-th iteration. Then the probability p^i_{j+1} is calculated in the following way:

$$p^i_{j+1} = \frac{1}{2}\left(p^i_j + \frac{n^i_j}{n} \right) \tag{1}$$

Table 1 presents the way in which user's preferences can change in time under the influence of other users. There are two available services and values in rows with "neighbors' choices" labels represent number of user's neighbors which decided to choose the service.

Table 1. Example of user's preferences changing during iterations

Iteration No.		Services 1	Services 2
j	user's preferences	0.5	0.5
	neighbors' choices	1	3
j + 1	user's preferences	0.375	0.625
	neighbors' choices	1	3
j + 2	user's preferences	0.3125	0.6875
	neighbors' choices	2	2
j + 3	user's preferences	0.40625	0.59375
	neighbors' choices	0	4
j + 4	user's preferences	0.203125	0.796875

4.3. Special users

The probabilities that user is connector and (or) maven are determined by global variables r_c (describing connectors rate) and r_m (mavens rate). These probabilities are independent, so any user can be a connector, a maven, or both.

Connectors have more neighbors in network (which is determined by a global variable r_c). Mavens opinion are more important – in the model it means that their choices count as they were two or even more users (described by global variable m responsible for the strength of mavens influence).

5. Simulation results

There were two kinds of simulations performed. Each of them consisted of a few simulation series, differed in some parameters. Each variant of simulation was repeated 500 times and then some aggregate numbers were calculated. Statistical significance was tested according to [2], as a significance level α accepted 5%.

Table 2. Notation used to distinguish simulation runs with different parameters

	description
c0	connectors rate $r_c = 0$ (no connectors)
m0	mavens rate $r_m = 0$ (no mavens)
c10	minimal neighbors number for connector is 10
c14	minimal neighbors number for connector is 14
m2	$m = 2$ (maven's choice counts twice)
m3	$m = 3$ (maven's choice counts three times)

All simulations were performed with following parameters: $n_u = 200$, $n_s = 2$, $n_c = 4$, $r = 0.15$. Table 2 presents symbols denoting different simulation variants used in the article.

5.1. Simulation duration

First variants of simulations were to test if the presence of special users can shorten the time when one service gains maximum popularity. There were seven series of simulation runs, conducted with different parameters. In series where mavens and (or) connectors were present parameters r_c and r_m were equal 0.1 (10% chance that a user was maven and/or connector). Figure 4 presents average numbers of iterations until simulation stopped in each series (averaged from 500 runs).

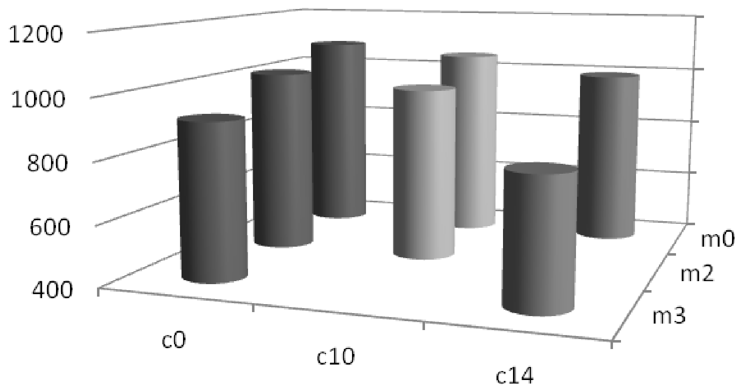

Figure 4. Average simulations' durations

The figure clearly shows that increasing the "power" of special users' features (i.e. neighbors number in case of connectors and strength of influence in case of mavens) results in shortening the number of iterations. The accurate numbers are presented in Table 3. The average number of iterations until simulation stops when there are no mavens and no connectors (c0m0) is 1089.5. The presence of special users lowers the average number of iterations. In three cases (c0m2, c10m2, c14m3) the difference is statistically significant.

Table 3. Simulations' durations – means and standard deviations

		m0	m2	m3
c0	mean	1083.498	1016.052	917.608
	stdev	761.641	801.994	675.948
c10	mean	1051.996	979.898	-
	stdev	777.917	675.716	-
c14	mean	993.752	-	817.216
	stdev	762.581	-	616.1006

It is worth noting that the winnings' proportion (by "winnings" it is meant that one service has 100% ratings) of each of the two services was very close to 50% in every series. It proves that the implementation is not biased towards any of the services.

5.2. Winnings' proportion

This time six simulation series were performed. Their aim was to check if the proportion of winnings will be significantly different from 50% if one service will be the first choice (i.e. will be chosen in the initial phase) by all special users. There was a 20% chance that a user was maven and (or) connector, but only users which at the beginning chose service 1 were considered. This way, like in the previous case, about 10% of all users were mavens and about 10% were connectors. Service 1's winnings ratios in each of the six series are presented in Figure 5.

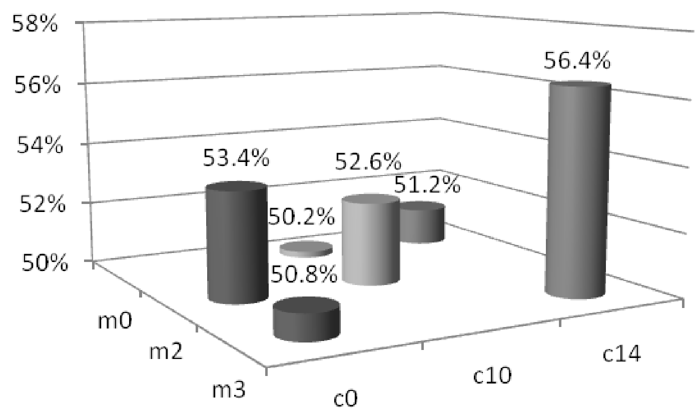

Figure 5. Service 1's winnings ratios

It can be read from the figure that every time simulations ended more often with the success of service 1, but the differences in the winnings number were very small. Only in one series (c14m3) the proportion was significantly different from 50%.

5.3. Conclusions

The results clearly show that role of mavens and connectors in social networking is nontrivial. Even when the rules of behavior are very simple, they can contribute in rapid popularity growth of one of the services. However their presence is not unambiguous. It is not enough to ensure that all or at least most of the users identified as connectors or mavens use the same service at the same moment, hoping that network effect will guarantee its success.

6. Summary and further research

The article presents studies over the role of connectors and mavens in social networking. An agent-based simulation was built and series of simulation runs were performed. One potential extension to the model could be implementation of the mechanism of agents learning about services available to them. In the current model users have full information – results could be different if they recognized new options through the social interactions. Another future work is development of a more sophisticated agents' behavior. Users could make their decisions not only relying on their friends' choice, but there could also be included some kind of preferences or even external factors (e.g. commercials).

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