# WORD-OF-MOUTH MARKETING AND ENTERPRISE STRATEGIES: A BOTTOM-UP DIFFUSION MODEL

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***Abstract***

*A comprehensive simulation model is presented, aimed to show the dynamics of social diffusion based on the word of mouth (e.g.: viral marketing) over a social network of interconnected individuals. The model is build following a bottom-up approach and the agent based paradigm; this means that the dynamics of the diffusion is simulated in real time and generated at the micro level, not calculated by using mathematical formulas. This allows both to follow – step by step – the emergent process and to be able – if needed – to add complex behavior for the agents and analyze how this impacts the phenomenon at the macro level.*

**Key-words:** *viral marketing, social diffusion, word of mouth, simulation*

**JEL Classification**: $M_{10}$, $M_{20}$

## Introduction

Word of mouth (WOM) recommendations are very important for customer acquisition, especially for small and medium enterprises (SMEs). This is why "viral marketing" and other forms of WOM marketing have gathered much attention in recent researches. Even if there are many mathematical models, often based on the dynamics of biological infections, trying to analyze the process of information diffusion undergoing in social context, these are usually built following the top-down approach and employ equations to show how, to a certain "limit", the phenomenon will evolve. Those models are surely useful to have an overview of the power of communication and social diffusion, but do not allow to directly experiment on them, since it's very difficult to model complex behaviors (like opinion leadership, mass communication, human preferences and biases) by means of mathematical equations. Moreover, these models usually give a static result (e.g.: what percentage of a population will be reached by the "contagion", after a given time) and don't show the evolution of the phenomenon in real time. This is particularly important when the purpose of the research is not the phenomenon itself, but rather the strategy that a firm can follow to be able to "hit" as many potential customers as possible, with its message.

The model presented in this paper, on the contrary, follows a bottom-up approach; instead of mathematically building a framework to be analytically solved, the goal is that of defining the entities at a micro level (i.e.: the enterprises, the customers, the opinion leaders and so on) and then giving some interaction rules (i.e.: the "infection" strength, the average number of neighbours, the bias towards a particular decision, the value of reputation and so on) so that the result is emergent and not already hidden in the premises.

This allows analyzing how a particular communication strategy, based on the WOM, could be effective for an enterprise and how other – often exogenous – factors could leverage or compromise it. Besides it's possible to make "on the fly" modifications to the scenario, so to simulate sudden problems or changes to the environment, and create a sensitivity analysis for the main variables employed in the model.

Below the structure of the model will be analyzed and described in details, but not employing a formal and technical description. The model has been internally designed by the author himself and a programming framework (Microsoft .NET) developed by the author of this paper with the technical support of Maria Anna Cataldi and Maurizio Destefanis.

### Literature review

The literature about WOM advertising and viral marketing is wide and addressed by both academicians and practitioners.

WOM Marketing has been called by many terms such as viral marketing, buzz marketing, network marketing, media leveraging, and exponential marketing, to mention a few. The methods of message propagation for this type of strategy have been likened to a virus or a disease which gets easily transferred from one person to another, hence the term Viral Marketing. E-mail messages with free product offers or trial privileges for a certain application are just one of the varied ways to launch a viral marketing campaign. So WOM marketing describes any strategy that encourages individuals to pass on a marketing message to others, creating the potential for exponential growth in the message's exposure and influence. Like viruses, such strategies take advantage of rapid multiplication to explode the message to thousands, to millions. According to Wilson (2000) there are six fundamental features about a good WOM marketing strategy. It: gives away products or services, provides for effortless transfer to others, scales easily from small to very large, exploits common motivations and behaviours, utilizes existing communication networks and takes advantage of others' resources. Traditional marketing is in crisis, because customers are increasingly inured to television commercials, direct mailings, etc. At the same time, companies like Amazon, Google and Hotmail succeed with virtually no marketing, based solely on word of mouth (Dye, 2000). A study found that positive word of mouth among customers is by far the best predictor of a company's growth (Reichheld, 2005). Word-of-mouth marketing has the key advantage that a recommendation from a friend or other trusted source has the credibility that advertisements lack (Jurvetson, 2000). Because it leverages customers themselves to do the marketing, it can also produce unparalleled returns on investment.

Some models about WOM marketing already exist, that try to represent it in an analytical way, by using mathematical equations. An interesting one, found in

Domingos (2005), tries to be predictive, rather than just descriptive, by using data mining techniques on social networks.

### Theoretical background

Agent based simulation (ABS) consists in building models of societies founded on artificial agents, i.e.: autonomous and interacting entities, mimicking the behaviour of humans or other real world parts of a given system. The methodology consists in designing the behaviour of the individual agents and the interaction rules among them and with the environment that hosts them. So, the aggregate behaviour is not designed, but rather emerges as a consequence of the interaction itself, exactly as in the real world.

This approach is characterized by the assumption that artificial data, obtained as a result of the simulation process, allow to build theories, useful to face real problems and analyze real situations. ABS is particularly interesting when applied to Social Sciences and Enterprise Economics and Management in particular, since it allows studying these systems in a scientific way, resembling that used to study Physics or Chemistry. Those subjects like Enterprise Management, in fact, can't be studied in a laboratory: the experiments can't be replicated "coeteris paribus" on them, and besides the human factor often makes these systems non deterministic. By building a scaled model of a real social system, on the contrary, it will be possible to test on it as if it were in a laboratory, and "what if analysis" becomes possible and effective on it. By changing a parameter at a time and replicating the experiment, it's possible to understand how that factor will affect the system. Besides the system can be "cleaned up" of all the exogenous factors that do not interest directly a given research, so that focusing on a particular problem is possible.

The model presented in this paper follow the ABS approach and studies a social network of interconnected agents.

### Model description

In the presented model, all the entities are interacting agents. The set of agents is composed by three main categories: A, B, and C. This has been introduced to allow different linking possibilities among the agents; in particular, A can only be linked to B, and at the same way also C can only be linked to B. B, on the contrary, can be linked with A, C and also with B itself. So, no A to A, A to C and C to C links are allowed. For a basic diffusion model, in which no rules for the linking connectors are considered, B agents can be employed alone (without A and C), so that they all are at the same hierarchical level and can be connected among them with no restrictions. The total number of possible links equals to $n * (n-1)/2$ for a fully connected graph in which only n agents of the B type are present. In general, be n the number of agents B, m the number of agents A and p the number of agents C, the total number of possible links equals

$n * \left(m + p + \frac{n-1}{2}\right)$. From this value, it's possible to calculate the number of the existing links in a given scenario, by considering a connection percentage.

The first step in the model is the random network creation, given the number of agents A, B and C, and the connection percentage; at the end of this process, if one or more nodes are left without any connection, the user can decide either to remove these nodes from the simulation, or to give them a random link with another agent (according to the described rules), or to leave them without any link. The system can optionally check for the presence of "isles" i.e.: not a single unique network, but several networks not inter-linked. If found, users can decide to keep them or to add more links to avoid them. Of course, by adding links, the final connection percentage can be slightly different from that indicated by the user.

Besides defining the number of agents in the simulation and the connection percentage, the user sets, for each category: the infection force, the percentage (or number) of infected agents at time 0, the infection duration and possible decay dynamics, the percentage (or number) of immune agents, the possibility to get infected again (and, in that case, the number of steps after which this could occur).

Each agent in the simulation features the following attributes:

- *ID*: a unique identifier.
- *Type*: <A, B, C>.
- *Infection*: a Boolean value identifying the current state.
- *Virulence*: if infected, a % defining the probability to infect other connected agents.
- *Infection duration*: an integer defining the number of turns since the agent turned infected.
- *Possible recovery*: a value identifying if the agents can heal from the infection or not.
- *Time for recovery*: an integer defining the number of turns after which an agent can recover from the infection. A value of zero indicates that no recovery is possible.
- *Decay*: if recovery is possible, this parameter allows selecting one out of five different types of infection force, overtime: Uniform, Linearly decreasing, Linearly increasing. Exponentially decreasing and Gaussian model. Default value is Uniform. If the value of Infection duration is equal to 0, the Decay parameter is ignored and the infection force is always equal to the value described in "virulence".
- *Multiple infections*: indicates if an agent can get the infection again, after he recovered.
- *Immunity time*: defines the number of turns in which an agent is immune after recovering.
- *Immunity*: a Boolean value identifying if the agent is immune to the infection (for the whole simulation or after he got an infection and recovered).

Each class features an optional sub-class, which comprises the so called "opinion leaders"; these are agents that (typically but not compulsorily) have an higher probability to infect others, due to their higher importance (weight) in the network and this is particularly useful for social models (e.g. word of mouth). These agents are treated as separate ones, in the sense that all the variables for them can be set independently from those regarding the basic kinds, except that their links follow the rules of the original class to which they belong.

At each simulation step, all the infected agents are considered; for each of them, the neighbours list is analyzed. For each neighbour, if not infected, the probability to become infected is calculated using the "virulence" value of the infected agent connected to it. If an agent is immune, then it won't be infected even if it should. If an agent is infect and time for recovery is higher than zero, then an agent can recover after the given steps. In this case, if immunity time is higher than zero, the recovered agent is immune for the desired amount of steps. Otherwise, it can immediately be infected once again.

The system ends when a combination of the following conditions (chosen by checkboxes) occurs within the simulation: After N steps, When all infected, When % infected, When all immune, When % immune, When all uninfected, When no changes for N simulation steps, If all infected at least once, If % infected at least once.

The conditions can be individually selected or can be chosen in combination; in this case they can be set in a logical AND/OR situation among them, in order to create combined conditions suited for any analysis.

## Conclusions

In this paper an agent based model is presented, dealing with the diffusion of a message coming from an enterprise through WOM marketing techniques. Differently from most existing models this one does not explore the results of a diffusion by using mathematical equations, but rather aims to build the social system from the bottom, by defining the individual entities and then having them to interact, based on given rules. This approach allows to explore the dynamics of the phenomenon step-by-step, and to change some parameters to see how this affects the rest. In future works the model will be used to experiment different scenarios and derive strategic hints for those enterprises using WOM marketing as a way to communicate with potential customers.

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