Multi-Agent Based Simulation of News Digital Markets

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Abstract

Over the past few years it has become clear that the Internet will play an ever greater role in the distribution of digital contents. Businesses have to start now understanding the dynamics of this new market and gaining insight into how to exploit the impending paradigm shift in contents, marketing, and distribution. Our main aim is to provide businesses in the digital contents sector with a tool which will enable them to take informed business strategy decisions and become more competitive by adapting their traditional business models to the new, demanding reality. To achieve this objective, we have implemented a first version of a news market model called SimwebAB that is based on multi-agent simulation technology.

1 Introduction

Digital content distribution is changing rapidly due to the emergence and spread of new business models and technologies. Specialised portable hardware, designed to store and give digital access to contents such as news, books, music, or video, will soon make digital contents reachable by a large number of consumers. To achieve success, e-businesses are being forced to rethink traditional, strategic business models, the role of IT (information technology), processes and relationships along the whole length of the supply chain ([1]). This is because, as Wurman ([2]) argues, with the advent of e-commerce, the marketplace as traditionally understood (in the 'town square') has become more global and to a greater extent more virtual. Businesses need to understand the dynamics of this new market and gain insight into how to exploit the impending paradigm shift in content, marketing, and distribution.

Our main aim is to provide businesses in the digital contents sector with a tool which will help them to take informed business strategy decisions and, therefore, to become more competitive by adapting their traditional business models to the new marketplace.

At this aim, we have implemented *SimwebAB*, a first version of a news market model that is based on multi-agent simulation and market data extracted both from extensive sector surveys (see [3] and [4]) and from close interaction with real content providers. SimwebAB allows market participants in the digital contents sector to run a variety of scenarios and observe the impact they have both on their businesses and on the competitive digital contents landscape.

Multi-agent based simulation (MABS) ([5]) uses models that incorporate agents, where agents are understood as autonomous computer programs (or parts of programs) that are goal-directed and interactive and that are located in, and react to their simulated social and physical environment ([6]). In our simulations, agents represent market stakeholders that act autonomously according to their interests and interact with other agents inside the market environment. This allows end users to investigate the implications of a variety of decisions and strategies by running simulations starting from different initial conditions. Simulation results can be then analysed, either intuitively or through a statistical analysis, and this (together with flexibility) provides one of the main advantages of this MABS approach.

2 Market Model

We have focused on modelling the structure and behaviour of the on-line news market and their constituents or stakeholders. The model consists of a population of content providers and customers that mainly interact by buying and selling products. We have chosen to simulate a business-to-business (B2B) on-line news market, and thus, all stakeholders are companies. A stakeholder usually has an intention to reach certain goals and uses strategies that allow it eventually to reach these goals.

SimwebAB is an ongoing project, and in due course we shall extend the model to include a larger number of stakeholder categories and interactions, a more sophisticated range of stakeholder actions and the possibility of agent learning.

Using SimwebAB, the user can create markets, and for each market, define as many products, providers and customers as required (see Figure 1):

- Every *product* is characterised by its own features (attributes that take values based on the type domain chosen by the user). Product offers and requests are central to the model, since they define what is being traded in the market.
- *Provider* agents offer products under certain conditions (e.g. subscription period) and interact with customers by advertising and selling these product offers.
- *Customer* agents reach their goals by buying product offers that best satisfy their preferences.

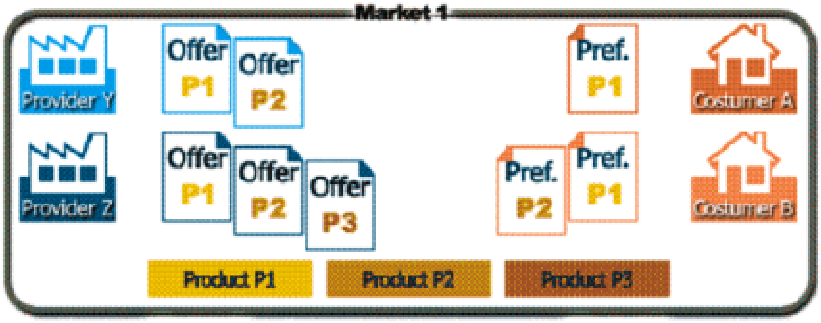

Figure 1. Conceptualisation of the main components in the market model

The market acts as the environment for both provider and customer agents. It includes the products they trade, and provides general utilities such as model setup, advertising facilities, or market information. This last service includes information about reached deals and the most fashionable product. Fashion is modelled in terms of market sales, and hence the product in fashion is the top selling product.

2.1 Products

Products represent goods traded in the market, and can be defined by sets of features such as size or price. In SimwebAB, products are generic descriptions specified as sets of attributes, each of them having a name, a type and, when required, a set of possible values. Types are:

- Numerical: the attribute having this type can take any numerical value.
- Numerical Range: values must be comprised between a minimum and a maximum value.
- Set: the attribute values belong to an unordered list of labels. For example, a list of colours.
- Ordered Set: values belong to an ordered list of labels (e.g. quality: {low, medium, high}).

Products define the domain of what providers offer to customers: product offers. As next subsection states, an offer is a product representation containing specific values per attribute.

We have defined nine different products for our on-line news model. Some of them are: Breaking news; Printed newspaper; Sport news; Finance and business news; or Alerts. These products have many attributes in common. As an example Figure 2 illustrates our ´Breaking news' product definition.

Product name: Breaking news
Attributes:

- Price: Numerical interval [0,500]. Prices must be comprised between 0 (meaning free) and 500. Values are normalised to price per 1 day. Units are euros (€).
- Format: Set of {“WEB”, “HTML”, “SMS”, “WML”, “MMS”, “PDF”, “PDA”, “E-mail”, “All formats”}.
- Quality of sources: Ordered Set of {“Poor”, “Good”, “Very good”, “Excellent”} values.
- Ads: Set of {“Available with ads”, “Available without ads”} values.
- Subscription period: Set of {"1 day", "1 day per week", "1 week", "2 weeks", "1 month", “6 months”, “12 months”, "24 months"} values.
- Delivery Frequency: Ordered set of {“Once a day”, ”Twice a day”, ”Three times per day”, ”Every three hours”, ”Every two hours”, ”Every hour”, “Every half an hour”, ”Real time”).
- Number of Themes: Ordered Set of {“1-5”, “6-10”, “11-15”, “16-20”, “More than 20”} values
- Offline expertise in this field: Ordered Set {“No”, “Yes”}
- Dedicated editorial staff: Numerical Interval [0, 1000].
- Customisation: Ordered Set of {“No”, “Yes”} values.

Figure 2. Breaking news product definition (including attribute names and their corresponding domains).

2.2 Offers

Providers can offer a product with different conditions, and thus they can generate any number of offers by assigning different attribute values to one product. Nevertheless, customers not only buy products because of their specific features, but also because of the characteristics of the provider itself. Therefore, SimwebAB allows to add a set of provider attributes to each offer analogously to product attributes.

As shown in figure 3, seven different provider attributes have been defined for our news model: Offline brand, Credibility, International, Editorial scope, Area of expertise, Market share, and Editorial Staff.

Offered product: “Breaking news”
Product Attributes:

- Price = 133
- Format = “WEB”
- Quality of sources: “Excellent”
- Ads = “Available without ads”
- Subscription period = "1 month"
- Delivery Frequency = ”Twice a day”
- Number of Themes = “1-5”
- Offline expertise in this field = “Yes”
- Dedicated editorial staff = 13
- Customisation = “Yes”.

Provider attributes:

- Offline brand = “Yes”
- Credibility = “High”
- International = “Mixed”
- Editorial scope = “Generalist”
- Area of expertise = “Non-applicable”
- Market share = 28
- Editorial staff = “Medium”

Figure 3. Example of a Breaking news offer

2.3 Requests

Requests allow customers to define desired values for each attribute in the offer definition (analogously to offers, they include both product and provider attributes). See figure 4 for a request example.

Customer agents state their preferences as either a single value or a range of preferred values. In the latter

case, all values in the range are desirable, although customers can establish slopes for the preferences. In this manner, a FLAT preference means all values are equally preferred; MIB (More is Better) indicates higher values are preferred to lower ones; whereas LIB (Less Is Better) states the opposite.

When customer agents specify their preferences for product attributes, they also need to provide a weight value per attribute, which signals the importance the customer gives to that attribute. By convention, all weights in the product attributes collection must sum to 1. And the same applies for providers' attributes.

SimwebAB assumes requested values are preferred but not mandatory. Therefore, a customer will still consider an offer not perfectly fulfilling all its requirements. For each attribute in the request, customers can specify whether its attribute value is mandatory or not. In our model, this feature is very useful for attributes such as format because if, for example, a mobile operator needs WAP format, then a very good offer in HTML format is of no value.

Requested product: Breaking news

Product Attributes:

- Price = [5, 20] LIB, 0.2
- Format = "WEB", 0.1, MANDATORY
- Quality sources: ["Very Good", "Excellent"] MIB, 0.1
- Ads = ["Available with ads", "Available without ads"] MIB, 0.1
- Subscription period = "1 month", 0.1
- Delivery Freq.= ["Once a day", "Real time"] MIB, 0.1
- Number of Themes = "More than 20", 0.1
- Offline expertise in this field = "Yes", 0.05
- Dedicated editorial staff = 7, 0.05
- Customisation = "Yes", 0.1.

Provider attributes:

- Offline brand = "Yes", 0.1
- Credibility = ["Medium", "High"] MIB 0.2
- International = ["Mixed", "Yes"] MIB, 0.2
- Editorial scope = "Generalist", 0.1
- Area of expertise = "Non-applicable", 0
- Market share = 50, 0.3
- Editorial staff = ["Medium", "Large"] MIB, 0.1

Figure 4. Example of a request for Breaking news

2.4 Matching requests and offers

When buying, customers do always look for offers that satisfy their necessities. SimwebAB computes this satisfaction by matching requests and offers.

Matching degrees are computed with iSOCO's fuzzy matching engine iMatcher, which scores and ranks each offer according to the customer's preferences (see [7] and [8] for details). Each attribute preference in an offer is is internally represented as a satisfaction function, which corresponds to the membership function of the fuzzy set [9] defined by the preference. X axes on these functions correspond to attribute domains (types in product definitions) and Y axes are satisfaction degrees normalized to 1. Y values are assigned based on the preferences (preferred values and slopes).

As an example, figure 5 shows the satisfaction function for the Quality attribute: most preferred value (Excellent) gets maximum satisfaction (that is, 1); last preferred value (Very Good) gets a satisfaction degree of 0.5; and values outside the preferred range get satisfaction degrees that decrease proportionally down to 0 so that offered values that do not match preferences exactly still can have a positive (but small) satisfaction. Considering the offer shown in figure 3, the 'Excellent' Quality value will result in a satisfaction degree of 1.

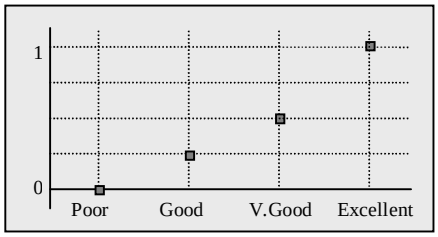

Figure 5. Satisfaction function for the Quality attribute.

Overall matching degrees are afterwards computed as a weighted mean of individual attribute satisfaction degrees. This weighted mean uses the weights the customer has specified for each attribute in its request. Following the examples in figures 3 and 4, the overall matching degree is 0.7256.

3 Agents

3.1 Provider agents

The on-line news market includes a variety of stakeholders: journalists, news agencies, portals, on-line media companies, search engines, telco/PTTs, Internet service providers, and technology providers. Nevertheless, our current implementation focuses on on-line media companies (that is classical content providers such as news agencies, generalist newspapers or sports newspapers), and we have modelled six different provider agents that correspond to real players in the on-line news market such as Reuters, Publico.pt or Record. For each of them, we have characterised their attribute values and we have defined both the set of products they can provide and their corresponding offers. Our implementation includes a total of 109 product offers.

3.1.1 Provider behaviours

In order to sell a product, every provider agent must advertise their offers, so that customer agents are aware of what is on the market when choosing the one to buy. Customers are modelled without the ability to remember the advertisements and so providers must keep advertising their offers at each step in the simulation if they want their products to be known.

Advertising is done to all customers in the market, and providers do not segment customers to target them accordingly. Similarly, provider agents sell products as soon as there are customer agents willing to buy them, and do not favour companies belonging, for example, to the same parent business.

In our current model, provider agents have information that is currently used for display purposes, but we plan to apply it in marketing policies in future implementations. This information is about:

- Each provider agent keeps information about all the deals it has reached during the current step, as well as about all its deals done during the whole simulation.
- Provider agents also listen to the advertisements of their competitors, and thus they know which products are being offered and under what conditions.
- The market provides the “product in fashion” service. This service allows each provider agent to know the top-selling product.

3.2 Customer agents

Together with content providers, customers are key players in content distribution markets. As in our simulation, they have purchasing goals and present a variety of buying behaviours.

Since our market models an online B2B news market, we have defined customer agents representing four different business customers. All of them buy pieces of news from news providers (newspapers and news agencies) in order to add value to their own products:

- Mobile operators buy pieces of news in order to distribute them to their consumers through SMS and WAP (so these are the format attribute values they request).
- Web portals. In order to increase the attractiveness of their web sites, web portals include pieces of news they do not produce.
- Institutional sites. Some big companies have their own sites and want to provide their customers and employees with a news service.
- Newspapers. Newspapers can also buy news from other news providers. For example, some generalist newspaper buy from sports or financial newspapers.

3.2.1 Buyer behaviours

We have defined and implemented five buying behaviours. Nevertheless, all behaviours have in common that they always respect subscription periods and mandatory attributes. Before considering an offer, a mandatory attribute in a request forces to check whether the offered value matches with a value in the preference. Otherwise, the offer is discarded. Following the example in figure 5, an offer having Quality other than Very Good or Excellent would be discarded.

Buy Best offers behaviour

This behaviour models the "rational" customer and tries to satisfy its own request as much as possible. In order to do this, it first computes the matching degree of each request against all providers' offers for the same product, and then chooses the best one provided that it is satisfying enough (we have set a 0.7 threshold). Matching degrees are computed as explained in subsection 2.4.

Buy Cheapest offers behaviour

This behaviour models "bargain hunter" customers. Customer agents with this behaviour use requests to look for products to buy but do not consider attribute preferences (except for any mandatory ones), since they simply choose the offer with lowest price

Be Loyal to Provider behaviour

Although rational, some customers have such strong preferences for specific providers that they always buy from them. In B2B markets this often happens when companies belong to the same conglomerate. The implementation of this behaviour requires the specification of the provider to be loyal, and then it uses the request to see which offers from this provider fit best (otherwise do not buy).

Follow Fashion behaviour

Some other customers decide to buy fashionable products. SimwebAB implements this behaviour by first checking whether the product that is currently in fashion is required (that is, the agent has a request for it), and afterwards, choosing among all available offers.

Satisfy Requests Exactly behaviour

This final type of behaviour models customers that are extremely demanding, so that their requests must be satisfied exactly. This behaviour has been implemented by treating all attributes in the request as mandatory.

4 Simulation

Once the model has been defined, it is possible to simulate its evolution with time. We use RePast [10] as the underlying simulation engine. From the many well - known software development environments for agent-based simulation (Swarm; RePast; Ascape; NetLogo; AgentSheets; MAML and, SDML); we have chosen RePast on the grounds of criteria such as portability and support. SimwebAB's agents and environment classes are hooked to RePast classes so we can use its simulation controls and display library.

Figure 6 shows SimwebAB's simulation toolbar (as an extension of Repast's). Simulation consists of repeating steps (ticks) until a preset limit is reached or the user clicks on the stop button in the control bar.

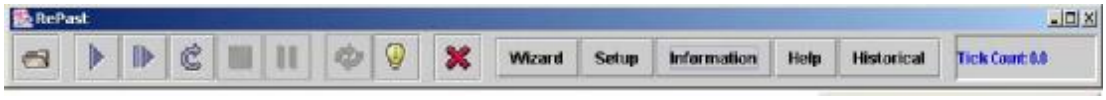

Figure 6. SimwebAB simulation toolbar (RePast enhanced): Start, Step, Stop, Wizard for output definition, Agent Information…

For each time step, the following sequence of actions is performed:

1. Provider agents advertise their offers.
2. Both customer and provider agents listen to advertisements.
3. Customer agents try to satisfy their requests: they acquire products based on their buying behaviours. Each purchase involves a deal with the corresponding provider and prevents the customer from buying this product for the period of time set by the subscription period.
4. There is a deliberation period for all agents. Mostly, this time is used to perform actions such as updating historical data

4.1 Results

Simulation results are provided as graphical output information that can be interpreted and analysed by users. Our model has been derived from a close interaction with real on-line news providers such as Publico.pt, who are the targeted end users. Business strategy decisions are mainly taken based on provider performance indicators. Thus, SimwebAB displays providers' variables such as market share or actual sales, which proved to be understandable by users.

Simulation setup allows users to create different scenarios by defining new products, offers and requests, or by changing the number of agents and their behaviours in the news market model. Then, for each step in the simulation, SimwebAB refreshes the output graphs in order to show the market evolution. As an example, figure 7 depicts market shares in a given time step for four different news products and six content providers. Additionally, sequence graphs are used to display number of sales x time per provider (distinguished with colours), and histograms show the range of prices and number of product units that are being sold in the whole market.

Finally, users can compare the results of different simulations by recording and replying them.

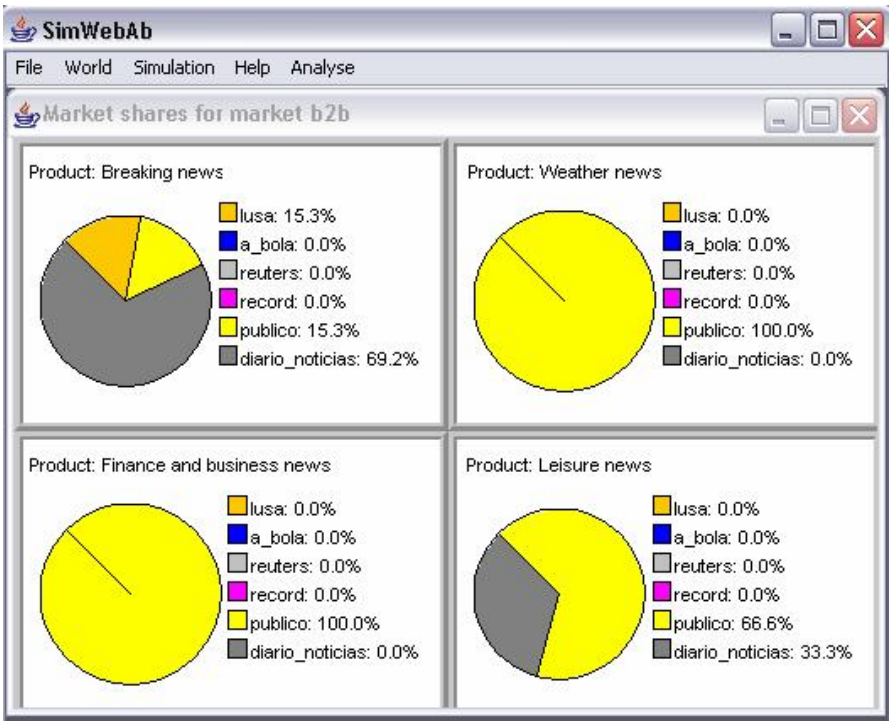

Figure 7. Example of simulation output: market share

5 Conclusions and Future Work

Still in its infancy, organisational simulation is currently a booming area of research in both academia and practice ([11] and [12]). In this work, we apply the MABS approach because of its intuitive analysis (agents represent stakeholders, act according to their interests and interact within the environment) and flexibility to define different scenarios.

Based on RePast, we have developed SimwebAB [13], an application where we have modelled an online news market, where provider agents represent news providers, and customers represent companies who buy on-line news products. However, the application is totally flexible and could also be used to model other markets (in fact, it has been already done in [14] for the on-line music distribution market). In the end, it is the user who decides what attributes the products have and who the providers and customers are.

This paper presents an ongoing work. We are currently working in two dimensions: the model and the software tool. On the one hand, we are adding budget considerations and strategy rules to agents in the model.

And, on the other hand, we are improving the software tool (which by now is a prototype) to become a real product. Long term plans include adding learning capabilities to agents.

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