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1 May 2004

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ABSTRACT

The online content market for news and music is changing rapidly with the spread of technology and innovative business models (e.g. the online delivery of music, specialised subscription news services). It is correspondingly hard for suppliers of online content to anticipate developments and the effects of their businesses. The paper describes a prototype multi-agent simulation to model possible scenarios in this market. The simulation is intended for use by business strategists and has been developed using a participatory, rapid prototyping methodology. The implications of the method and the characteristics of the domain for the design are considered.

BACKGROUND

Multi-agent based simulations are rather rare in the strategic management and business modelling field (but see, e.g. Robertson 2003). They are used increasingly in other fields of social science, and although there is a range of economic agent-based models, most focus on the market rather than the individual firm. However, to inform users from a practical rather from a theoretical perspective, the point of view should be the individual firm.

The work reported here was conducted as part of a larger project whose main aim is to develop simulation tools that enable stakeholders in the online music and news content sectors to explore possible future developments and scenarios. Quite clearly, a simulation has to focus not in the market in total, but on the businesses' strategies and their consequences.

Internet business models are still in formation. Successful models and strategies cannot be constructed using conventional techniques from management science that involve long-term deliberative planning. Successful models tend to combine a mix of strategies and components from separate approaches in management (Amit and Zott 2001). Often models that have been successful for a period are outdated only a few years later, as a result of technological developments and changes by competitors (Rayport 1999).

Modelling the online content sector with multi-agent based simulations appears to be a quite natural solution for two reasons:

1. Compared with econometric or other forecasting models, they represent individuals explicitly, thereby offering the possibility of centring the model around the firm, not the market.
2. Fewer assumptions have to be made about relationships observable at the aggregate level (e.g. price elasticities, and correlations between web-site traffic and advertisement income). Instead, such relationships are allowed to emerge from the effects of the activities of the individual agents.

For the prototype described later on, online news was selected as the domain, and it may serve as a typical example of the situation online businesses will find themselves in – an increasing pressure to become profitable in a not yet matured market. Internet users still expect content from the Internet to be free, which necessitates the invention of new business models. Selling advertisement space for (targeted) users is the classical example, and other examples include the set-up of specialised classified advertisements or paid services (often with an extension to the offline world). However attitudes towards paying are in flux, and offering paid content is becoming more common.

REQUIREMENTS FOR A SIMULATION TOOL

Among the project aims is the intention to build software that enables stakeholders, and not only specialists, to appreciate better the business consequences of their actions. Besides building a model that can to some extent reproduce a range of possible strategies and eventually enable users to explore alternative future scenarios, the simulation has to take account of the requirements and information needs of end users. This means that the results and the model itself have to be understandable and interpretable by non-expert users, although it must also be powerful enough to model the online content market. Finally, the end-user should not only be confronted with the results of a simulation run, but also be able to interact with the model him/herself (not only because the market may change quite quickly, but also because views on it may differ from one user to the next due to a lack of reliable data).

PARTICIPATORY RAPID PROTOTYPING

The nature of the domain, an initial lack of clear definition of the practical use of the final software and requirements about how to use it, and the need to enlist input from potential users, although they had little direct experience of business modelling software, led to the adoption of a prototyping methodology for the development of the model. The approach is based on a combination of participatory methods, the Rational Unified Process and Extreme Programming (XP), all of which have proven useful in unexplored domains and which build on the close cooperation between end-users of the software and developers during the development process (Ramanath and Gilbert 2003). In an iterative process with frequent releases, the final product is developed with the help of continuous feedback and input by end-users and domain experts.

The development was divided into three major iterations A, B and C. Prototype A implemented the very core of the model in form of a market process with customer agents purchasing products offered by firm agents. Prototype B added more domain knowledge and explored ways of implementing behaviours and options for graphical output. In Prototype C, which is presented in the following sections, the central concepts of the former prototypes are being integrated, usability enhanced and the scope of the simulation broadened, as the requirements have become clearer and domain knowledge more available. Nevertheless, being a prototype, it does not offer full functionality, which is left to the final tool that is to be developed by the end of the project, in 2005.

Several approaches for knowledge acquisition were used to define the domain. In addition to frequent and mostly informal communication between developers and the end users of the project and ongoing evaluations of released prototypes, extensive explorative, qualitative and quantitative research is being carried out (e.g. Swatman et al 2003) which generated insights into the main topics, stakeholders and structure of the market. From these results the relevant dimensions and attributes of market participants, products and interesting trends that should be present in the simulation could be derived directly and modelling started using the incremental approach described above.

SIMULATING BUSINESS STRATEGIES

The purpose of prototype C is to simulate a market that reflects some of the issues online businesses see themselves confronted with. As a market simulation, its components consist of provider agents, customer agents and the products to be traded between them. As an application, it provides features to create scenarios, manipulate and run them.

It was decided to model the domain along the lines of classical economic theory and subsequently add features unique to the online field. Some of these unique features cannot be covered by classical theory: the importance of cooperation between competitors ('cooptition'), and the acceptance of online payment methods are examples of aspects that were identified as crucial for success in the internet marketplace, but are not dealt with in most texts on the economics of business markets.

There are three steps to set up and run a simulation.

1. The user specifies a market in terms of supply (of content) and demand (from customers), either using the provided default values or by modifying these. The 'offers' of the products to be available from each provider and the preferences of each customer are also defined.
2. For each kind of agent, behaviour can be specified in the form of rules from a range of predefined conditions and actions that aim to represent the decisions that would need to be made in the marketplace.

Although the main relationships and definitions are fixed, there are opportunities to influence the simulation during runtime on a global level, which can be done before running the simulation. For example there is an option to change customers' budgets – the system will then periodically increase or decrease the money available to these agents. Further options which could be included but have not been implemented are the automated insertion of new competitors, changing customer preferences and so on.

3. In the final step the model can be run. During each simulation step, customers buy products from providers, which results in a certain market structure after each step. This state is presented as a display of the market shares of the providers (see Figure 2).

The core of the system is implemented using a traditional agent architecture. The market in total can be considered as the environment of each agent – it is the aggregated result of each individual's actions and gives feedback to each agent. A number of indicators are calculated to represent the state of the environment. Agents react to changes in their environment by simple rules that depend on the values of these macro-level indicators. For example, if the number of customers is decreasing, a rule might propose that a provider should start an advertisement campaign.

Business strategies are modelled by collections of such rules. Such collections can be interpreted as the long-term plan with which a firm intends to react to (and influence) its market environment, depending on anticipated possible states. This reflects to some extent an adaptive strategy, which characterises a firm as situated in a network of stakeholders, trends, events and competitors, having as its goal the alignment of the organisation with its environment, and requiring the constant monitoring of internal and external conditions (see Chaffee 1985 for a discussion of different strategy models). The simulation can thus provide some insight into the effects of interactions between different strategies with a changing environment, and help understand which mixes of strategy might be successful for individual firms and for the sector as a whole.

IMPLEMENTATION

The current prototype offers the user a set of classes for the central components: provider-agent, customer-agent, and product, which serve as a template to set up a model. These classes are represented graphically for direct manipulation on the screen by the user (See Figure 1). The classes ease the specification of a model by providing default values and behaviours. The user can create new sub-classes that inherit from these top-level classes, modify the pre-set default values, and change or add behaviours and preferences for customer agents, or offers for provider agents. It is thus possible to define (hierarchies of) prototypes for individual agents and objects before actually creating them, allowing their specification in a top-down manner, starting with common properties for all agents and working down to levels where more and more differentiations can be made.

Individual agents are "instantiated" from their class, inheriting the default properties and behaviours of their class and its super classes. Values, preferences/offers and behaviours in the instances themselves can also be modified to achieve differentiation at the individual level. If values/objects are changed at the class level later on, these are filtered down to their subclasses and instances.

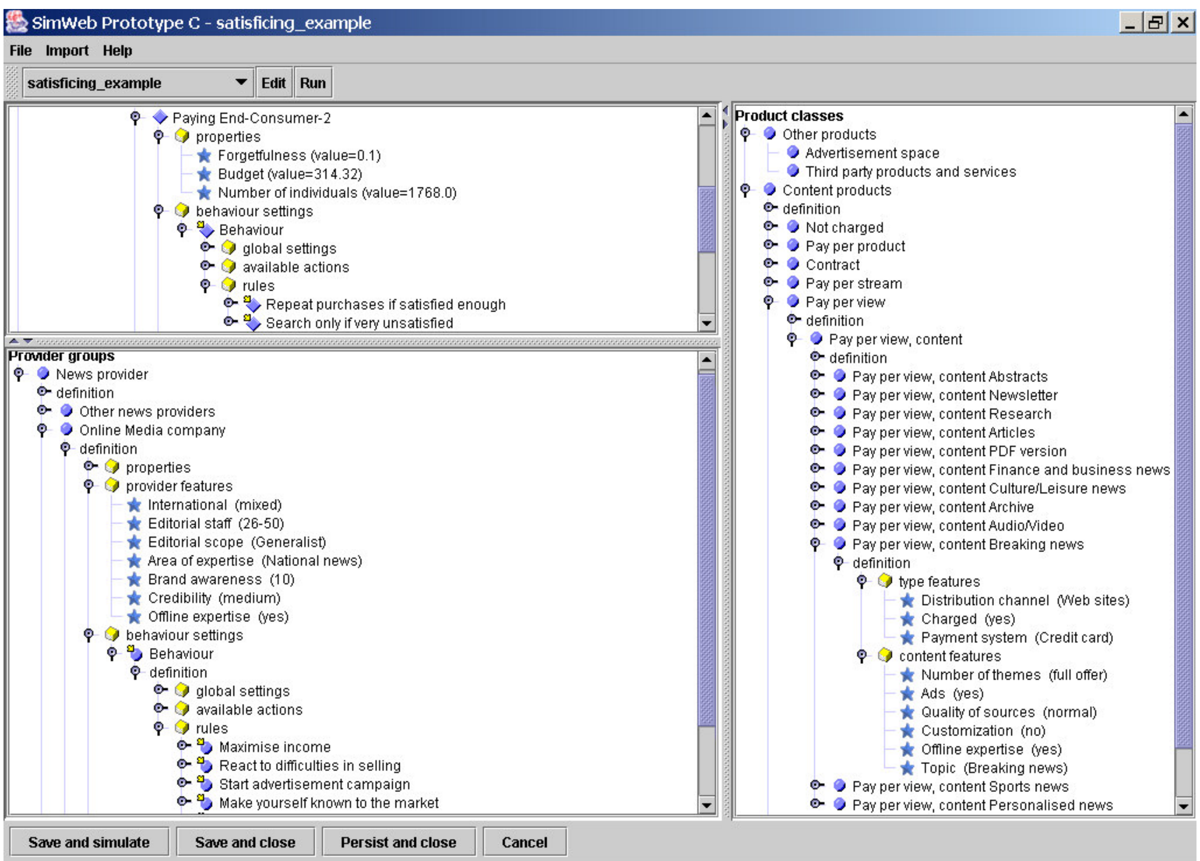

Figure 1: The user interface for the set-up of a model

An agent is defined by

- a property list in which the parameters that are used during the simulation are defined (such as the budget or the speed at which a customer agent forgets advertised products),
- a list of behaviours and
- a list of "runtime variables" that serves as working memory during the simulation. These store, in the case of a customer agent, the level of need satisfaction during the last round, a ranking of providers that describes their potential to fulfil a customer agent's needs, and similar facts.

Whereas these lists are either not editable or only editable in a restricted manner, each agent also has a number of attributes and objects which are optional and which can be modified by the user. For example, a provider has an attribute list of characteristics (e.g. credibility, expertise and so on), and an object list of offers that are available to customers. Customers have only a list of preferences. Preferences (which describe the customer's preferred products and the providers that supply them) are created by selecting (classes or instances of) products and providers. Offers are similarly created by selecting a product from the products list.

Behaviours are added, modified or deactivated using a simple editor that allows the user to assemble rules by selecting from the range of predefined conditions and consequences.

On the customer side these rules activate some of the modes of search suggested by economic and consumer theory: Deliberate search, a satisficing search (Simon 1955), trend following and habitual behaviour. By setting thresholds for the satisfaction level the user can control the condition under which the action will be applied.

On the provider side, actions include price variations, different advertisement modes and actions that represent new content innovations. By setting the thresholds for sale-, income- and market share related indicators, the user can specify the conditions in which these actions are to be applied.

Products are represented by the attributes that characterise them. This is a common approach in consumer theory (Lancaster 1991) and builds on the assumption that products are purchased for their attributes, and that consumers usually value these attributes in their buying decisions differently according to personal taste and context. Preferences are represented in terms of the attributes of an ideal product to be bought from an ideal provider, each of the attributes having a relative importance value. For example, a journalist deciding to access a newspaper archive will look for one which provides documents of high quality, where expertise in the field can be found, and so on, and these attributes would be valued highly, while the cost of the subscription may be relatively less important. On the other hand, the journalist may be perfectly satisfied with the average, free available news content for their own personal use.

On the provider side, products appear as offers, exposing a bundle of attributes that, together with the provider's attributes, can be compared by the customers to their ideal conceptions. Products are divided into 'content' and 'other' products. While 'other' products currently have no attributes of their own, content products have two configurable feature lists to represent their more 'technical' aspects and the characteristics of their content. The technical dimension is used to determine the basic fit of a searched product (for example, consumers surfing the net are only looking for products distributed through web-sites, although the same product can be offered through other channels such as on mobile phones). The content dimension describes the nature of the product itself. Most attention was paid to content products as these are of the greatest importance for decision makers – they are naturally the main instrument that allows content providers to attract and bind users and are thus at the very core of the most (existing and proposed) business models.

The central activity of the simulation is that customers buy products. To decide which product to buy, a customer agent ranks combinations of offers according to the degree that they match its preferences. The combination with the highest value and with a total price below the agent's available budget is chosen.

To determine the match between a preference and an offer, the fuzzy matching component iMatcher, provided by iSOCO, one of the project partners, is used. Given an offer for a product and the preferences of a customer for this product, iMatcher defines a fuzzy function for each product attribute, which computes a measure for the proximity of the preferred attribute value to the actual attribute value of an offer. After computing scores for each attribute, the weighted mean of these are calculated, using the importance values that were defined for a customer's preference during set-up. The resulting value ranges between 0 and 1 and can directly be interpreted as the satisfaction level of a customer with a provider's offer for a specific product.

After calculating the scores for each preference and storing them, a customer agent computes a table of all possible combinations of offers that match its demand, and calculates the overall satisfaction level of each combination as the average of their matching scores. The price information that is associated with the offers is summed for each combination and recorded in the table. Finally, after ranking the combinations by their overall satisfaction levels, the customer agent selects the first combination whose total price is above its budget.

The algorithm thus implements a utility maximising homo oeconomicus, but extends it by treating preferences explicitly, and, depending on the search mode of the consumer, allows for suboptimal results due to limitations in the search space.

Running a simulation involves the instantiation of the model and agent classes that extend the classes defined by the user interface (using the RePast agent-based modelling library, http://repast. sourceforge.net/). These classes are responsible for adding methods specific to the simulation (e.g. to access the model and calculate indicators) and for the creation of the rule base which determines each agent's actions (using the JESS rule engine http://herzberg.ca.sandia.gov/jess/). To create the rule base, the rules defined by the user are translated to a script that is used by the JESS rule system to create the engine.

During a simulation step, the model first calls a provider agent method to initiate the application of indicators representing the internal state of the agent and of its environment, collected in the previous step, to its rule engine. For each matching condition, the rule engine applies the consequent by instantiating and executing the corresponding action class. These provider actions may modify a provider's offers by adding or modifying product attributes, or communicate their offerings to the market.

After all providers have executed their actions, the model calls a customer agent method, which analogously triggers the execution of actions depending on the values of the indicators calculated in the previous step. Customer action methods incorporate the matching process described earlier. These actions report the matches back to the customer agent, which computes its satisfaction level. The customer agents then buy products by sending buy-messages to the providers from which it wants to purchase. These are answered by a sell-message from the provider to finalise the deal.

After all the agents have acted, each agent 'reflects' on their actions and their effects, by calculating and storing the indicators describing their internal and external state. These indicators are applied to the rule engine in the following step.

After each step, the output display of the simulation is updated. It shows a log of activity, a table describing a firm's success in terms of market share, a table displaying the agents and the actions they carried out, and some simple graphs using the graphical libraries of RePast (Figure 2).

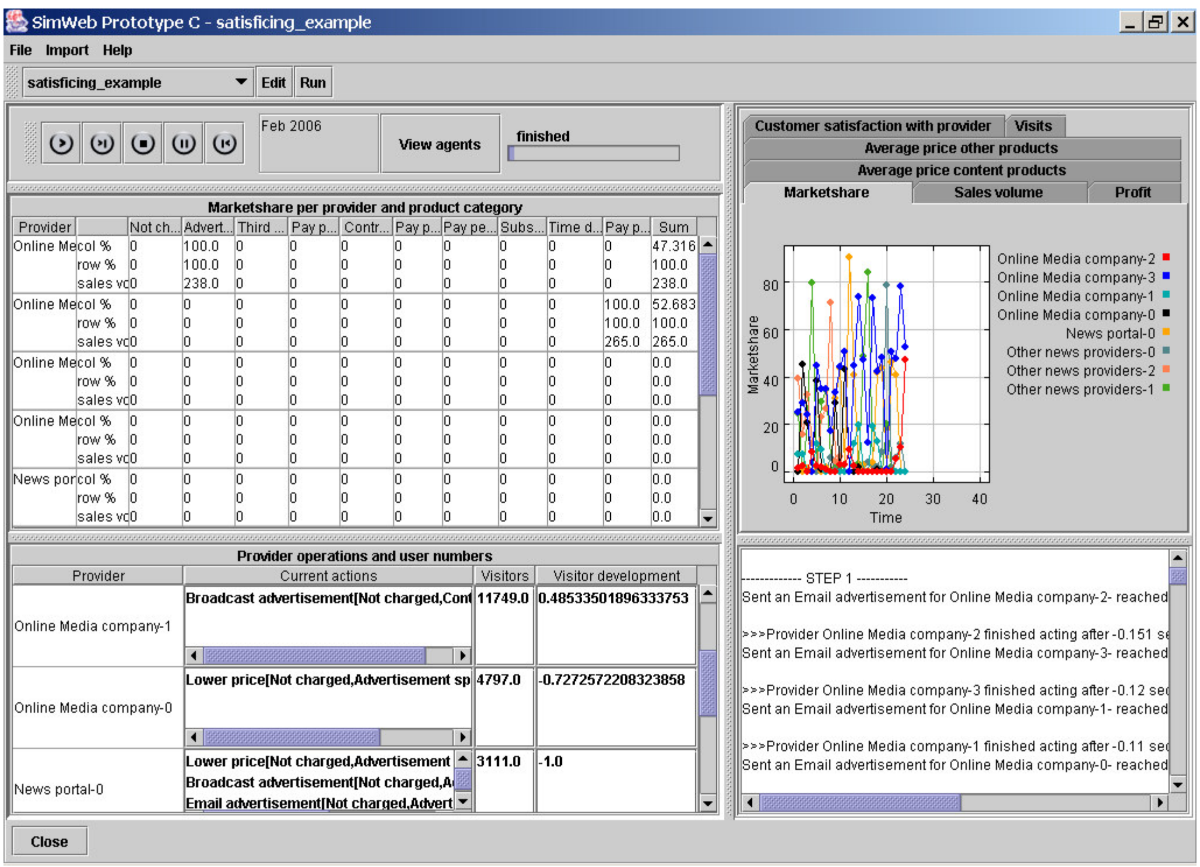

Figure 2: The output display of a simulation

USING THE TOOL TO CREATE SIMPLE SCENARIOS

The principal competitors in the online news domain are the traditional newspaper that has started an online version (e.g. the *Guardian*, the *Wall Street Journal*), News Portals which aggregate news from other providers (e.g. Google News), Internet Service Providers, which generally buy in news to provide content for their domestic customers, and other technology providers. Each of these stakeholders has a different approach to using and distributing news. These differences can be represented by creating sub-classes of the basic 'Provider' class, such as "Online media company", "News portal" and so on. The range of actions available to newspapers is generally larger than it is for other providers – it is easier for them to create new products with the backing of their offline products than it is for some other providers, such as portals, which mainly rely on purchasing their content. This may be represented in the model by specifying different conditions for the predefined action "create content product".

Having established these differentiations on a class level, variations at the individual level can be introduced, for example by assigning different budgets to different providers, which will have the effect of restricting their ability to apply certain actions. Corresponding steps apply on the customer side. The most obvious segmentation between customers is the one that distinguishes business and individual consumers. Assuming that business customers use a more rational form of economic behaviour than individuals, default rules would be created for business customers applying actions that involve a thorough search.

As can be seen from these examples, building a useful simulation depends on having both a participant's understanding of the domain (so that one knows who the stakeholders are and what their likely relationships and strategies will be) and wide-ranging knowledge of the current situation (so that the parameters can be set to appropriate initial settings). The former is achieved through the orientation of the model to use by participants themselves, possibly assisted by consultants or, for the moment, project members. The latter is being addressed by a range of quantitative and qualitative data gathering exercises undertaken by the project, which has included a web-based survey of the online-news sector (104 respondents) and a programme of face-to-face and telephone interviews with people from provider organisations, together with data from a wide range of academic and commercial reports describing the sector.

CONCLUSION

We have described the architecture and implementation of a multi-agent simulation tool that may be used by online firms to evaluate the impact of strategy options in an uncertain and dynamic business environment. We have noted that it is critical to the success of the model that business users should be able to understand the model, that they should be able to input their own knowledge of the business environment in which they are working, and that they should be able to interpret what the model tells them about possible future scenarios. In this, the model we have described has some parallels with the many participatory models that have been developed in the very different context of rural environmental management in less developed countries, where farmers, for example, also face difficult decisions about planting strategies in the face of a dynamic environment that is affected by the actions of other farmers (Barreteau et al 2003).

As a prototype, the model has a number of limitations, and these are being explored with the help of participants in a series of interviews and demonstrations. The prototype, which at present is oriented to the online new sector, will also be adapted to develop scenarios for the online music sector, which has similar but not identical characteristics to online news. The outcome will be a detailed requirements specification for the final version of the model which will be one of the project deliverables.

ACKNOWLEDGEMENTS

The work on which the paper is based has been conducted as part of a European Union supported project, Simweb (http://www.simdigital.com/), contract IST-2001-34651. We thank other members of the project, especially Kornelia van der Beek, Mary Ebeling, Cornelia Krüger, Barbara Llacay, Maite López, Xavier Noria, Gilbert Peffer, Ana Maria Ramathan and Miguel Varela.

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