Market Efficiency of a Digital Business Ecosystem*

multiagent systems, genetic algorithms, market-oriented programming

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Abstract

The Digital Business Ecosystem (DBE) project aims to build an Internet-based environment in which businesses will be able to interact with each other efficiently. It is envisaged that when this platform is realised it will allow Europe's Small and Medium Enterprises (SMEs) to compete at world-class level no matter how small, remote, or obscure their business. A multi-agent system simulation of the DBE environment is used to study the effects the DBE and the knowledge it provides to its members will have on market efficiency. Preliminary experiments show that the exchange of information between SMEs about the services they provide has a positive impact on the efficiency of the market.

1 Introduction

The overall objective of the DBE project [DBE, 2002] is to launch a new technology paradigm for the creation of a digital business ecosystem that will interlink SMEs and software providers. The project is encompassed by the European Union's initiative to become a leader in the field of software application development and to strengthen its SME industry. An open source distributed environment will support the spontaneous evolution, adaptation and composition of software components and services, allowing SMEs that are service providers to cooperate in the production of applications adapted to local business needs. This will allow small software providers in Europe to leverage new distribution channels providing niche services in local ecosystems and extend their market reach through the DBE framework.

The main goal of this work, which is carried out as part of the DBE project, is to study how the efficiency of the market is affected by the interactions between the SMEs within the Digital Business Ecosystem environment. Efficient Markets Theory [Fama, 1970], states that at any given time, the price of an asset reflects all available *information* [Bodie *et al.*, 2002].

Within the environment of the DBE business alliances, networks and supply chains require less effort to be formed. This promotes cooperation and easier dissemination of information between the SMEs. On the other hand, competition for a share of the market becomes more direct. The way the DBE environment is modelled here is different than an asset market, in that it is driven by demand which is fixed and unaffected by the supplied DBE services. In this case the market is efficient if, at any given time, the supply of a service reflects all available information.

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2 Model of Interaction

SMEs are modelled as agents in a multi-agent system. The services the SMEs provide are bit strings, each bit symbolising a feature of the service. Finally, the underlying market is modelled by a set of requests (market needs). A request is a bit string of the same size as a service bit string. Each SME has a population (or portfolio) of services. This population is not static throughout the lifetime of the SME. If a service is successful, the SME adds similar services to the portfolio while an unsuccessful service is discarded. The whole process is modelled by a Genetic Algorithm within the portfolio which involves mutation and survival of the fittest. Through this population each SME chooses which market segment(s) it will satisfy. The Genetic Algorithm represents the R&D businesses perform in order to improve their services.

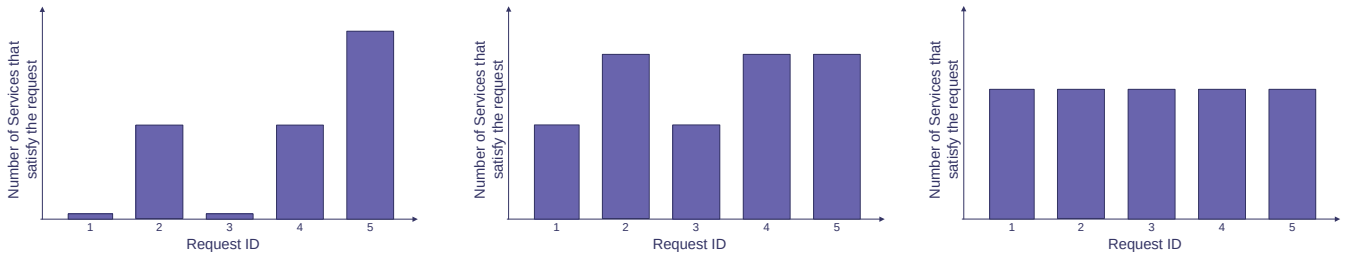
The fitness of a service measures how profitable it is to its owner. Profitability depends on: (a) how close the service is to the market needs (service-request similarity) and (b) how many other services satisfy those needs (limited demand). The fitness of an SME equals the total fitness of the services it offers.

Consider a service S and a request R, each represented by a bit string of fixed length. Similarity is measured by the percentage of shared bit values between S and R, denoted by $d(R, S)$. If the market requests are $R_1, R_2, ..., R_n$, fitness of a service S is

$$U(S) = \sum_{i}^{n} (e^{-\frac{1-d(Ri,S)}{\sigma^2}})$$

The term $e^{-\frac{1-d(Ri,S)}{\sigma^2}}$ is used to parametrise the fitness landscape, σ being a shape parameter.

The demand in the DBE market is limited. This is represented in the model by a penalty on the fitness of a service in



(a) Unlimited demand (b) Limited demand (c) Population exchange

Figure 1: Services per Request when the market has reached steady state. Numbers 1-5 denote 5 different requests/market needs in the DBE. The height of the bars shows how many services satisfy these requests.

the case where there are many similar services in the population of all SMEs. Let $T(S) = \{S_i : d(S, Si) < \tau\}$ be the set of 'neighbouring' services to S, i.e. those that have less than $\tau\%$ bits different than S. The taxed fitness of a service will be

$$U^*(S) = U(S) - \alpha|T(S)|$$

where α is a constant and $|T(S)|$ is the cardinality of the set $T(S)$.

To highlight the necessity of introducing a limit on the demand in the model, a simulation of the DBE market has been run with unlimited demand. Figure 1(a) shows the services offered in the DBE when the system reaches steady state. Note that some requests are fairly well satisfied by the SMEs while others are not satisfied at all and represent good opportunities for profit. With unlimited demand in the market, there is no incentive for SMEs to search for those opportunities. Figure 1(b) shows the services offered after the same experiment was run, this time with limited demand. There is a much better coverage of the underlying market needs but it is clear that the market is not efficient as the SMEs that cater for requests 2, 4, 5 lack information about requests 1, 3.

There are several allocations of SMEs to market needs, each one providing a level of efficiency. There are many local optima in this space of allocations and the system on its own does not always find the global optimum. The market mechanism is such that the SMEs lack information about the market. One of the basic assumptions of Efficient Markets Theory is that greater dissemination of information leads to higher levels of efficiency.

A simple way to increase information available to SMEs is to give them access to parts of each others' service portfolio. This method can provide to the SMEs the information needed so that the system reaches the global optimum of allocation of SMEs to market needs. Population exchange (or migration) has been studied in Genetic Algorithms' literature [Cantu-Paz, 1998]. It is generally used to introduce diversity in populations.

The market mechanism used for the simulation is modified such that at regular time intervals[1] an exchange of service populations happens between the SMEs with low fitness. This corresponds to an exchange of information on the market, with an SME voluntarily giving away some of its trade secrets to a competitor. Figure 1(c) shows the services offered in the DBE when steady state has been reached after several rounds of exchanges have taken place. In contrast to previous experiments, there now is a fair coverage of the market needs when the system reaches steady state, as the individually unsuccessful SMEs 'join forces' to reach a mutually beneficial state.

The results of this experiment suggest that the exchange indeed knocks the system into the globally optimal allocation of SMEs to market needs. Exchange leads to fuller information which in turn brings about greater market efficiency.

[1]The simulation was left to run for 600 time ticks with an exchange happening every 150 ticks.

3 Discussion

The launch of the digital business ecosystem will bring about a new economic paradigm. In this work, mechanisms that will make the DBE market efficient are studied. A model of the market has been devised, which is used to conduct simulations. Experiments have shown that the efficiency levels of the market rise when the participating SMEs share information about their service portfolios with each other.

The sharing of information is beneficial to the operation of the market, however it is not always gainful for the SMEs that make their services public. Current work focuses on identifying incentives that will make it worthwhile for a company to share some of its services. The results of this work might provide insight as to what drives the development of free/open-source software.

References

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