Social Network Simulation and Self-Organisation

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1. Approach for Cooperation

Inception, analysis, conceptualisation, specification and evolutionary implementation and boot-strapping of a Digital Business Ecosystem (DBE) infrastructure need systematic integration of the key-domains of Business, Computing, Science and Socio-economics (Linthicum et al., 2003). Thus it represents a paramount challenge in communication and collaboration efforts to jointly optimise and develop further this distributed infrastructure that is based on knowledge and research outcomes from all the above-mentioned disciplines. In the following we present an effective means of collaboration by introducing a simulation framework called Evolutionary Environment Simulator (EVESIM; Kurz et al, 2006) that offers a modularised framework where different stakeholders can collaborate by plugging in modules into EVESIM and by utilising modules of other stakeholders.

Besides the potential of making benefits of DBE visible amongst all stakeholders, EVESIM acts as important building block for the conceptual study of the intrinsic optimisation potential of the DBE. It offers pre-flight features for further steps in conceptual and technical development and it makes it possible to adjust technical aspects of the infrastructure based on hypothesis testing and prior emulation. Also the demonstration of specific boot-strapping behaviour and the visualisation of social science research’s results and convincing forecasts for potential future DBE users and organizations are at scope of this simulation framework.

In principle, the development of evolutionary algorithms and the analysis of social networks could be performed independently, thereby, however, excluding any potential of mutual benefits. In this aspect, the EVESIM can be considered a kind of ‘middleware’ between the Natural Science and Social Science domain. The EVESIM is the software simulation framework which facilitates the communication between the Natural and Social Science “applications” that possibly base on identical meta-concepts. That does not mean that EVESIM solves all issues of communication but it is a starting point of how different areas of science can effectively collaborate and take advantage of each other.

We discuss in the following the issues in the context of Social Science and Natural Science and detail the Evolutionary Environment Simulator itself.

1.1. Natural Science

To imitate Digital Business Ecosystems the real-world behaviour has to be simulated which is achieved by using evolutionary algorithms, well known from the study of life as explained in section 1.1 “Natural Science Paradigms”. Evolutionary algorithms are used to find an optimum solution for different types of problems. In the case of the EVESIM, the challenge is to find the best-fitting service for a specific task of a SME. Thus by using evolutionary algorithms the self-organizing features of natural ecosystems are utilized to simulate and enhance business networks.

Furthermore, it is possible to check the effects of different social and business parameters onto the ecosystem. To achieve this, the individual SMEs in the ecosystem are simulated by independent software agents (Note: In the context of EVESIM, the terms agents, SMEs and actors are used interchangeably). These agents can interact and individually adapt to the changing business needs. The possibility to adapt dynamically to a changing ecosystem in a self-organizing way is the major advantage of utilizing biological

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1 According to [2], middleware is a software that facilitates the communication between (two) applications.
approaches in the Digital Business Ecosystem. Therefore evolutionary algorithms are the fundamental optimisation mechanism of the EVESIM.

As was mentioned in section 1.1.5, it is hard to predict how a real-world ecosystem will evolve. This is true for a simulated ecosystem as well. But by utilising a simulator it is possible to find out key parameters influencing the evolution of an ecosystem. One of these key parameters is the critical mass of participants that is needed to get the ecosystem work as detailed in (Kurz and Heistracher, 2007). As research on evolutionary algorithms, for example, is often done on random high-scale networks (Colin, 2002) the availability of real-world data from Social Science would be highly beneficial to make simulations more ‘naturalistic’.

The input of social science in this sense is mainly correlated to the concept of social capital; that of relational and business territorial networks is, in fact, one of the theoretical approach social researchers choose for interpreting the DBE community building process. From this specific point of view the simulator can be understood as an instrument for visualize, in a dynamic way, ongoing dynamics and as a tool for validate different hypothesis on the capacity of DBE to boost territorial social capital by improving the level and the quality of collaboration among SMEs and other local actors.

1.2. Social Science

Researches carried on by social scientists in the DBE consortium have been focused not on technology itself – considered as an independent factor of business attitude - but on the correlation between technological innovation and existing social relations. A key question was represented by the possibility for DBE to reinforce already existing business and social relationship and/or create new links among local players in this way contributing to improving the territorial social capital, i.e. the level and quality of collaborations among local players. The simulator come into play after the first network analysis research, as an useful tool for improving results visualisation and multi variable analysis.

When analysing results from a range of different researches, it emerges clearly that the capacity to collaborate and take advantage of social capital is a decisive factor in the diffusion of innovation within a given local production system and in its SMEs and this could be the case also for the DBE diffusion. SMEs collaboration and cluster is a well know catchphrase in the innovation debate, however, the latest research carried out by Censis indicates the pressing need to abandon the use of slogans and focus, instead, on the various levels of collaboration, highlighting which models they give rise to and which benefits they can bring to companies implementing them. An approach of this type makes it possible to analyse the concept of collaboration more systematically, highlighting the way in which SMEs are still too often involved in so-called ‘limited-horizon collaborations’ that are implemented through the use of shared services, through participation in trade fairs and by accessing shared credit services. We use the term ‘limited temporal horizon’ to underline how this type of initiative - even when formalised and persistent over time - does not face up to the problem of company development in project terms. This model can guarantees economic benefits in the short term but should not be considered suitable as a facilitator for product or process innovation. DBE has been see as an instrument for open up new collaborative process, with a wider horizon. The advantages of collaboration, in fact, increase in proportion to two factors:

- The centrality of the corporate functions engaged: what is being collaborated on?
- The heterogeneous complexity of the network: who is the collaboration between?

In other words, the advantages for companies increase as they move from collaboration on support functions to collaboration on strategic functions (R&D, marketing, internationalisation, and so forth) and as they open up their networks to university, research centres, intermediate actors as Chambers of Commerce and Development agencies an so on. DBE – thanks to its flexible architecture – can easily adapt to different territorial characteristics and include different local actors accordingly to their missions and SMEs real needs. In order to evaluate in which grade this is not only possible in theory but also already observable in practise, Censis carried out two different surveys on existing networks and present territorial social capital using network analysis methodology[^2]. The role of simulator, here, is that of visualizing and making dynamic

[^2]: An initial definition of social capital is required here in order to understand the rapid conversion from social capital to networks. In accordance with Bourdieu, we may define social capital as “the sum of resources, actual and virtual, that accrue to an individual or a group by virtue of possessing a durable network [...] of mutual acquaintance and recognition” (Bourdieu, 1980:22).
data that are normally only static. The simulator has been used in order to visualize the growth of the already existing territorial networks during the process of SMEs recruitment. It make possible to picture those networks on which DBE can rely on, individuate missing links, and give in signs to the SMEs recruitment strategy adopted. Evaluating the networks in terms of social capital is essential for at least two reasons:

1. The networks, being relational infrastructures between actors, are, invariably, a useful way of defining the context in which those actors operate, and describe – at the same time - the actor’s characteristics.
2. Describing how the network is composed can help the consortium to understand which are the most important actors that should be included in the DBE in order to make the ecosystem grow and reach the critical mass needed to be self-sustaining.

An important element when studying territorial networks is that of group characteristics. In this regard, we have explored the possible types of contacts that can be considered as different types of collaboration. The potential answers were as follows: personal contact; participation in associations or institutional bodies; participation in projects; sharing of resources; information exchange; and no contact, meaning “I am aware of their existence but have no contact with them”. By diversifying the types of contact, we were able to conduct important research into:

- Formal contact vs informal contact
- Intensive relationships, i.e. highly focused collaboration projects vs extensive collaboration (sharing of information and/or resources)
- Presence or absence of subgroups and types of subgroup: associations, working groups, clusters

Thanks to network analysis first and thank to the simulator in a second step, all those information take the form of relational networks. Interviewees were given the opportunity to provide more than one answer for each relationship, meaning that Drivers may indicate different types of contacts for the same actor. Overlaps of this nature, when they occur, are very interesting because they can function as a tool with which to measure network density. Indeed, as Portes has stated, “an intrinsic characteristic of social capital is that it is relational. Whereas economic capital is in people’s bank accounts and human capital is inside their heads, social capital inheres in the structure of their relationships. To possess social capital, a person must be related to others, and it is these others, not himself, who are the actual source of his or her advantage” (Portes, 1998). In short, social capital exists only when it is shared. But is not simply a matter of the extent to which people are connected to others, but the nature of those links. Social capital benefits grow together with the grow of network density. While social capital is relational, its influence is most profound when the interaction occurs between heterogeneous clusters. From an economic perspective, several recent studies conducted as part of the World Bank’s Local Level Institutions Study (Grootaert and Narayan, 2000) confirm the importance of heterogeneity in group membership and economic outcomes. Among other, Florida also confirmed that the dimension of diversity is strongly connected to the innovation level of a given group or region. In these studies, the capacity of a group to include a high level of diversity comes across as crucial, since a high “level of tolerance”, as the author puts it, makes is easier for that group to innovate and, consequently, become more competitive. Making further reference to the metaphor of the ecosystem, it may be said that biodiversity is one of the most important conditions for sustaining the life of the system. In light of this, we introduced the question of diversity. We asked participants to grade the level of diversity in their workplaces, in order only, at this stage, to help us build up a snapshot of Driver SMEs from this particular perspective. The interviewees were asked to consider a variety of factors such as differences in levels of education, wealth, social status, gender and ethnicity, age group, party/political affiliation or religious beliefs and length of residency. In addition to the internal level of diversity described above, the level of network diversity (i.e. the number of actors with which SMEs interact and the ‘nature’ of those actors) is also important. All the above mentioned network characteristics have been introduced in the simulator and constitute what we called Territorial Social Capital.
In recent years, some scholars have proposed an additional conceptual classification. Called “linking” social capital (Woolcock, 2001), this dimension refers to a given individual’s ties to people in positions of authority, such as representatives of institutions, public (police, political parties) and private (banks) alike. Whereas the operation of bridging social capital is, as the metaphor implies, essentially horizontal (that is to say, it connects individuals of more or less equal social standing), linking social capital is more vertical, connecting individuals to key political (and other) resources and economic institutions - in other words, across power differentials. Importantly, it is not the mere presence of these institutions (schools, banks, insurance agencies) that constitutes linking social capital, but rather the nature and extent of social ties between such different actors. Defined as such, access to linking social capital is demonstrably central to producing economic wealth. The survey also explores respondents’ subjective perceptions of the trustworthiness of key institutions that shape their lives as a crucial dimension in the potential for collaboration, and this is closely related to the concept of linking social capital discussed above: reciprocal trust is a precondition for collaboration and is the ‘glue’ that makes it possible to engage with the risks and benefits of long-term projects such as DBE.

1.3. Role of the Evolutionary Environment and EVESIM

The name Evolutionary Environment Simulator comes from the initial intention to set up a simulator of the so-called Evolutionary Environment in the DBE project (Heistracher et al, 2004). The Evolutionary Environment is a network of DBE nodes and services which enable the self-organisation of the DBE network and provide a test bed for various research topics like natural language business modelling (OMG, 2006), evolutionary algorithms (Colin, 2002) and distributed intelligence (Briscoe and De Wilde, 2006). For more information on the Evolutionary Environment see also (Masuch, 2006).

Although the name Evolutionary Environment Simulator results from this particular Evolutionary Environment, the intention of the EVESIM is not only to simulate the behaviour of the Evolutionary Environment, but also to provide partners from Natural Science, Social Science, Business and Computing a framework to collaborate and test their findings together. During the ongoing collaboration in the past, the EVESIM emerged to be a generic framework for simulating self-organisation and SME networks for a broad audience from different research domains.

The approach of choice for communication and collaboration was to meet the needs of the different partners and to avoid influencing their very particular way of working as long as possible. Therefore, generic interfaces had to be found and a couple of transformation modules, import and export capabilities had to be added.

Specifically for Natural Science stakeholders, a plug in mechanism was developed to use both the evolutionary algorithms developed especially according to the EVESIM model and the evolutionary algorithms with binary representations. Through a transformation module from binary representation to the
representation of SMEs and services according to the EVESIM model, additional optimisation algorithms can be added and evaluated in their usage in a DBE. More details about the model used in the EVESIM can be found in subsection 1.7.3. Furthermore, a XML-based import mechanism enables importing real-world business network data during runtime.

Specifically for Social Science stakeholders, the EVESIM provides import capabilities for Comma Separated Files (CSV). That enables non-technically experienced people to export data from any spreadsheet software for subsequent import into the EVESIM. Moreover, the configuration of actors along seven predefined ‘social variables’ influences the behaviour and set-up of the agents in the simulation. These variables are described in the following.

2. Social Networks present and future dimensions

As we already mentioned, Censis carried on a first survey in the associated regions about RC and Drivers’ relational networks. Data gathered in Aragon have been the starting point for the collaboration with computer science specialists and the simulator adjustment to social science needs. In this first survey 7 typologies of relation were take in consideration:

- personal contact
- share of information
- share of resources
- partaking in projects
- participation in association or institutional bodies
- superficial recognition (I know them but I have not contact we them)
- no contact

In the simulator to each connection typologies correspond a different grade of strength that impact of the network grow rate. In the next research, when more SMEs will be interviewed (drivers, as well as implementer and users) we wish to be able to introduce in the simulator more variables, mainly correlated to SMEs economic characteristics (size, sector, turnover, N. of client and providers and so on) but also related to their approach to innovation, ICT and collaboration and we’ll try to simulate possible impacts of those variables on the network growth rate, service migration rate and connectivity rate.

Fig.2 Possible variable for future simulator development

By introducing those variable the simulator will acquire a new use for social science. Beside the possibility to visualize in a dynamic way static data, it will be also an interesting instrument for training and communication. By modifying each SMEs characteristics would be possible to visualize the outputs in term
of collaboration pats and related business benefits. Introducing those new variables will imply a modification of the simulators and will require more research from both side, that of social science and that of computer science.

3 Evolutionary Environment Simulator - EVESIM

In the following, we discuss the technical implementation of the EVESIM. The according source code can be found at (Kurz et al, 2006). To keep the simulations as realistic as possible while attaining the goal of speeding up the process of evolution, a number of tools were used to simulate the DBE system. The EVESIM tackles the goal of having a system where the network nodes remember past interactions with different other nodes and services to continually improve the system in a smooth way. Moreover, the EVESIM provides a simulation framework with rich configuration and visualisation capabilities for being applicable for different digital ecosystems during future research (see Fig. 3).

The implementation of the simulator itself required the collaboration of many different disciplines. The EVESIM stands to benefit from the input of partners concerning genetic algorithms, global optimisations, symbiosis and competition, social networks as well as software engineering. These groups, consequently, can utilise the EVESIM sources. By adding code and features to this project it became a cross-domain collaboration platform.

The results of the simulations, though, do not claim to be a one hundred percent realistic. The intention of the cross-domain collaboration is to make the results more realistic and the EVESIM provides a test bed for this endeavour. Moreover, by restricting the variables used in a system, the disciplines can run first there simulations on a restricted area, e.g. high scale networks for genetic algorithms research, and then afterwards apply the algorithms to a more realistic and customized network structure.

Fig. 3 Representation of a SME and Habitat, respectively within the EVESIM called Actor

Although the EVESIM model is intended to be as close as possible to reality, the model represents an abstraction layer, which enables the simulation of the behaviour of small real-world networks as well as the simulation of well-defined problems in high-scale networks. The representation of SMEs and especially of service descriptions within the EVESIM are an abstraction of Semantic Business Vocabularies and Business Rules (SBVR) and therefore a mapping of SBVR logic into a set of features (flattening), which results in a simplified model that does not take into account the full set of SBVR capabilities. SBVR is a natural language approach for business modelling (see MOG, 2005 and OMG, 2006). Nevertheless, this model is a
compromise between the real SBVR representation and the abstraction level that facilitates a simulation that is close to reality. Additionally, the matching of SBVR models and its theoretical implications are still in research status. Consequently, a level of abstraction has to be found so that a generic objective function can be defined, capable of being applied to a broader set of service descriptions (potentially any version of business modelling language).

As delineated as A in Fig. 3, each service is represented by a number of attributes. These attributes can be symbolic (color of a car) or numeric (discount for a price). As symbolic attributes can be simplified by using natural numbers, the range of attributes could be chosen as real numbers for both, symbolic and numeric values. As SBVR describes models and as the search will also be on the basis of models, real numeric attributes are not the main focus. Therefore, the values of attributes within the EVESIM are currently set as a subset of natural numbers. In case of service combinations, the attributes of the individual services are merged and consequently construct a new service description, e.g. a word processor consisting of word processing, thesaurus and spell-checker. The comparison of two services is a comparison of all the attributes of one service to all the attributes of another service and service combination, respectively. When a new service is produced it appears first in the portfolio of its producer SME. The producer SME is presented by the actor which produces or offers a service. In case of a service combination of two existing services, the actor who combined the service becomes the owner of the new service. This is why we assume that additional effort was needed to combine existing services. From user perspective for example, a travel agency is the owner of the travel-service, though it merely books the corresponding flights, the airport transfers and the hotel.

![Fig. 4 Screenshot of the EVESIM with different actors in a small network.](image)

The social network analysis within the DBE currently uses a SME table for retaining the relationships between SMEs. Rows as well as columns hold the names of the SMEs. The type of relationship is represented as the value in the intersection of axes. As to provide a common import from a broad range of spreadsheet software, the import files for the EVESIM have to be CSV (Comma Separated Values) using a semicolon for separation.

For visualising the capabilities of the Evolutionary Environment, the actors, services and the whole network topology can be displayed through the EVESIM Display (see Fig. 4). For each type of actor, a picture label can be chosen from the file system to indicate the different actors in the network. The edges between the actors represent the bidirectional relationships of two actors. Beside the visualisation of the network, a label for displaying the gross Network-Fitness was introduced. The algorithm for calculating this network fitness as well as other parameters can be easily modified according to the users' needs.

In order to set up the network based on the social variables described in Section 2.7.2, we introduced capabilities for variable actor configuration. Each actor can be configured along seven social variables and can be represented by a user-defined picture and a name. For assigning this configuration to the SME agents, two approaches are possible. First, a network of a region is imported through a CSV file import and the types of actors can be defined through the seven social variables. After importing the SMEs in terms of name and social connectivity to
other SMEs, each SME can be associated with a type and therefore the specific behaviour is set, e.g. number of services on offer and demand.

Second, by configuring types of actors and including a number of actors present in the network, a higher-scale network can be extrapolated for testing algorithms for certain topologies and types of actors. One important indicator here is the so-called ‘social capital’ which indicates the connectivity of a certain actor with other actors in the network. Though, extrapolating a network is hard and not accurate at all, the usage of roughly defined actors make a simulation of a higher-scale network at least closer to reality than using a random network independent of the types of regional actors.

The technical aspects outlined here enable the EVESIM to emulate boot-strapping behaviour of digital business ecosystems based on real-world-data which is an important feature for providing visualisation-based convincing forecasts for new DBE users and organizations.

4 Collaboration: A Process of Reciprocal Understanding

The collaboration between Social Science and Natural Science has been focused in the first step on the possibility to transfer knowledge on engaged SMEs to the EVESIM. Social research, in fact, focuses on SMEs relational networks and - thanks to network analysis - visualises the correlation among SMEs and other local players.

The successful transfer of data is a first result of the collaboration described here. Respective data was related to regional catalysts (RC) and driver SMEs only and did not impact the general structure of the simulator (variables, SMEs profile, algorithm, etc.). Now that implementers and users have been engaged, new data will be available and will be integrated in the simulator thanks to the input/export features provided by EVESIM. This first impact on the structure of the simulator is now visible. The connection typologies studied so far have been already introduced above. These connection typologies go from personal contact and sharing of resources (as maximum of connection among SMEs) to more sporadic or absent relations. Those networks are not networks of services (pieces of software migrating from one ambient to another) but relational and business networks of SMEs engaged in the DBE. Nevertheless, the two layers - network of services and real-word connections - show important points of contact.

For example, three SMEs involved in several projects together may wish to share an agenda and look in the DBE platform for an agenda synchroniser. Besides this, face-to-face or business collaborations can have an impact on the level of trust between two enterprises. A high degree of trust, consequently, may invite one SME to prefer services provided by an already known enterprise instead of an unknown entity by this way introducing an important element in the migration pattern.

In both examples, a real word connection impacts a digital activity and service exchange. Besides this, the collaboration developed so far provided a common ground for understanding and developing a common language. This is a first step for real interdisciplinary research.

The next step was to define different actors by introducing certain characteristics for each actor in a DBE network. We tried to visualise a possible definition of different actors (drivers, implementers, users, other local actors) in terms of interactions, i.e. trying to understand if a connection exists between the actor’s role in the network and its level of interaction/collaboration with other local players. Besides this, social analysis provides a sort of typology of SME profile in terms of business domain, business organisation and possibly of a service to be requested.

In the future it will be important - again thanks to the collaboration of Social Science with Natural Science via the EVESIM - to understand the possible relationship between SMEs profile and service migration rate. This will require further analysis but will be of great impact on the simulations itself. At this stage it is interesting to consider different advantages that different DBE partners can take of the simulator.

From a computing perspective, the simulator is an important tool for visualising positive aspects of Peer-To-Peer Networks and self-organisation. From a Social Science perspective and a training respective RC’s perspective, the simulator can become an interesting instrument for explaining to SMEs and regional players the relevance of collaboration and of DBE. By modulation of SMEs’ profiles and other contextual variables it is possible to show which are the positive mechanisms of knowledge sharing, collaboration and clustering.
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