D.B.E. - The Digital Business Ecosystem

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List of participants

Participant Number	Participant short name	Name	Country
C1	IBM	IBM Business Consulting Services	BE
C2	LSE	London School of Economics	UK
C3	T6	T6 scarl	IT
C4	SUN	Sun Microsystems Iberica	ES
C5	FZI	Forschungszentrum Informatik	DE
C6	ICL	Imperial College London	UK
C7	IESE	IESE Business School - Universidad de Navarra	ES
C8	INTEL	INTEL Ireland	IE
C9	ISUFI	Institute for Advanced Interdisciplinary Studies University of Lecce	IT
C10	TUC	MUSIC - Technical University of Crete	EL
C11	STU	Fachhochschulgesellschaft Salzburg	AT
C12	3vSOFT	3vSOFT	IT
C13	TTC	Tampere Technology Center	FI
C14	TCD	Trinity College Dublin – Computer Science Dep.	IE
C15	UBHAM	University of Birmingham - Computer Science Dep.	UK
C16	UCE	University of Central England	UK
C17	UniS	University of Surrey	UK
C18	ITA	Aragon Technological Institute	ES
C19	CENSIS	Centro Studi Investimenti Sociali	IT
C20	WIT	Waterford Institute of Technology	IE

www.digital-ecosystem.net
info@digital-ecosystem.net

This paper was written by

Paolo Dini, London School of Economics (p.dini@lse.ac.uk)
Andrea Nicolai, T6 (a.nicolai@t-6.it)

Abstract

The two overarching objectives of the DBE project are to provide Europe with a recognised advantage in innovative software application development by its small and medium-sized enterprises (software producer SMEs) and to achieve greater information and communication technology (ICT) adoption by SMEs in general. The DBE will achieve these objectives by adopting a multi-disciplinary approach based on biology, physics, business and social sciences mechanisms and models to develop an open-source distributed environment that can support the spontaneous evolution and composition of (not necessarily open-source) software services, components, and applications. DBE transposes mechanisms from living organisms like evolution, adaptation, autonomy, viability, introspection, knowledge sharing, and self-organisation, to arrive at novel architectures and technologies, business processes, and knowledge, thus creating a network of digital business ecosystems for SMEs and software providers to improve their value networks and foster local economic development. Four areas of research encompassed by the DBE project are: 1) ICT transfer and adoption, training, ethnography, etc.; 2) business modelling; 3) Computer Science, Software Engineering and enabling technologies (web services, software agents, distributed architectures, ontologies, etc); and 4) fundamental models (Maths, Physics, Biology, AI). One of the outputs of the project will be an open-source, component-based software infrastructure that will act as a commons to support the evolutionary optimisation of software services for SMEs. This digital infrastructure will fit the local cultural identities and socio-economic needs of SMEs to support their participation in regional and sectorial innovation clusters. The DBE will change the way SMEs and EU software providers use and distribute their products and services. It will allow SMEs to link enterprise-wide external resources and value networks, and to allocate them based on their business goals and priorities. The DBE is based on the key finding that with such an evolutionary and self-organising system Europe could harness the complexity of software production and its SME software industry could regain competitiveness in the market.

THE DISCUSSION PAPER FROM THE E-BUSINESS UNIT[1]

The initial impetus to tackle these ambitious research and practical problems came from a discussion paper published by the e-Business Unit in the IST Thematic Priority of the European Commission. The paper starts by highlighting two types of Digital Divide; the regional divide refers to the wide difference in ICT adoption between Northern and Southern Europe (to which we could now also add an East-West component), while the size divide refers to the much greater adoption of e-Business practices found in large companies relative to SMEs. It then mentions that in the Fifth Framework Programme of Research (FP5) those research projects that involved SMEs directly resulted in greater levels of ICT adoption, hence confirming the importance of coordinating the research work with specific technology transfer methodologies as are provided, for instance, by so-called Regional Catalysts. Even in the more successful cases, however, we cannot forget that the ladder of ICT adoption is not static, new technologies are continually introduced and it is a significant burden even for the more motivated and technologically advanced SMEs to keep up.

At a high level, the general approach suggested by the paper for overcoming these obstacles is by connecting ICT adoption to new and more effective business models. New and more effective business models, however, are not easy to come by. As discussed above this is mainly due to the fact that SMEs

[1] Nachira, F, et al., "Toward a network of digital business ecosystems fostering the local development", Sept 2002, http://www.europa.eu.int/information_society/topics/ebusiness/godigital/sme_research/index_en.htm

are already under very significant market pressures to survive, they have already optimised their business models to remain competitive, and are likely to perceive initiatives that are meant to support them as a source of distraction and therefore a net loss in revenue in the short term. The way out of this impasse, according to the paper, is to approach the problem from multiple points of view simultaneously. Firstly, to fund longer-term research that can output results to SMEs iteratively; secondly, to make sure that the research results are practical and usable at the local level; thirdly, to develop policies of knowledge sharing between SMEs, their organisations, and local governments.

After a description of the major obstacles to ICT adoption (shortage of skills, lack of technological interoperability, costs, regulatory complexity, and shortage of capital), the paper proposes a "ladder of adoption" (adapted in part from other sources) where six stages are identified:

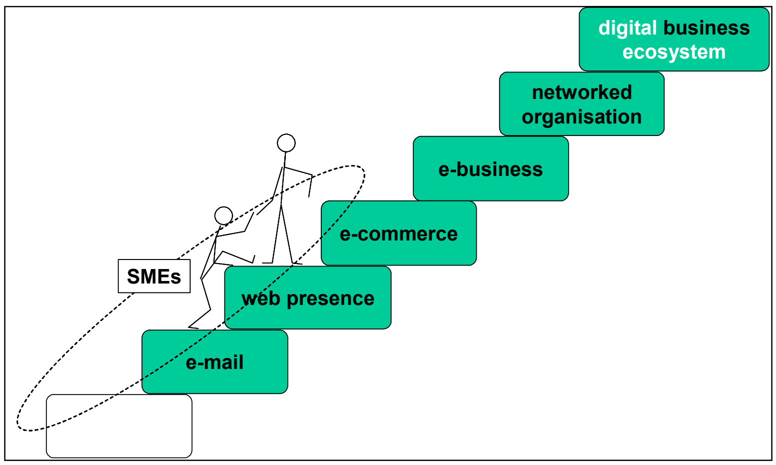


Fig. 1 Ladder of adoption of internet technologies[2]

Each stage builds on the previous, steadily approaching the bold vision of an ecosystem of digital species interacting with the business ecosystem. The appeal of this vision is undeniable, partly because the ecosystem metaphor has been used for many years in the business and socio-economic literature and is therefore familiar.

The paper proceeds with a general architecture for digital business ecosystems which is described mainly from the point of view of their geographical structure and of what they will provide, as shown in Fig. 2. This diagram can be interpreted as a cross-section of a three-dimensional solid: there is one such cross-section for each industry sector, and for each sector there are many instances of the DBE in different regions. Thus, the bottom layer is common to all instances of the DBE, throughout Europe; the middle layer is specific to a particular sector but common to all regions where that sector is present; and the top layer represents the different instances of a sector-specific DBE to be found in the different regions.

Measures for implementing the DBE are discussed next. Here a clear indication is given about two overarching principles that are considered essential to the attainment of the DBE vision:

1 – complementing theoretical research with applied research and engineering to produce a working open-source technological infrastructure
2 – re-thinking complex systems models from Biology and Physics in order to adapt and apply them to software and business

[2] Ibid

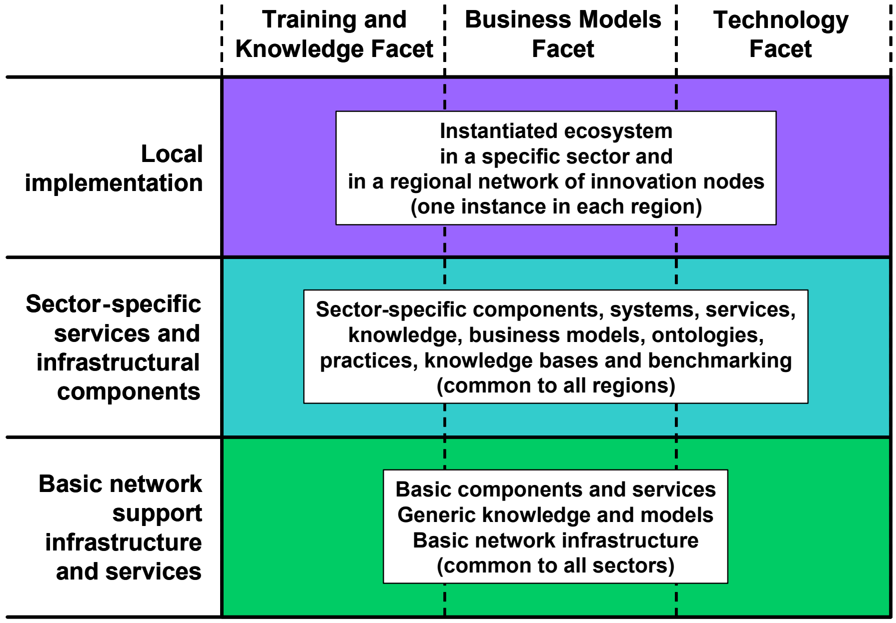


Fig. 2 View of sector-specific DBE presented in EC paper

References are made to the work of Stafford Beer in 1970-73 to apply cybernetics to more efficient management of Chile's economy and to the Intelligent Manufacturing System programme that led to Holonic Systems in manufacturing in the 90s. Actions to counter-act the major obstacles mentioned previously in the paper are then listed:

Obstacle	**Actions**
Shortage in skills and knowledge	Creation of local competence centres on e-business Building virtual learning communities Sharing e-learning and e-training modules Sharing knowledge bases of e-business models and DBE instances
Lack of technological interoperability	Use and promotion of open standards Sharing common solutions Implementations of DBEs
Costs	Software sharing, open-source software Open and distributed common infrastructure Reliance on DBEs
Regulatory complexity	Knowledge base of norms and laws Alternative methods of conflict resolution e-learning and e-training modules
Shortage of capital	Support for venture capital, investment fora

For the implementation of the three layers of the ecosystems the paper gives recommendations for different development models. The main points are open source for the infrastructure, open standards for sector-specific services, and regional catalysts for the local implementations. Finally, the paper presents the new FP6 instruments, Integrated Projects and Networks of Excellence, as the most suitable financial means to support research leading to a working DBE.

Figs. 3 places the main points we have made so far within a broader context for sustainable growth. The diagram captures the main message in Nachira's paper, i.e. that the DBE should be based on Open

Source, on a technology development research effort, and on isomorphic models (and not just metaphors) from Biology.

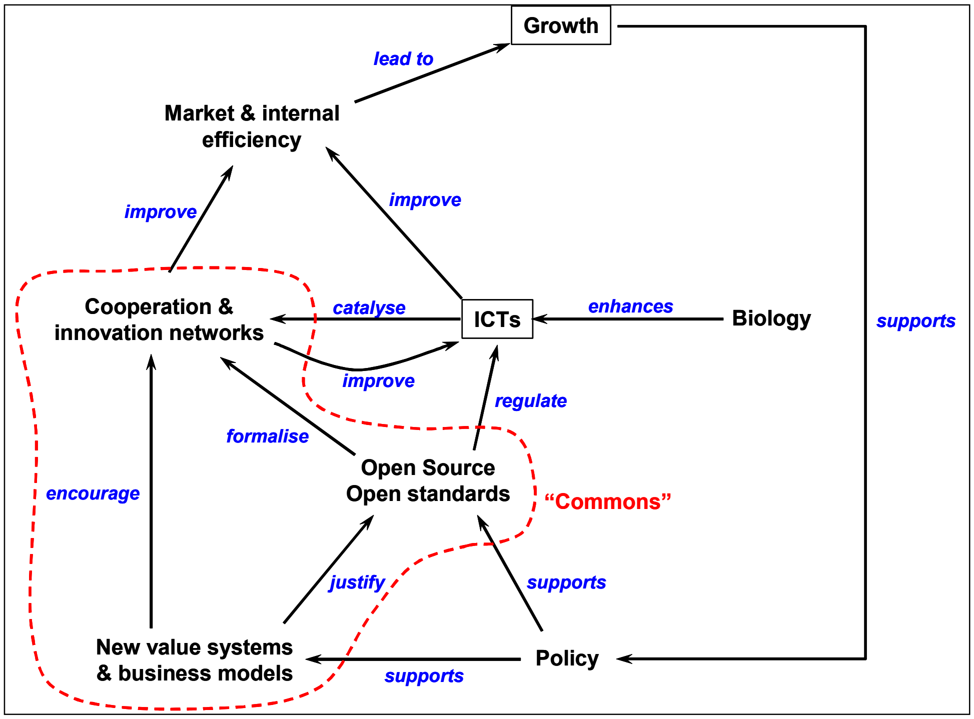


Fig. 3 Flow diagram for growth catalysed by ICTs

ON AIMS AND METHODS

Nachira's paper provides policy guidelines and suggestions for specific actions, but its most interesting contribution is to throw the project into the middle of an interdisciplinary Maelstrom. In other words, it says that there are no easy answers to the problem of growth catalysed by ICTs and only through a concerted effort from business, regional governments, and regional catalysts; from theoretical and applied research; and from different disciplines may we hope to make some progress. The DBE project has put together a plan of action that addresses all these facets. We have found that there is generally good alignment between business, governments, and regional technology transfer centres. There is also a fairly clear consensus between the theoretical and the applied aspects of the research on the overall aims. It is, however, much less clear how much alignment we have in the aims and methodologies between the different disciplines. One of the challenges we must face to succeed in this project, therefore, is to construct a common view of what the problem is and how to solve it.

During the last half-century a very significant body of work has been published in the socio-economic dynamics of development and innovation. In recent years, an increasing proportion of this work has been concerned with the role ICTs and new media can have in this dynamic. The consensus generally is that the new technologies have the potential of acting as a catalyst, or accelerator, of the development and innovation process. ICTs are meant to facilitate the transition from regional societies governed by rigid cultural norms to the popular concept of the global Information Society; and from economies based on the exchange of material goods to the Knowledge Economy.

One of the tasks we face, and that needs to be included in some of the research activities of the project, is to relate the literature on ICTs for development to the Economics literature on the Commons. The former is in itself already a multidisciplinary field that involves some technical know-how, policy and regulatory experience, ethnographic and analytical methods from Sociology, and familiarity with the problems that small firms face on a daily basis in the relevant regional and cultural contexts. Thus, the various flavours of Game Theory that formalise the sharing of resources, the balance between cooperative and competitive strategies, the utility of the players as a function of different free-riding levels within their peer group, etc provide a very useful theoretical framework by which to understand the dynamics of idealised economies based on a Commons. However, these theories and the assumptions upon which they are based may need to be adjusted to account for complex regional idiosyncrasies. For example, the questionable tax behaviour of some SMEs is not likely to change overnight, it has not prevented an impressive economic growth over the last 40 years in certain regions of Europe, and it probably is not very compatible with information sharing and transparency. It will indeed be a big challenge to understand to what extent sharing and transparency can improve the efficiency of the overall economy, and an even bigger challenge to convince individual SMEs that the utility they will derive from such efficiency is worth attempting a gradual change from how they have been running their companies for the last few decades.

Thinking a little more optimistically, the sharing of at least some aspects of knowledge and information relevant to different regions or different industry sectors may present a lower adoption barrier than attempting to introduce new business models right away. In other words, if we wish to introduce a model of economic interaction different to cut-throat competition and free-riding, let's start by proposing an alternative at a higher level of abstraction: the investment and the ROI should be at the level of knowledge rather than cash flow. While we identify opportunities for knowledge sharing, DBE technology should offer practical solutions for supporting how SMEs are normally run, acknowledging that for us this may initially represent a very narrow window of opportunity. Fig. 5 shows the most simplistic view which the DBE system can be understood: an open-source infrastructure that supports the dynamic compostion of not necessarily open-source web services. The DBE, in fact, will support both the provision of real-world services (the market) by means of web services (DBE services) as well as the sale and distribution of the DBE services themselves (the meta-market). Fig. 6 shows this distinction, and emphasises that the DBE transcends the technology through its coupling to the real market. Fig. 7 shows the initial locations where SMEs will gain access to the DBE through the Regional Catalysis and how the DBE may be grow in subsequent years.

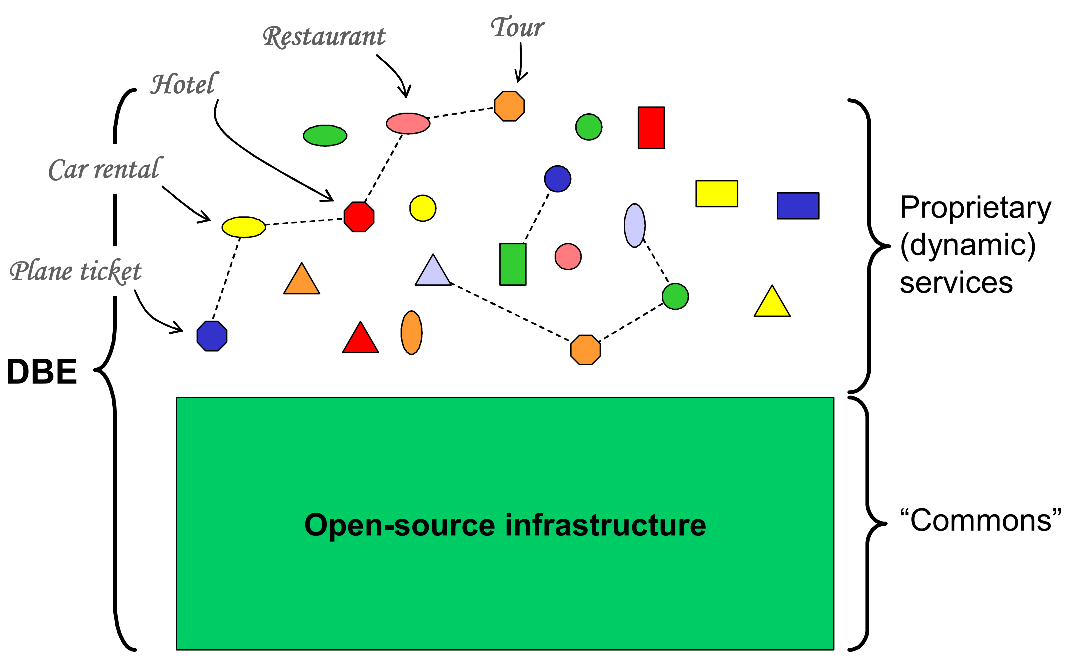


Fig. 5 High-level view of DBE technology

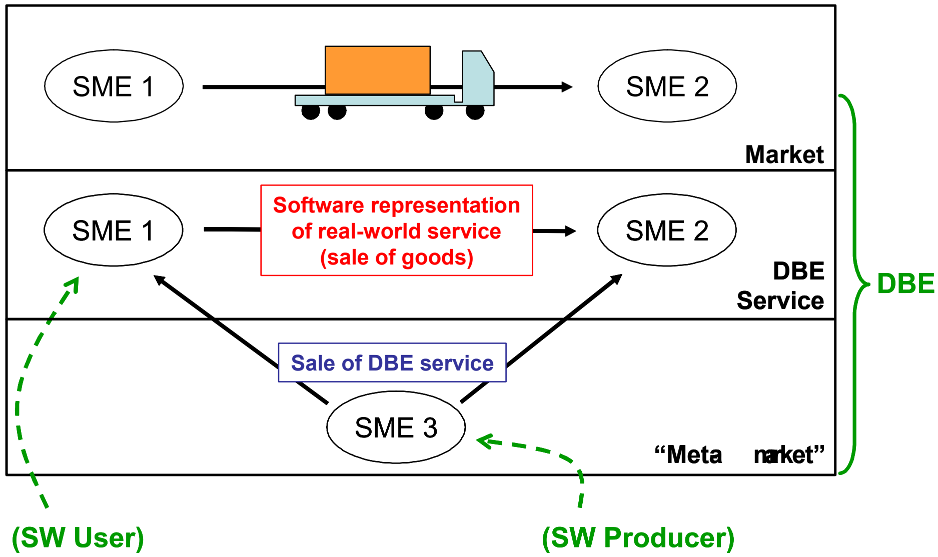


Fig. 6 Market and meta-market in the DBE

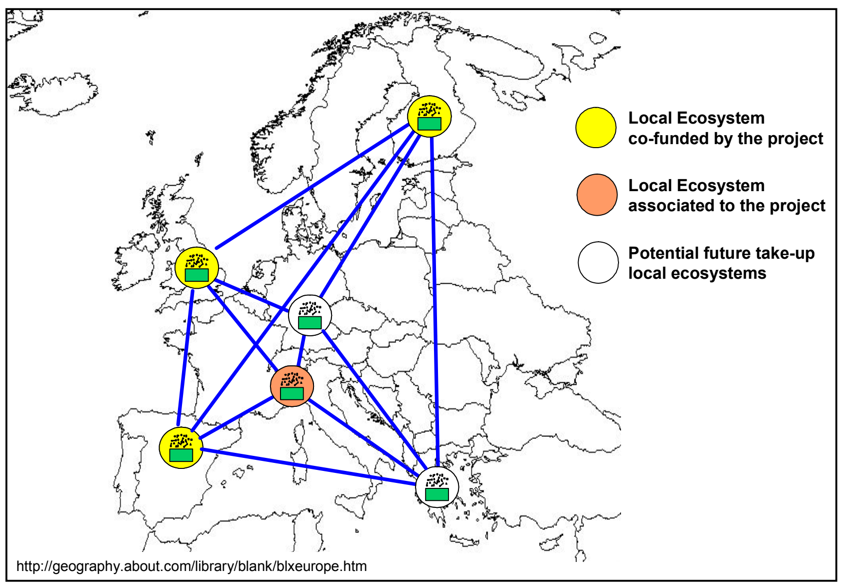


Fig. 7 Longer-term DBE vision

Nachira's paper conforms pretty well to the socio-economic and policy model of research and intervention. However, it also throws two very significant spanners (aka "monkey wrenches") in that well-constructed research and implementation model, the two overarching principles mentioned in the previous section. The construction of a software infrastructure called for by the first principle is undeniably an engineering effort, with all the deterministic and reductionist properties that it implies. With the second principle the paper goes a significant step further. It calls for self-organisation and evolutionary models from Biology to be applied to software, and it does so based on the assumption that such biological behaviour of the software, if attained, is likely to optimise the catalytic function of the ICTs in question for socio-economic growth and innovation. These are very big claims, that we have enthusiastically embraced. We are not oblivious, however, to the huge theoretical and applied research challenges that they imply, which are to be added to the social, cultural and economic challenges I have hinted at above. These challenges motivate us to dig deeper into the theoretical foundations of the various disciplines, looking for ways in which they can interact constructively. Accordingly, Fig. 8 shows a classification of the main groups of tasks of the DBE Project into four inter-connected and inter-dependent layers.

Socio-economic context	Regional policies Socio-economic dynamics Value systems Organisational forms Open Source/Open Standards	**Because we are always looking for alternatives to the status quo**
Business	Business modelling Requirements gathering, User profiling Regional Catalysts Training & adoption Regulatory framework	**Because we truly want to achieve ICT adoption by SMEs**
Computing	Knowledge base, Recommender BML, SDL, Fitness Landscape Dynamic service composition DBE UML profile P2P networks, Architecture Test automation, Accounting	**Because we want to deliver technology that works**
Science	Evolution Self-organisation Optimisation & Networks Complex systems dynamics Language & DNA	**Because we want to abstract a quantitative model of sustainability from Nature, the ultimate sustainable system**

Fig. 8 Snapshot of main research activities in the DBE Project

OUTLINE IMPLEMENTATION PLAN

Within the wide field of e-business, user needs are many and are constantly evolving. Traditional methods of software development rely on a "product creation" process involving market demand, user requirements, software engineering, and finally selling and supporting. The process is circular in that feedback from sales and support provides marketing information, which re-starts the cycle. This process originated from the early days of software when equipment and expertise were expensive, and functionality was limited, so that "right first time" was an economic necessity. This traditional method of development is mechanically satisfactory but is extremely crude when compared to the self-organisation and selection processes that are seen in Nature, and actually it neither satisfies the real technology needs of small and medium enterprises (SMEs) nor does it increase the competitiveness of the small and medium European software provider.

The DBE project aims to provide an open-source distributed environment that can support the spontaneous evolution and composition of software services, components, and applications. We believe there is much to be gained from basing the complex and distributed software technology that the DBE will require on design principles and theoretical models derived from the physical and biological sciences. Thus theories of self-organisation and algorithms from evolutionary computation are of key importance. The idea is to generate, through the DBE, software that can adapt to the SMEs rather than the other way around. In this manner the project aims to provide SMEs with a new cost-effective technology paradigm for achieving business results through the innovative use of ICTs, reducing their time to market and facilitating the enlargement of their business networks. The transformation of ICT adoption from a burden into an opportunity for local and international growth reflects the two core objectives of the project:

- Enable ICT European SME providers to gain competiveness in the software market.
- Provide e-business software solutions able to self-adapt to the needs of local SMEs, fostering ICT adoption and economic growth in local innovation nodes.

To achieve this vision, the Digital Business Ecosystem integrates a distributed environment with the software species that populate it and that combine to form complex services and applications, in response to user needs and demands. The core of the DBE is therefore fundamentally dual: to use an image, a "swarm" of software services "hovering over" an architecture that enables their dynamic composition and global connectivity. The architecture is the top layer of a stack of middleware technologies that start at the physical substrate and whose behaviour is, like an environment, fairly stable. While the DBE runs over IP and the Internet and therefore has a reasonably clear lower boundary, on the top side there is no clear boundary where the DBE ends—for instance at the user interface. This is because the dynamic behaviour of the software components is coupled to the business dynamics. New business opportunities lead to new combinations of software services and, conversely, the discovery of new software service combinations will lead to new business alliances or new markets.

In order to enable the dynamic aspects that allow discovery, coupling and mapping, the middleware will be leveraged applying meta-modelling infrastructure and description languages at the business, the component and the service levels. Meta-modelling will be the enabling factor for establishing a self-described environment. This feature will enable intelligent agents to extract behaviours, functional interfaces, and semantics. The support components of the DBE, and the services themselves, will be designed and realised with reference to meta-services, meta-SMI, meta-ontology and so forth, hence enabling interoperability at a higher level, never attempted before in IT.

Our goal is to develop a system where the software can increase the efficiency of markets without detracting from the effectiveness of individual small and medium enterprises. Thus, while the SMEs are themselves subject to the laws of the market, that can be interpreted in terms of Darwinian metaphors, the DBE can only improve the chances of survival of the companies that make use of it. On the other hand, we mean to apply very literally evolutionary processes to the software itself, in order to enable the DBE to select the “fittest” software components for given user requirements. The emulation in software of the apparently simple mechanism of evolution requires an in-depth understanding of the structural principles and dynamical processes upon which it is based and a strategy for translating these principles and processes from physical and biological systems to information systems. For this reason we propose to build a Digital Business Ecosystem through the integration of three different domains: Business, Computing, and Science, while adopting a critical perspective on the socio-economic context and value systems upon which business models and ICT adoption strategies are based. Thus, in addition to modelling businesses and applying biological theories to software, we will interact with several industrial, academic and regional development partners to construct a strategy for sustainable innovation based on Open Source and ICT adoption that can influence policy making at regional and European levels.

Fig. 9 shows the theoretical and applied flows of knowledge, between these three domains, upon which this project is built. At the heart of the diagram we find as a subset the traditional requirements-driven software engineering development process. Following the arrows Language, Implementation, and Adoption, in fact, business requirements are translated through suitable ontologies and modelling languages such as UML into a software specification that is implemented and fed back to the users. We are trying to do much more in order to achieve the evolutionary self-adaptive behaviour of a digital ecosystem. These additional capabilities of the system will be “grafted”, both at theoretical and at applied levels, at specific points along this more traditional workflow. The diagram shows how even at this high level the Science is contributing to all three stages of the cycle. Memory-based learning from embodied cognitive science will form the basis for the adaptive and self-optimising properties of the DBE; through the retention and reinforcement of usage and behavioural patterns obtained from user profiling this will lead to the self-organisation of service components into complex services. Algorithms from evolutionary computation will be applied to select candidate services in a run-time automated testing environment against specifications modelled as fitness landscapes updated continually by active and passive feedback. The point of view of dynamical systems and statistical physics will be applied to the optimisation of networks at both the software infrastructure and the business interactions levels.

Innovation in the DBE is the result of a deep blending of the scientific findings that will be used to model the technology infrastructure and that will be matched with the results of the business research on the involvement of regional catalysts in industrial clusters. In the following pages therefore we will outline the various parts of this project, divided in sub-projects, highlighting the more innovative aspects and showing how the different modules interlock. It is helpful to show, also at a high level, the flow of information and the principal functional blocks we envision in the run-time DBE environment (Fig. 10).

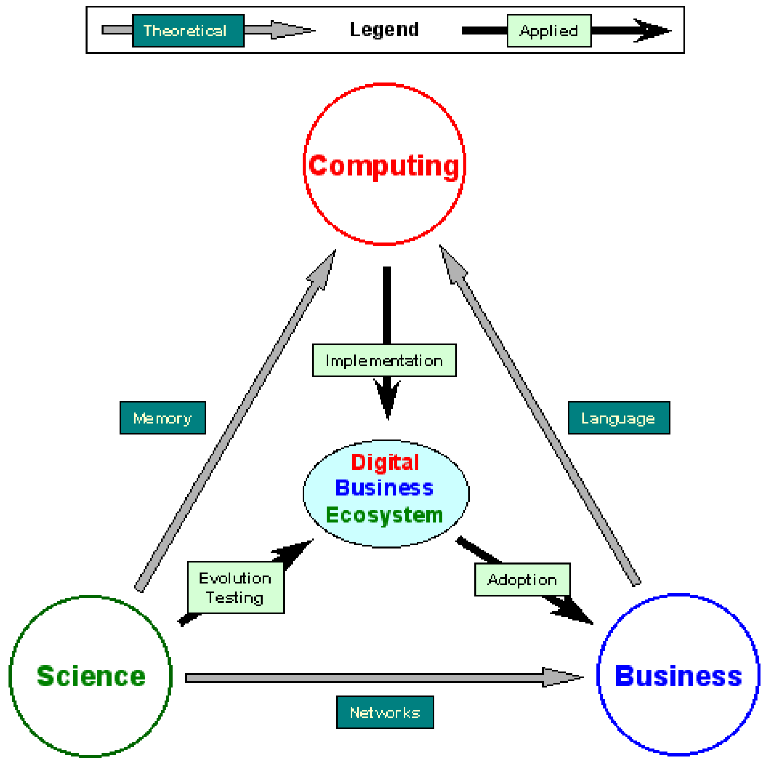


Fig. 9 DBE knowledge flows

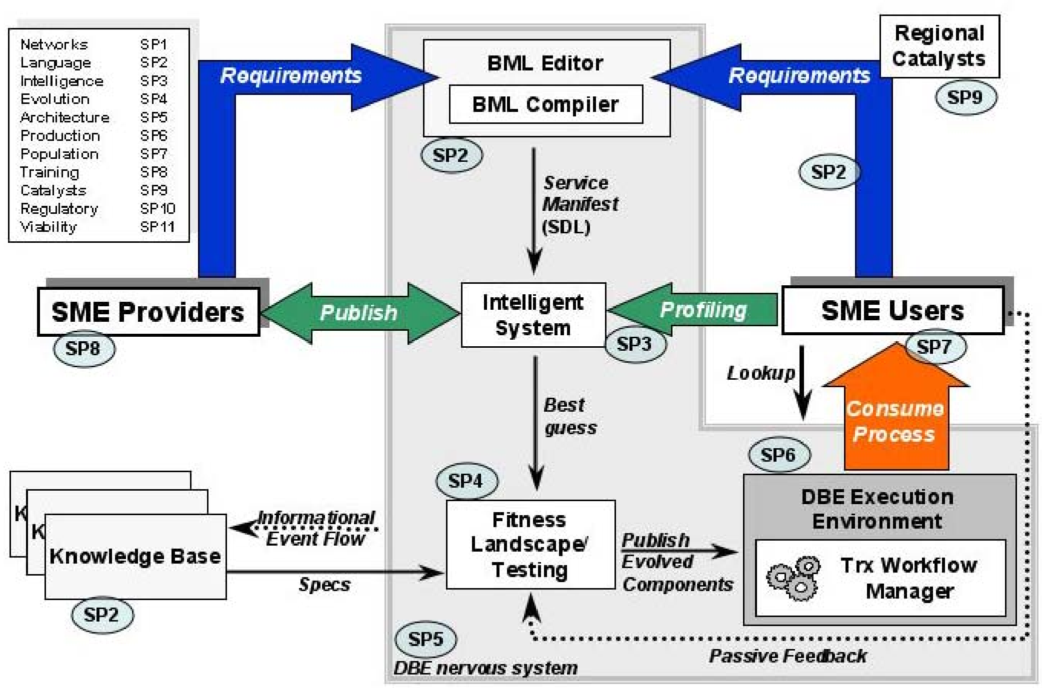


Fig. 10 Main functional blocks of the DBE

DBE workplan structure

The project has been structured in 11 sub-projects that coherently group the workpackages in multidisciplinary activities, enhancing as much as possible the overall exchange between the partners. Each sub-project is composed of a set of workpackages that build specific macro-activities of the project. This clustering approach for the DBE workpackages has been decided in order to group homogeneous and connected activities.

An important guiding principle in the proposal is that, given the long-term research objectives of the DBE, we envisage three phases of implementation that will release at regular intervals a working, and each time increasingly complex, software implementation of the DBE:

- An early release of the network abstraction layer based on the outputs of the FETISH project[3]
- a demonstrator at 18 months, prototyping some initial results from the science and language subprojects that will be used to showcase the DBE to the SMEs that will become users and providers of the DBE
- an initial distributed implementation at 2 years
- a final distributed implementation at 3 years, that will be the bootstrapped and populated digital business ecosystem

In the discussion that follows, therefore, references to existing technologies are biased toward the earlier implementations while the more ambitious innovations are biased toward the final implementation.

Sub-projects description

The description of the implementation plan will follow the logical flow of the activities among the sub-projects and work packages to reach the final objective of the DBE. The following table and Fig. 11 show the SP list:

Sub-Project
SP0: Project Management
SP1: DBE Business Networks
SP2: DBE Language
SP3: Intelligent Service Composition
SP4: Evolutionary Dynamics of DBE
SP5: DBE Core Architecture
SP6: DBE Bootstrap and Production
SP7: DBE population
SP8: Training
SP9: Regional Catalysts for DBE
SP10: DBE Regulatory Framework (IESE)
SP11: DBE System Viability

As is clear from the previous figure, the SPs are multidisciplinary, 50% of them are mixture of at least two DBE domains. Is it also clear that the DBE is not a theoretical research project. Science, indeed, is only functional in the definition of the evolutionary processes, of the intelligence and of the optimisation of Computing and Business.

In **SP1**, DBE Business Networks, we will model the relationships between businesses from the point of view of equilibrium and non-equilibrium thermodynamics, through agent-based simulations, and by simulating the software flow through the DBE networks. Our aim will be to understand how the efficiency

[3] fetish.singladura.com

of SME markets can be improved by transaction and information channels mediated by adaptive and modular software services, and to translate these insights into algorithms that can be implemented in the form of an optimiser in the DBE recommender system. Conversely, we will also analyse the existing structures, organisational forms and regulatory frameworks of European SMEs from the point of view of their suitability for taking part in the DBE and for exploiting its benefits. This analysis will inform the bootstrap and deployment plan of the DBE during the project and will lead to recommendations and training/learning modules to be developed in collaboration with the SMEs who are directly participating in the project.

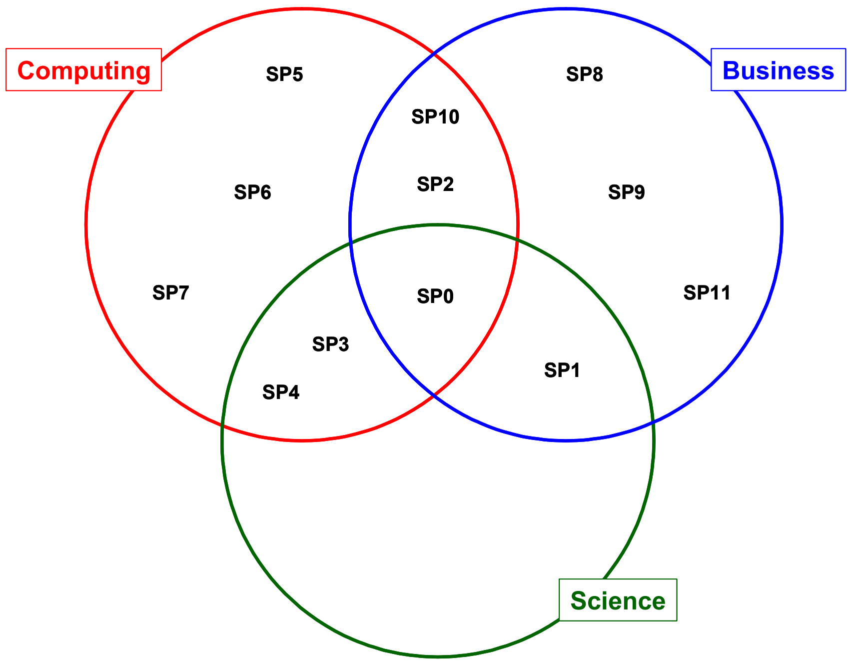


Fig. 11 DBE sub-projects

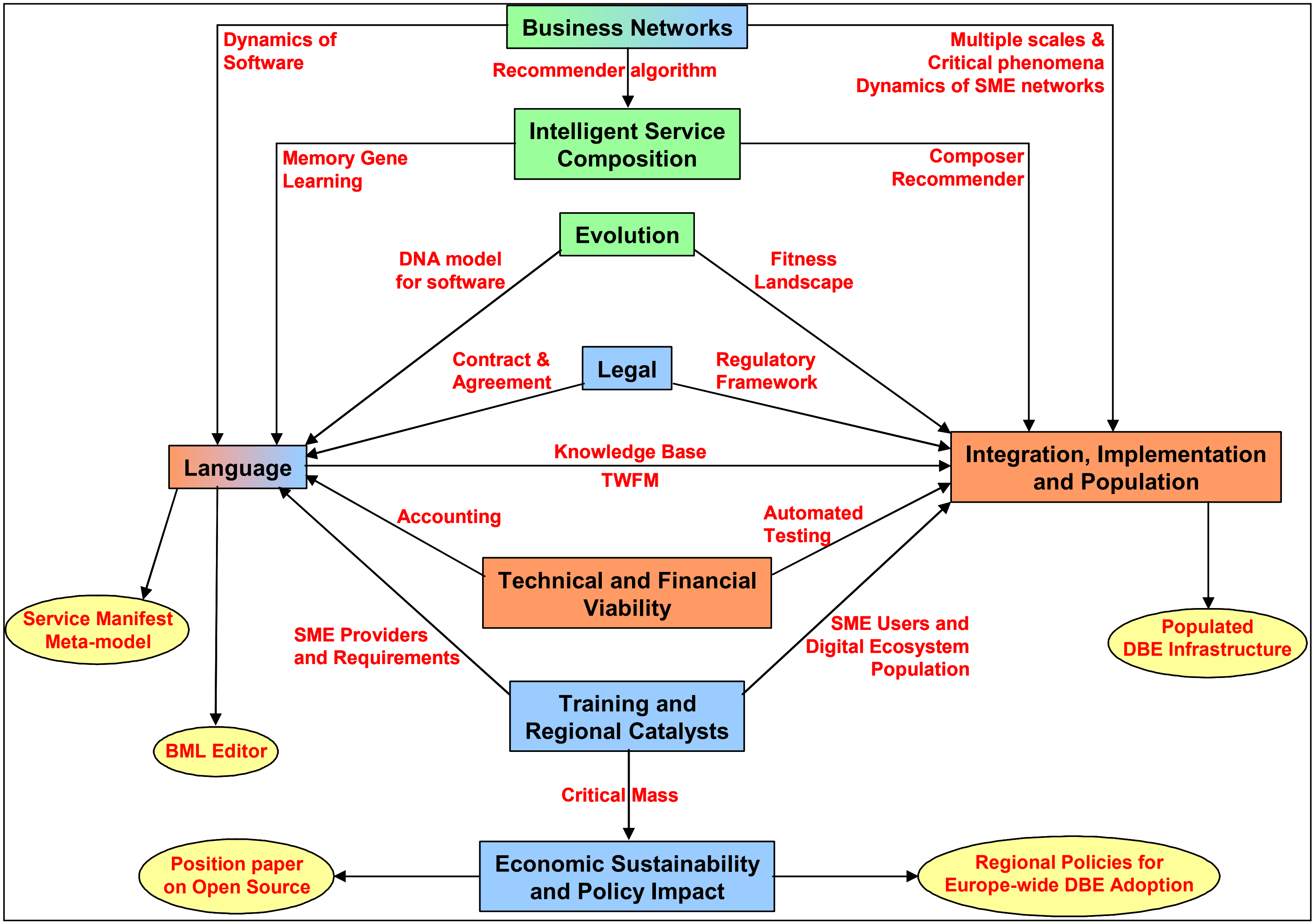
In parallel with the research on networks we will engage in the huge task of building knowledge representations of business entities, processes, and relationships. This will be the starting point of **SP2**, DBE Language, that shares similar goals to initiatives such as the Semantic Web. The most significant difference is that while the Semantic Web has a focus on information and taxonomy, the DBE enhances these objectives by concentrating on services and service aggregation (that in turn transform data). The sophisticated digital infrastructure that we will develop, and that to a significant extent already exists, in fact, needs to be interfaced to human users whose trust needs to be won through the offer of a reliable and more convenient alternative to their well-proven business practices. Starting with the analysis of SME needs and requirements we will design ontologies and knowledge bases and construct a semantic hierarchy that will enable the expression of business declarative statements through a Business Modelling Language. BML will be compiled into a Service Description Language for describing the services that, when formed into suitable chains, can enact the required functions. SDL statements will define the Service Manifest that naturally serves the function of genes of the instantiated services, offering the scientific challenge of exploring the connection between DNA and language through software. As shown in Fig. 10, the DBE nervous system carries the signals and the information that flows and gets transformed through SDL and Service Manifest.

We will complement the familiar process of deriving functionality from the representation of knowledge, by descending from higher levels of abstraction through language compilers, with the self-organisation of static and dynamic patterns of user behaviour captured incrementally by a memory-based distributed learning system. This is the subject of **SP3**, Intelligent Service Composition. The fundamental issue that this sub-project addresses is that, while in principle the automated representation of user requirements into a descriptive low-level language is not difficult to envision, there remains a big gulf between *setting* the requirements and *constructing* an algorithm that satisfies them. As a first step toward the construction of such a solution the Intelligent Composer will learn over time through user profiling data which combinations of services are more likely to satisfy a particular set of requirements. We will use the more probable usage patterns to refine the knowledge base, providing a feedback loop that will make the SDL specifications increasingly precise over time. The best-guess service chain devised by the Composer in response to user requests will be published so the SME software providers can develop the code of the various service components.

Memory-based self-organisation promises to be an effective approach to search the large and growing combination space of service chains, but it is not very discerning. Therefore the output of the Intelligent Composer will be fed to a part of the DBE that implements evolutionary optimisation algorithms in the form of a fitness landscape, the subject of **SP4**, Evolutionary Dynamics of the DBE. In the initial implementation the mutation and selection will be performed on populations of chains of services where their fitness will simply be measured as a function of their “distance” from the requirements obtained from the BML compiler. This will set the stage for a more ambitious and longer-term research challenge. Namely, we will search for the right balance of feedback and coupling between the knoweledge bases, the SDL, the Intelligent Composer, and the fitness landscape that will allow the semantics of SDL to become increasingly complex. This will give us a way to test the boundary between the description of an algorithm and the implementation of the algorithm. In the biological metaphor, this corresponds to the boundary between the genotype and the phenotype.

SP5 is concerned with the definition of the architecture that can support these distributed and interacting parts of the infrastructure and of the software components that inhabit it. The main challenges of SP5 are on the one hand to design a system that can support the ambitious projected results from the science while, on the other, specifying an internal language system that is representative of the business processes while allowing the various parts of the DBE to communicate. Attention will be given to the crucial aspect of user interfaces to ensure that the DBE will indeed provide a competitive advantage to the participating SMEs while opening an innovative channel of software distribution from European software houses. This sub-project will also explore different peer-to-peer network topologies for greater resilience, distributed storage to support the distributed intelligence and core functions and avoid a single point of failure, and security. Connected to these aspects is the Regulatory Framework for the DBE (**SP10**). The DBE infrastructure will be implemented in its various phases in **SP6**, Bootstrap and Production, and it will be populated with software services, SME users and SME providers in **SP7**, Population. **SP8**, Training, and **SP9**, Regional Catalysts, will look after the transfer and adoption in regional innovation clusters, and **SP11**, System Viability, will connect the result of this work to standards bodies and to the ERA policies and vision.

The final figure shows how the various sub-projects are related and the main outcomes of the project. This figure also highlights the two main attractors of the project: the infrastructure (on the right) and the services (on the left).


Business Networks
Dynamics of Software
Recommender algorithm
Multiple scales & Critical phenomena Dynamics of SME networks
Intelligent Service Composition
Memory Gene Learning
Composer Recommender
Evolution
DNA model for software
Fitness Landscape
Legal
Contract & Agreement
Regulatory Framework
Language
Knowledge Base
TWFM
Integration, Implementation and Population
Accounting
Automated Testing
Technical and Financial Viability
Service Manifest Meta-model
SME Providers and Requirements
SME Users and Digital Ecosystem Population
Populated DBE Infrastructure
Training and Regional Catalysts
BML Editor
Critical Mass
Position paper on Open Source
Economic Sustainability and Policy Impact
Regional Policies for Europe-wide DBE Adoption