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Dynamic Business Process Formation for Instant Virtual Enterprises

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Preface

This book is devoted to automated support for the establishment and operation of a new kind of business organization, the process-oriented *instant virtual enterprise* (IVE). This new organization type brings a combination of business dynamism and explicit business process structure to domains where on-the-fly formation of well-organized business networks is required to deal with the complexity of new products or services under high time pressure. We use the automotive domain as our main example, but the approach presented is well applicable to many other domains (as we argue in the last chapter of this book).

In writing this book, the results of the CrossWork IST project have been used as a basis. These results have been extended and generalized, however, to provide a broader view on the subject area. Consequently, the book reflects more general developments in the use of advanced information technology in support of highly dynamic organization structures in modern day industrial supply chains and business service networks. To further underline the broad view of this book, we have included a number of invited case studies from other projects to complement our view.

A number of industrial and academic authors have contributed to this book. To obtain a well-structured presentation with a homogeneous style, the contributions were planned and edited by a small team from two of the partners in the project. As a result, we can present a balanced amalgamation of research-oriented and application-oriented elements.

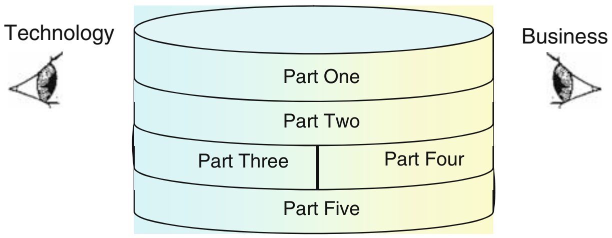
The subject matter of this book covers both business and technical aspects of instant virtual enterprises. The contents have been organized into five parts:

- Part I. *Introduction* provides a general introduction to the context in which IVEs are needed and to the CrossWork project as a basis for addressing this need.
- Part II. *Business, Organization and Architecture* discusses how IVEs are managed and supported from business, organization and information system architecture perspectives.
- Part III. *CrossWork Technology* provides a detailed elaboration of the information technology required for IVE support, based on the design of the architecture discussed in Part II.

Part IV. *Case Studies* gives an overview of the IVE case studies elaborated in the CrossWork project, as well as the invited case studies from related research efforts.

Part V. *Conclusion* concludes the book by emphasizing its main points and providing a look into the future and broader application context of IVEs.

Based on the organization of the parts, the book can be read in different ways depending on the interest of the reader. This is illustrated by the figure below, which serves as a route-map through the book.



These are the four main routes through the book's contents:

- Readers mainly interested in the business side of the field are advised to concentrate on Parts I, II, IV and V.
- Readers mainly interested in the technology side of the field are advised to concentrate on Parts I–III and V.
- Readers that only want a high-level introduction into the subject area can limit themselves to Parts I and V.
- Obviously, readers who desire a complete introduction into the IVE field and the CrossWork project are warm-heartedly invited to read the entire book.

Manchester, UK, and
Eindhoven, Netherlands, 2009

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Part I
Introduction

Chapter 1
Introduction

Nikolay Mehandjiev, Paul Grefen, and Santi Ristol

This chapter provides a general introduction to this book. As such, it also describes the context of the CrossWork project that is the main source of information for this book. This project is introduced in the next chapter. We start below with discussing the business conditions for the raise of the virtual enterprise as an organization form in the modern economy. As we focus on process-oriented virtual enterprises in this book, we continue with an overview of developments in business process support technologies. Then, we introduce a framework with four aspects that can be used in a combined demand pull and technology push context – this framework is used later to structure topics discussed. In the last section of this chapter, we explain the structure of the book.

1.1 Business Conditions for the Rise of the Virtual Enterprise

The differences between the business environment at the start of the twentieth and twenty-first centuries are staggering. Take the well-known example of Ford as one of the first mass-producers of automobiles, a company which operated then and is still in business today. The first affordable automobile Ford Model T was produced for 19 years (1908 till 1927), a comfortably long life cycle. In contrast, the best-selling car in the world for 2000 and 2001, Ford Focus Mk 1, was manufactured for 6 years, a three times shorter lifespan. A shorter product lifespan is complemented by an increase in product variability and complexity. Between 1915 and 1925, Ford Model T was only produced in a single colour – black, to speed up the production, whilst throughout its lifespan, Ford Focus Mk 1 had more than a dozen different engines, including a separate set of engines for the US market, 4 body styles with 14 trim levels, and 12 special editions. The level of competition on the marketplace has also changed beyond recognition. By 1918 half of all cars in the United States were Ford Model T, and the commercial success meant Ford was working to full capacity and did not spend any advertising money between 1917 and 1923. Today's

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environment is rather different – Ford Focus Mk1 competed in the same market sector with 25 different cars by other manufacturers. These trends also hold true for other sectors of the economy, for example the average cycle of pharmaceuticals is reduced from 25 years to 7 years [16], again roughly threefold. Market opportunities are also shrinking in duration, for example a specific financial service in the pension industry had a window of opportunity of 3 months to coincide with a quirk in tax laws and interest rates [11].

The ability to reconfigure the enterprise rapidly to meet changing market needs and demands is one of the six grand challenges identified by [6]. Figure 1.1 summarizes these trends in product life cycles and market dynamics and illustrates the tension created by their opposing forces. Indeed, the developments in information and communication technology, together with general advances of science and technology, are causing the appearance of products with ever-increasing complexity, which have shorter and shorter life cycles.

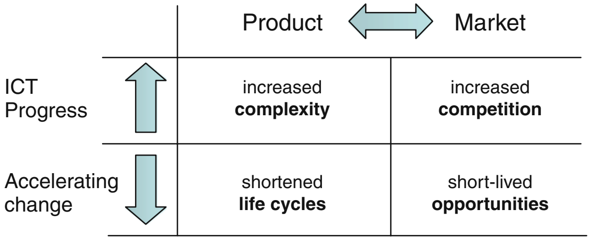

Fig. 1.1 Contemporary forces in product and market development

At the same time, advances in communications and socio-political developments mean organizations have to operate in increasingly competitive global markets which demand greater efficiency, developing complex products to address short-lived market opportunities. These pressures on resources and competences of individual companies have motivated an increased presence of *Virtual Enterprises* (VEs), where companies assemble forces to address a business opportunity. Once the opportunity is gone, so is the VE.

Figure 1.2 shows the life cycle stages of a VE [1] in relation to the lifespan of the business opportunity addressed by the VE. These stages are:

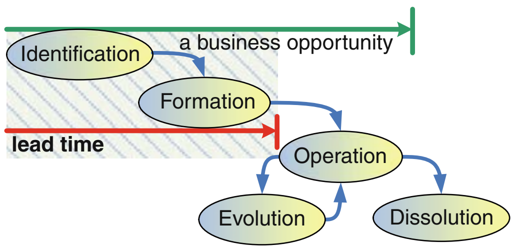

Fig. 1.2 Stages in the life cycle of a virtual enterprise pursuing a business opportunity

- *Identification*: This stage involves the identification, evaluation and selection of business opportunities that may be met by the formation of a VE.
- *Formation*: This stage involves partner identification, partner evaluation and selection and partnership formation, including the binding of the selected candidate partners into the actual VE.
- *Operation and Evolution*: This stage is characterized by the controlled integration of the services and resources offered by the VE partners in VE-wide collaborative processes, leading to the achievement of shared business objectives. Membership and structure of VEs may evolve over time in response to changes of objectives or to adapt to new opportunities in the business environment. Changes of VE context may necessitate contract amendment or adaptation of policy and business process enactment.
- *Dissolution*: This stage is initiated when the market opportunity is fulfilled or has ceased to exist. The major decision processes in the termination stage include operation termination and asset dispersal.

It is clear that the greater the lead time between the appearance of the business opportunity and the start of the operation of the VE, the greater the losses to earlier entrants on the marketplace or earlier bidders for the opportunity.

One industry where VEs have existed since the middle of the twentieth century is the film industry (or "Hollywood") [5] where actors and special-effect small and medium enterprises (SMEs) are joining forces to create a movie under the management of the producer and director. This project-based virtual organization model succeeded the vertically integrated large studios and is one of the earliest examples of VEs. A number of temporary formed organizations of individuals and enterprises, can of course also be found throughout Europe. The reasons for their existence range from investigating a challenging research topic to setting up a supply chain for producing the latest car. They are intrinsically linked with more permanent groupings, formal or informal, where members share interest in a specialist topic. These organizations can be either informal communities of practice or formally constituted organizations, like chambers of commerce. In relation to the virtual enterprises they play the role of Virtual Breeding Environments (VBEs), providing social and informational prerequisites for the formation of VEs.

To illustrate the difference between a VBE and a VE, let us take the example of the Automotive Clusters, or Networks of Automotive Excellence. Such organizations exist in many European countries, including Austria, Slovenia, Belgium, Hungary, etc. Their role is to support local communities of automotive suppliers, helping them bring their complementary skills and create VEs that successfully bid to develop major automotive subsystems such as engines or car doors for an automotive manufacturer such as Ford. The Automotive Clusters are playing the role of VBEs in relation to the VEs created within them.

Other examples of VBE as regional clusters seeking to facilitate project collaboration among their members are Swiss Microtech (SMT), ISOIN/Helice and Supply Network Shannon (SNS). SNS[1], for example, is an open network of

[1] http://www.snshannon.com

companies in the Shannon region of Ireland. It is established as a limited liability company. SNS has developed a framework for indigenous companies to collaborate in joint marketing, training development and quotation activities. SNS is a regional VBE with individual members currently creating subnetworks on a global scale. Federazione Regionale Ordini Ingegneri Pugliesi is a VBE focused on individuals rather than companies, and thus called a Professional Virtual Community (PVC). Its membership comprises the Apulian engineers, and it is established to facilitate collaboration among professionals and between professionals and SMEs in the concurrent engineering domain, again leading to project-based collaborations or virtual enterprises.

Moving to examples of VEs, one well-known example of a virtual enterprise in the high-tech industry is Airbus. Airbus consists of a number of autonomous parties that produce and assemble parts of airliners. Airbus was formed to counterbalance American forces in the airline industry. Note that Airbus is a rather stable VE; it has been in existence for a number of decades now, with a few different consortium configurations which evolved over time. An example of a VE with a much shorter lifespan (3 years) is the CrossWork project. CrossWork was organized in 2002 and 2003 in order to officially start in January 2004 as a European IST research project. It was running for 3 years and evolved over this time; individual persons came and left, as did enterprises. Dissolution was also a process that started in January 2007 and lasted for several months (till all reports and financial statements were delivered to the European Commission). Another example for such a temporary organization is ECOLEAD (European Collaborative networked Organizations LEADership initiative; for more information see http://www.ve-forum.org). ECOLEAD and CrossWork are both VEs which study the support and emergence of other VEs, used as examples in this book.

Today VEs exist in many industry and research sectors. An example in the *insurance industry* is the alliance[2] between the specialist online broker for health insurance, eHealthInsurance, and the general customer-facing financial services provider Countrywide Credit Industries, allowing Countrywide customers to shop for health insurance from a number of third-party providers via eHealthInsurance. In the *financial sector*, Special Purpose Vehicles[3] are tax-exempt companies formed for the specific purpose of buying off (or securitizing) a large pool of mortgage rights from a bank, which link together the bank, the mortgagees and its own investors in a complex financial instrument to ensure stability of the credit system.

A common feature linking the variety of VEs is that their work is often technology-mediated and geographically distributed. In a widely cited example, the Digital Media technology enables the distributed development of a new video clip for a chart-topping single. The recording session is located in London, where the singer lives, the design is done in San Francisco, the writers work from their homes (Paris and Barcelona) and the animation of the characters is outsourced to China.

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[2] http://www.ehealthinsurance.com/content/pressNew/CountryWide.shtml

[3] http://en.wikipedia.org/wiki/Securitization_transaction

The global network and the interactive cycle of recording, writing and animation "around the clock" allow the recording of the clip to take place in a very short time, including repeated takes and rewrites.

An interesting interplay exists between VEs and supply chain arrangements. In the domain of the automotive manufacturing, for example, the large manufacturers are seeking to reduce the number of component suppliers they have to interact with. This has caused smaller companies to form VEs, which can deliver larger subsystems to the producer. This trend is reflected in several of the case studies covered by this book. The trends in product and market developments are highlighted in Fig. 1.1.

- *Developments on the product side*: Rapidly increasing product complexity is addressed by combining knowledge and skills of individual organizations in a VE. A tension is created between the increased difficulty in forming the right combinations of knowledge and skills, and the requirement to shorten the formation stage of a VE. The latter is motivated by shortening the overall product life cycles and business opportunity lifespans. Overall, a greater efficiency in forming and dismantling of VEs is needed.
- *Developments on the market side*: Market dynamics requires effectiveness in the selection of members in VEs. Currently, partners are selected from static "acquaintance" networks. Effectiveness, however, demands a more open and dynamic manner of finding the right organizations with the right skills at the point of need. Increasing competition, on the other hand, requires high speed in setup and deployment of VEs, and their efficient management.

In an environment of increased competition and reduced life cycles for increasingly complex products, we need to find ways to effectively and efficiently compose a VE and to coordinate its operations and processes. Manufacturing is an excellent example sector but not the only one where such developments are badly needed.

1.2 Developments in Business Process Support Technologies

Management of business processes is currently supported by a number of technological developments. Below, we briefly discuss three important areas of development – workflow management (which we use as a synonym for business process management in this book), agent technology and service-oriented computing. In the following chapters of this book, we revisit these areas.

Workflow Management (WFM) technology has been around since the early nineties of the previous century and has been receiving ample attention in both industry and research. A number of general purpose WFM systems are on the market and WFM technology has been integrated into enterprise information systems, such as Enterprise Resource Planning (ERP) systems. Much of the existing WFM technology, however, focuses on intra-organizational workflows, assuming a possibly distributed, but homogeneous WFM system in a trusted environment, i.e. in the context of a single organization. When WFM is extended across organizational boundaries, the complexity is heavily increased. Early developments in the area of inter-organizational WFM have targeted the cooperation between organizations specified at process definition time. An example is the WISE project [3], which aimed at providing a software platform for process-based business-to-business electronic commerce, focusing on support for networks of SMEs. WISE relies on a central workflow engine to control inter-organizational processes (called virtual business processes). In the approach presented by WISE, a virtual business process consists of a number of black-box services linked in a workflow process. Slightly more recent, there are developments towards the dynamic integration of business processes in a workflow-based service outsourcing paradigm. An advanced approach has been developed in the CrossFlow project [7]. The CrossFlow approach uses a proprietary contract specification language to specify business relationships in two-party, dynamic virtual enterprises. A dedicated Java-based collaboration layer is used for support of dynamic business process outsourcing on top of standard workflow management software.

Agent Technology is a comparatively recent and very active field of research which has roots in general artificial intelligence research. The key idea behind agent-based technology is to form systems from communities of independently reasoning, goal-driven agents who communicate using natural language like constructs. Crucially, an agent will only take a particular action when it judges it to be in its best interests to do so. This basic structure makes multi-agent technology well suited to building systems containing multiple self-interested components. A further feature of multi-agent system is the extensive use of negotiation to enable the agents to reach mutually agreeable outcomes. This combination of features means that multi-agent systems are able to represent the interests of every company through individual agents. This is highly suitable for supporting the formation of virtual organizations [4, 15], for coordinating the work of business partners in a supply chain [12] and for controlling the scheduling and execution of detailed workflow processes [13, 14]. Agent standards are fairly mature and FIPA (http://www.fipa.org) has recently been adopted as an official standards committee of the IEEE.

Service-Oriented Computing (SOC) is a relatively new computing paradigm that promises flexible, dynamic, component-oriented interoperability between encapsulated business functionalities of autonomous organizations, called services. The functionality of a service can be quite diverse, depending on the application domain, from very simple (e.g. the functionality to convert an amount of money from one currency to another), to very complex (e.g. the functionality to invoke complex business applications). SOC as a concept is usually closely linked to Web Services as a technology. The Web Service paradigm allows the dynamic composition of application functionality using the Web as a medium [2]. A Web Service is an encapsulated piece of software functionality with a well-defined interface that is made available on the Web. Web Service technology is based on a stack of standards. The basis of the stack is typically formed by HTTP as a basic communication protocol, XML as a basic language and Simple Object Access Protocol (SOAP) as an interaction protocol on top of these two. On top of SOAP, we see languages for service interface definition (Web Service Description Language (WSDL)) and service composition (Business Process Execution Language (BPEL)). Again on top of that, there are protocols for collaboration and transaction management. Further, there are standards for various aspects of collaboration, examples of which are brokering, service level (agreement) management, and security. Recently, there are developments to integrate SOC and explicit inter-organizational process management (e.g. [8, 10]).

> Current technology developments make it possible to provide software support for near-automatic formation and coordination of virtual enterprises.

1.3 Demand Pull and Technology Push

In the domain of automated support for VEs, we see a combination of demand pull and technology push forces, which when combined enable fast developments. To analyze this domain and design a system for it in a well-structured manner, we distinguish four aspects to describe a VE e-business scenario. These aspects together form the BOAT framework [9]:

- *Business (B):* the business aspect describes the business goals of e-business, or the economic model behind its existence. As such, it answers the question of why a specific e-business scenario exists or should exist or what should be reached. Topics can include leverage of efficiency levels, access to new markets, reorientation of interaction with customers, etc. How things are conducted is not of interest in this aspect.
- *Organization (O):* the organization aspect describes how organizations are structured to achieve the goals defined in the B aspect. Organizational structures and business processes are the main ingredients here. Automated systems are not yet in scope at this aspect.
- *Architecture (A):* the architecture aspect covers the conceptual structure (architecture) of automated information systems required to make the organizations defined in the O aspect work. As such, it describes how automated systems support the involved organizations.
- *Technology (T):* the technology aspect describes the technological realization of the systems of which the architecture is specified in the A aspect. The T aspect covers the concrete ingredients from information and communication technology, including languages and protocols, software and (if relevant) hardware.

In traditional information system design practice, analysis and development of systems proceeds in a linear manner from the business to the technology side (also referred to as the waterfall model of system design). In the BOAT framework, this would mean starting from the B aspect and working stepwise to the T aspect, where each preceding aspect defines the requirements that must be fulfilled at the succeeding aspect. This leads to a design process as depicted in the left hand side of Fig. 1.3 which we call the stack model for BOAT.

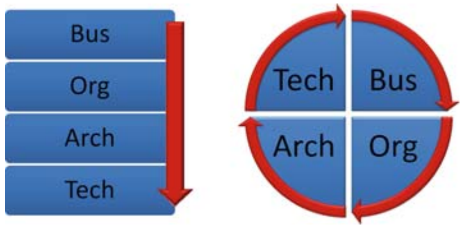

Fig. 1.3 Stack and wheel models of BOAT

In the e-business field, the relation between business and technology is not so linear; business "pulls" technology development by stating new requirements, whilst technology "pushes" business by offering new opportunities. To model this, we need to organize the BOAT aspects such that we get a more cyclical dependency between the aspects.

This results in the picture shown in the right hand side of Fig. 1.3, which we call the "wheel model" for BOAT. With the wheel model, we can make two important observations. Firstly, a development process can, in principle, start at each aspect of the model (although B and T aspects may be most common). A new organization structure in the O aspect, for example, may be the trigger for a new e-business scenario. Secondly, the wheel model suggests a cyclical process: An e-business development process does not end after one cycle around the wheel, but is rather a continuous process of adjustment to new business and technology contexts.

> The complexity of automated VE support requires a framework to distinguish the various aspects. The BOAT framework provides the Business, Organization, Architecture and Technology aspects for this purpose.

1.4 Structure of this Book

To provide an easy overview for the reader, this book in organized in five parts, of which you are currently reading the first. Each part contains a number of chapters.

Part I provides the introduction to the book and the European research project on which its contents are mainly based. The current chapter covers the introduction. The next chapter in this part introduces the notion of an "Instant" VE as a target for the research in automated support for VEs, and introduces several influential efforts in this dimension, including details of the CrossWork project. The chapter explains the goals of this project and places it against the background of related work. Parts

II and III of the book present the ingredients of the CrossWork approach, following the BOAT framework outlined in the previous subsection.

Part II discusses the conceptual side of the approach described in this book. It covers the business, organization and architecture aspects of the BOAT framework – each aspect in one chapter. As such, it goes in three chapters from the business goals to the structural blueprint of the means, which will be made concrete in the next part.

Part III discusses the technical side of the approach, covering the technology aspect of the BOAT framework. The chapter structure of Part III is based on the main architectural clusters of the architecture described in Part II. Five chapters describe the information technology used for the realization of the five main clusters in the architecture.

Part IV presents the real-world case studies that have been conducted in the CrossWork project. These case studies show how the concepts and technology described in Parts II and III are actually deployed in the context of the automotive industry. To embed the CrossWork approach in a broader context, we also briefly present approaches and results of related research efforts here.

Part V concludes the book. Its first chapter gives an overview of the main observations with respect to the concepts and technology covered in this book. Its second chapter provides a look into future developments. Finally, a bibliography detailing the references found throughout the book is presented.

This introductory chapter has shown that

- We need to find ways to effectively and efficiently compose a VE and to coordinate its operations and processes.
- Manufacturing is an excellent example of a business sector for VEs, but not the only possible one.
- Current technology developments make it possible to provide software support for near-automatic formation and coordination of VEs.
- The BOAT framework illustrates the interplay between business and technology considerations underpinning this book.

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Chapter 2
Towards New Frontiers: CrossWork

Nikolay Mehandjiev, Alexander Haemmerle, Paul Grefen, and Santi Ristol

This chapter gives a general introduction into the CrossWork project and the relation to the context in which it has been set up (as explained in Chapter 1). It explains the goals and structure of the project and positions CrossWork with respect to related research efforts.

2.1 The World of the "Instant Virtual Enterprise"

Picture a world where companies are formed "on demand" to address a market opportunity, and then reformed as needed. Constituents of such companies could be individuals, small companies or project teams from bigger enterprises. Faster formation of such a VE would mean shorter delay in addressing the market opportunity, and better chances of success.

In contemporary VEs, formation activities involve a number of face-to-face meetings and negotiations, making the formation stage far too long. A compelling example is the automotive industry, where Original Equipment Manufacturers (OEMs) tend to outsource development activities to (Tier 1) suppliers. A single supplier might not be able to fulfil such a development activity. The challenge for suppliers in the automotive industry (a vast majority of them being SMEs) is to instantly form a development team (i.e. a VE) to be able to quickly react to the OEM request. For example, one of the main activities of the Upper Austrian Automotive Association is the formation of dynamic and project-oriented teams of different companies from different countries. The establishment of such teams is based on a pool of more than 280 association member companies with links to other European automotive clusters. The team formation process is very time-consuming, involving several steps from analysis of OEM requests to so-called "innovation workshops" with potential team members.

At present OEMs are typically procuring system suppliers by sending out a "request for quotation". Potential suppliers have to prepare a concrete quote within

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5 days. Currently, a typical Automotive Cluster has difficulty in supporting the creation of such teams and bids, and can only manage to support around seven such quotes per year. Imagine the effect of the economy of Upper Austria if they could support the creation of 50–70 such teams? Looking in the detail at where the time is taken, introducing software-based automation can introduce significant savings in time and effort and speed up the formation processes to the level of "Instant" VE.

Figure 2.1summarizes the differences between the "instant" and "conventional" virtual enterprise in relation to the main stages of VE life cycle shown in Fig. 1.2 and aligned with [1]. Detailed description of each stage follows.

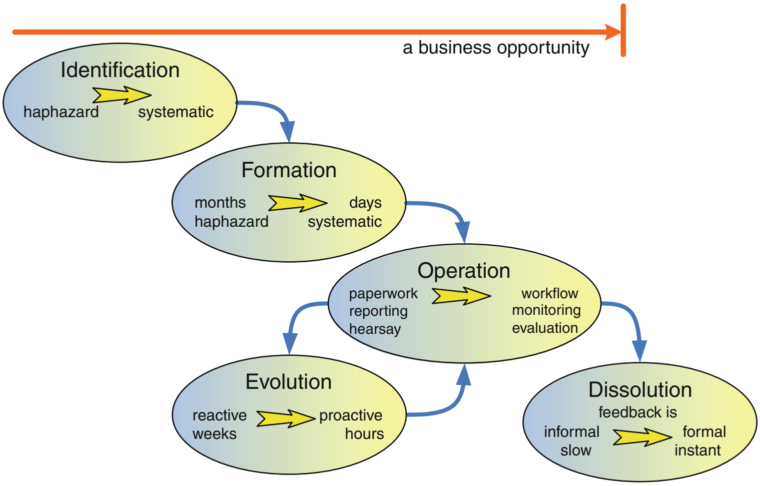

Fig. 2.1 "Conventional" versus "Instant" virtual enterprises

An Instant Virtual Enterprise (IVE) is distinguished by a systematic support for the identification, analysis and selection of business opportunities in the *Identification* stage.

It also brings about a significantly faster *Formation* stage where the time to analyse the business opportunity and form a consortium is reduced from *months* to *days*, thus ensuring rapid reaction to a business opportunity. This reduction is made possible by software automating the formation activities such as matchmaking and negotiation using advanced reasoning mechanisms. A sy*stematic* search for partners replaces the existing *haphazard* search mechanisms.

During the stage of *Operation*, the coordination of cross-organizational processes, which is conventionally based on sending documents such as shipping notes and invoices, is replaced by *workflow*-based coordination and ordering based on genuine dependencies between activities. Traditional periodic *reporting* is replaced by run-time *monitoring* of processes and exceptions. The *hearsay* channels for appraising partner performance are complemented by formal and systematic *evaluation* mechanisms.

The availability of real-time monitoring information and systematic evaluation mechanisms allows an instant VE to also excel at the stage of *Evolution*, where it can be *proactive* in optimizing its membership and performance rather than follow the conventional *reactive* approach of "firefighting" when changes occur. The systematic mechanisms for search and evaluating new replacement partners, and for exploring new opportunities of coordinating work between the current set of partners reduce the time taken to reform from *weeks* to *hours*.

During the *Dissolution* stage, the same mechanisms for systematic and formal performance evaluation help the instant virtual enterprise to retain *formal feedback* about the performance of team members and of the team as a whole, which is then retained for improving future formation stages.

These characteristics of the IVE are brought together by the combination of technology with new business practices and coordination mechanisms. Indeed, all VEs have technology at their core as a main enabling factor; achieving "instancy" requires that the latest technology achievements are combined with innovative business elements. In terms of the BOAT model introduced in Chapter 1, this denotes that the world of IVEs operates in "wheel mode". It is driven by new technological possibilities towards new business models as much as it demands new technological solutions to cater for new business models. The fusion between technology and business is what characterizes our work and this book.

Summarizing, we can define an IVE as follows:

> An instant virtual enterprise is a temporary virtual enterprise forged with support of automated systems to fulfil a specific business goal and subsequently operated with support of automated systems.

This definition highlights the main differences with traditional B2B e-business collaboration:

1. An IVE has a temporary, explicit goal-oriented character (accounting for the I);
2. The organizations participating in an IVE operate as a single business entity (accounting for the VE);
3. The creation and operation of the IVE relies on automated support (to obtain the required levels of efficiency to deal with 1 and 2).

> In the "brave new world" of the IVE, companies will use software matchmaking and negotiating on their behalf to form consortia bidding for market opportunities. These consortia will be evaluated by the client in the same automated and transparent manner. Once a consortium is selected, the same software will coordinate the activities of different partners creating an IVE. A company will never have to miss an opportunity because it did not have sufficient time to prepare a bid or because it was not visible to other consortium members on the marketplace.

2.2 Introduction to CrossWork

The impetus for this book and the majority of material and examples in it were inspired and sourced from an EC-funded project called *CrossWork,* which aims to bring the vision of IVE closer to reality. The focus of CrossWork is illustrated in Fig. 2.2. It covers the Formation, Operation and, to a lesser extent, the Evolution stage of the VE life cycle, but does not cover the Identification or the Dissolution stages.

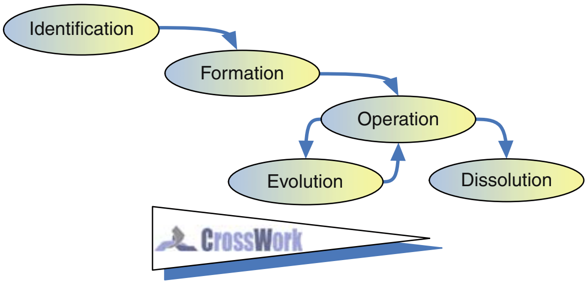

Fig. 2.2 Focus of CrossWork within the IVE life cycle

CrossWork seeks to deliver the key characteristics of the IVE idea by fusing together the advances in IT reviewed in Section 1.2 with innovative business processes:

- *Workflow modelling and management* captures existing business practices within the IVE partners and uses advanced algorithms to create a global workflow, which coordinates work performed (enacted) by different partners during the *Operation* stage of the IVE.
- *Software agents* represent individuals and organizations, mapping the social nature of the VE formation into artificial societies and thus handling the reasoning and negotiation aspects during the *Formation* and *Evolution* stages of an IVE life cycle.
- *Service-based infrastructures* join existing systems of the partners with the global workflow engine to enable seamless and efficient coordination of activities and monitoring of work across partners during the *Operation* and *Dissolution* stages of the IVE.

Following the feedback principle illustrated by the "wheel" version of the *BOAT* framework described in Section 1.3, CrossWork uses input from leading European automotive manufacturers and organizations regarding their needs and current practices. Grounding CrossWork in the needs of the *automotive manufacturing sector* reflects the acuteness of the problems which can be addressed by the concept of the IVE in this sector, and its importance for the European economy. However, the results of the project are applicable to other sectors such as the financial services.

The reader may notice that many case studies and examples in the following chapters of this book are written from the perspective of SMEs. Indeed, the increased complexity of technology demands narrow the specialization required from SMEs. When this is combined with the increased complexity of products and services, participating in IVE becomes a competitive necessity rather than luxury for this type of companies.

CrossWork did not develop its concepts in a vacuum, but interacted with a thriving community working in the area of virtual enterprise and business networks. Some members of this community contributed information about their approaches to Chapter 12. Over and above this, some of the ideas in this book were formed during the multitude of informal discussions with members of this community and we would like to acknowledge this influence and these contributions.

CrossWork brought together four academic and six industrial partners for a 3-year collaborative effort financially supported by the European Commission, which was designed to build upon the results of several other projects and existing know-how. Most influential were the following projects:

- *MaBE – IntLogProd* investigated the use of agent technology to achieve run-time optimization of a Virtual enterprise taking different locations and manufacturing/logistics costs/time into account [8].
- *CrossFlow* investigated the use of contracts and workflow modelling for enabling the coordination across participants in a VE [5].

Within CrossWork there were three groups of partners; academic, software developers and end users. Research-wise CrossWork integrated know-how from agent-based business systems (The University of Manchester), workflows and business outsourcing (Eindhoven University of Technology), information logistics (University of Växjö), and human–computer interaction, usability and learning organization research (Johannes Kepler University Linz).

CrossWork was created with a clear remit of bringing the vision of IVE closer to reality. Initially it targeted the automotive sector since the trends described in Chapter 1 are clearly at play there, and the need to support SMEs and make them competitive is very strong. Indeed, the need to support SMEs is greater since they need collaborative networks to deal with the complexity of contemporary products.

2.3 CrossWork and the IVE Formation Stage

An IVE is enabled by the confluence of advanced IT and innovative business methods, and CrossWork sets out to develop software and business mechanisms, which can bring the IVE vision closer to reality by automating the formation of an IVE and support its operation and evolution. Automating the formation of the IVE is challenging in both technical and business sense, and the dearth of systems and even published research in this area focused CrossWork on this stage of the IVE life cycle.

The Formation stage of the IVE life cycle can be described as comprising the following five intertwined activities, illustrated in Fig. 2.3:

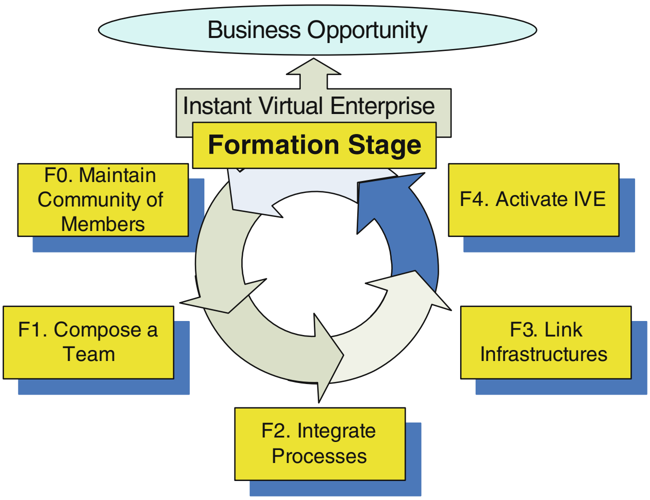

Fig. 2.3 Five activities within the formation stage of the IVE life cycle

The activity "F0. Maintain a Community of Members" is an ongoing maintenance activity, transcending the life cycle of a single IVE. The Community of Members (often called "VE Breeding Environment (VBE)" [4]), can be organized in a number of ways ranging from a closed club to a fully open marketplace. In the automotive manufacturing sector, one particular form of such organization gathering momentum is the Automotive Cluster, with examples in Upper Austria, Slovenia and Hungary. To ensure effective collaboration within such a community, its members should subscribe to a *common framework for representing and sharing knowledge*, and implement *a common software platform*. Developing such a framework and a platform are two of the main objectives of CrossWork.

The activity "F1. Compose a Team" analyses the target *Business Opportunity* and the existing Community of Members and produces a team, which is to form the IVE. Automating this activity is also one of the main objectives of CrossWork. After studying a number of approaches, CrossWork developed a *design-led dynamic team formation mechanism driven by software agents*, which is based on the knowledge representation and sharing facilities provided by the common framework and platform.

The activity "F2. Integrate Processes" composes the relevant publicly visible processes of the selected team members and, after dealing with any potential conflicts, creates a global workflow model to coordinate the operation of the IVE. CrossWork's main objectives include automating this activity using *Petri-net-based algorithms* and *developing sophisticated formalisms for modelling* not only the workflow dependencies, but also other enterprise aspects relevant to cross-enterprise coordination.

The activity "F3. Link Infrastructures" connects the systems of the IVE participants with the global workflow system in preparation for deployment. Automating this activity using *service-based infrastructures and processing of knowledge about participants and their systems encoded in ontologies* are also two of the main objectives of CrossWork.

The activity "F4. Activate IVE" is the final deployment activity before the IVE starts to operate. To support this activity, CrossWork's main objectives include the development of *open deployment platform using service-based infrastructure*.

Further details about the contributions developed in pursuit of these objectives are provided in Chapters 4 and 6–Chapter 10.

CrossWork has set an ambitious goal to enable IVE by automating their design and the composition of the workflow, which will coordinate the work across a newly created IVE. Achieving this goal requires new theoretical results as well as advanced development work at both the levels of business mechanisms and software prototyping.

We have selected appropriate technology for the different stages of the IVE life cycle, mapping the social nature of the cross-organizational team formation into a multi-agent system, where software agents represent individual companies and handle the negotiation and reasoning aspects typical for the formation and evolution stage. The formally founded workflow composition work ensures consistency and smooth flow of work across organizational boundaries, and deployment architecture based on cutting-edge Web-service standards ensures standard-compliant open deployment of the workflow coordination system.

2.4 Extending State of the Art

A number of research and development projects aim to support the efficient formation of VEs. Comprehensive reviews are available elsewhere [4], so this section focuses on several projects and systems which we consider to be most similar to CrossWork and compare their features with the corresponding aspects of the CrossWork goals. After having discussed the details of the CrossWork approach in the sequel of this book, we revisit the comparison in Chapter 13, where we analyse the contribution of CrossWork to the state of the art.