D2.1 Project Vision Consensus Document

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This document will act as a guideline along the project and will be used by all partners to stay focused on the main ideas and goals of the project even in complex and technical phases of the project. Although this description of work gives a clear description of what the project will achieve and how the achievements will happen, there are naturally still a lot of questions that need to be clarified when it gets into details for the different subtasks.

SEVENTH FRAMEWORK PROGRAMME

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ADVENTURE

The research project ADVENTURE – **AD**aptive **V**irtual **ENT**erprise manufac**TUR**ing **E**nvironment – is funded in the Seventh Framework Programme by the European Commission. It aims at creating a framework that provides the tools to combine factories in a pluggable way to manufacture a particular product. This includes the creation of manufacturing processes, finding partners as well as real-time monitoring of the processes that are put into play.

The concept of combining the power of several independent factories to achieve complex manufacturing processes as so-called virtual factories is not new and has been addressed by several research projects in recent years. However, most of them are limited to create virtual factories at a business level and in many cases they concentrate on the partner-finding and factory-building processes. Still, no proven tools and technologies exist in the market to provide valuable end-to-end integrated Information and Communication Technology in such environments.

ADVENTURE will help virtual factories and enterprises move beyond existing operational limitations by providing concrete tools and approaches for leveraging the information exchange between factories. Factory process optimisation will be enabled by the integration of runtime factory selection, forecasting, monitoring, and on-the-fly collaboration.

ADVENTURE aims at simplifying the establishment, management, adaptation, and monitoring of dynamic manufacturing processes in virtual factories by building on concepts and methods from the field of Service-oriented Computing and therefore benefiting from the progress that has been made in this domain over the last few years. Technologies form the Internet of Things, e.g., wireless sensors, will be adopted in order to support the monitoring and governance of processes, i.e., give information about the current status of manufacturing and delivery.

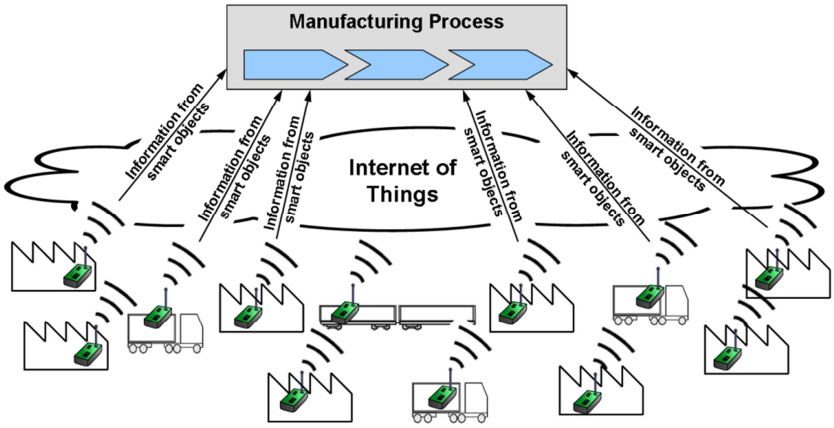

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Table of Abbreviations

B

BPC – Business Process Compliance
BPMN – Business Process Modelling Notation

D

DOW – Description of Work

E

EPC – Event-driven Process Chain
ERP – Enterprise Resource Planning

I

ICT – Information and Communication Technology
IPR – Intellectual Property Rights
IT – Information Technology

P

PCF – Product Carbon Footprint, Product Carbon Footprint

S

SOA – Service-oriented Architecture

Executive Summary

The purpose of this ADVENTURE deliverable *D2.1 Vision Consensus Document* is to enforce a common understanding of the project vision and the overall aims and objectives of the project. In the further course of the project, this document – together with the project handbook – will be used as a guideline to ensure that the partners are following the same goals and will help to synchronise ideas and goal-oriented RTD work.

The Description of Work (DOW) of the ADVENTURE approach builds the basis of this document. Additionally, the real-life use Cases from the manufacturing industry will play a crucial role and will also act as a basis of the Vision Consensus Document. It will bring the ADVENTURE project description to the next level of detail hence elaborating the overall goals of the project and integrating constraints coming from the use case partners.

Detailed descriptions of the RTD work investigated to achieve the ADVENTURE objectives will be provided within the following deliverables.

1 Positioning

1.1 Problem Statement

Currently, few manufacturing companies bear the ability to react quickly to changing market circumstances. Recent developments such as globalisation or the financial crises challenge these abilities. In addition, European manufacturing companies, especially small medium enterprises (SMEs), suffer from higher production and labour costs compared to their non-European competitors. They are required to decrease their production costs, increase the degree of utilisation of their resources and provide a variety of sophisticated products in a short time frame in order to remain competitive.

The ADVENTUTRE project aims to address these issues by providing SMEs with tools and methods for improving and leveraging information exchange between SMEs within virtual factories and distributed manufacturing processes leading to increased production and cost efficiency and thus to a higher degree of competitiveness of SMEs. ADVENTURE aims at improving distributed manufacturing processes along the value chain for: (1) quick response to changes in customer demands and preferences and (2) quick anticipation and mitigation of delivery risks.

Manufacturing is seldom a self-contained process that can be carried out by a single company. In fact, a number of partners are typically integrated into manufacturing processes forming so-called “virtual factories”. Relationships are established on the short-term as well as a long-term basis. The general requirements of manufacturing companies that tackle the issues mentioned above are at least the ability to create flexible manufacturing processes that are controllable and manageable and thus sustain in global, highly competitive markets. Concerning these processes, a variety of challenges arise, e.g.:

- Currently, the real-time information that is often necessary to assess the risks and status of manufacturing processes is missing, e.g., information on available and missing available manufacturing parts is not shared by respective Information Technology (IT) systems. E.g., FISUB (unit of ABB Finland), which is a Finnish manufacturer of protection relays, would like to make the production status transparent to their customers allowing each customer to see – in real time – the status of all parts.
- Deficient operation due to missing interoperability between IT systems of manufacturing partners causes high integration efforts. Control 2K for instance, which is a UK based company (and one of the lead members of TA-Net, cf. Table 1) offering integrated solutions for monitoring production machinery to SME’s, would like to make information delivered by Control 2K’s software more easily accessible to otherwise non compatible software systems of their customers.
- A further challenge is the missing ability to automatically generate data and information of the production process for further (automated) processing or manual consideration. There are often manual steps in data retrieval that form obstacles in this respect. E.g., FISUB would like to forecast their delivery status based on current information about their production.

- As a consequence, this lack of control due to missing knowledge, leads to poor flexibility in manufacturing processes, and processes need to be adapted manually. E.g., Azevedos Indústria, which is a Portuguese SME manufacturer of machines, requires flexible manufacturing processes and therefore requires quick (and IT supported) adaptations of its manufacturing processes, as it is facing changing requirements from its Italian customer FRIZE, which places orders for different type of products with varying special features as, e.g., utilising a special wood cap on the top, on short notice and on a very short delivery frame.
- Current existing solutions require manual work to find appropriate business partners or to establish a business community. Such solutions do not provide tools or technologies to help align manufacturing steps with appropriate partners, i.e., they do not support the complex task of seamless integration of partner factories into processes. E.g., Azevedos Indústria requires quickly involving further partners to, e.g., conceive a new head cap subsystem due to the mentioned order of FRIZE. Thus, automated partner finding facilities would help in this context.
- Across different partners, a realistic estimation of the current status of manufacturing is still a problem. Monitoring of manufacturing processes is important, i.e., to permanently update, integrate, and consolidate process information provided by different sources. It requires well-integrated open infrastructure supporting partner interoperation and the ability to constrain data access and handle data respecting specific further restrictions, such as privacy concerns. (ADVENTURE targets this by exploiting “Internet of Things” Technologies). E.g., ABB would like to make information regarding the current production status available only to dedicated, involved partners.
- Measuring the environmental friendliness of a product (as intended by PCF – product carbon footprint) is yet another challenging issue when considering large stakeholder-spanning manufacturing processes. It requires tight integration, coordination, and unification of processes, standards, and data exchange. E.g., Azevedos Indústria needs to adhere to certain requirements regarding carbon footprint as issued by its customer FRIZE.

Summarising, there are a variety of integration, interoperability, and collaboration challenges for manufacturing companies. In addition, SMEs usually do not have efficient facilities for publishing detailed information which would be necessary for their successful involvement into distributed manufacturing processes. This concerns not only the relatively static information about their products and manufacturing capabilities, but rather issues dynamic information about temporary availability in terms of capacity and resources which would help SMEs to get concurrently selected for participating in large cross-organisational processes. Overcoming and solving these problems bears the potential to support in particular SMEs, which usually neither have the capabilities to control the whole manufacturing lifecycle nor the market power to enforce their own interfaces and standards, in manufacturing, to massively reduce cost, to increase competitiveness, and to generally improve production processes.

1.2 Business Opportunities

ADVENTURE is addressing the aforementioned integration, interoperability, and collaboration challenges for SMEs in the manufacturing industry. Based on the paradigm of Service-oriented Architectures (SOA), exploiting latest technologies from the "Internet of Things", and leveraging recent developments in the area of Grid and Cloud computing, ADVENTURE will provide SMEs with tools and methods to tackle the challenges described in Section 1.1 by improving information exchange with other SMEs within virtual factories and distributed processes.

For this, ADVENTURE will make use of a SOA manufacturing approach, which enables the description of single manufacturing steps as services. Thus, ADVENTURE will enable SMEs to model their manufacturing processes as a composition of services.

As already mentioned in the previous section, manufacturing is seldom a self-contained process but often requires the interaction and collaboration of multiple factories. The issue of missing interoperability between IT systems of collaborating manufacturing partners causing high integration efforts, as described in the previous section, will be tackled in ADVENTURE by enabling semantically enriched descriptions of these stakeholders and their factories indicating their manufacturing capabilities and products, and exposing these descriptions as (offered) services. I.e., having enabled the description of factories including their manufacturing capabilities as services, ADVENTURE will provide interoperability at a deeper technical level. Thus, ADVENTURE will take care of data conversions and will thereby enable and simplify message and data exchange between the IT systems of collaborating manufacturing partners, i.e., their Enterprise Resource Planning (ERP) and legacy systems.

Besides describing a factory including its manufacturing capabilities and products, parties such as buyers may also describe required manufacturing capabilities, e.g. for the accomplishment of certain steps of their manufacturing processes, as services. This way, SMEs can model whole (cross-organisational) manufacturing processes by specifying the necessary manufacturing capabilities as a composition of services. Appropriate services will easily be found in ADVENTURE due to the mentioned semantically enriched descriptions of offered "physical services". By matching the offered services of potential partner factories with the required services and selecting appropriate ones, the respective SME will become the broker of a virtual factory. The modelled manufacturing process is thereby realised by loosely the selected "physical services" offered by the partner factories. Thus, ADVENTURE will enable SMEs to generate, adapt and control manufacturing processes in virtual factories.

Making use of an abstract process model, ADVENTURE will allow the integration of appropriate, potential suppliers at design time based on their skills, while the actual decision for the partners, which are finally integrated, takes place at runtime. This way, processes modelled by utilising ADVENTURE tools, which are called Smart Processes in the following, will become much more flexible, as they can be easily adapted to changing requirements by selecting appropriate partner factories and services, respectively, for each part of the manufacturing process during design and

runtime. E.g., processes will be able to react to price changes or to delays in the supply chain.

As potential partners usually might differ in their capabilities regarding, e.g., cost, lead time, technical advancement, carbon footprint, etc., ADVENTURE provides a simulation framework enabling SMEs to assess alternative partner selections. An optimised solution for the selection of appropriate partner services will be prepared and proposed by ADVENTURE according to predefined and specified requirements and preferences of the user – the broker of the virtual factory. Thus, finding the best fitting business partners will therefore no longer be solely manual work, which was stated as a challenge in the previous section. The ADVENTURE simulation framework will also allow estimating the impact of adaptations and changes of one process on other processes.

In addition to supporting SMEs during generation and adaptation of manufacturing processes, ADVENTURE will provide tools and methods to control and govern their execution. Considering events and information from the Internet of Things, *Smart Objects* will be utilised to control the status of single items as well as of complete processes. In order to make applied resources, intermediate and finished goods in this context “smart”, they have to be enriched with identification, sensor and communication technologies. Making use of current developments in the area of Cloud computing, information coming from these Smart Objects will be stored in a Cloud-based data storage – ADVENTURE’s Knowledge and Information Repository – and will be available via the ADVENTURE Dashboard to those partners, which are involved in the respective manufacturing process, while adhering to privacy and security issues.

Thus, ADVENTURE addresses the challenge of required real-time information, as stated in the previous section, by making information about the current production status available to concerned partners enabling them to assess risks and to forecast potential delivery issues. It therefore not only enables and simplifies message and data exchange between the IT systems of the collaborating factories as mentioned before but also allows and realises exchanging messages and data originating from Smart Objects.

Summing up, ADVENTURE will support SMEs in ad hoc participating in (large) supplier-/ customer networks utilising a SOA manufacturing approach. It will provide SMEs with tools and methods to build, optimise, monitor, and maintain dynamic (virtual) factories by enabling SMEs to establish and adapt manufacturing processes themselves. Thus, ADVENTURE will lower market access barriers for SMEs, which usually neither have the capabilities to control the whole manufacturing lifecycle nor the market power to enforce the own interfaces and standards, and increases their competitiveness.

1.3 Stakeholders

Several stakeholders are typically involved in a manufacturing process. In ADVENTURE, stakeholders are considered users (organisations) that are interested in the project results. In this section, short profiles and a categorisation are provided. In particular, the following issues are addressed:

- Identification of stakeholders and their requirement
- Impact of project outcome on stakeholder groups

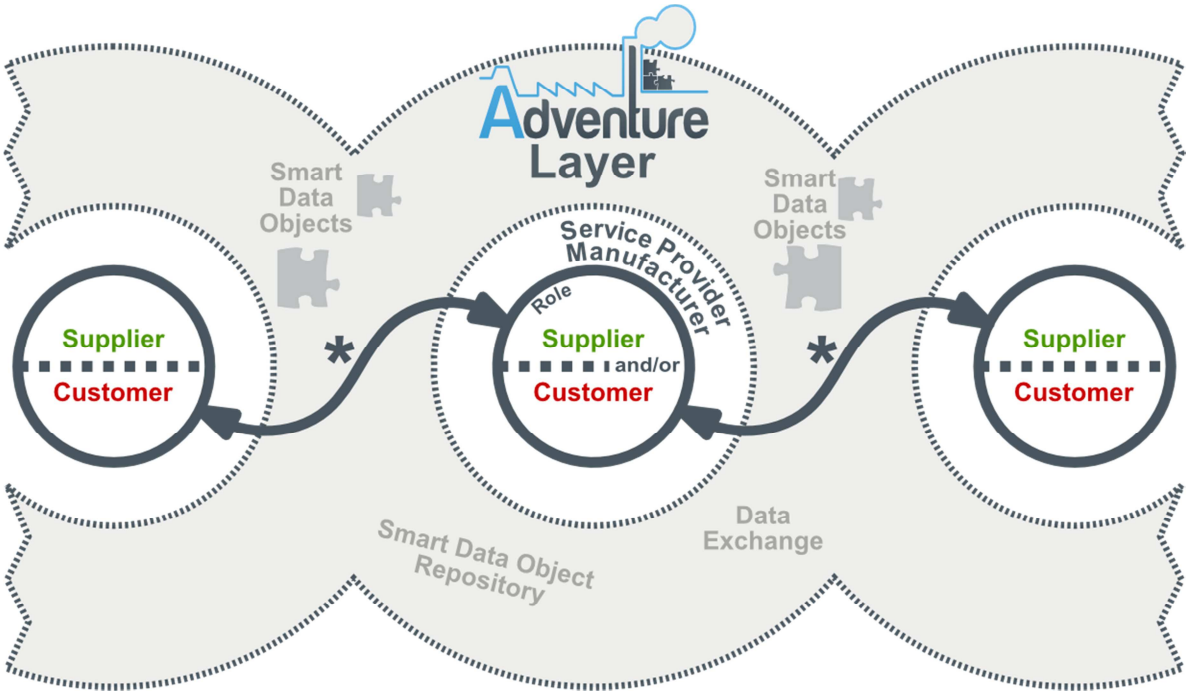

Figure 1: The ADVENTURE Layer

In ADVENTURE, the main stakeholder groups in the manufacturing domain comprise manufacturer and service provider, respectively, supplier, and customer. Note that manufacturer and service provider, respectively, can also be customers and suppliers in most cases. Thus, a customer is meant to be the “final customer” in this context. Manufacturer and service provider, respectively, interact with further suppliers and customers. Figure 1 outlines their connection for the manufacturing interaction – the so-called ADVENTURE Layer.

Further stakeholder groups such as technology providers (including consultants) as well as standardising organisations and industry associations can also benefit from the project’s outcome. Details are provided in Table 1.

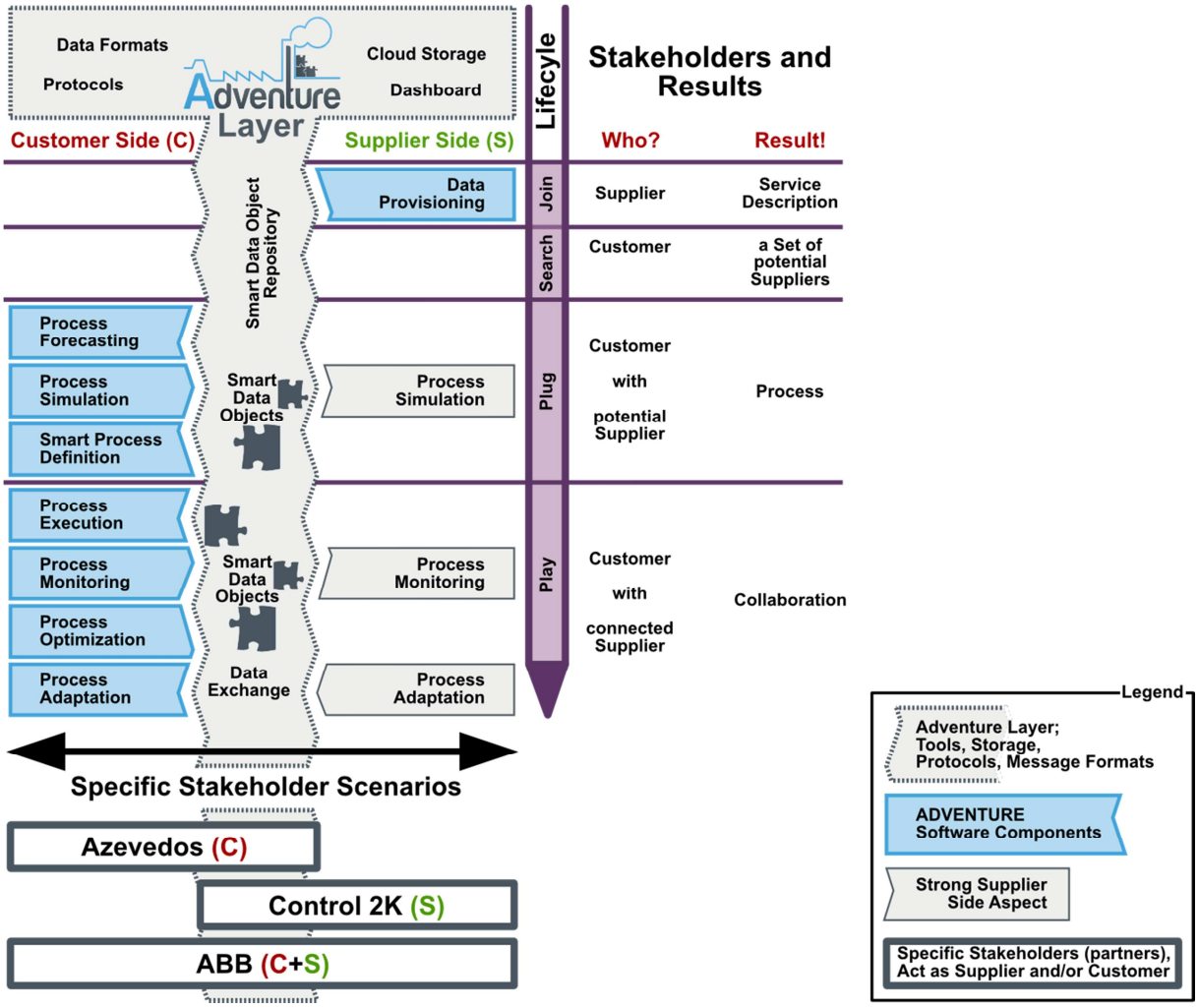

Figure 2: Functionality provided by the ADVENTURE Layer

Figure 2 outlines the functionalities covered by the ADVENTURE Layer and assigns the involved stakeholder groups.

Stakeholder	Project Outcome: Fit and Impact
Manufacturer	
(generally)	By covering (supporting, extending, and improving) important and mission-critical functionalities of the traditional manufacturing process in the area of process management and inter-organisational collaboration (cf. Figure 1, the ADVENTURE Layer), ADVENTURE improves existing processes at the manufacturer's. Contributing technologies are, e.g., smart data objects, repositories, and flexible data exchange.
Azevedos Industria	Azevedos Indústria SA focuses its activities on the equipment and machinery design, product manufacturing, and commercialisation (mostly) for the cork transformation industry. The compa-

	ny's activities cover all areas of the preparation, transformation, finishing and laboratorial control sectors of the cork industry. Solutions developed by Azevedos Indústria are complex. Equipment can be composed, in some cases of approximately 500 spare-parts from different technology types, such as pneumatic, electric/electronic and mechanical parts. As a project partner from the manufacturing domain, Azevedos will be an ADVENTURE Member and will be visible to the ADVENTURE Business Environment. This fact will contribute for new participation opportunities in collaborative networks as equipment suppliers. On the other hand, using ADVENTURE concepts will increase Azevedos' manufacturing flexibility, enable strict runtime monitoring from the supply chain as a whole, and also improve its manufacturing capacity. Finally, using the ADVENTURE framework and being part of its creation will be a distinct advantage compared to their challengers.
ABB	ABB Oy Distribution Automation is a leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact. ABB develops and manufactures (in collaboration with its supplier network) protection and control solutions to ensure reliable power transmission and distribution. The virtual factory shall be an umbrella factory that would enable a light forward and backward integration of existing real factories in the real value chain. Information and Communication Technology (ICT) tools developed for such integration shall bring about runtime and on-the-fly collaboration for exchange of information. This information exchange would enable faster and better quality decisions to govern and adapt the processes in each real factory which would in turn result in higher management and operational efficiency, i.e., reduced costs.
Manufacturing Broker	A broker in the manufacturing domain who can act as product and service supplier and customer, respectively, without possessing real productions capabilities profits from ADVENTURE regarding enhanced possibilities of identifying and assigning appropriate partner factories to modelled manufacturing processes due to semantic enriched descriptions of ADVENTURE enabled factories including information about their manufacturing capabilities as well as about adhered standards, offered quality, price, time constraints, etc.
Supplier	
(generally)	ADVENTURE increases the visibility of manufacturing suppliers as it enables semantically enriched description of supplied manufacturing capabilities, so that suppliers can be found and involved in larger supply-chains more easily.

SME	SMEs, which usually neither have the capabilities to control the whole manufacturing lifecycle nor the market power to enforce their own interfaces and standards, profit from ADVENTURE as they become more visible as potential partners and therefore have new opportunities to participate in the global markets. Thus, ADVENTURE opens the market of manufacturing suppliers to SMEs in this domain. Additionally, SMEs will benefit from the power of combining many small suppliers and therefore being able to compete with big companies which might cover the full manufacturing process.
Large Organisation	Large organisations usually have a lot of established (large and complex) business processes employed and running, which require sophisticated monitoring and control structures. Due to such large decision and control structures, which often include several control and hierarchy layers, changes to already existing, established processes which have hitherto run safely for 10 years or more are often hard to achieve. Thus, the necessary degree of flexibility required to quickly adapt to changing requirements and changing environments is missing.
Control 2K	Control 2K is one of the lead members of TANet (Technology Application Network Limited) which is a legal entity and trades as a limited company (not for profit). TANet Limited is concerned with enhancing the collaborative capabilities of SME's through the deployment of a range of products and services. TANet typically operates in the field of IT interoperability and collaboration, utilising European and National emerging technologies to disseminate and develop products and deliver services to SMEs across the UK. SMEs may benefit through research activities of TANet members. As a service provider for the manufacturing domain, Control2K will be an ADVENTURE Member visible in the ADVENTURE Business Environment. This visibility, as well as the detail and structured information about Control 2K and the processes it employs for its projects will lead to an increasing number of business opportunities. The ADVENTURE framework will also allow Control 2K to cover more business scenarios, as (1) ADVENTURE allows for interoperability between different enterprise systems, and (2) it can take advantage of complementary products without the necessity for continuous adoption of the own products. Finally, using the ADVENTURE framework and being part of its creation will be a highlight. The innovative nature advantages of Control 2K's products.
Technology Providers	
(generally)	Technology providers such as consultants and technology providing enterprises, especially in the area of process manage-

	ment and SOAs (software services) will profit from the experiences made by the application of these paradigms within ADVENTURE's innovative improvement idea for the manufacturing domain. As mentioned before, contributing technologies are, e.g., smart data objects, repositories, and flexible data exchange.
Ascora GmbH	Ascora GmbH provides IT solutions for end users and business customers. Reusing developed components and solutions for existing Ascora business solutions is one of the main objectives for Ascora. Ascora will extend its existing product line by integrating the ADVENTURE results and software components. Ascora is very active in the serviced domain already but at the moment, Ascora is purely focusing on virtual services. ADVENTURE will allow Ascora to transport its expertise from the virtual world into real world manufacturing scenarios, which will open a new business field with many opportunities for Ascora. Additionally, Ascora will be able to provide value added services around the ADVENTURE solution. This will include consulting activities for the ADVENTURE environment helping companies (and especially SMEs) to use the project results and to adopt them to their own needs. Ascora will be able to therefore gain new contacts and new cooperation partnerships in the course of this project.
TIE	TIE has already invested heavily in service technologies and recently has begun explorations on how to apply these in other areas beyond eCommerce such as in the NET-Challenge research project. TIE would thus like to: • Take advantage of these investments in fields such as process management and SOA which can generate further development revenue • Take from these domains insights which can adapt our investments in other domains • Ensure a continuity of research to build on insights and developments within the service and semantic domains Thus TIE will morph the ideas, knowledge, specification, components of the project into TIE's existing products and services and use the knowledge, e.g., during prospecting and sales processes.
I-SOFT	ISOFT company will gain experience from the ADVENTURE development approach: involving partners representing a wide range of stakeholders, keeping close to the latest technological achievements, using scientific knowledge in semantic content, establishing dynamic teams, developing products for running in global context. ADVENTURE provides modern IT instruments for supporting distributed production by dynamically involving partners in the pro-

	duction processes. As far as software development processes are especially appropriate for introducing ADVENTURE, ISOFT intends to apply the ADVENTURE experience, business models and technical tools in the distributed software production organisation. For ensuring high level of efficiency of the ISOFT's software solutions, modern technological means such as SOA, Cloud computing, Semantic Enterprise will be introduced in the development of company's IT models, frameworks and reusable components. The participation in ADVENTURE is expected to bring the technical skills, needed for such production modernization. The e-Business Suite applications in the ISOFT product portfolio lacked so far a really effective solution for production processes designing and monitoring. ADVENTURE will allow ISOFT to provide new solutions that will help its customers to easily manage their business processes and integrate them with their partners' ones without major complications and investments.
Researchers	
(generally)	On the scientific side, ADVENTURE will drive and enhance research in the field of Service-oriented Computing, Business Process Management, Wireless Sensor Networks, and Forecasting and Simulation by integrating artefacts from the Internet of Services and from the Internet of Things into processes' specifications and definitions, creating and leveraging enriched semantic specifications for data and services discovery, enhancing strategies and algorithms for process optimisation, and improving forecasting and simulation techniques to enable adaptive process execution.
TUDA	The Technische Universität Darmstadt focuses on research and teaching tasks. It will thus primarily benefit from ADVENTURE by applying the ADVENTURE framework to drive empirical and theoretical research in the area of Service-oriented Computing, Cloud Computing, and the Internet of Things regarding service composition, Cloud-based data and service storage, provisioning and discovery, as well as Smart Object integration. Research results will be published (partly in cooperation with other members of the ADVENTURE consortium) in scholarly journals, edited books, and scientific conferences and workshops. The TUDA further uses the ADVENTURE framework as an example for the usage of adaptive process environments and the application of process optimisation techniques in seminars, lab exercises and students' projects
INESC	ADVENTURE will contribute to build knowledge about collaboration networks and virtual factories. This project allows INESC to develop and validate concepts regarding collaboration networks

	topics. Furthermore, by creating new tools and instruments to support the setup and management of the virtual business environments and virtual factories, INESC will be capable to disseminate virtual enterprise concepts and practices within Portuguese SMEs and thus will be leveraging the international cooperation.
UVA	As a research institute, the main focus of University of Vaasa is to enhance knowledge and expertise through teaching and state-of-the-art research activities. Keeping this objective in mind, it is expected that the ADVENTURE framework will contribute to upgrade the knowledge specifically in the field of business collaboration by implementing the concept of virtual factories. The acquired knowledge from the ADVENTURE project would act as a guideline for the research institutions as well as for manufacturing enterprises (mostly SMEs) to set up and perform real-time monitoring and managing of collaborative business processes. The developed tools from the project will allow UVA to motivate and interact with Finnish SMEs to participate in the ADVENTURE Business Environment for mutual benefits and to be competitive in the global market. The research outcomes from ADEVENTURE will be published in an international audience through participating conferences, referred journals, edited books and arranging scientific workshops along with project partners. The project results also would be an added value for the prospective students in the University of Vaasa to get both theoretical and practical knowledge on implementing the concept of virtual factories in future business environment.
UVI	The University of Vienna, Workflow Systems and Technology Group, is engaged in research as well as in teaching. Regarding research a broad focus is on Process Aware Information System, with particular interest in Mobile and Adaptive Execution Engines, Repair, Optimisation and Compliance Checking. Furthermore Organizational Aspects and Security are addressed. The ADVENTURE project will allow pursuing the goal of Modular Cloud Based Process Corroboration. Research results will be published (partly in cooperation with other members of the ADVENTURE consortium) in peer reviewed journals, as well as peer reviewed scientific conferences and workshops. Furthermore, concepts and prototypes resulting from ADVENTURE research will be tested, evaluated and discussed in lab courses and seminars. If appropriate, also Bachelor and Diploma Thesis will be supervised covering AVENTURE relevant topics.
Other Stakeholders	

Standard Organisations	The consortium covers several partners that have expertise in manufacturing industry standards (e.g., at Azevedos, the Quality Management System is certified by ISO 9001:2008.). Experiences made and achieved research outcomes concerning the collaboration process between manufacturing partners elaborated in the ADVENTURE Layer can provide valuable input to novel best practices in this domain.
Industry Associations	Several consortium members are members of industry associations (e.g., ABB Oy Distribution Automation is part of the Power Product group, Azevedos Indústria is a member of the National Competitiveness Pole in the field of Production Technologies (PRODUTECH) including about 40 companies that provide production technology for different industrial sectors). For ADVENTURE, this represents a transfer opportunity of project results and experiences to industry beyond the boundaries of project partners.

Table 1: Impact of project outcome on stakeholder groups

2 ADVENTURE Objectives Summary

ADVENTURE envisions leveraging information exchange between factories by building on concepts and methods from the field of Service-oriented Computing, exploiting latest technologies from the Internet of Things and applying recent developments in the area of Grid and Cloud computing.

This section addresses the project objectives. They will be categorised and described in the following Sections 2.1 and 2.2. Section 2.3 explicitly indicates topics which are out of scope for the ADVENTURE project. The outcomes of the objectives will (also) be measured in an explicit ADVENTURE evaluation (cf. DOW).

2.1 Business objectives

The business objectives bear the facilitation of business innovation on the one hand and the consideration of environmental aspects on the other hand. Thus, they address stimulating the business and simultaneously making its effects on environmental issues explicitly visible.

2.1.1 Facilitation of Business Innovation

One of ADVENTURE's business objectives concerns the facilitation of business innovation. In this context, ADVENTURE aims at relieving the execution of tasks for already existing production processes and at providing innovative approaches to manufacturing.

Especially for SMEs, a higher degree of flexibility should be achieved increasing their ability to quickly react to changing market circumstances and enabling them to participate in larger, cross-organisational manufacturing processes lowering the entrance barriers to global markets.

SMEs will also benefit from the power to combine many factories for fulfilling one specific task, hence allowing them to offer new products and services in the market.

In addition, SMEs will benefit from a higher degree of availability of further information regarding the status of their running processes as this will enable and improve their decisions related to these processes and to future processes according to, e.g., new business opportunities. Improved decisions would then lead to higher manufacturing and cost efficiency.

For the assessment of the outcome of this objective, different possibilities and patterns of manufacturing processes will be identified in the Conceptual Manufacturing Reference Model task (cf. DOW). Hence, the assessment of this objective will also be related to potential adoptions of the reference model by companies. E.g., the project results regarding ADVENTURE Virtual Factory concepts, environments, tools, and practices will be disseminated within Portuguese and Finnish SMEs and therefore leverage the international collaboration. The assessment of this objective will be finished at project month 24 (cf. DOW). Furthermore, the outcome will be assessed in the overall evaluation taking place at project month 36. In addition, the number of industry participants in the ADVENTURE workshops will also indicate the objective's achievement.

2.1.2 Consideration of Environmental Aspects

Another business objective concerns environmental aspects. ADVENTURE aims at facilitating the consideration of environmental aspects. The main means to reach this objective in ADVENTURE is the description, annotation, and usage of environmental information based on the PCF.

Considering these aspects, it will be easier to assess the environmental friendliness of actual manufacturing processes and resulting products and services and will therewith assist in creating awareness on the ecological impact of utilising certain resources and doing business in a certain way.

The achievement of this objective will be measured to the degree the PCF (or similar concepts) have been adapted for the usage in the different phases of service-based manufacturing processes enabled by ADVENTURE. This objective will be periodically assessed – every six months starting from project month 12 – and finally at the end of the project – project month 36 (cf. DOW).

2.2 Research and Technological objectives

The research and technological objectives address enhancing research in different research areas to enable service-based manufacturing processes and to allow adaptive process management and process compliance as described in Sections 2.2.1 and 2.2.2. They also address applying and driving technological solutions in order to realise end-to-end ICT integration for achieving improved interoperability of different ICT systems, which is described in Section 2.2.3.

2.2.1 Service-based Manufacturing Processes

One of ADVENTURE's research objectives concerns a beneficial integration of concepts from the paradigm of Service-oriented Architectures into manufacturing processes in order to enable service-based manufacturing processes targeting a facilitation of collaborative, cross-organisational manufacturing processes.

For this, ADVENTURE will drive and enhance research in the field of Service-oriented Computing, Business Process Management, Wireless Sensor Networks, and Forecasting and Simulation by integrating artefacts from the Internet of Services and from the Internet of Things into processes' specifications and definitions, creating and leveraging enriched semantic specifications for data and services discovery, enhancing strategies and algorithms for process optimisation, and improving forecasting and simulation techniques to enable adaptive process execution.

It will create knowledge about service-based collaboration networks and virtual factories and develop and validate concepts regarding such service-based collaboration networks as well as regarding collaborative processes run within a virtual factory. For this, a methodology will be formulated for running a virtual factory successfully.

Summarising, knowledge required for enabling and synchronizing the planning, assembling, maintenance, adaptation and execution of virtual enterprise will be developed.

This objective will be measured by the ability of the ADVENTURE platform to facilitate the planning, assembling, maintenance, adaptation, and execution of a virtual enterprise environment based on cross-organisational manufacturing processes.

Therefore, each step in this process lifecycle will be individually assessed with respect to its individual degree of performance. Regarding the assembling and execution of service-based manufacturing processes, the outcome will be assessed with regard to the degree of process composition automation achieved by ADVENTURE, e.g., through the semantic analysis of collaboration partner services in order to find suitable partners. The maintenance and adaptation will be assessed based on the realisation of monitoring and control mechanisms within ADVENTURE. For this objective, the abovementioned comparison between specific manufacturing scenarios with and without the application of the ADVENTURE platform will be of particular importance. Last but not least, these functionalities will be provided through the ADVENTURE Dashboard. The usability of the Dashboard will be assessed based on a user survey.

This objective will also be periodically assessed – every six months starting from project month 12 – and finally assessed at the end of the project – project month 36 (cf. DOW).

2.2.2 Adaptive Process Management and Process Compliance

An important goal for ADVENTURE is to enable seamless integration between virtual factories and specifically the processes that drive them. This will both address the initiation of collaboration as well as of its continued operation. Both phases in the life cycle require extensive planning and not only involve (the potentially incompatible) processes, but also a lot of information maybe not explicitly inherent to the process such as expected constraints at the partners' side.

In recent years Business Process Compliance (BPC) has gained significant momentum in research and practice. BPC is about a set of domain rules (e.g. laws, regulations, contracts, security, internal decisions) and their enactment and/or monitoring regarding certain criteria such as process resources, process data or time. This has led to possibly complex rule sets which differ from business to business, country to country and from sector to sector. Additionally different rules can be monitored by either different systems or through manual audits, and are available in different forms.

One objective of ADVENTURE is to structure, unify and offer these diverse rules as an integrated basis for planning the initiation and later adaptation of processes. In addition, the heterogeneity of process constraints has been neglected so far. For ADVENTURE it is proposed a unified representation framework that enables the identification of process constraints from domain rules and their later unification within a process constraint base. Separating process constraints from domain rules can lead to significant reduction of planning and compliance checking effort and thus lead to easier and better integration of virtual factories. Furthermore the project will investigate the interplay between process adaptations and BPC, e.g., find solutions to answer questions such as "does a certain constraint hold for Partner X after inserting a new partner service"?

This objective is directly related to the Adaptive Process Execution task and will be assessed through a separate prototype. This prototype has to consist of two parts: (1) a decision support system for process designers that allows them to view and understand the consequences of changes, and (2) a monitoring infrastructure that alerts

process designers of imminent changes. It will also be measured with respect to the ability of the ADVENTURE platform to integrate different process engines of different partners. Its validation depends on the degree the envisioned software prototypes will be deployed. It will be periodically assessed – every 6 months starting from project month 12 – and finally assessed at the end of the project – project month 36 (cf. DOW).

2.2.3 End-to-end Integration of ICT Solutions

ADVENTURE aims at enhancing the concept of virtual factories by integrating end-to-end ICT solutions into such environments for supporting dynamic networked manufacturing processes that allow for

- Innovation
- Higher management and operational efficiency
- Enabling partner-selection and factory-building processes.

This includes, but is not limited to, the ability of the ADVENTURE platform to support the integration of existing and established mechanisms, i.e., product taxonomy systems, semantic vocabularies, etc., the annotation of gathered services, and the customised annotation and integration of sensor networks.

Tangible results in terms of software components will include a Cloud-based Data Storage, a tool for Data Provisioning and Discovery, a Data Exchange and Messaging Platform, a Smart Object Integration component, a Smart Process Definition component, a Process Simulation Framework for acting-on and creating forecasts, a Process Optimisation component, an Adaptive Process Execution Engine and a Real-time Process Monitoring facility.

Thus, new tools and instruments for supporting the setup and management of virtual factory environments and virtual factories as well as for real-time monitoring and managing of operational processes will be developed. In addition, solutions for measuring the performance of each operational process dynamically should be created. These components are integrated in a usability-optimised graphical user-interface called Dashboard.

This objective will be measured with respect to the ability of the ADVENTURE platform to integrate the IT systems of different partners in manufacturing processes. Its validation depends on the degree the envisioned software prototypes will be deployed. It will be periodically assessed – every 6 months starting from project month 12 – and finally assessed at the end of the project – project month 36 (cf. DOW).

2.3 Non-goals

Topics that are out of scope for the ADVENTURE project form “non-goals” and are as follows:

- ADVENTURE does not aim at developing new business process description languages. It makes use of existing languages as, e.g., the Business Process Modelling Language (BPMN), Event-driven Process Chain (EPC), etc.
- ADVENTURE does not aim at providing a framework for defining financial related information such as contracts between organisations. Thus, realising the actual contracting between the participating partners – between real entities –

is out of ADVENTURE's project scope. The process of contracting will however be supported in the sense that manufacturing capability descriptions already give hints to the behavioural execution of services offered by suppliers, which can be used for the actual contracting. Thus, ADVENTURE simplifies and assists contracting, but does not provide a means to realise it.

- ADVENTURE will not target the handling and management of Intellectual Property Rights (IPR) regarding the data, information, and knowledge created during the usage of the ADVENTURE Framework. Thus, such IPR considerations have to be included separately – out of ADVENTURE's scope.
- ADVENTURE does not aim at explicitly incorporating warranty and guarantee issues of the end product as developed through virtual collaboration. Such warranties and guarantees will surely be provided for the collaboratively manufactured goods, but the explicit management of these issues is out of project scope.
- ADVENTURE does not address and consider cross-border (legal) aspects and issues which may arise due to different regulations and laws prevailing in different European countries. Such aspects will be subject to juridical compliance validations, which are out of ADVENTURE's scope.
- ADVENTURE does not aim at providing automated cross-language support. Thus, automated translation functionalities for translating, e.g., linguistic descriptions from English to Dutch or Finnish are out of ADVENTURE's scope.

3 Vision Enablers

In order to tackle the issues and the obstacles mentioned in Section 1 and to achieve objectives presented in Section 2 several results enabling ADVENTURE's vision are expected from the project. These are not only limited to various software components, but also include a knowledge and information repository and a methodology. The results will form the ADVENTURE Framework (which is displayed in Figure 3) and help a virtual factory leverage the information exchanged between (real) factories.

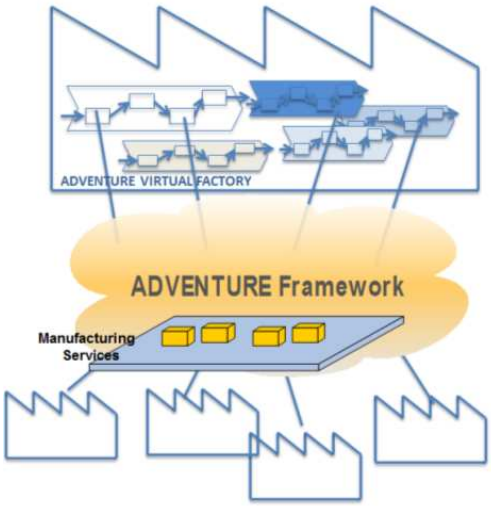

Figure 3: ADVENTURE Framework

The factory illustrated at the top of Figure 3 is the virtual factory which will be designed, executed, adapted, and improved by utilising the ADVENTURE Framework. This virtual factory is not a legal entity. It can rather be seen as a temporary strategic alliance of real factories, typically owned by different stakeholders, providing a set of dynamic cross-organisational manufacturing processes which are indicated below the ADVENTURE Framework. In other words, real factories can be seen as a set of (manufacturing) services used in the ADVENTURE Virtual Factory's process activities.

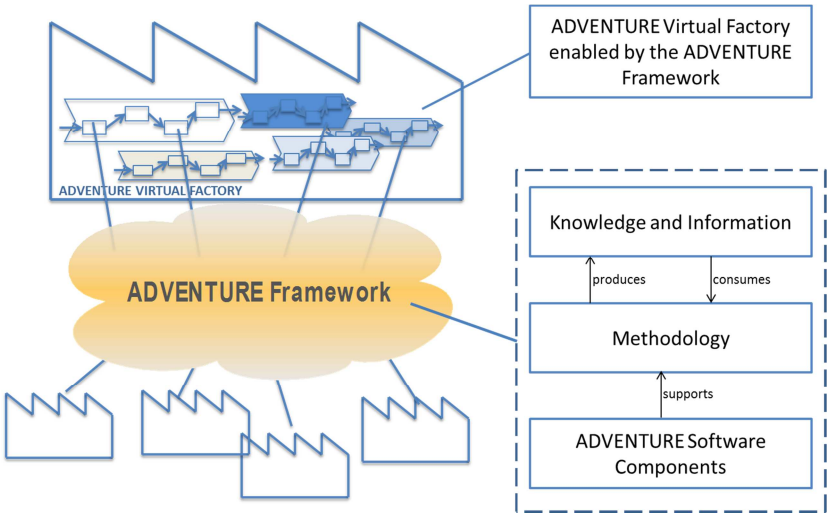

Figure 4: ADVENTURE Framework Elements

Figure 4 illustrates the elements of the ADVENTURE Framework, i.e., the mentioned knowledge and information repository, the methodology, and the ADVENTURE software components, which are described in the following subsections.

3.1 Methodology

When a company considers the usage of the ADVENTURE Framework, two main stages should be considered, indicated in Figure 5. For each stage, the ADVENTURE methodology defines the five main phases (depicted in different colours in Figure 5), their sequencing, the tools that support them and the information that is produced and consumed in each phase.

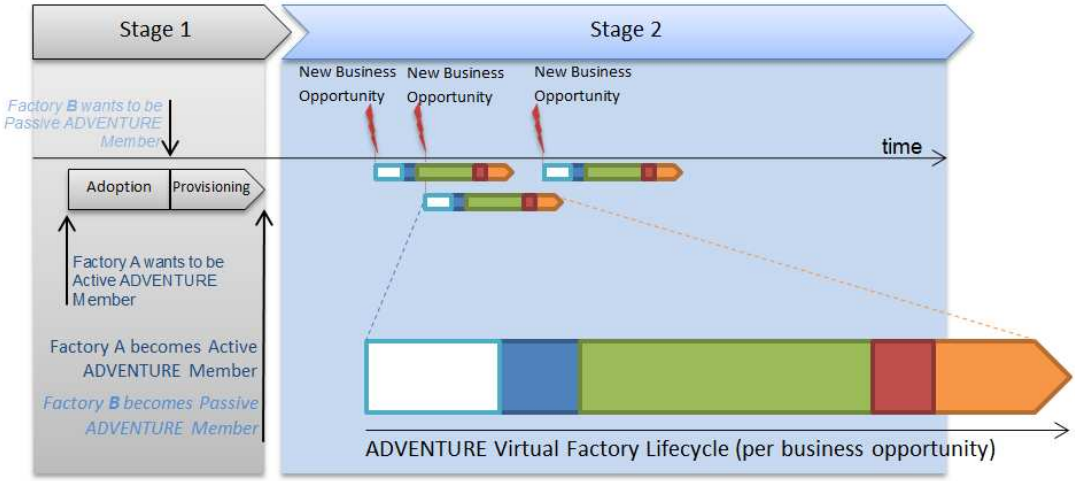

Figure 5: ADVENTURE Methodology

The first stage of figure 5 comprises the ADVENTURE Adoption, i.e., the implementation and setup of the ADVENTURE Framework in a (real) factory, and the ADVENTURE Provisioning, i.e., the provision of information about a factory including its manufacturing capabilities and products.

The ADVENTURE Adoption involves the business and technical analysis in order to select the modules that should be implemented and configured as well as to gather and understand the requirements to realise the integration and configuration with legacy systems. It includes setting up of the necessary hardware and software required to use the ADVENTURE Dashboard and the tools ADVENTURE provides, the integration of the ADVENTURE Platform with the factory's systems, e.g. ERP systems, legacy systems, etc., and performing the ADVENTURE Provisioning, which means providing the necessary data and information about a factory and its manufacturing capabilities and products, which are needed to take part in Smart Processes (i.e., the manufacturing processes that are to be executed and realised by an ADVENTURE Virtual Factory), as well as the formatting of this data and information in appropriate ways, so that it is compatible to the ADVENTURE Repository.

By performing the ADVENTURE Provisioning, a factory becomes an ADVENTURE enabled factory, i.e., a *passive* ADVENTURE Member, which actually is a precondition to participate in Smart Processes. If this factory additionally performs the ADVENTURE Adoption, it becomes an *active* ADVENTURE Member. Only active ADVENTURE Members can actively enter the second stage.

The second stage of Figure 5 covers the operational lifecycle of each the ADVENTURE Virtual Factory. Its main activities are depicted in Figure 6.

Note that ADVENTURE Adoption will be performed only once for each company. On the other hand, there will be several instances of ADVENTURE Virtual Factories, so that the mentioned activities of the ADVENTURE Virtual Factory's lifecycle will be performed multiple times – once for each ADVENTURE Virtual Factory.

Referring to Figure 5, the ADVENTURE Virtual Factory lifecycle encompasses five main phases: Process Analysis, Design, Execution and Adaptation, Improvement and Dissolution as shown in Figure 6.

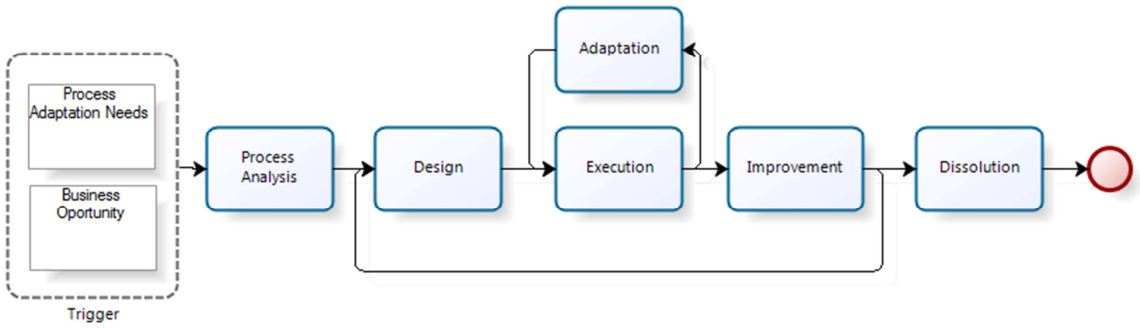

Figure 6: ADVENTURE Virtual Factory lifecycle main phases

The main phases are described in the following:

- **Process Analysis**: The process analysis phase refers to a preliminary business opportunity analysis in order to decide, whether an opportunity is reasonable and profitable or not. In this phase, the objectives, boundaries, inputs,

outputs and stakeholders of the potential Smart Processes as well as the performance measures and recommendations are defined and developed, respectively.

- **Design**: The design phase, which is displayed in Figure 7, includes tasks of data discovery, process definition, partner search and assigning, process simulation, process forecasting, and process optimisation. Afterwards, before the actual execution phase may start, agreement and contract negotiation has to be achieved among the involved partners. As mentioned in Section 2.3, the actual contracting will be supported but not realised by ADVENTURE.

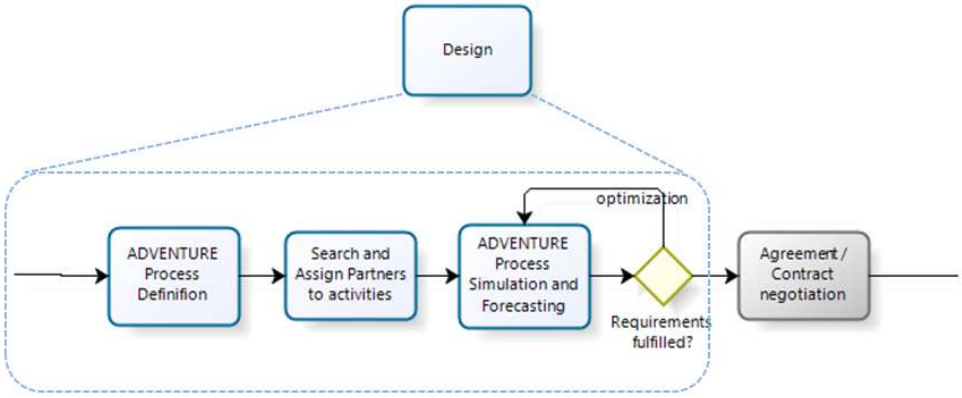

Figure 7: Design phase activities

- **Execution and Adaptation**: The execution and adaptation phases, which are displayed in Figure 8, include tasks of process execution (Virtual Factory Run), monitoring, and adaptation.

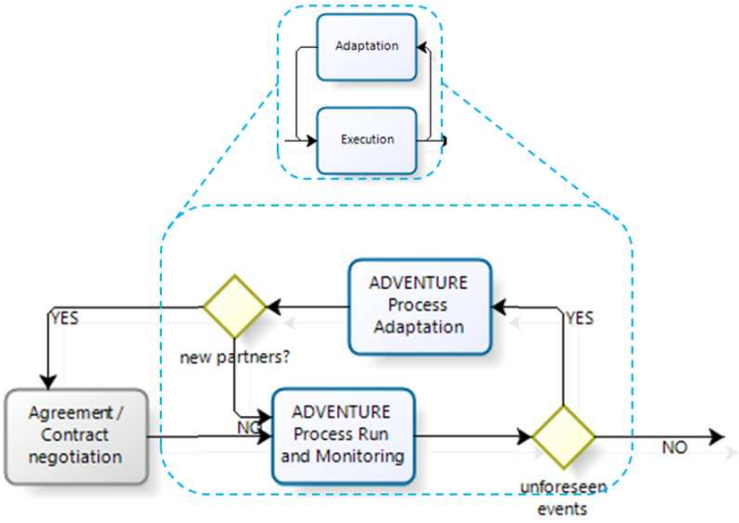

Figure 8: Execution and adaptation activities

- **Improvement and Dissolution**: The improvement and dissolution phases of Figure 9 refer to evaluating the executed process and members inquiry. Within ADEVENTURE all the achievements (information, knowledge and experience) are stored in the cloud base data storage – the ADVENTURE Knowledge and Information Repository – which enables future ADVENTURE Virtual Factories to profit from this enhanced knowledge base.

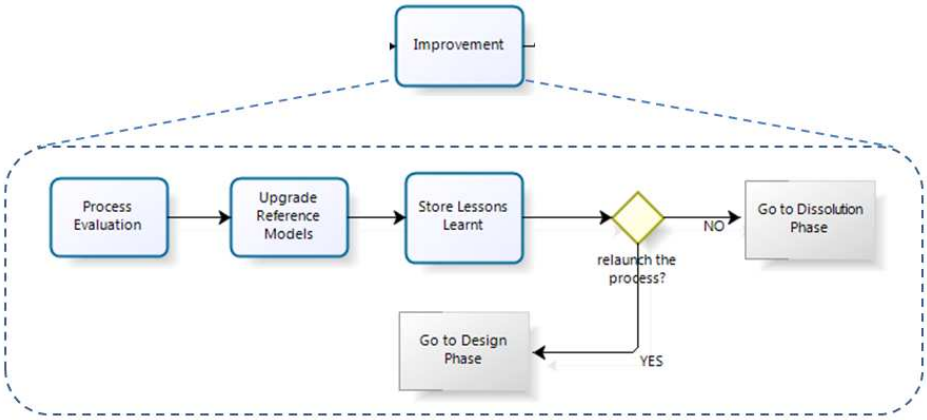

Figure 9: Improvement and dissolution activities

If all the stakeholders of the ADVENTURE Virtual Factory are satisfied, the process ends with the ADVENTURE Virtual Factory Dissolution. As the "produced" data, information and knowledge will be stored in ADVENTURE's Knowledge and Information Repository, which is described in the following section, future needs for an already manufacured product can be satisfied by reusing the stored data, information and knowledge.

3.2 Knowledge and Information

All knowledge, information and data related to each activity of the ADVENTURE Virtual Factory lifecycle will be stored in ADVENTURE's Knowledge and Information Repository, which will be realised in cloud-based fashion.

Data can be base events and raw data, i.e., unprocessed facts and figures without any added interpretation or analysis. Data examples constitute the company attributes, the process execution data, simulation data and Smart Objects data.

Information is the processed and related data, i.e., data that has been interpreted in a way that it has meaning for the user. Some examples are process models, business models and service descriptions.

Knowledge refers to the information that has been assessed and validated and may be reused in benefit of the organisation, e.g., reference models, best practices, guidelines and patterns.

In order to specify and design the knowledge and information repository, it is necessary to get an overall view of the information resources that are accessed and produced along the ADVENTURE Virtual Factory lifecycle. Thus, a mapping between

different data, information or knowledge and the activities of the lifecycle should be performed.

In order to develop the overall information resources view, a two axes taxonomy will be used as exemplified in Table 2. One of the axes relates to the lifecycle activities and the other one to the information resources taxonomy.

		Overall Virtual factory lifecycle				
		Business Analysis	Design	Execution	Improvement	Dissolution
Overall Information resources	**Knowledge** • Reference models • Best practices • Patterns	business reference model,	process templates		process templates	
	Information • Particular models • Service descriptions • …	business model	process model		process model	
	Data • Company attributes • Process execution and simulation data • Smart Objects data		simulation data	execution data; Smart Objects data		

Table 2: Data, information and knowledge used along ADVENTURE Virtual Factory lifecycle

3.3 ADVENTURE Software Components

According to Figure 10, the software components that will be developed and provided by ADVENTURE are categorised in the areas:

- Virtual Factory Management
- Process Definition, Forecasting, and Simulation
- Real-time Monitoring, Process Adaptation, and Dashboard

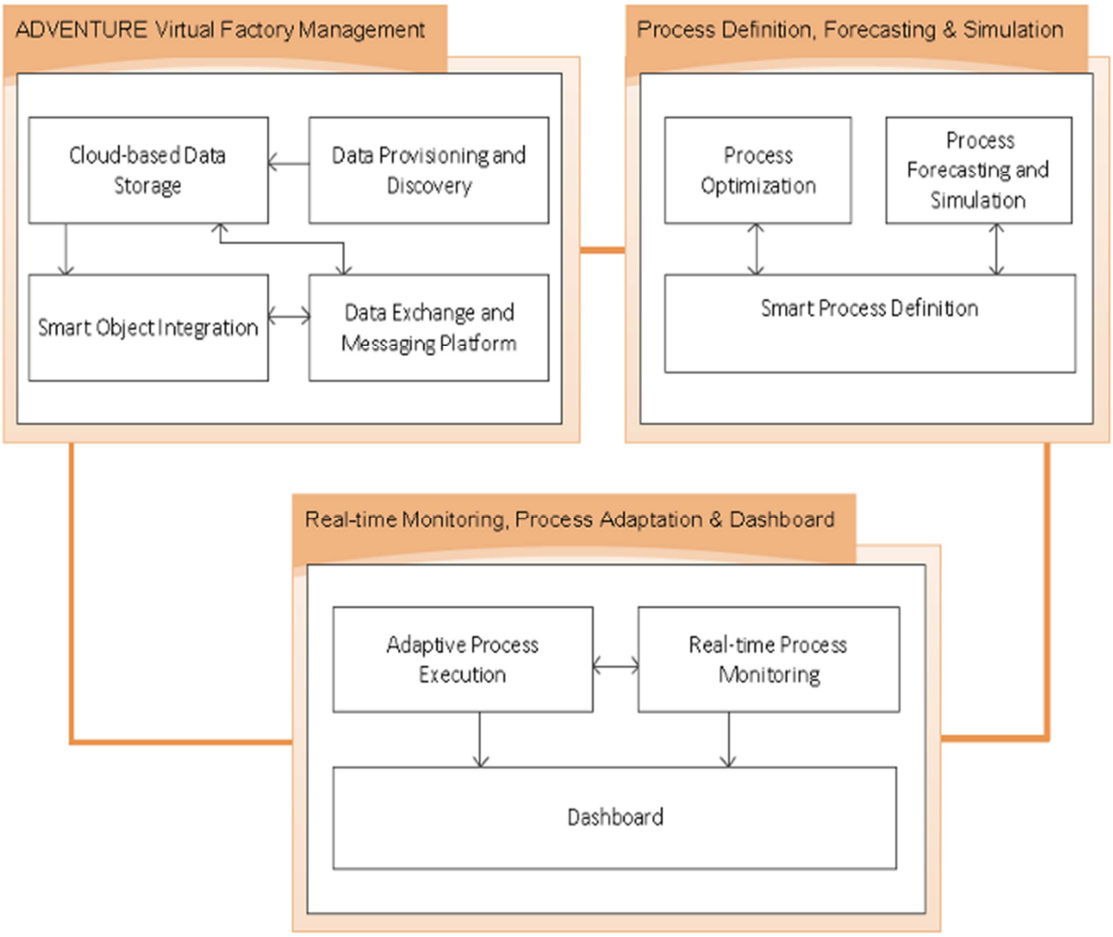

Figure 10: ADVENTURE Modules

The approaches are as follows:

3.3.1 Virtual Factory Management

As mentioned, ADVENTURE envisions leveraging the power of *Service-oriented Architectures* for virtual factories in order to realise a *Plug-and-Play Virtual Factory*. Thereby, besides partner-finding and factory-building processes, ADVENTURE enhances current solutions to virtual factories by addressing virtual factories on a deep technical level (albeit hidden from the user) and providing means to easily adapt virtual factories to changing requirements and circumstances.

To enable adaptations, ADVENTURE requires a formalised and semantic-based way for describing such changing requirements and circumstances regarding involved factories, their services, and their properties as, e.g., location, quality standards, regulations, costs, material, machine capabilities, maximum capacities, etc. Appropriate description schemata as well as data representations and semantics are provided by the Data Provisioning and Discovery component, which is described in Section 3.3.1.1. These descriptions also include the definition of data formats for exchanging information between factories (and between factories and Smart Objects) in order to enable and ensure that factories can be technically connected and that they can be involved in complex processes based on their manufacturing capabilities – the plug-

and-play virtual factory. To realise the message exchange, a Data Exchange and Messaging Platform will be implemented, which is described in more detail in Section 3.3.1.2. In order to enable the adaptations to changing requirements, it firstly has to be recognised that some circumstances change. For this, appropriate (process) monitoring techniques are necessary. This issue is addressed by ADVENTURE's Smart Object Integration component described in Section 3.3.1.3, which utilises information form the Internet of Things to monitor and control manufacturing processes. The gathered data and exchanged messages between the collaborating factories as well as the mentioned semantic descriptions of involved factories, their services, and their properties are stored in a Cloud-based Data Storage (which realises the ADVENTURE Knowledge and Information Repository) as described in Section 3.3.1.4. Coupling these components (in a service-oriented fashion) realises the ADVENTURE Virtual Factory Management.

3.3.1.1 Data Provisioning and Discovery

The ADVENTURE Data Provisioning and Discovery component concerns the provisioning and discovery of data, information, and knowledge, as e.g., manufacturing capabilities offered by ADVENTURE Members (as services), Smart Processes, resources, etc. This component deals with everything required for the main functionalities of the platform with respect to data. The term "data" thereby represents data and information and knowledge, as separated and explained in Section 3.2. The main functionalities thus include the definition (and execution) of Smart Processes, the handling of inter-organisational communication over the platform, as well as the handling of company information, resources information, and more. ADVENTURE Data Provisioning and Discovery will provide efficient solutions and mechanisms to realise and act directly upon the representation of data for ADVENTURE Provisioning (or deployment on the platform) and discovery (or search inside the platform).

Thus, all activities concerning data modelling and discovery including data representations, semantics, description schemata, and proposed standards are addressed in this task. For interoperability between data formats, results from the FP6 STASIS project will be reused where possible.

3.3.1.2 Data Exchange and Messaging Platform

In order to communicate between ADVENTURE Members as well as with Smart Objects about Smart Processes and status information, data has to be exchanged. In order to enable this, an integration of the legacy (production and logistics) systems and platforms into ADVENTURE providing information from these valuable sources will be realised. As this integration bears security issues regarding data security and especially data privacy, the privacy model applied to the Cloud-based Data Storage described in Section 3.3.1.4 will be reused and correspondingly adapted. Secure communication channels will be used for the resulting platform. This will be based on B2B partner TIE Kinetix platform.

Thus, the Data Exchange and Messaging Platform enables the communication between ADVENTURE Members as well as with Smart Objects. For this it realises the integration of mentioned legacy systems into ADVENTURE and thereby pays attention to privacy and security issues to guarantee secure communication.

3.3.1.3 Smart Object Integration

Smart Objects will be considered and utilised in ADVENTURE in order to provide valuable information about current status of production, delivery, etc., e.g., the incoming and dispatch of products from a certain manufacturing area. For this, information from sensors and other Smart Object technologies will be fed to ADVENTURE's Cloud-based Data Storage, pre-processed, and integrated into Smart Processes. As the communication with the Smart Objects should include a wireless infrastructure, a conceptual model for a privacy-preserving, secure WLAN-based infrastructure for the integration of Smart Objects will be developed.

Thus, Smart Object technology will be exploited in order to enrich ADVENTURE's Smart Processes with further sensor information, enabling the assessment of delivery issues and risks.

3.3.1.4 Cloud-based Data Storage

In order to enable the usage of data and information (as well as of knowledge) originating from different components, Smart Objects, ADVENTURE Members, etc., it is required for them to be stored in a way that each party which is allowed may access this data and information. For this, ADVENTURE's Knowledge and Information Repository will primarily make use of cloud-based data storage. Cloud computing has gained much momentum and has become a major trend both in the software industry and research. Thus, ADVENTURE, will benefit from cloud attributes like the illusion of infinite computing and storage resources on demand in order to realise a cloud-based data repository, which contains the mentioned data and information. This way, the access to and the exchange of necessary data and information becomes very easy, but should and will be restricted to only those partners, who are allowed to actually access and change the data, which will be realised by a role model for data access.

Thus, the Cloud-based Data Storage defines and implements a data repository in a cloud-based fashion, where information from different sources, as e.g., from Smart Objects, will be integrated and pre-processed, and realises the access to this repository through a role model, which is also developed.

3.3.2 Process Definition, Forecasting, and Simulation

Having described the ADVENTURE Virtual Factory Management in the previous section, this section addresses defining and simulating Smart Processes as well as forecasting, which aims at timely recognition and identification of potentials risks with respect to the defined processes.

Using a graphical process editor, the Smart Processes are established following a service-oriented approach including processes such as single production steps and existing sub-processes as well as supplier engagement, product part information and further manufacturing resources. Process definitions will thereby be based on business and technical requirements. In addition to this, requirements and constraints as, e.g., limitations in costs, carbon footprint, delivery time, etc., may also be defined for the overall process. For this, a Smart Process Definition component will be developed, which is described in Section 3.3.2.1.

A Process Forecasting and Simulation component, which is described in Section 3.3.2.2, provides simulation and forecasting functionalities in order to assess the risk and impact of, e.g., changes applied to one process instance influencing other process instances as well as changing process requirements on a per-process and cross-process basis. It further includes methods and tools for forecasting the influence of events on the successful process execution.

In addition, optimisation techniques are applied to established processes in order to achieve efficient process execution. For this, process optimisation methods are designed and implemented in a Process Optimisation component described in Section 3.3.2.3. It supports the selection of partner factories by proposing optimised assignments of certain factories and manufacturing services, respectively, to specific production steps according to mentioned specific requirements and constraints issued by the ADVENTURE Virtual Factory broker. These requirements and constraints include, e.g., limitations in costs, carbon footprint, and delivery time. This way, an optimised manufacturing service combination for a particular product (of the ADVENTURE Virtual Factory) is achieved.

3.3.2.1 Smart Process Definition

In order to develop the Smart Processes – the manufacturing processes that are to be executed/realised by an ADVENTURE Virtual Factory – ADVENTURE provides a Smart Process Definition tool, which enables to define, design and orchestrate abstract processes, which apply a service-oriented manufacturing approach. An active ADVENTURE Member may easily define the required manufacturing capabilities as well as constraints for each step of this process, so that an assignment of appropriate, potential partners to different steps and sub-processes of the Smart Process is possible.

Thus, the Smart Process Definition component will provide the means to specify the manufacturing process in terms of abstract process models, which are to be realised by an ADVENTURE Virtual Factory, in a service-oriented fashion.

3.3.2.2 Process Forecasting and Simulation

The ADVENTURE Process Forecasting and Simulation component enables performing simulations of different alternatives – regarding different specified process models or different assignments of partners to specific process steps – for the actual establishment of a process instance upon information provided through process design, as e.g., manufacturing capabilities or assured delivery time. Also the impact of events as e.g., updates of production status or capacities, coming, e.g., from involved partners or Smart Objects, may be forecasted by the Process Forecasting and Simulation tool and thus considered when specifying and modelling a Smart Process.

Thus, the Process Forecasting and Simulation component, which will be implemented as a plugin for the ADVENTURE Smart Process Definition component, covers process forecasting and simulation. For this, it takes information from different sources into account and integrates them.

3.3.2.3 Process Optimisation

The Process Optimisation component will also be implemented as a plugin for the Smart Process Definition Component. It provides techniques to optimise the assign-

ment of potential partners to specific steps and sub-processes of a specified process model according to predefined preferences of the user as, e.g., delivery time, capacity, cost, etc. Even in case, the number of appropriate potential partners is very high, an optimised combination of partners for an ADVENTURE Virtual Factory will be provided. The optimisation additionally includes mechanisms to generally improve the specified process, e.g. to parallelise certain process steps and sub-processes.

Thus, the Process Optimisation component provides means to automatically optimise a specified process regarding the combination of appropriate partners and the general improvement of the process according to predefined attributes. It will also be implemented as a plugin for the ADVENTURE Smart Process Definition component.

3.3.3 Real-time Monitoring, Process Adaptation, and Dashboard

Once the process definition has been finished and an optimised assignment of potential factories and manufacturing services, respectively, to the different process steps of the Smart Process has taken place, the execution of this process can be started.

To enable process execution control, a holistic process execution and monitoring environment is developed. An Adaptive Process Execution component, which is described in Section 3.3.3.1, provides functionalities, tools, and methods in order to enable the operation of the ADVENTURE Virtual Factories, i.e., an adaptive execution of the Smart Processes. Adaptive in this context means that the execution is adapted to (monitored) events which probably change requirements and circumstances.

Thus, a Real-time Process Monitoring component is necessary allowing a step-by-step execution of the manufacturing process. This component is described in Section 3.3.3.2. After the execution of each manufacturing step, the Adaptive Process Execution component will decide about the execution of the next step based on (recognised) unexpected events such as delays in the manufacturing process, strikes, delays in the transportation, etc. and on monitored results from the monitoring component.

The ADVENTURE Dashboard serves as a graphical user interface to all ADVENTURE functionalities. It is described in Section 3.3.3.3.

3.3.3.1 Adaptive Process Execution

After having modelled a collaborative Smart Process utilising the ADVENTURE Smart Process Definition component, the ADVENTURE Adaptive Process Execution component enables establishing an instance of the modelled process and initialising and performing its execution. The ADVENTURE Adaptive Process Execution component thereby provides the involved partners with real-time information about the current status of the process. In case recognised events or changed requirements make an adaptation or a re-planning of the process instance necessary, the Adaptive Process Execution component will utilise ADVENTRUE's forecasting, simulation, and optimisation methods and components as described in Sections 3.3.2.1, 3.3.2.2, 3.3.2.3 in order to automatically perform the adaptation.

Thus, the ADVENTURE Adaptive Process Execution component will implement and provide functionalities required for executing the modelled Smart Process. It further allows to plug-in other functionalities as, e.g., forecasting and simulation, through an interface and will also be extendable even after project end.

3.3.3.2 Real-time Process Monitoring

In order to enable adaptations to Smart Processes during runtime, it is necessary to monitor their execution and to compare them with their given process requirements and constraints. The monitoring information is thereby not only gathered and collected from the legacy systems of the partners participating in the current ADVENTURE Virtual Factory but also from Smart Objects integrated and utilised in ADVENTURE as described in Section 3.3.1.3. Comparing the current with the target state of a process, the Real-time Process Monitoring component will automatically inform the ADVENTURE Members about detected deviations from envisioned target-performance, so that, e.g., the broker of the Virtual Factory has the possibility to react to potential problems arising during process execution. For instance, exchanging certain parts of the Smart Process instance as exchanging partners or adapting the structure of the Smart Process will be enabled based on the Adaptive Process Execution.

The monitoring component can get information about potential changes of the process from either the process status (e.g., by getting information from a Smart Object or from a factory status update) or by getting updates from the process itself (e.g., if a delivery date has been extended).

Thus, The Real-time Process Monitoring component provides monitoring and control functionalities for enabling up-to-date, real-time diagnosis of the process execution status required for enabling potentially necessary adaptations to the Smart Process.

3.3.3.3 ADVENTURE Dashboard

A graphical interface to the functionality of the components offered by ADVENTURE is provided by the ADVENTURE Dashboard. In addition to the Smart Process Definition component and the Adaptive Process Execution component, which can be utilised for the day-to-day activities facilitated by ADVENTURE, also the Cloud-based Data Storage, which contains various production-related data and information from Smart Objects and legacy systems of participating partners, can be accessed and queried in order to find required data. Further, in order to align business object models and Smart Objects and to enable direct message exchange between the ADVENTURE Members, the Data Exchange and Messaging Platform and the Smart Object Integration Component are made available by the Dashboard. Encapsulating these functionalities, the ADVENTURE Dashboards aims at making information allocation and discovery transparent to the user, so that there is no difference between a company-internal process and a Smart Process carried out in a virtual factory from a user perspective.

Thus, the ADVENTURE Dashboard provides a holistic graphical user interface to the functionalities of ADVENTURE in terms of software components and manufacturing information.

4 ADVENTURE Scenarios

Following is a rough schema for the scenarios and use cases considered in ADVENTURE. This information is illustrative only, but it shows an example of what the project aims to enable. The actual use cases will be defined within a separate task in ADVENTURE (cf. DOW). The use cases will be SME-driven and located in the manufacturing domain.

In the following sections, a generic scenario is depicted to firstly abstract from the actual manufacturing domains of the industrial partners in ADVENTURE. While the outcomes of ADVENTURE will be evaluated in the domains the industrial partners are operating in, they will be universally valid and not bound to a particular manufacturing industry. However, the use case schema accounts for the needs of ADVENTURE's industrial partners in order to react quickly and adequately to events like, e.g., new incoming orders and changes in the supply chain.

After the generic scenario, potential scenarios from ADVENTURE's industrial partners are described.

4.1 Generic ADVENTURE Scenario

The generic scenario is organised according to the three ADVENTURE framework elements as presented in Figure 4. Section 4.1.1 presents the methodological layer, i.e, activities all along the lifecycle of the ADVENTURE Virtual Factory. Section 4.1.2 addresses ADVENTURE's software components layer and shows for each of the lifecycle activities the tools that support those activities. Finally, Section 4.1.3 addresses the knowledge and information related with each one of the activities.

4.1.1 Methodological Layer

John Doe is working at Factory A, which is a factory that offers a wide range of products to different customers. In order to get (Factory A) ADVENTURE enabled and to become an ADVENTURE Member, John follows the first stage of ADVENTURE's methodology, the ADVENTURE Provisioning and the ADVENTURE Adoption, which is the implementation and setup of the ADVENTURE Framework as described in Section 3.1. For this, and after having performed a business and technical analysis, John selects information resources from the range of resources provided by the ADVENTURE Framework and implements the ADVENTURE Software Components appropriate for Factory A. This way, John connects Factory A's ERP and legacy systems to the ADVENTURE Platform. He further arranges the corresponding semantic environment needed for creating, maintaining and performing the processes for the production and delivery of a concrete product produced by Factory A. For this, utilising the ADVENTURE Data Provisioning and Discovery component, John adds semantically enriched resources and descriptions of Factory A including its manufacturing capabilities to the ADVENTURE Knowledge and Information Repository, i.e., ADVENTURE's Cloud-based data storage, which already contains semantic information resources and descriptions of other ADVENTURE Members, as, e.g., Factory B.

Utilising these resources and the implemented ADVENTURE tools and modules, John is able to carry out the necessary tasks and activities described in the following

to instantiate an ADVENTURE Virtual Factory in order to satisfy orders in a short time and avoid bottlenecks while controlling the whole manufacturing process carried out by a virtual factory.

According to the ADVENTURE Virtual Factory lifecycle (depicted in Figure 6), John performs respective activities of its main phases, which finalise the second stage of the ADVENTURE methodology as described in Section 3.1:

Process Analysis phase

During process analysis phase, John (i.e., Factory A) examines the new business opportunity and the process adaptation needs in order to be able to create an abstract model of the Smart Process for the envisioned ADVENTURE Virtual Factory. He defines the objectives, boundaries, inputs, outputs, and stakeholders of the potential Smart Processes as well as the performance measures and recommendations. John can search and query the Knowledge and Information Repository in order to obtain information about similar processes that have been executed in the past. Using the ADVENTURE partner search engine, John is able to search partners and filter them by industry type, location, work load level, etc. Furthermore, John can do some preliminary simulations in order to decide whether an opportunity is reasonable and profitable or not.

At the end of this phase, John has gathered all the information necessary to decide if the process should be implemented or not.

Design phase

During design phase, the mentioned abstract model of the Smart Process is developed, which describes the whole envisioned manufacturing process, and the therefore required services in terms of resources and manufacturing capabilities, which are offered by real factories. This way, Factory A becomes the broker – the ADVENTURE Broker – in an ADVENTURE Virtual Factory.

Referring to Figure 7 in Section 3.1, a detailed view on the design phase is indicated. The design phase includes the following activities:

- Description of the whole process, i.e., Smart Process definition, including constraints as, e.g., environmental and ethical questions, lead time, costs.
- Search and assignment of appropriate partners to each of the (above) described steps of the Smart Process according to the issued requirements.
- Process simulation and forecasting, i.e., having realised a connection between the software systems of Factory A and the ADVENTURE platform during the mentioned ADVENTURE setup at stage 1 of the ADVENTURE methodology – the ADVENTURE Adoption – John can utilise ADVENTURE's simulation and forecasting facilities to simulate and forecast the process' potential progression regarding a stand-alone process as well as its integration into the overall processes running at Factory A. He may equally use information originating from resources as, e.g., sensors and Smart Objects or other ADVENTURE

Members as input for his (Factory A's) ERP system which then is performing the mentioned simulations and forecasts. In order to access this information, a messaging takes place, i.e., John's ERP system automatically exchanges messages with the mentioned ADVENTURE resources.

- In case the performed simulation and forecasting shows that the specified requirements of Factory A remain unsatisfied for the current selection of partner factories, John can either select appropriate partners manually or benefit from ADVENTURE's assisted partner selection, i.e., he can utilise the optimisation tool provided by ADVENTURE which prepares and proposes an optimised solution for the selection of appropriate partner services according to John's predefined and specified requirements and preferences.
- If all requirements of Factory A are fulfilled during the simulation and forecasting, John can start negotiating contracts with eligible candidate partner factories in order to achieve the best results.

Execution and Adaptation phase

During the execution and adaptation phase, the designed Smart Process will be executed and adapted if needed. Referring to Figure 8 in Section 3.1, the correlation between these two phases is visualised.

The execution phase includes the following activities:

- During process runtime, the best-fitting and contracted partner factories, identified and selected during the design phase, are employed and John's modelled Smart Process is executed, i.e., the established ADVENTURE Virtual Factory is run. Its execution is monitored.
- Assigning factories to production steps or to sub-processes of the whole Smart Process can also imply that a distinct production step is distributed over different partner factories, if the best-fitting partner is not able to provide as many goods as needed. This way, production bottlenecks are eliminated.
- While the actual execution takes place, ADVENTURE's monitoring component collects and provides real-time information about the current status of the Smart Process. Unforeseen events may either be recognised by this monitoring component or by (intermediate) products or product parts enhanced with monitoring and error detection capabilities, which turns them into Smart Objects. These Smart Objects provide monitoring information from the involved factories using wireless communication technologies. Hence, information from the different ICT systems, sensors and Smart Objects of the customers, suppliers and shipment partners as well as from human input is also integrated into process monitoring.
- The process status information will be prepared in such a way that there will be no difference between executing and monitoring a company-internal or cross-organisational manufacturing process.

The adaptation phase includes the following activities:

- If the monitoring shows unforeseen events which might change the outcome of

the process with regard to deadlines, costs or other criteria, of if something different goes wrong with the contracted suppliers during the process runtime, an automatic alert indicating necessary adaptations of the process will take place, e.g., for redirecting distinct manufacturing steps to other partners or for exchanging underperforming, unsatisfying partners. Again, the selection of alternative or complementary candidate factories and their manufacturing services, respectively, can either be performed manually or can be automatically assisted and performed by ADVENTURE's Process Optimisation component, which automatically composes a list of best matching partners and proposes this list to John. The system thereby lets John take the final decision or automatically selects the best fitting suppliers depending on John's preferences.

- Also if requirements of the process change, e.g., because more products are needed or different features of a product are mandated, the process adaptation or optimisation option as described above will be presented automatically.

Improvement phase

When an ADVENTURE Virtual Factory lifecycle reaches its end, an evaluation is taking place in the improvement phase. For this, John agrees with the partners, who have participated in this ADVENTURE Virtual Factory, on evaluating the executed Smart Process. The reference models can be improved and lessons learnt are stored in the ADVENTURE Knowledge and Information Repository. John and other ADVENTURE Members can access it in the future. This knowledge and information thereby is owned and maintained by the ADVENTURE Members.

Thus, in the improvement phase, information from the virtual factories such as best practices and lessons learnt are created (and stored) so that an ADVENTURE Broker can query the Knowledge and Information Repository in order to obtain information about Smart Processes that have been executed in the past, (probably) applying retrieved best practices and avoiding mistakes which have been identified. This way, ADVENTURE builds a knowledge base which is enriched and updated each time a Smart Process is executed.

Dissolution phase

After having updated the ADVENTURE Knowledge and Information Repository, the ADVENTURE Virtual Factory finally is dissolved. However, as all the information and configurations of the dissolved virtual factory have been stored, John can (try to) reinitiate this virtual factory – conducting adaptations based on lessons learnt which have been stored during former improvement phases – in case, the same product has to be manufactured again.

Besides instantiating an ADVENTURE Virtual Factory according to an upcoming business opportunity for Factory A, John could equally participate in other ADVENTURE Virtual Factories, initialised by other ADVENTURE Members.

4.1.2 Software Components Layer

The activities described above will be supported by the ADVENTURE Software Components. In the following, the generic activities for the design, execution and improvement phases are mapped to these software components.

4.1.2.1 Design phase support software components

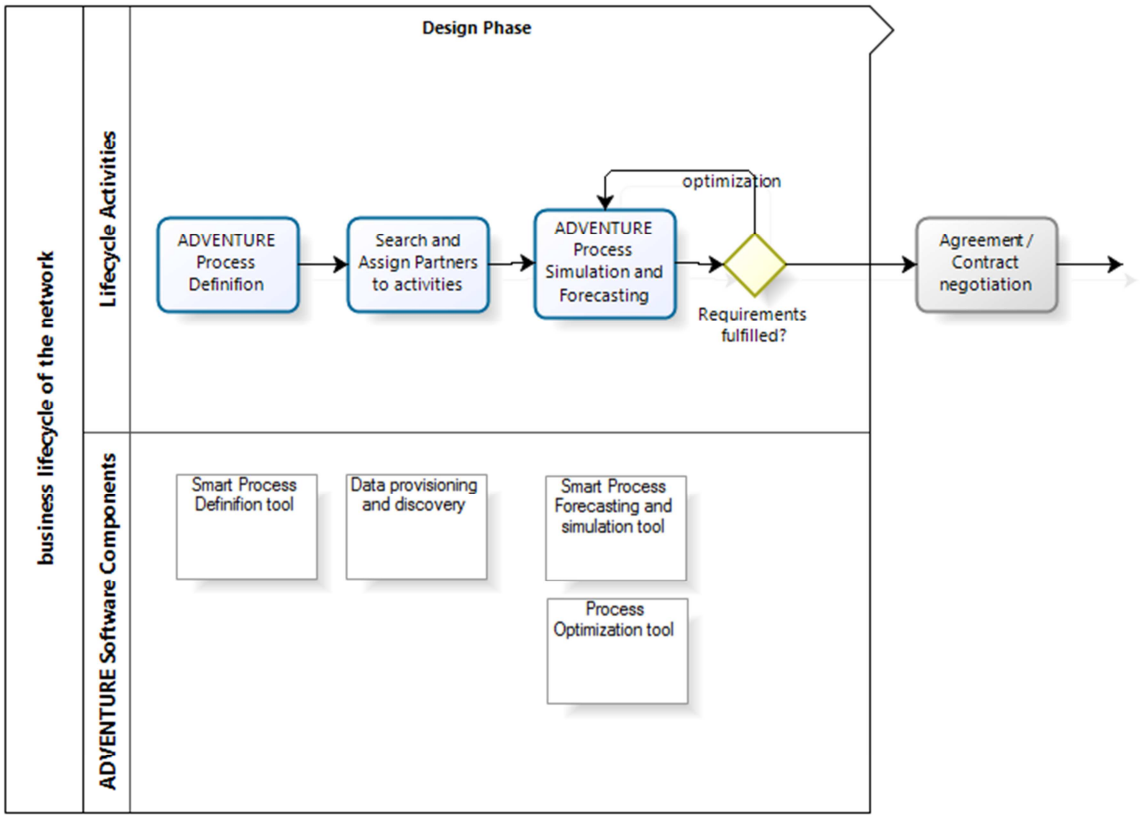

Figure 11: Design phase software components

Using the Smart Process Definition component, the Smart Processes are designed following a service-oriented approach. The John (acting as ADVENTURE Broker) searches for partners based on manufacturing capability descriptions, available in ADVENTURE's Knowledge and Information Repository, including, e.g., delivery time, quality and technical requirements, and assigns them to process activities or sub-processes.

Once the process is completely defined, John can run a simulation in order to evaluate whether all requirements are satisfied. Otherwise, he applies optimisation techniques to the modelled Smart Processes in order to make sure that Factory A's requirements are met and to achieve efficient process execution. These optimisation techniques include support for achieving an optimised selection and assignment of partners to respective process steps as well as propositions for rearranging and restructuring the modelled Smart Processes. E.g., if step A and step C of the Smart Process will be executed in Italy and step B will be realised in Spain, it will be proposed to change the order of step B and step C if possible.

4.1.2.2 Execution phase support software components

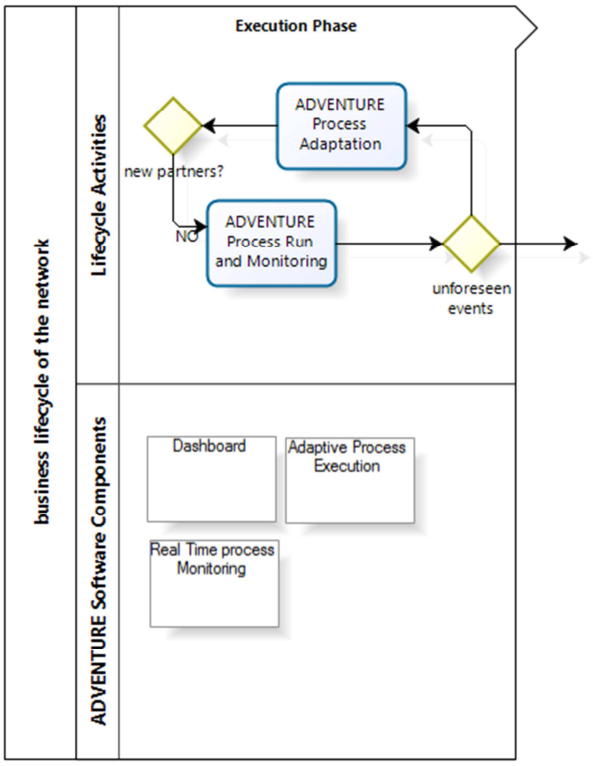

Figure 12: Execution phase software components

The Virtual Factory Run and Monitoring step uses the Real-time Process Monitoring component. Messages and data sent from Smart Objects and from IT systems of ADVENTURE Members provide information about the current process status. If an unforeseen event occurs, the Adaptive Process Execution component will act and alert users for changes.

4.1.2.3 Improvement phase software components

During this phase all the information collected during execution time will be stored in the Knowledge and Information Repository. This way, John builds a knowledge base for future queries.

4.1.3 Knowledge and Information Layer

4.1.3.1 Design phase knowledge and information base

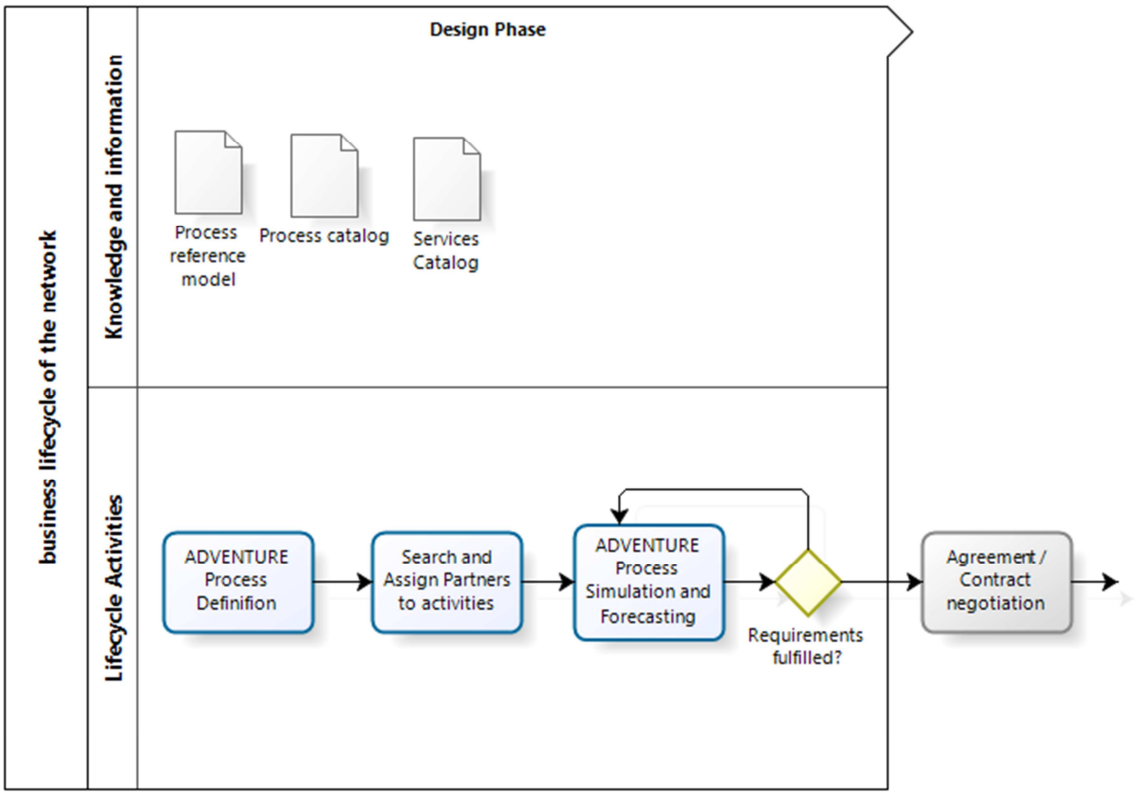

Figure 13: Design phase knowledge and information phase

During the design phase, John queries the Knowledge and Information Repository to find appropriate services offered by ADVENTURE Members – representing the available services catalogue. During the definition of Smart Processes, John can use process reference models to assist the process definition. The defined Smart Processes are stored for future use and improvement. Utilising ADVENTURE's Process Simulation and Forecasting as well as Process Optimisation components, John is able to improve the process models stored in the knowledge base (in case further improvements are possible).

4.1.3.2 Execution phase knowledge and information base

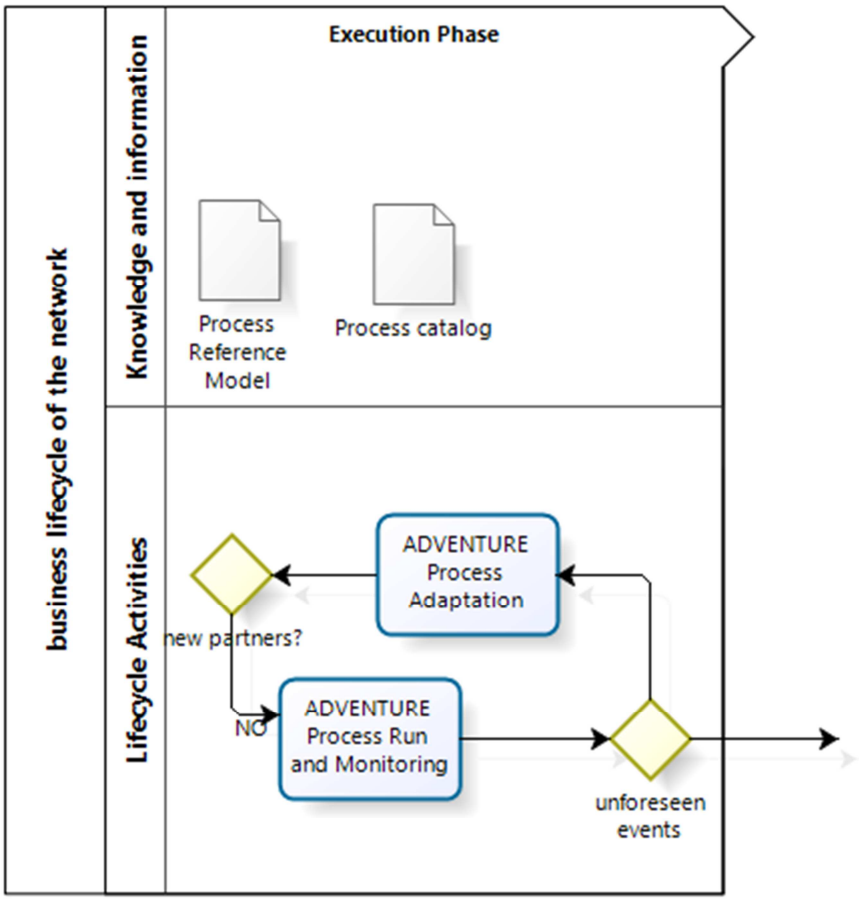

Figure 14: Execution phase knowledge and information phase

In this phase, John may update process reference models and catalogues as a result of performing the process adaptation activity.

4.1.3.3 Improvement phase knowledge and information base

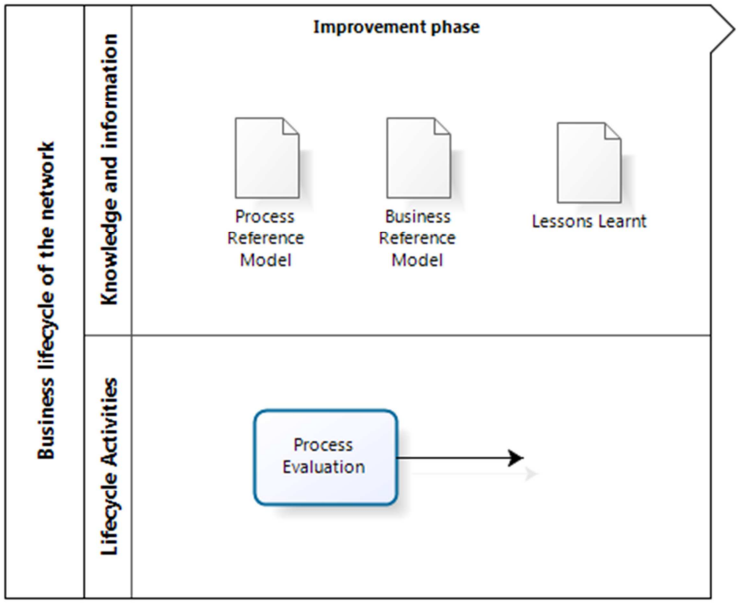

Figure 15: Improvement phase knowledge and information phase

Having executed the Smart Process, John may update process reference models and catalogues and adapt existing or describe new best practices and lessons learnt.

4.2 Azevedos Indústria Scenario

Azevedos Indústria, is a Portuguese SME manufacturer of machines and receives an order from its Italian customer FRIZE. FRIZE wants to offer a high-quality variant of their capsulated cork stopper. This different type of product should have a special wood cap on the top. While Azevedos is actually able to fulfil this specific order, there are a number of obstacles which may prevent the successful business transaction, as, e.g., FRIZE requires Azevedos to assure that the machines have a throughput of at least 20.000 corks per hour and that a specific automation technology with a specific programming language is used, which Azevedos doesn't support at the moment. Furthermore, FRIZE wants the machine with a minimum carbon footprint and a delivery frame of 45 days. Due to the tailored wood cap, it will be necessary to conceive a totally new system for handling these caps. The head cap's subsystem is one the main parts of the whole solution.

Analysing this set of main requirements and constraints, Azevedos figures out that it will be necessary to involve further partners. In order to fulfil the order's needs, Azevedos requires and demands, respectively, specific manufacturing capabilities to

- conceive the new head cap subsystem
- perform all surface treatment required
- develop, implement and test all new automation subsystems.

For this, Azevedos uses the ADVENTURE's Smart Process Definition component to model the envisioned Smart Processes, which require the integration of several partner factories to be realised.

As Azevedos has modelled its "Special wood cap machine process" using the tools and methods provided by ADVENTURE, it is the broker in an ADVENTURE Virtual Factory that produces cork machines for FRIZE. Utilising ADVENTURE's Data Provision and Discovery Component, Azevedos is able to identify suitable suppliers by defining the precise requirements of the product to be manufactured, based on the semantic information about necessary manufacturing standards and product characteristics as well as on attributes like price and delivery. Thus, it is easy to exchange Azevedos' usual automation systems supplier by another one, which adheres to the requirements issued by FRIZE.

Furthermore, ADVENTURE provides the means to integrate status information, coming from the involved partners, for example originating from monitoring software or Smart Objects deployed at the partners' sites. This information will be provided through the ADVENTURE Dashboard. It will also be included in risk estimation, i.e., Azevedos can estimate if it is necessary to trigger countermeasures in order to minimise the risk of delivery failure of any of the involved subsystems (e.g., the automation system).

Because of its increased efficiency, high quality and transparency, Azevedos gets more and more customers. The amount of new automation systems that are needed cannot be delivered by a single provider anymore and therefore, Azevedos now interacts with two different providers.

Thanks to ADVENTURE, Azevedos can manage the automation system production with multiple partners very easily. Utilising ADVENTURE's Adaptive Process Execution component and Process Optimisation component, the best factory for automation systems provisioning among available ADVENTURE enabled factories with appropriate products and comparable attributes will automatically be proposed and their delivery time and capacities will be considered during runtime. If Supplier-A has reached its maximum capacity, ADVENTURE will route future automation system orders to Supplier-B, until Supplier-A has capacity left. Because of this unique feature, ADVENTURE can coordinate the orders between all potential factories easily and it will ensure that an optimised result is produced in terms of Azevedos' requirements (e.g., regarding carbon footprint, quality, price, and time constraints).

However, one day, one of Azevedos' suppliers cannot deliver anymore. Azevedos therefore uses ADVENTURE's Data Provisioning and Discovery Component to find additional factories that are already ADVENTURE enabled. In addition to this, Azevedos also uses a web-based search engine to find additional factories, which are not yet ADVENTURE enabled, but can produce the required automation systems. Before connecting these factories to the ADVENTURE platform – i.e., before performing the ADVENTURE Provisioning to make these factories become (at least passive) ADVENTURE enabled – Azevedos qualifies them, supported by its suppliers' qualification quality process.

This way, two additional suppliers are identified that can produce the necessary components and Azevedos utilises the Smart Process Designer to add the two new companies to its PLC production process. As soon as the ADVENTURE Provision is performed, the new factories can be considered by ADVENTURE and can be involved in Smart Processes without the need for any additional manual steps.

4.3 ABB Scenario

FISUB (unit of ABB Finland) is a Finnish manufacturer of protection relays offering power supply services to a large amount of different customers. It receives orders from these customers according to its offered products and services. E.g., FISUB receives a large quantity order from a switchgear manufacturer CZELS (unit of ABB Czech), which wants to offer a high-quality variant of their bestselling Switchgear. In order to increase its visibility to potential new customers, FISUB describes and specifies its capabilities and offered manufacturing services including information about standards, capabilities, etc. It therefore utilises ADVENTURE's Data Provisioning and Discovery Component which offers tools and methods to achieve semantically enriched (machine readable) descriptions of its factory.

Apart from CZELS, FISUB also delivers high-quality, made-to-order relays to 15 other switchgear manufacturers. These companies have ever-changing requirements (Type x Variant x Quantity) based on the end customer demands. This means it is necessary to optimise and adapt certain parts of the manufacturing process according to resource (manpower/machines) availability and interact with different suppliers to ensure availability of inputs/materials.

Thanks to ADVENTURE, FISUB can automatically check offered manufacturing capabilities of its partners and integrate the best fitting suppliers into its adapted manufacturing process. Furthermore, there might be interdependencies between manufacturing the new order and other orders. For example, if a material is required that is common to other variants, it could bind the available material and restrict its availability for other orders. Hence, FISUB's managers need to simulate CZELS' order to find information about to which degree accepting the new order by CZELS might influence the production of other orders.

In addition, FISUB would like to make the production status transparent to their customers allowing each customer to see – in real time – the status of all parts and a forecast of their delivery status. Utilising the ADVENTURE Real-time Process Monitoring component, the delivery status of FISUB' suppliers can be used to announce the delivery situation and risks to CZELS on real time basis which in turn helps CZELS to plan or reschedule their deliveries, thus minimising the consequences of risks due to potential delivery failures of FISUB' suppliers.

This is possible as ADVENTURE provides the means to integrate information from Smart Objects, which can monitor the transport of LCD HMI's required to fulfil CZELS' order. For this, ADVENTUREs Data Exchange and Messaging Platform will be used to realise the message exchange. This means it can be quickly visible if an event occurs that might lead to a LCD HMI being potentially damaged (e.g., a physical shock or the temperature has fallen below a critical temperature). The Smart Object technology employed shall also enable the geographical tracking of the HMI consignment, i.e., the transportation of the HMIs are monitored utilising Smart Objects.

This information will be provided by the ADVENTURE Dashboard. It will also be included in risk estimation enabled by ADVENTURE, i.e., FISUB can estimate if it is necessary to trigger countermeasures in order to minimise the risk of delivery failure of the LCDs or delays in transportation. Of course, only the information should be available which concerns a particular partner (as is CZELS in this case).

Because of the close collaboration with FISUB, CZELS is expecting a large order that includes large quantity of relays. Major share of the relays are expected with low voltage power supply and an Ethernet communication module. FISUB is prepared to deliver these relays without any obstacles.

Thanks to ADVENTURE's knowledge management and information exchange capabilities, and because CZELS is also plugged-in to ADVENTURE (i.e., CZELS is an ADVENTURE Member) the forecast of CZELS's prospective order is captured and made visible to FISUB on the ADVENTURE Dashboard. FISUB processes the forecast from CZELS to give further forecast to PCBA (Printed Circuit Board Assembly) and other suppliers. As also the PCBA supplier is plugged-in to ADVENTURE, the forecast from FISUB is also visible to them on the ADVENTURE Dashboard.

The availability of forecast knowledge and control leads to improved scalability and flexibility of manufacturing due to avoiding manual adaptations of the processes after the receipt of CZELS's order.

CZELS has already placed the order for relays on FISUB for the switchgear that is due for delivery very soon. However due to customer requests, CZELS accepts certain engineering changes to its switchgear. This results in changes to relay specifications as well. CZELS revises the order, which impacts the earlier ordered types, variants and quantity. CZELS also places a new "urgent" order with shorter delivery time as the relays are required for customer inspection and testing.

Thanks to ADVENTURE, FISUB can simulate the impact of changes to orders and confirm the delivery dates to CZELS. FISUB is able to quickly react to the changes by adapting the Smart Process (revision of work queue, shifting of resources, adding a shift etc.).

After a quick check of availability of resources, FISUB is able to squeeze in the urgent order. Thanks to the real-time monitoring of the Smart Process, FISUB is able to ensure that the relays for the urgent order will be ready in time and makes the status visible to CZELS via the ADVENTURE Dashboard. Furthermore, Smart Object-technology, deployed in the consignment of relay to CZELS provides information about its status and geographical location to CZELS via the ADVENTURE Dashboard, too.

With increased volumes, FISUB decides to out-source manufacturing of certain products, i.e., adopt a "box-built" approach. Various customers including CZELS place orders on FISUB for such products, FISUB in turn places orders on a supplier (partner) to deliver the box-built products to CZELS. For the supplier, "sold-to-party" and "billed-to-party" is FISUB, whereas "shipped-to-party" is CZELS. FISUB then bills the products to CZELS. Customers cannot accept any deterioration in delivery performance and expect the same amount of status information as if FISUB itself was delivering. Since the supplier is an ADVENTURE Member, FISUB is able to monitor all its processes in real-time. This allows FISUB to anticipate and estimate risks to trigger countermeasures in order to minimise the risk of delivery failure of box-built prod-

ucts. The delivery status of the supplier are mirrored by FISUB and made visible to CZELS via the ADVENTURE Dashboard, as CZELS is also an ADVENTURE Member. A higher degree of management and operational efficiency is enabled by ADVENTURE's ability to fill-in the missing interoperability between the IT systems of FISUB's business partners, e.g., CZELS, and PCBA supplier. The process-based collaboration for integration of partners (CZELS-FISUB-Supplier) into the ADVENTURE Virtual Factory enables increased degree of utilisation of resources, reduced costs and the ability to deliver in a short time frame.

4.4 Control 2K Scenario

Control 2K is a UK based company that offers an integrated solution to SME's for monitoring production machinery. It is one of the lead members of TANet (cf. Table 1). One day it receives a request for business from the Bearings production company ETMCO. ETMCO has recently been experiencing increased production quality issues. Some of production lines have developed random errors and are producing a higher quantity of defective bearings resulting in increased waste figures. The errors have shown up on the day logs, when machine data has been manually collected and evaluated. Thus ETMCO wishes to upgrade its machines with automatic error detection capabilities, making them "smart" in order to send out automatic alarms. ETMCO hopes to cut the time for error detection, thus avoiding waste.

Control 2K is very interested in installing the required hardware and software for ETMCO. In order to enhance its customer relationship management strategy, Control 2K has developed a business process which should ensure a successful implementation of their Industreweb Software solution. Control 2K requires from ETMCO information about:

- How many machines are involved in the monitoring
- What kind of machines are involved in the monitoring
- How many data points are to be monitored from each machine
- How the monitored information is to be presented
- A list of contact persons (e.g. the production manager, technicians) responsible for and entitled to handle the project.

In order to be able to create a final quotation for the whole plant, Control 2K needs to carry out a pilot project at ETMCO during which one of the more complex machines will be first upgraded with additional monitoring hardware to connect to Control 2K's Industreweb software. During this extended requirements engineering phase it is possible for ETMCO to refine its requirements, and for Control 2K to gain better insight into the surrounding complexities.

After successfully establishing an initial pilot evaluation contract with ETMCO, Control 2K commissions a subcontractor to install the hardware as well as a monitoring PC, and then remotely connects the installed hardware to the Industreweb Software in-

stalled on the monitoring PC. The collected data and alerts (according to specified rules) are then available to the ETMCO production manager in real time through a web browser.

In order to successfully complete its project Control 2K relies on several aspects of ADVENTURE: **(1)** Customers can find Control 2K through the Dashboard (utilising ADVENTURE's Data Provisioning and Discovery component), get detailed information about its products and services, and also examine the project implementation processes required by Control 2K. **(2)** While negotiating the exact terms of the business relation, Control 2K mandates a pilot project. ADVENTURE allows both sides to stick to Control 2K's pilot project process, during which selected data from the customer can be accessed and utilised through smart data objects. **(3)** The smart process consisting of activities and process pieces contributed by Control 2K, allows both parties to monitor and control the resources exchanged through smart data objects. The process derived from (2) furthermore acts as a behavioural contract for both parties.

ETMCO wants to integrate the information delivered by Control 2K into its CRM software as its decision support and evaluation systems. As Control 2K's Industreweb software is not compatible to these custom systems, they recommend a set of companies that have products that allow for such a connection. All the proposed companies have different API's and fortunately, Industreweb is able to present the contained information in a way that makes it usable for the different proposed solutions.

As all interfaces provided by Control 2K are wrapped by ADVENTURE, several other suppliers exist that are specialized on providing data formats required by ETMCO. When ETMCO decides to rely on one of these suppliers it can allow them to utilise the data provided by Control 2K, which in turn is then converted to fit ETMCO's requirements.

Control 2K wants to develop its software for a special set of common production machines that are easily adaptable for connection via a wireless communication protocol system. For these types of production machines it is only necessary to install minor hardware components to collect data and thus transform them into Smart Objects. This now opens the door for Control 2K to have many potential customers from all over the world. Control 2K still wants to stick to its trusted process which includes a pilot project. This requires Control 2K to remotely ensure that potential customer's machines fulfil the minimum required specifications before agreeing to begin contract negotiations. Furthermore deploying its software to different countries, Control 2K needs to be mindful of different data retention laws and policies, which requires trustworthy partners in these countries to handle backups.

The necessary information about customers' production machines is made available and translated through smart data objects. Customers have fine-grained control over which information is exposed during the plug phase. Control 2K is able to plan, execute and monitor its pilot project remotely. As the customers data retention policies are available through the ADVENTURE Dashboard (together with information about partners already working with the customer) Control 2K has the ability to easily propose and agree on partners with its customers.

Control 2K's customers become more accustomed to the idea that minimum monitoring hardware has to be present at their location to turn their machinery into Smart Objects and Control 2K starts to implement Industreweb as a remote cloud solution (Platform as a Service). The monitoring and visualization part is provided to the companies as Software as a Service (SaaS) which can access the data store for particular companies. Data from the Industreweb platform is frequently required to be queried as part of processes in place at customer companies. Control 2K has to ensure that changes in these processes do not lead to inconsistent interaction with Industreweb and that upgrades to Industreweb can be rolled out without (a) delaying the operation of customers and (b) disrupting their processes.

ADVENTURE's Smart Process Adaptation component allows Control 2K to check if changes are disruptive for customers. ADVENTURE supports Control 2K in that it allows for different versions of its services to coexist, and it supports its customers by providing an adaptation plan.

Appendix A – Glossary

ADVENTURE Virtual Factory

A temporary strategic alliance of factories from multiple partners (in fact, it could also be factories from the same company), managed by a distributed, integrated, computer-based system – the ADVENTURE Platform – that interfaces with all systems necessary to make design, production and delivery of a product possible.

The core of the ADVENTURE Virtual Factory are Smart Processes, which integrate reusable smaller processes and other metadata from the ADVENTURE Knowledge and Information Repository, defined by active ADVENTURE Members.

Smart Process

In a Virtual Factory, several steps and sub-processes need to be executed to produce the desired product. In the ADVENTURE context, the manufacturing processes created by combining individual process steps and existing sub-processes' fragments designed utilising the ADVENTURE Framework and collaboratively executed by the parties participating in an ADVENTURE Virtual Factory is called a Smart Process. The Smart process can be adapted to changes at runtime.

ADVENTURE Framework

The framework provided by ADVENTURE comprises…

1. **ADVENTURE Platform**: The complete technological and software components of ADVENTURE.
2. **ADVENTURE Methodology**: A guideline to perform ADVENTURE Adoption and creation of a Virtual Factory.
3. **ADVENTURE Knowledge Base**: A knowledge and information repository that encompasses patterns, guidelines, best practices, reference models, etc. for the context of ADVENTURE and the ADVENTURE Methodology.

ADVENTURE Broker:

1. The person who designs/creates a process and/or proposes business opportunities to ADVENTURE Members.
2. The person who watches/supervises the Smart Process while it's in the execution phase.

The ADVENTURE Broker usually will also be an employee of a real factory. He is the person who uses the tools provided by ADVENTURE. The subparts 1) and 2) could be different persons with a different set of access rights though.

ADVENTURE Adoption

The ADVENTURE Adoption includes three steps:

1. Setting up the necessary hardware and software to use the ADVENTURE Dashboard and the tools provided by ADVENTURE

2. Integrating the ADVENTURE Platform with the systems used in the factory, e.g. ERP systems, etc.
3. Performing the ADVENTURE Provisioning for the factory.

ADVENTURE Provisioning

ADVENTURE Provisioning is the process of providing the necessary information about a factory including its manufacturing capabilities and products, which are needed to take part in Smart Processes, and the formatting of this data in appropriate ways (so that the data is compatible with the ADVENTURE Knowledge and Information Repository) and the process of putting this data into the ADVENTURE Knowledge and Information Repository. ADVENTURE Provisioning is supported by the ADVENTURE Data Provisioning component accessible through the ADVENTURE Dashboard.

ADVENTURE Knowledge and Information Repository

A cloud-based data storage for all data needed in the ADVENTURE Framework.

ADVENTURE Business Environment

The group of all (active and passive) ADVENTURE Members constitutes the ADVENTURE Business Environment.

Passive ADVENTURE Member

Performing ADVENTURE Provisioning on a factory enables this factory to be a part of an ADVENTURE Virtual Factory. This factory then becomes a passive ADVENTURE Member.

Active ADVENTURE Member

Performing ADVENTURE Adoption for a factory lets this factory become an active ADVENTURE Member. Similar to passive ADVENTURE Members, active ADVENTURE Members can also take part in Smart Processes. But only active ADVENTURE Members can use the ADVENTURE Platform to create Smart Processes, as they have performed the necessary ADVENTURE Adoption.

Adventure Virtual Factory Lifecycle

The ADVENTURE Virtual Factory lifecycle refers to the activities that are performed when the ADVENTURE Framework is used to exploit a new business opportunity. The lifecycle encompasses five main stages: process analysis, design, execution and adaptation, improvement and dissolution. There will be a complete lifecycle for each business opportunity.