Pilarcos Business Networks

Lea Kutvonen, Alex Norta

1 Introduction

The globalisation of business and commerce makes enterprises increasingly dependent on their partners. Competition takes place between supply chains and networks of enterprises. In this competition, the flexibility of enterprise information systems becomes critical. The IT system and development teams should be able to respond in a timely manner to the requirements arising from the changing co-operation networks and their communication needs. Besides being able to establish new business networks for new business opportunities with a relatively low cost, enterprises should be able to participate in multiple networks simultaneously. The existing business networks should even be modifiable in terms of partnership or operational policies. Furthermore, a level of automation on collaboration contracting and collaboration correctness monitoring is necessary, as well as protection from service and information misuse by partners.

The Pilarcos architecture [22] goal is to support enterprises with selected infrastructure services in the provision of business services on an open service market, dynamic eContracting and establishment of new business networks (like instant virtual enterprises in CrossWork), and enforcement of the governing eContract rules on the collaboration at operational time. The focus of the supporting infrastructure is on the distributed business network management functionality and interoperability management at technical, semantic and pragmatic (processes, policies) levels.

Traditionally, inter-enterprise collaboration has been supported by business process driven integration solutions that focus on the business functionality needs and the technology-homogenizing needs of the collaboration. This leads to situations where a change in the business processes induces large re-development projects.

Lea Kutvonen, Alex Norta
Department of Computer Science, University of Helsinki, e-mail: {Lea.Kutvonen | Alexander.Norta}@cs.Helsinki.FI

Furthermore, technology changes may cause domino effects cascading on the computing system of dependent collaborations.

The present goal is to narrow the gap between business management concepts and the computing solutions. It has become plausible to address the call for enterprise interoperability (e.g.[29]) and social networking (e.g. [3, 31]) with the rise of service-oriented computing (SOA, SOC [30]) and web services technologies [2], model-driven engineering (e.g. [38] and and multi-agent techniques and contemporary work on business-IT-alingment (e.g. [4, 24, 37].

This chapter presents the Pilarcos approach to virtual enterprises (VE) as a federated approach and compares the architectural features to the unified CrossWork approach. This comparison refers to a rather commonly accepted categorisation of interoperable architecture types: Integrated solutions interoperate by design and hard coded mappings, unified solutions interoperate by design, with dynamic mapping of technical solutions to the joint model, and finally federated solutions rely on dynamic negotiation about the differences in models, dynamic mapping of technical solutions to the agreed model, and monitoring of arising problems at operational time solution. Section 2 introduces the intended architecture of the global ecosystem of open service markets and temporary business networks formed for various business opportunities addressing the main concepts and supporting infrastructure services. Section 3 discusses the creation of a large-scale, shared knowledge-base of interoperability information and the thus formed open service market and vocabulary for negotiations. Section 4 addresses the Business Network lifecycle, that is most closely comparable with the CrossWork Business process formation phase, but also extends to the operational time. Section 5 compares the Pilarcos and CrossWork concepts and services, and evaluates the Pilarcos architecture through a number of targeted architecture properties. The section concludes with suggestions for future research evolving out of CrossWork and plans for future Pilarcos enhancements.

2 Overview and concepts

The Pilarcos architecture describes an open, global ecosystem where new business networks can be established [19, 21]. In this global ecosystem, enterprises make available business services that they administer independently. Together with other enterprises they form task forces in which a new kind of business scenarios are developed; together yet again other enterprises form business networks instantiating such business scenarios, using the available business services. Business networks are ad-hoc, loosely-coupled, eContract-governed collaborations.

The ecosystem relies on some new infrastructure services (B2B middleware services) in the open network, such as services for business service discovery and selection, knowledge about existing business network models, and ontologies related to service types. In order to be able to participate in this ecosystem, the enterprises have to have a private agent too, for supporting local decision-making and running the joint B2B middleware protocols with other partners in the ecosystem. The protocols are involved with eContract negotiation, monitoring, breach management, and reputation information distribution.

The key concept in the Pilarcos architecture is that of business service. A business service is a software-based (distributed) service, administered by a single authority. The providing enterprise may have policies restricting its behaviour. The business service may in addition be governed by an eContract in each collaboration it provides service for, the terms of scope/functionality, properties and accessibility of the service. There is no guarantee that discrepancies between eContracts, enterprise polices and service capabilities would not a rise. Instead, a breach detection mechanism through monitoring is an essential part of the architecture.

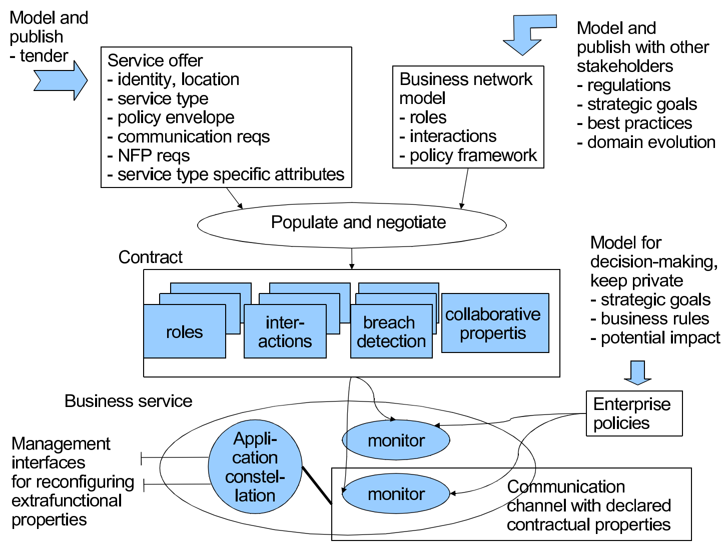

Fig. 1 Pilarcos architecture view.

As a reminder of the ecosystem behaviour, Figure 1 illustrates the general architecture and functionality. Each enterprise can make tenders to the open marketplace by describing the (functional and nonfunctional) properties of its service; each enterprise can on the other hand participate the design process of business network models that create a template for the rules in the forthcoming business networks. These events of publishing metainformation are, however, not dependent on each other, but the models meet at population and negotiation time. For the necessary negotiation, control and management protocols between potential peers, each enterprise is represented by a private agent. The automated negotiation process (with human intervention possibilities) results into the eContract governing the business network membership, behaviour and breach management. For the operational time monitoring, the enterprise policies and eContract rules can be fed into local monitors guarding the business services. When a breach is detected as a monitor detects a message contradicting its rules, it sends a notification to the local agent, that in turn may request a breach recovery process to be started among the partners. On the other hand, the monitors can detect a reaching of processing milestones as well, and thus notify of significant state changes in the business network status. As Figure 1 illustrates, the technical properties of the business services are managed locally, taking into consideration the declarations of their properties in the eContract and enterprise policies. Thus, the properties of business services and the acceptable business process it conducts with its peers, can be modified at operation time.

Characteristic to the Pilarcos architecture is that the eContract addresses multiple business services, but is negotiated and committed between several enterprises. The eContract captures external business processes and selections made between alternative behaviours in it at the business level, but also complements this information with technical and semantic requirements for interoperability between the service-providing service elements. However, the business services and enterprises involved in the business network, preserve their privacy and autonomy. The reasons for agreeing or refusing to join a business network are not totally revealed. The business network establishment is a two-phase process, where the first phase (population) utilises public property information and the second (refining negotiation) only asks for private decisionmaking for commitment or withdrawal from the negotiation. Further, the method of implementing services is not revealed: the strong encapsulation of business services hides software implementations, local workflows, application platforms and other details, only making visible the external behaviour of the service (control exchange points, information exchange, quality and type of messaging services required for these).

Another characterising property of the Pilarcos architecture is the use of clearly separated viewpoints on the managed business network and the use of eContracts for capturing all viewpoints. The viewpoints are closely related to those of the RM-ODP standards (Reference Model for Open Distributed Processing) [9, 10, 12]. The five ODP viewpoints are addressed as follows: First, the enterprise viewpoint corresponds to the Pilarcos business network model that is expressed in terms of roles, interactions, and governing policies. We have suggested the present RM-ODP ammendment to include additional organisational concepts on top of the traditional concepts of federation (joint management of an aspect over the administrative domain boundaries) and community (in case of Pilarcos: business network). Second, the information viewpoint specifies the relevant information items and repositories, and the rules for information modifications and invariants. These schemata are reflected in metainformation repository consistency rules. Third, the computational viewpoint gives structures and interfaces for logical computation. For example, in Pilarcos, we consider different information exchange protocols as valid mappings for business network model requirement of passing a piece of information between parties. Fourth, the engineering viewpoint specifies what kind of platform support is expected. This includes the Pilarcos facilities (populator, negotiation protocols, eContract management, monitoring, service offer repository, type repository, BNM repository and various ways of realising an abstract communication platform for exchanging messages with distribution transparency properties (transaction support, confidentiality, nonrepudiation, access transparency, etc). Fifth, the technology viewpoint specifies which concrete implementation or standards must be used. In Pilarcos, we have placed this viewpoint information as descriptive policy values in service offers or private decision-making information in negotiations. Further description on the relationship between Pilarcos and RM-ODP can be found in WODPEC (ODP for Enterprise computing) workshop publications in 2004-2008(e.g., [14, 17]).

The Pilarcos architecture is designed in a way that in each development process the designers need to consider only one aspect or abstraction layer at the time; the infrastructure facilities carry the burden of keeping the aspects together. The approach is rather pragmatic, although steps in the overall process will address some of the same issues as more detailed work (e.g. utilising logic, rulebased systems, and semantic web on ensuring hierarchy of normative systems to produce valid eContracts [7]; using formal techniques for expressing business contracts [28]; ontologies and XML as structured language [8] and agent societies [6].

The establishment and maintenance of business networks requires automation support at the infrastructure level. The Pilarcos B2B middleware provides local agents (Business Network Agent, BNA) for each enterprise for their representatives in negotiations, maintaining eContract and progress information, and participating in renegotiations in breach situations or when any of the involved parties suggest changes to the eContract policies. For the agents, a shared (and updated/evolving) vocabulary is essential; this vocabulary comes to existence through shared metainformation repositories (as described in Chapter 3).

The following sections first introduce the way business network models are designed and the interoperability metainformation gathered to form the ecosystem infrastructure. The section thereafter explains how this information is used in establishment and maintenance of actual business networks, focusing on the potential for dynamic changes in the networks.

3 Maintaining interoperability knowledge and evolving the ecosystem

The ecosystem for dynamic business networks is supported by a breeding environment for new business network instances and by generic agents and protocols for the federated maintenance of their governing eContracts. The necessary metainformation elements describe available business service offers, templates for eContracts to define the structure of the collaboration, and reputation information about potential new business partners' services for trust-based decision-making.

Thus, the Pilarcos architecture relies on the following metainformation repositories or flows:

- *Service offer repository* for storing tenders published by enterprises; the service offers identify the service interface and externally visible behaviour (exchange of information and control exchanges), declare the properties of the service (price, policies accepted, required communication channels, etc), and publish expectations on the peers and their properties. This is the ”open service market” from which business networks are built [13, 18, 21].
- *Business network model repository* for publishing potential business scenarios. The scenarios are expressed in terms of business network models (BNM). A BNM is a set of (external) business processes (roles and interactions between them), declaration on how the roles of individual processes must be simultaneously played by the same business service provider (e.g.,buyer of goods and receiver of bank's invoice are the same), and policies with which the partners can agree to restrict the BNM alternatives. These models are used as structural templates for eContracts [21].
- *Service type repository* for publishing identified descriptions of service types together with the definition of required properties and their data types when publishing service offers [36]. The type repository is a key vocabulary-forming element in the architecture [15].
- *Flow of reputation information* from business network partners with experience on each others trustworthiness to be used by those who contemplate on taking on a partner they themselves have limited experience of [18]. This provides a basis for managing trust on business services dependability.

Together, these metainformation sources form the ecosystem knowledge base, breeding environment. This chapter focuses on business network design and lifecycle steps, and refer for further reading for creation of service offers, learning the lifecycles of service offers and service types outside the scope of this text, and service types [21], as well as reputation information [33].

Traditionally, the establishment of business networks starts by negotiation of joint objectives and goals, and collaborative definition of the joint processes, and definition of the methods of connecting individual computing elements to a coherent whole. This phase is supported by breeding environments where a selection of partners, learning about their capabilities, and designing the joint business network model takes place. In this process, the set of functionality is determined, as well as a set of business policies that must be adopted.

Although all this is necessary for the business network establishment, it is not necessary to perform the whole process independently for each business network. Neither is it necessary to repeat the whole process when partners have wishes to make changes to the collaboration goals, processes, or supporting applications or computing platforms.

We have separated the business network design phase from the network establishment phase. The business network models can be collaboratively designed, verified and validated for their suitability. These models provide a common vocabulary for enterprises to match pragmatic interoperability (processes and policies) between partners. A separate vocabulary is necessary, as the services are independently developed and thus carry no inherent, implicit interoperability context information.

It is beneficial to create rather abstract behaviour groups when designing business network models, to support evolution of collaboration styles. Each model can be further refined into alternative behaviours by choosing the guiding policy value at the eContract. The ability of dynamic policy management is a strong tool: selecting policy languages and targets suitably, most business management needs related to strategies and business rules can be modelled and transformed to rules that can be monitored at runtime. Effectively, the introduction of different types of policies allows mapping business domain guidelines directly to B2B middleware facilities.

For defining the business network models, a design tool and environment is needed. The business network models comprise of business process models expressed in terms of roles (service requirements) and interactions between the roles (as in [11]). Considering the present business process definition languages (e.g., BPMN, WS-BPEL, XPDL, WS-CDL) we do not deviate from the commonly used set of concepts for partners and interactions, but emphasise some special features that are relevant for service-orientation, management of nonfunctional properties, and evolution support on the service markets.

The design of business network models is by nature a distributed activity: The business network models are created in a unification process affected by all stakeholders, regulatory frameworks, and best practices [27], and the resulting model should even follow the regulations on that business domain or domains addressed. Therefore a common vocabulary is needed on-line for the designers to use, and strong guidance towards reuse of existing business process models is necessary. Therefore, we use the type repository to provide a shared knowledge base for the modelling tools used in the enterprises.

The created models are published in an abstract (black box [26]) form, only revealing the obligated interactions, frameworks for nonfunctional property management and breach management rules. This view is then to be refined by other design and configuration phases. The business network models are constructed by connecting together business processes that each have a single starting point, single termination point and one functional goal (which is essential for verification purposes too [1]). Connecting the processes together takes place by explicating which roles at each process model must collocate at a combined role. The new role inherits the service requirements from all these collocated roles. The business process models are annotated by criteria for assignment of business services and operational time criteria for not causing a breach. When the combined roles are created, annotations are added for restricting collocations, for example, to avoid legally invalid combinations of supervision relationships.

The nonfunctional properties of interest for business network management include modifiers of the functional interaction patterns between peer business services and negotiated declarations of business service or interaction qualities [16, 35]. For example, policies can be used to separate purchases with required pre-payment and loyalty-program credit payments. Further, a communication property declaration may require that all interactions between purchaser and seller are certified with a nonrepudiation system involving a third-party notary that is not visible in the business level abstraction of the business scenario.

The rules determining breaches are explicit, as well as agreement on what recovery process to use. For this purpose, a) multiple recovery business processes are defined and consistently viewed as a set of best practice definitions, and b) all business network models should be analysed to determine their recoverability style; some networks are not able to recover from breaches but need to be terminated, while others may recover from the loss of some members, and further some require a set of compensation actions to take place before either continuing operation or terminating.

Before publication, the business network models must be analysed and verified for properties like liveliness, fairness, privacy-preservation (data-flow sufficiency and minimality), termination of processes, and recoverability. For this purpose, existing business process verification tools are applicable, when each functional business network part is separately analysed.

4 Business Network lifecycle

The main steps in the business network lifecycle are a) the negotiation and eContract establishment, b) enactment and monitoring and c) breach and termination management.

4.1 Negotiation and establishment

As the negotiation of the business network structure and goals have been factored to a separate step that results to an explicit, published model, the eContract negotiation between enterprises becomes more restricted in its scope. Effectively, the negotiation must result in a situation where it is ensured by static validation that interoperability at all levels exists between all parties, and that all parties are willing to participate in the collaboration. Furthermore, the refining negotiation must select the policy values to be used for this particular collaboration and stored into the eContract.

The supporting facilities to be used here are as follows [19, 21]. First, the B2B middleware provides population of the business network followed by a generic negotiation protocol between the enterprise agents. The population process ensures that according to the claims in service offers, the business services becoming members of the business network can be interoperable at all levels. Then, the proposed eContract draft is set to each enterprise to gather commitments of participation, or further refinements on the policies suggested. In the service offers, acceptable alternatives for policy values can be announced, but final decisions need to be made during the negotiation.

The negotiation cycle ensures privacy of decision-making for each participant. In routine cases, it is possible for the enterprises' agent to provide an automated response to the collaboration proposals: an explicit meta-policy guides the agent to pick routine rejections or commitments. Other situations can be recognised, for example, by uncertainty of the trustworthiness of the peers, uncertainty of the strategic benefit of the collaboration, or uncertainty of the acceptability of negative reputation effects caused by a refusal.

Both for the automated decision-making and for the support of human intervention, we propose to use an expert system to gather the relevant knowledge and to feed governing policies to the enterprise system, i.e., the relevant NFPs of the collaboration and its contributing services [16]. The policies that guide the expert system decisions include the following:

- meta-policies governing the decision-making; some collaboration proposals or business interactions are clearly either to be accepted as routine cases of normal operation, or clearly to be rejected because the proposal is of uninteresting or not trusted due to, for example, proposed partners, or business network model [16];
- decision-making policies with respect to reputation-based trust, risk and importance tolerances [32];
- privacy policy that may overrule any other decision-making reasoning in collaborative interactions; each service, information source and metainformation source must be protected [16];
- constraints for granting use of services;
- furthermore, the service type and business network models should include observable properties that are relevant for the business process re-engineering needs. Such an observable property is for example the satisfaction of clients after completing a session on a business service.

The decisions to join a collaboration must balance between the risk of failure or loss of assets as a consequence of participation, and the potential benefits of participation [32]. That is, the expert system should compute a three-value outcome (agree, disagree, call for human intervention) on whether a service or a collaboration is dependable and beneficial for the enterprise in a given context and situation [16]. A dependable service fulfills its business purpose and the use of the service does not involve intolerable risk of monetary loss or reputation loss, for example caused by delivery failures or unacceptable delivery delays. Semantically, the decision to join the collaboration means two things. From the service providers viewpoint, an outsourcing relationship to the rest of the collaboration community becomes effective. From the collaboration point of view, an in-sourcing relationship takes effect. We consider in-sourcing and outsourcing to have technically identical ”clauses”: three levels of interoperability and commitment to behaviour according to the eContract.

For the decision-making, the system computes values for risk and risk tolerance, both of which are vectors over a set of assets, such as monetary assets, reputation, fulfillment of purpose, and control of property [34]. For the risk values, the essential input comes from reputation information, i.e., positive and negative recommendations by members of earlier collaborations. For the risk tolerance, the essential input is from the perceived importance of the tasks or business network. The starting values for the importance and loss scenarios should be created by an extensive risk analysis and strategical business analysis. When the risk vector is compared to the tolerance vector, the decision should be to a) agree, when no tolerance thresholds for acceptability are violated; b) disagree, when no tolerance vector values for disagreeability are violated; and or c) propagate to human decision-making, when any tolerance vector value gets classified differently from the other vector values, all vector values fall between acceptability and disagreeability thresholds, or the meta-policy classifies the case as nonautomatable. When the request is forwarded to human consideration with all the relevant information; the formulations and scope are yet to be detailed. The information should support the understanding the proposed collaboration, its business values and risks, trust on potential partners, privacy-preservation and so on. For the automated cases, the similar decision is based on a set of interoperability levels and nonfunctional properties[16].

Once the agreement has been reached, the eContract data is formed to carry all relevant metainformation about the business network structure, behaviour, partners and policy values selected. In addition, a distributed eContract agent is established and replicated between the business network partners. At the business network startup phase each partner uses the eContract information for configuring its business services through its local service management interfaces. Likewise, the eContract includes policies declaring properties for the communication channels between business services, and the local managements are expected to establish bindings using these requirements. The eContract also collects information about the progress of the activities at each partners' services. Furthermore, the monitoring system is able to notify the eContract of detected breaches. Due to these features, the eContract and the local service management facilities jointly form a community-wide reflective system for the duration of the business network lifetime.

In relation to other work (e.g., survey [23], eNegotiation [5], OMNI [39], QAME [25]) and outsourcing management systems, we emphasise a) use of predefined contract templates that capture not only business level or technical level issues, but both; b) running a multi-partner negotiation instead of bilateral negotiations; c) support of contract template evolution through the facilities for creating new business network models and policy variations; d) agility of business networks gained by operational time negotiations and renegotiations that is based on ontologies and abstract enough behaviour models created at design time; e) privacy of decision-making and using interoperability knowledge effectively for it; f) potential to use multiple negotiation protocols for different types of collaborations (auctioning systems, simple commitment protocols).

4.2 Enactment and monitoring

Once the eContract has been established, the business services are allowed to start their local processes. The services are expected to be "agents", i.e., make initiative and respond to service requests, and internally follow (implicit/explicit) local business process. Especially, no joint enactment platform is expected, as is done in distributed workflow systems. One of the main design goals for Pilarcos has been to encapsulate as much as possible, even the local computing platform. Besides the local agents and globally distributed services for metainformation and service discovery, the Pilarcos architecture requires little from the computing and communication platforms. Naturally, technical interoperability can only be achieved if the service offers utilised in peer roles actually can exchange messages over a shared communication protocol or can be supported in configuring a channel structure with mediators to reach connectivity. Elsewhere we discuss the relaxed matching and configuration support [13].

As the business services themselves are responsible for running the computations and initiating the exchanges of messages, the eContract and enterprise policies govern and restrict this behaviour. The processes in the BNM are split into tasks, vaguely similar to business transactions. For these, the same kind of trust-related decision-making takes place, balancing between risk and risk tolerance. Thus, even within a business network, partners have a level of mistrust towards the success of each others services.

During the operation of the business network, the monitors governing the business services can proactively, actively or passively scan the messaging, reporting to enterprise level agents if the eContract is breached. Proactive monitoring holds the message till a decision has been made whether it is safe to send or receive it, while active monitoring lets the message pass but reports breaches thus potentially causing breach recovery or termination of the collaboration. The passive monitoring just audits the events for later processing.

The breaches can mean failing to fulfill an obligation, or failing to provide the agreed quality level of the service; more formally, failing to provide the level of dependability expected. The concept of dependability, in terms of fulfilling the contracted aspects, can be concertised on two fields. There are general properties that can be set as service level expectations for any service, such as availability, timeliness, and privacy-preservation, or interaction relationship, such as nonrepudiation and immutability. In addition there are properties that are relevant for individual service types, each requiring a definition of value domain and metrics for defining the service levels relevant for the property. For example, reputation information (recommendation) can have a credibility property associated to it, determining how completely a recommendation from that source is assumed truthful. Another example is the traditional QoS levels with different metrics for data bandwidth and jitter in transfer.

The monitors receive rules from eContract and from their local policy repositories. These rules are not guaranteed to be nonconflicting, as they a) may address different issues and they b) can be changed after eContract establishment.

At detected breach situations, decisions are needed on whether the event is serious enough for terminating or leaving the business network. The same type of knowledge about the operational environment can be used, and again the expert system can make automated decisions or redirect the request for human intervention.

Transformation rules are required to automatically map the various styles of monitoring rules captured in the eContract to such monitoring rules or state machines that can be used to control the running service software. Despite the wide range of issues to address at business, semantic, pragmatic and technical levels, the analysis of the various monitoring needs shows that the required monitor techniques fall into a few simple cases:

- detectors of denied values or value combinations in message fields;
- detectors of nonacceptable ordering of messages, including failure to complete a task in time;
- detectors of series of messages jointly exceeding the acceptable limits calculated from the messages as they pass the monitor; and
- authorisers that hold the message while investigating whether the intended business transaction is to be trusted.

Using these techniques in various combinations in the application domain context, and utilising the business semantics building from the messages, a rigorous set of constraints can be built. Especially, the business semantics and social requirements can be encoded.

5 Comparison of CrossWork IVE and Pilarcos Business Networks

The goals of the CrossWork and Pilarcos projects has been somewhat different, although the results complement each other. The projects share a vision of dynamic virtual enterprises in future and create facilities to reach that goal. On the surface level, a couple of differencies are easy to detect though. First, while Pilarcos wishes to automate routine formation of similar business networks and support the evolution of knowledge about useful type networks, the CrossWork approach targets for one-time consortia. Table 1 captures the general architecture goals and challenges tackled, as well as key concepts and major design choices in respect to technologies.

The type of technical contribution from the projects differs accordingly. The technical contributions from Pilarcos include

- generic, commonly available services for maintaining knowledge about available services and their properties, interoperability qualities, reputation and business network models (i.e., predefined BN structures to choose from);
- generic, local services to support eContract negotiation, monitoring, membership and transaction-involvement decisions based on trust;
- facilitation for dynamic choices and changes during BN establishment and operation, including membership, policies, and technical solutions; and
- automation supprot for BN establishment and maintenance in routine cases.

The technical contributions from CrossWork include

- formation of IVEs (team formation: systematic discovery and matching of partners, selecting coordinator and supplying partners, creating bilateral contracts between parties where communication/service provision is needed);
- global and local workflow enactment on standard workflow engines (each partner allows the coordinator to control its process partially, each partner informs the IVE and its members of local progress made);
- framework for harmonising local workflows of service provider and consumer (eSourcing) with business process composition and verification; and
- user interfaces that guide user organisations trough the process of selecting a team and forming an inter-organizational business process to orchestrate the individual activies.

The goals of the projects and thus the facilities created provide different scope for the dynamic decision-making and change management in each architecture. Table 2 comments on the potential for quick changes in actual business networks or slow evolution in the ecosystem.

As the CrossWork project has aimed for supporting unique teams and collaborations, it is clear that less support for the dynamically changing aspects is required. On the other hand, the Pilarcos models for business scenarios are very generic, and making the BNMs public allows temporary collaborations to be established by adjusting the dynamic properties to match the unique situation. Thus, the application areas of both approaches can be rather close to each other.

6 Conclusion

The preceding chapters report extensively the CrossWork approach and results. Interestingly, in Chapter 9 it is reported that the industrial case studies revealed that companies are reluctant to use a fully automated system. This is because the team selection is a strategically important decision that full automation is considered too much a risk. Instead, a user interface to the CrossWork system that gives a decision-support or expert-system view to the process is preferred. In the Pilarcos work, we have made a similar conclusion and plan for an expert system view [20]: Furthermore, in the strategically important decisions, more trustworthiness information is clearly needed. In Pilarcos work, the need for a reputation-based trust management support subsystem was carved in the initial design challenges (see Table 1).

The CrossWork project provides a methodology and toolset for automation on workflow formation. This tool approach is close to the ideas used in Pilarcos for the BNM design phase. Where necessary, functionalities of Pilarcos include a support system for distributed design processes that utilises a globally shared BNM repository. Furthermore, a verification of each model is performed before accepting it to the repository as a) a standalone model and b) as a linked model to existing models in the repository and utilising the ”vocabulary” of service type repository correctly. The BNM modeling tool has to provide for analysis information about the market situation, relationships to existing models, and multiple correctness measures. One

Pilarcos	CrossWork
General architecture goal and challenges	
A business network (BN) is a temporary, eContract-governed collaboration of business services provided by autonomous enterprises. The business scenario that determines the BN structure represents/extends the best practices on the business domain and is repeatable in other BNs with slight variation to better address each business opportunity at hand. Challenges from a BN viewpoint: addressing social and contractual needs(enterprise autonomy, trust between partners, privacy of decision-making, actions of the agent system mappable to business/legal actions, responsibilities and breaches automatically monitorable, automation of BN establishment, automation of interoperability management, embedded mistrust to even known partners, nonfunctional properties affect business functions. Challenges from an enterprise viewpoint: supports modern enterprise architectures where portfolios of business services, knowledge of external business processes and strategies for collaboration (and their renewal cycles) needs awareness/controlled visibility of/to other members of the ecosystem; isolation between business model and technology platform; after initial architecture change investment, the cost of technology changes is lowered, and the cost of BPR is lowered; Challenges from the ecosystem viewpoint: no single platform or metainformation ontology assumed (would restrict evolution)	An instant virtual enterprise (IVE) is an on-demand formed company to address a market opportunity. The IVE consortia formation is triggered by a business opportunity. The targeted service determines the requirements for the producing team, the IVE design and the roles needed for the production. The IVE support methodology relies on a systematic search for best qualified partners and collaborations best supported. Homogenising the partners' existing production/information-exchange processes are supported by tools. Challenges from an enterprise viewpoint: The IVE setup is commencing with semi-automatically decomposing global business goals into a structure of local business goals. Based on the local business goals, a set of organizations are semi-automatically identified that have the capability to reach the global goal by implementing each of the local goals. Challenges from a BN viewpoint: Based on local business goals and an organization with appropriate capabilities, the external-level specification of one or several local business processes must be semi-automatically obtained that implement the local goals. A semi-automatic composition of the local business processes into an inter-organizational business network process (BNP) needs to be achieved. The resulting BNP must be validated before process enactment to find irregularities, e.g., deadlocks in the control-flow perspective. Additionally, the BNP must be mapped automatically to the IVE that performs an automatic enactment of the BNP. During enactment, the interaction with the legacy systems of respective collaborating parties must be facilitated. Challenges from the ecosystem viewpoint: The IVE must support the accumulation of domain-based knowledge into knowledge stores that are accessible with automated reasoning mechanisms.
Key concept	
An eContract is multilateral and structured according to a business network model. It is (semi)automatically negotiated and each involved enterprise will use local monitoring to detect breaches against it while the BN is operational.	After automated goal decomposition and semi-automatic team formation, the result is a joined and correct business process that combines the local processes of the producing team members. The business process can be performed (enacted) as a distributed workflow across enterprise boundaries within the IVE.

Table 1: General architecture goals and key conceptual differences.

Pilarcos	CrossWork
Design choices	
Generic support services form a B2B middleware layer that separates and encapsulates the enterprises' technology platforms (no distributed workflow engines assumed); business services are active agents and thus are governed by monitoring and restricting their behaviour; breeding and operational time environments share metainformation about services and BN models for interoperability management; different policies in the independent enterprises may cause discrepancies at operational time, thus expecting breach management to exist.	For the CW architecture, three distinct levels achieve a separation of concerns. The external level bridges the boundaries of collaborating parties and comprises components for establishing harmonized business process collaboration. The conceptual level projects conceptually formulated business-process details to the external level and also maps these processes to the internal level where back-end legacy systems of the respective collaborating parties are located. The three architecture levels are populated with components that are clustered by four interrogations: *What* is the localized goal of an IVE deducted from a global goal specification. *Who*, i.e., which organizations have the capabilities to reach the goal specifications. *How*, i.e., which processes operationalize the goal specifications. *With* which automated infrastructure can the business process be enacted.
Variability in collaboration negotiation	
• *BNMs*: Consortia of enterprises can publish new (completely new or versions of existing) business network models. The abstract models can have replaceabilty or subtyping relationships defined between them, and various more concrete models can be captured by selecting alternatives within the abstract model by declaring selective policy values. • *eContracts*: Adding properties to the service type specification enforces addition of property values to service offers and thus also the agreement process for eContracts. Availability of BNM models and quality/market value of the competing BNMs affect the use of certain type of eContract. The BNM design consortia can be quite different from the actual BN memberships. • *Service offers*: The availability of service offers for a certain type of BNs is subject to market forces (enterprises are pushed to provide certain services if there is demand or potential for competition on the market). • *Reputation information:* Good and bad experience of business services in various BNs is distributed and can be used for decision-making support in the BNM negotiation. • *Negotiation process:* The BN establishment process has a public matching phase and a refining negotiation phase where each partner can make private decisions based on self-selected reasons.	• *IVE business process*: The BNP is negotiated and validated individually for each IVE with respect to different perspectives of which control-flow is considered dominant. • *Membership*: The IVE membership is fixed after goal decomposition that is followed by semi-automated team formation. Still, the binding between roles and actors is dynamic during BNP enactment. • *Process properties*: The process properties (business functions) can be designed at the detail level of choose. The nonfunctional aspects of the IVE become determined by the design, local workflows and the underlying workflow management system. • *Goal and team adjustments*: When the global business-process enactment fails, the IVE resumes a negotiation of workflow composition that requires a renewed goal decomposition and team formation.

Table 2: Design choices and negotiation variability.

Pilarcos	CrossWork
Changes at enactment phase	
• *Membership*: For each BN, the membership is individually selected from the open service market (unless the initiating partner has indicated preselected parties). At the operational time, a breach situation can lead to changes in membership, or any of the members may initiate leaving the BN itself. • *Properties and policies*: In each BNM there is a policy framework attached, that declares policy ”variables” for modifying the general behaviour pattern. In addition, the BNM can declare property matching requirements for business services to be selected and considered as acceptable at the operational time. The BNM level policy values are given by the initiator of the BN establishment; the service offers carry values to be matched against the peers corresponding values. At the operational time, it is in principle possible to renegotiate these properties, although in practice the abilities of business services to reconfigure themselves accordingly will be limited and thus lead to rejection of the suggestions. • *State information*: progress monitoring and synchronisation at epoch boundaries (milestones defined in the BNMs) • *Policy discrepancies*: As the enterprise policies can be changed after eContracting, the business services can fail to meet the contract, and there is no consistent ontology (even wanted) to harmonise the set of enterprise policies and eContract policies, operational time discrepancies are bound to happen and trigger breach severity analysis and recovery if needed. The recovery process is rather an independent, temporary BN in itself. Different BNMs will have different levels of recoverability; the safe version is to terminate the BN.	• Alternative methods for team selection based on roles, competencies, permissions, organizational position, and so on. Based on condition statements, a dynamic binding between roles and actors takes place during enactment. • IVE progress reported to all partners by dedicated user interface components. The interfaces showing enactment progress must secure the business internals of a collaborating party that should not be revealed to the counterparts. • Failures to provide agreed functionality or quality of service must be reported by the workflow engines. In that case, business rules are employed for exception and compensation handling that manage failures and achieve a semantic business-process rollback respectively. • When one collaborating party invokes a termination, all parties involved in an enacted instance of a BNP are affected.

Table 3: Dynamic change aspects allowed by the architectures.

of the essential new correctness measures is the privacy-threats created by new information flows in the BNMs.

As strengths of CrossWork that are also desirable for Pilarcos, we can identify the new tool chain starting with a business opportunity, detecting and combining goals, orchestrating local business processes to a unified, interoperable system, and enacting the resulting workflows on existing standard workflow platform.

As suggestions for enhancing CrossWork functionality, the main issues in priority order might be as follows.

- Including trust concepts in the team formation phase.
- Separating the abstract business processes from the concrete instances of supplying services. By indirection, more dynamicity can be introduced to membership.
- Inclusion of policies for adjusting the IVE behaviour at the operational time.
- Adding instrumentation to the platform for reporting success or problems of the IVE design and match to the business opportunity.

Looking from the Pilarcos side, the following CrossWork contributions complement the present set of prototype software. First, the BNM modeling tools package can use the workflow verification methods described if BNMs are split into a set of business processes verified separately. Second, the user interface for guiding the IVE formation would fit in as a BNM repository front end, if the models remain abstract.

In future, the Pilarcos facilities are extended (see: //cinco.cs.helsinki.fi) towards a fuller tool-chain that supports business network model design, feasibility (market gaps, privacy concerns, availability of business services for collaboration) analysis and verification, as well as the related service-oriented, model-driven software production facilitates. In the

References

1. Aalst, W., Weske, M.: The P2P approach to Interorganizational Workflows. In: K. Dittrich, A. Geppert, M. Norrie (eds.) Proceedings of the 13th International Conference on Advanced Information Systems Engineering (CAiSE'01), *Lecture Notes in Computer Science*, vol. 2068, pp. 140–156. Springer-Verlag, Berlin (2001)
2. Booth, D., Haas, H., McCabe, F., Newcomer, E., Champion, M., Ferris, C., Orchard, D.: Web services architecture. Tech. rep., W3C (2004). URL http://www.w3.org/TR/2004/NOTE-ws-arch-20040211/
3. Camarinha-Matos, L.M., Afsarmanesh, H.: Modeling framework for collaborative networked organizations. In: Network-Centric Collaboration and Supporting Frameworks. 7th IFIP Working Conference on Virtual Enterprises, pp. 3–14. Springer (2006)
4. Chen, H.M.: Soa, enterprise architecture, and business-it alignment: An integrated framework. In: H.R. Arabnia, H. Reza (eds.) Software Engineering Research and Practice, pp. 566–573. CSREA Press (2007)
5. Chiu, D.K.W., Cheung, S.C., Hung, P.C.K., Chiu, S.Y.Y., Chung, A.K.K.: Developing e-Negotiation support with a meta-modeling approach in a web services environment. Decision Support Systems **40**, 51–69 (2004). ISSN:0167-9236, Special issue: Web services and process management

6. Dellarocas, C., Klein, M., Phd, C.D., Phd, M.K.: An experimental evaluation of domain-independent fault handling services in open multi-agent systems. In: Proceedings of The International Conference on Multi-Agent Systems (ICMAS-2000, pp. 95–102. IEEE Computer Society (2000)
7. Gelati, J., Rotolo, A., Sartor, G., Governatori, G.: Normative autonomy and normative co-ordination: Declarative power, representation, and mandate. Artificial Intelligence and Law **12**, 53–81 (2004)
8. Grosof, B.N.: Sweetdeal: Representing agent contracts with exceptions using xml rules, ontologies, and process descriptions. pp. 340–349. ACM Press (2003)
9. ISO/IEC JTC1: Information Technology – Open Systems Interconnection, Data Management and Open Distributed Processing. Reference Model of Open Distributed Processing. Part 2: Foundations (1996). IS10746-2
10. ISO/IEC JTC1: Information Technology – Open Systems Interconnection, Data Management and Open Distributed Processing. Reference Model of Open Distributed Processing. Part 3: Architecture (1996). IS10746-3
11. ISO/IEC JTC1/SC 7: Information Technology – Open Distributed Processing – Reference Model – Enterprise Language (2004). Ammendments in progress
12. Kutvonen, L.: Architectures for distributed systems: Open distributed processing reference model. In: HeCSE Workshop on Emerging Technologies in Distributed Systems (1998)
13. Kutvonen, L.: Trading services in open distributed environments. Ph.D. thesis (1998). URL http://www.cs.helsinki.fi/TR/A-1998/2/A-1998-2.pdf
14. Kutvonen, L.: Challenges for ODP-based infrastructure for managing dynamic B2B networks. In: A. Vallecillo, P. Linington, B. Wood (eds.) Workshop on ODP for Enterprise Computing (WODPEC 2004), pp. 57–64 (2004). URL http://www.lcc.uma.es/ av/wodpec2004/papers/7-kutvonen.pdf
15. Kutvonen, L.: Building B2B middleware — interoperability knowledge management issues. In: Enterprise Interoperability II — New Challenges and Approaches, pp. 629–632. Springer, Funchal, Portugal (2007)
16. Kutvonen, L.: Tools and infrastructure facilities for controlling non-functional properties in inter-enterprise in collaborations. In: Workshop on ODP for Enterprise Computing (WODPEC 2008) (2008). URL http://www.cs.helsinki.fi/group/cinco/publications/kutvonen-wodpec2008.pdf
17. Kutvonen, L., Metso, J.: Services, contracts, policies and eCommunities – Relationship to ODP framework. In: P. Linington, A. Tanaka, S. Tyndale-Biscoe, A. Vallecillo (eds.) Workshop on ODP for Enterprise Computing (WODPEC 2005), pp. 62–69 (2005). URL http://www.lcc.uma.es/ av/wodpec2005/wodpec2005-Proceedings.pdf
18. Kutvonen, L., Metso, J., Ruohomaa, S.: From trading to eCommunity population: Responding to social and contractual challenges. In: Proceedings of the 10th IEEE International EDOC Conference (EDOC 2006), pp. 199–210. IEEE, Hong Kong (2006). DOI 10.1109/EDOC.2006.30. URL http://ieeexplore.ieee.org/iel5/4031176/4031177/04031208.pdf. Best paper award.
19. Kutvonen, L., Metso, J., Ruohomaa, S.: From trading to eCommunity management: Responding to social and contractual challenges. Information Systems Frontiers (ISF) - Special Issue on Enterprise Services Computing: Evolution and Challenges **9**(2–3), 181–194 (2007). URL http://dx.doi.org/10.1007/s10796-007-9031-x
20. Kutvonen, L., Ruohomaa, S., Metso, J.: Automating decisions for inter-enterprise collaboration management. In: Proceedings of the 9th IFIP Working Conference on Virtual Enterprises (PRO-VE 2008). Poznan, Poland (2008). To appear.
21. Kutvonen, L., Ruokolainen, T., Metso, J.: Interoperability middleware for federated business services in web-Pilarcos. International Journal of Enterprise Information Systems, Special issue on Interoperability of Enterprise Systems and Applications **3**(1), 1–21 (2007)
22. Kutvonen, L., Ruokolainen, T., Ruohomaa, S., Metso, J.: Service-oriented middleware for managing inter-enterprise collaborations. In: Global Implications of Modern Enterprise Information Systems: Technologies and Applications (2008). To appear.

23. Medjahed, B., Benatallah, B., Bouguettaya, A., Ngu, A.H.H., Elmagarming, A.K.: Business-to-business interactions: issues and enabling technologies. The VLDB Journal (12), 59–85 (2003)
24. Nayak, N., Nigam, A., Sanz, J., Marston, D., Flaxer, D.: Concepts for service-oriented business thinking. In: IEEE International Conference on Service Computing (SCC06)
25. Neisse, R., Pereira, E.D.V., Granville, L.Z., Almeida, M.J.B., Tarouco, L.M.R.: A hierarchical policy-based architecture for integrated management of grids and networks. In: In Fifth IEEE International Workshop on Policies for Distributed Systems and Networks, pp. 103–106 (2004)
26. Norta, A.: Exploring Dynamic Inter-Organizational Business Process Collaboration. Ph.D. thesis, Technology University Eindhoven, Department of Information Systems (2007)
27. Norta, A., Grefen, P.: Discovering Patterns for Inter-Organizational Business Collaboration. International Journal of Cooperative Information Systems **16**(3/4), 507–544 (2007). URL http://dx.doi.org/10.1142/S0218843007001664
28. O Marjanovic, Z.M.: Towards formal modelling of e-contracts. In: 5 th IEEE International Enterprise Distributed Object Computing Conference (EDOC2001) (2001)
29. Panetto, H., Scannapieco, M., Zelm, M.: Interop noe: Interoperability research for networked enterprises applications and software interop noe: Interoperability research for networked enterprises applications and software. In: On the Move to Meaningful Internet Systems 2004: OTM 2004 Workshops. LNCS 3292 (2004)
30. Papazoglou, M.P., Traverso, P., Dustdar, S., Leymann, F., Krämer, B.J.: Service-oriented computing: A research roadmap. In: F. Cubera, B.J. Krämer, M.P. Papazoglou (eds.) Service Oriented Computing (SOC), no. 05462 in Dagstuhl Seminar Proceedings. Internationales Begegnungs- und Forschungszentrum fuer Informatik (IBFI), Schloss Dagstuhl, Germany, Dagstuhl, Germany (2006). URL http://drops.dagstuhl.de/opus/volltexte/2006/524/
31. Rabelo, R.J., Gusmeroli, S., Arana, C., Nagellen, T.: The Ecolead ICT Infrastructure For Collaborative Networked Organizations. In: Network-Centric Collaboration and Supporting Frameworks, vol. 224, pp. 451–460. Springer (2006)
32. Ruohomaa, S., Kutvonen, L.: Making multi-dimensional trust decisions on inter-enterprise collaborations. In: Proceedings of the Third International Conference on Availability, Security and Reliability (ARES 2008), pp. 873–880. IEEE Computer Society, Barcelona, Spain (2008)
33. Ruohomaa, S., Kutvonen, L., Koutrouli, E.: Reputation management survey. In: Proceedings of the 2nd International Conference on Availability, Reliability and Security (ARES 2007), pp. 103–111. IEEE Computer Society, Vienna, Austria (2007). DOI 10.1109/ARES.2007.123. URL http://dx.doi.org/10.1109/ARES.2007.123
34. Ruohomaa, S., Viljanen, L., Kutvonen, L.: Guarding enterprise collaborations with trust decisions — the TuBE approach. In: Interoperability for Enterprise Software and Applications. Proceedings of the Workshops and the Doctoral Symposium of the Second IFAC/IFIP I-ESA International Conference: EI2N, WSI, IS-TSPQ 2006, pp. 237–248. ISTE Ltd (2006)
35. Ruokolainen, T., Kutvonen, L.: Managing non-functional properties of inter-enterprise business service delivery. In: Non Functional Properties and Service Level Agreements in Service Oriented Computing Workshop (NFPSLA-SOC) (co-located with the 5th International Conference on Service Oriented Computing, ICSOC 2007). Vienna, Austria (2007). To appear.
36. Ruokolainen, T., Kutvonen, L.: Service Typing in Collaborative Systems. In: G. Doumeingts, J. Mller, G. Morel, B. Vallespir (eds.) Enterprise Interoperability: New Challenges and Approaches, pp. 343–354. Springer (2007)
37. Sauve, J., Moura, A., Sampaio, M., Jornada, J., Radziuk, E.: An introductory overview and survey of business-driven it management. In: 1st IEEE / IFIP International Workshop On Business-Driven IT Management, pp. 1 – 10. IEEE Communications Society (2006)
38. Schmidt, D.: Model-driven engineering. IEEE Computer **39**(2), 25–31
39. Vaquez-Salceda, J., Dignum, V., Dignum, F.: Organizing multiagent systems. Autonomous Agents and Multi-Agent Systems **11**, 307–360 (2005)