Interoperability Contributions of CrossWork

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Effective cross-organisational collaboration enables a company to focus on its core business within a dynamic network of partners providing complementary expertise. This allows companies of all sizes to pursue immediate opportunities in the marketplace through participation in virtual organizations and dynamic supply chains. Such collaboration-based business models, however, place substantial demands on software infrastructures to ensure robust intersystem communication, meaningful information exchange and successful coordination of processes and activities. Interoperability at all levels is paramount and significant advances in enabling software technologies are needed to support this.

Interoperability issues are addressed by several EC-funded projects under the 6th Framework Programme. The focus here is on the specific contributions of one of them, *CrossWork*[*], which pursues the automated creation of cross-organisational workflows to support opportunistic collaborations among members of *Networks of Automotive Excellence*. These collaborations, also known as task groups or virtual enterprises, are formed to pool together resources in the pursuit of business opportunities, for example responding to a call for tender, and are characterised by their decentralised decision-making and transient nature.

Effective collaboration among task group members is a key success factor. This includes coordination of activities distributed amongst members, supported by cross-organisational workflows. Such workflows have to be formed in concert with the formation of the task group in a dynamic and opportunistic fashion.

Achieving such level of *process interoperability* relies on frictionless information exchange between the information processing infrastructures of the group members, or *interoperability at the systems level*, within the context of compatible legal and organisational structures predicating *interoperability at the business level*. Any successful collaboration is informed and underpinned by a shared understanding and this reveals a fundamental need for *semantic interoperability* at the information level and beyond.

Within this context, CrossWork focuses on the issues at process interoperability and semantic interoperability levels. We see interoperability as a systemic property of the set of collaborating entities, which arises in the context of their collaboration, rather than as an individual property of system components. We are therefore focused

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on interoperability issues arising when two or more entities attempt to coordinate their activities and communicate in a meaningful manner. This has impacted the mechanisms chosen to underpin CrossWork's approach to interoperability as follows:

Semantic interoperability in CrossWork is based on the use of ontologies and meaning negotiation processes to achieve common ground among interacting group members and a shared ontological committment. This results in a core ontology shared by all group members, and peripheral ontologies which are specific to sub-groups or to individual organisations. Novel negotiation protocols, informed by the theory of utility, and ontology mapping mechanisms enable the evolution of the central and the peripheral ontologies: for example, to incorporate new capabilities and services within the task team. Automatic reasoning within this context is underpinned by the use of *Formal Concept Analysis* [3] and *Lattice Theory* [1]. The resultant model [5], which we call *devolved ontologies*, integrates centralised and distributed approaches to ontology engineering.

Process interoperability in CrossWork relies on the use of collaborating software agents to achieve the goal-driven dynamic formation of both the team and the workflow needed to coordinate team activities. Intelligent agent technology can provide the capabilities for deliberative reasoning; dynamic goal-oriented behaviour; and explicit declaration of interaction intent and structure. Agents are therefore used to represent collaborating business entities, providing natural representations in software for business autonomy, information hiding, self-interested behaviour and coalition formation. Agents are also a natural choice for linking with the ontology-based approach to semantic interoperability, because they employ sophisticated communication mechanisms based on explicit declaration of intent and ontological commitment, and provide the negotiation and reasoning capabilities necessary to maintain a devolved ontology model.

CrossWork is based on the outcome of the EC-funded project MaBE (Multi-agent Business Environment), a distributed, service oriented architecture and middleware. MaBE supports both syntactic and semantic interoperability between partners in a virtual enterprise, using a simplified version of the *devolved ontologies* model [2] to inform the semantic interoperability mechanisms. It also provides support for the processes of negotiating and changing interoperability agreements and structures in open eBusiness environments. The MaBE consortium has decided to distribute the MaBE kernel via a public board under an open source license model (LGPL). The MaBE middleware is based on a widely established open source agent platform named JADE (Java Agent Development Environment), which is also organised via a public board using an LGPL licence model. Both initiatives work closely with the standardisation organisation FIPA (Foundation for Intelligent Physical Agents).

Technically, Crosswork extends MaBE to enable interoperability at process level. At the same time it serves as an application of MaBE, testing its capabilities to achieve automatic coordination of distributed, cross-organisational development processes in the domain of automotive manufacturing. Software agents are used to represent group members in the formation of both the group and the workflow which is to then coordinate the activities of this group. The team and workflow design [6] is based on the principles of Gero's FBS design framework [4] and executed as a combination of distributed planning and pattern-based workflow composition approaches.

This takes into account local rules and processes of collaborating partners whilst preserving their business autonomy and allows hiding of information regarding their business processes.

The process relies on the use of the standard process modelling framework XRL [7], which is based on Petri Nets. This provides the necessary formal basis to enable reasoning over models and constraints, and predictive analysis regarding their consistency and performance.

The dynamics of the resulting system involving humans and computers require novel approaches to dynamic user interface generation, providing necessary and sufficient information to the individual users at different locations. Role-based enactment of business-logic and security is also used to provide the necessary level of abstraction and ease of maintenance.

These core contributions provide the necessary complement of techniques for seamless collaboration and process integration within the target context of distributed and dynamic coordination of work.

The CrossWork's consortium has been chosen to provide key expertise in research, requirements and development in all these areas by including research centers, universities, automotive companies and systems integrators. Nine organizations joining the consortium are: Atos Origin sae (Spain, systems integration); University of Manchester (United Kingdom); Profactor Produktionsforschungs GMBH (Austria, research center); Technology Universiteit Eindhoven (The Netherlands); Växjö Universitet (Sweden); Institute for Communications Engineering Kepler University Linz (Austria); Exodus SA (Greece, software development); Intier Automotive Ebyl Interiors GMBH (Germany, automotive industry); OÖ. Technologie und Marketinggesellschaft m.b.H. (Austria, automotive industry).

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