K-FLOW: Knowledge Management in the Extended Manufacturing Enterprise


Abstract. K-FLOW is a project co-funded by the European Commission, in the GROWTH Programme, whose aim is to develop a Software platform and a set of supporting methodologies for managing knowledge in an Extended Manufacturing Enterprise (EME). Principal elements considered in an EME are: plant production stations, design office stations, customers and suppliers. The main objective is to provide to workers of the EME, the right knowledge, at the right place, in the right form, at the right time. The expected benefits for the EME are: to earn competitiveness, to improve production, productivity and quality rates, service, and reduce costs, lead time and time to market by co-ordinating activities amongst different actors that improve the overall performance of the EME. The societal objectives are: to improve the working conditions, quality of work and workers’ skills, and reduce the environmental impact of the production processes.

1. Introduction

New business models (such as e-business, virtual enterprises, extended enterprises, etc) that have emerged in recent years are affecting the ways of doing business. Accordingly, European companies and workers are changing their way of working and a natural consequence is that IT systems and tools are requested to adapt to these new trends and these tools provide a valuable support that makes companies competitive in the new scenarios and help people in performing new tasks.

One of the most innovative concepts is the Extended Enterprise (EE) that is defined as a conceptual business unit or system that consists of a leading company, suppliers and customers who collaborate closely in such a way as to improve the returns to each partner of the extended enterprise.

The IFIP WG5.7 conference that was held in Troon, Scotland in 1998, concluded that: "In the millennium, competition will not be between individual companies but will be between individual value systems" [1]

Thus contemporary manufacturing enterprise needs to transform their business models and their internal processes moving towards the new Extended Manufacturing Enterprise mode. Consequently, companies need to reconfigure IT tools and adopt new IT solutions for supporting this evolution: partners, suppliers and customers are located in different countries, even continents. Collaboration across supply chains and extended enterprise (EE), custom-driven manufacturing, parallel, distributed manufacturing, human-oriented manufacturing are issues to be incorporated now by the European manufacturers. Knowledge is at the core of the incorporation of these issues.

Explicit and tacit knowledge are two resources that are becoming more relevant in the contemporary enterprise. This knowledge is created, maintained and shared among people working in the different sectors and with different roles in the (extended) enterprise.

Currently, one of the aims of the EU New Enterprise Policies is to enforce the integration of manufacturing enterprises, especially the SME’s, into the European Knowledge based Extended
Manufacturing Enterprise paradigm (EME). Such integration looks for the improvement on the productivity of the production processes, quality rates, service, mitigation of costs and support the deliver right knowledge to the right workforce. The achievement of these benefits is strongly related to the continuous evolution of workers’ skills, the improvement of the working conditions and quality of work. Manufacturers, suppliers and customers need from each other also better and more knowledge about their business processes in order to improve them.

However, manufacturing companies, suppliers and customers are not the only stakeholders envisioned in the EME. The continuous degradation of the Earth also obliges enterprises to evolve in order to lessen negative environmental impact. Manufacturing enterprises and environmental management institutions need from each other more and better quality knowledge of their corresponding processes and procedures.

Thus, the winning solution for the modern manufacturing enterprises requires integrating manufacturers, suppliers, customers and other entities such as external subcontractors, machine manufactures and public institutions all together into an EME. The K-FLOW Project was started to give a solution to these necessities, allowing knowledge to be shared across the EME in order to fulfil the objectives mentioned above.

2. State of the Art of Knowledge Management in EE

Nowadays, most of the tools that are exploited for the management of information and knowledge within the EE are “specialised or extended” Content Management Tools that only provide and collect Knowledge as information dispatched to users of the EE through a portal. There are solutions that provide a communication link between business data and manufacturing data, which basically comes to be a mere interface between their shop-floor control software (SW) and an Enterprise Resource Planning (ERP) system. Other solutions are based on an extended supply chain implementation, mainly focused on scheduling and one-to-one enterprise business relationships. In Europe, the more advanced Enterprise Business Applications (EBA) developers, have basically worked in ERP and SCM systems monitoring.

None of the existing tools at the moment provides integration with the manufacturing shop floor knowledge, that is integration of knowledge exploited and collected by people working on the machines with knowledge managed by the other users of the EE. The K-FLOW project looks to fill this gap.

3. The K-FLOW Project

3.1. Scientific and Technological objectives

The K-FLOW project addresses the development of a SW platform and a set of supporting methodologies, for the integration of manufacturing enterprises, based on the share of knowledge paradigm and down to shop-floor machine level, with other users of the Extended Enterprise (EE).

Special attention is given to the continuously enhanced participation and implication of workers within the entire production process based on the share of knowledge paradigm, as well as the evolution of their role, skills, work conditions and work contents. The aim is to provide the right knowledge at the right place, in the right form and at the right time. The principal beneficiary of the results obtained from this project will be the European Manufacturing Enterprises which will earn in competitiveness and will see how their production, productivity, quality rates and service are improved, and costs, lead-time and time to market reduced. In terms of societal objectives, it is aimed at improving the working conditions, quality of work and workers’ skills, and reducing the environmental impact of the production processes.

K-FLOW is based on a standardisation-oriented sharable global knowledge area where
incorporating a new EE member at any time will be as easy as considering it for the EE knowledge flow process and customising the interaction with it having to define no extra platforms. European production plants and associated internal and/or external customers and/or suppliers, as well as public entities for the environmental impact and product life-cycle control, external subcontractors or machine manufacturers will all be able to share the same knowledge area. The openness of the platform will allow implementing the business process strategies management and performance measurement strategies, user collaboration strategies and workers’ role evolution strategies to be developed in this project.

These objectives will be achieved by developing knowledge driven tools and methodologies, where the principal ones are:

- an open, XML-based Knowledge-Flow Configurator which dynamically defines the knowledge management process for the whole EE, that is what knowledge, at what place, in what form and at what time will be provided;
- a Knowledge-Flow Engine, which gives the pace to all the system by continuously executing the knowledge flow process defined by the K-FLOW Configurator;
- a Knowledge-Flow Portal with two access doors: a Human-to-Machine Door, to implement the access point of any corporate or web portal, and a Machine-to-Machine Door, to manage the access point via workstations at machine, section, plant and enterprise level of a manufacturing enterprise.

The development of three novel sets of strategies, models and methodologies will be done to continuously enhance the integration of the manufacturing enterprises within the EE through the K-FLOW platform.

3.2. The K-FLOW Consortium

The K-FLOW Consortium consists of ten partners, representing four European Countries. The technology providers, responsible for the developments, are: Mondragón Sistemas de Información, from Spain, TXT e-solutions (Italy) and Technilog (France). The end-users are Iparlat, a Spanish food sector enterprise, FIDIA, an Italian capital goods and machine manufacturer and Peugeot Citroen Automobiles (PSA), a French automotive enterprise. Responsible for the analysis of the requirements and for the system design is Ikerlan, a Spanish Research Centre. There are three research and consulting-specialised partners, that are in charge of the methodological aspects of the project: ETEO-Mondragon University that is a Spanish University, University of Strathclyde that is a Scottish University, Efeso that is an Italian Engineering Services and Consulting company and it is responsible for developing strategies for the continuous enhancement of workers’ participation in the EE.

The conformation of this consortium is focused in studying and addressing three different industrial sectors (food, machine manufacturing, automotive) located in three different European countries. Having partners with important experience in the mentioned sectors and with a good knowledge of each country’s industrial situation, and partners running important research activities on the principal issues of Knowledge Management and worker oriented collaborative manufacturing, it is intended to develop a solid system, applicable across a range of industries and cultural contexts.

4. Knowledge and Extended Enterprise

The following sections provide some preliminary definitions of the key-concepts the K-FLOW project is based upon, elaborated within the Methodological work packages of the project.
4.1. Knowledge definition

To have a single definition of knowledge is an almost impossible task since the existent views on knowledge are far apart and often dismiss the view of the contrary camp. The main views of knowledge in the knowledge management field are those of the “Human Resource” perspective and the “Information Systems” perspective. [4]

On the one hand, the human resource view of knowledge links knowledge with a human being’s perception and could best represented by the definition of Knowledge as the capacity to act rationally. From this point of view, knowledge is embedded in people and hence knowledge management is a part of human resources management.

On the other hand, the “Information systems” perspective claims that knowledge can be made explicit, (i.e. the knowledge can be separated from the individual) and can be formalised in a document. From this point of view, a working knowledge definition can be that of Shin et al [2] who say that “Knowledge is information validated through proof against experience either by the individual or the organisation”. This definition could be summarised as:

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\text{Data + Context} \rightarrow \text{Information} + \text{Experience} \rightarrow \text{Knowledge}
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Both definitions are applicable to K-FLOW because:

- By ensuring that K-FLOW delivers the right knowledge to the right person, we would ensure that this person, with his/her previous experience is able to act rationally and solve the problem in hand or foresee possible implications of the actions taken. It is then important to ensure the suitability of the person to receive the designated knowledge.
- K-FLOW will also provide the possibility to validate information through proof against experience by the individuals, therefore, to generate knowledge, as well as to share it with those who do not have it. Hence, the second definition will be applicable in this case, especially since we intend to code the knowledge in some way (maybe narrative) and formalise it and make it readily available for later use. We must not forget that in organisations, knowledge often becomes embedded not only in documents or repositories but also in organisational routines, processes, practices and norms.

As it can be seen, although in the theoretical discourse the two points of view seem to be contradictory, we have found that a combination of both perspectives will give us a broader view of the future requirements of K-FLOW and will help us to develop a more complete system.

4.2. Extended Enterprise

In [3] the EE is defined as “a conceptual business unit or system that consists of a purchasing company and suppliers who collaborate closely in such a way as to maximise the returns to each partner”. This is the definition of Extended Enterprise that has been taken as a basis for K-FLOW. However, for K-FLOW, it is considered as incomplete. Therefore, the proposed definition of EE says: “The EE is defined as a conceptual business unit or system that consists of a leading company, suppliers and customers who collaborate closely in such a way as to improve the returns to each partner of the entire EE

A proposed structure of the Extended Enterprise is presented in Figure 1. Such structure would be comprised of an EE-wide mechanism (meta-manage process) in charge of co-ordinating the activities of extended business processes (that is, business processes that span across the different enterprises) in order to create value for the customer.
4.3. New role of Workers (Working Knowledge)

Employees in the contemporary enterprise can play a new crucial role as creators, brokers and managers of information and knowledge. The explicit and tacit knowledge of the workers can dramatically improve the organisations ability to solve problems and reduce losses, creating new knowledge to be exploited in the whole Extended Enterprise.

In this scenario, it is clear the importance of a KM system that does not flood workers with tons of messages, documents, various files etc, neither can simply provide access to a huge amount of data and information. A KM system must perform a pre-filtering of this information, to check the reliability of the sources and thus help the workers to evaluate the utility and applicability of information.

It is also important to stress that one of the methodological tasks of the K-FLOW project is devoted to the analysis of the Strategies for the Continuous Improvement (CI) of Workers’ Participation in the EE. This task addresses the customisation of already well-experienced tools for CI to make them applicable to the CI of workers’ participation in the EE.

In summary, the principal benefits that a worker can gain by the K-FLOW system are the following ones:

- Access the information in a customised way: the tools that visualise information, both on the EE Portal and on the PC placed at the shop floor, provides easily customisable GUIs
- Access to information regardless of its physical location and its format: information provided by the K-FLOW system is always updated and it is visualised in a uniform and friendly format through the GUI running on the shop floor PC accessed by the worker
- Access to timely relevant information: the K-FLOW system dispatches the right information at the right time; workers do not have to analyse a huge amount of information to individuate the part that is relevant in the current working context
- Content from trustworthy sources: the information dispatched by K-FLOW system has been generated within the system itself or it has been supplied by authorised users of the EE

5. K-FLOW System Architecture

The SW tools to be developed in K-FLOW will make up a platform for the different elements of an Extended Manufacturing Enterprise to get integrated in an easy manner. The elements to be considered for integration are: plant production stations, design office stations, customers and
suppliers, but also subcontractors, machine manufactures and public entities.

The main SW modules (see Figure 2) of K-FLOW are the Plantmanager, the Tdatamanager, the Portal, the Configurator and the Engine. The Plantmanager is mainly in charge of the control of the progress of the manufacturing process. The Tdatamanager performs and manage the integration between the knowledge produced and requested by the design/methods department and the knowledge produced and requested by the manufacturing plant. The Portal supplies the access (via internet), by the external (to the manufacturing plant) elements of the EE, to knowledge inside the plant through the Human to Machine (HtoM) door, as well as the access, by operators working on various stations in the shop-floor, to the knowledge through the Machine to Machine (MtoM) door. The Configurator and the Engine, are in charge of dynamically configuring K-FLOW’s SW modules and of managing the knowledge of the system, that is, to decide what knowledge to dispatch at which place, in what form and at what time. In fact, the “slogan” or motto of K-FLOW is: to provide the right knowledge, at the right place, in the right way, at the right time.

Figure 2: K-FLOW architecture

An example of knowledge to be managed in K-FLOW is the knowledge gained from the experience of people that is gathered and integrated in the system: plant operators, through the K-FLOW portal, will be able to input their knowledge to the system as well as to get personal information (information related to the work carried out by a person) from it. Through a user profiling system which defines access rights, the competencies and the skills of the different users. K-FLOW establishes a personal relationship between the company and the worker, who feels this relationship is special and peculiar.

For the purpose of this paper, we will focus on the description of the Portal and its influence on the way workers carry out their activities. The K-FLOW Portal is the tool that allows users fetching the knowledge needed (right knowledge), sharing it with other users (right place) and displaying it according to the user profile, preferences and options (right form) when the K-FLOW Engine determines it (right time). It allows local/remote knowledge access/transfer on demand. A real novelty of this portal is to have two access doors: a Human-to-Machine Door, which implements the access point of any corporate or web portal; a Machine-to-Machine Door, which manages the knowledge of the workers inside the plant.
The Workers in charge of attending production machines have customised access to knowledge of the K-FLOW system during production operations. This knowledge will be dispatched through the MtoM door of the Portal. The GUI for Operators will be formed by a **main-view**, surrounded by other **side-views** focused on Operator, Machine, Product-in, and Product-out. The main view is, in general, a sequence of steps: at each time just one of these steps will be the current one (that is the production step currently at work) and the side views will show the relevant information regarding the Operator (his preferred colleagues, his reports and comments, his interests), the Machine (next-previous maintenance intervention, faults, documentation, procedures), the Product-in and -out (characteristics, quality control, documentation).

6. **Methodologies**

In order to ensure an integration of the software in the culture of the company, a series of methodologies are currently under development. The methodologies are described below:

**Methodology 1.** This methodology looks at the implications of extending the business processes across the extended enterprise. The CIM-OSA business process model [5] and the SCOR model [6] are used for this analysis, specifically the operate processes (Develop product, get order, fulfil order and support product). As a result of this initial stage, a generic model of the EE operate processes has been drawn.

Based in the proposed structure in the first point, a strategy and performance management system will be developed to support the implementation of K-FLOW in the Extended Enterprise. This framework will be based on the Balanced Scorecard approach but will take account of the competitive structure of the EE. This will include a list of performance measures which could be used by the EE.

**Methodology 2.** The second methodology is in charge of identifying the different K-FLOW users across the EE. This helps defining not only the possible sources and recipients of knowledge, but also the different generic profiles that can be created in the K-FLOW software. Additionally, the existent IT technologies that can be integrated into K-FLOW are currently under investigation, as well as the emerging technologies that could be integrated in the future and the methodology for such integration proposed.

This methodology also outlines the way in which collaboration can take place across the EE using the investigated technologies. An IST Prototype will be implemented. Some of the proposed technologies will be put together in order to develop a web services based demonstration platform and analyse their usage and services.

**Methodology 3.** In this task, methodologies and SW developments are proposed for CI (Continuous Improvement) and PS (Problem Solving) management based on loss management for the EE. This framework, based on a data structure where the results obtained from measuring the losses, applying the developed methodologies and managing users contributions are stored and registered, is generic, that is, applicable to the three end users of K-FLOW.

7. **Plan for Dissemination of Results**

Along the project, SW tools, models, prototypes, demonstrators and of course practical implementations at the End User Sites, with at least one full implementation of the minimum expression of the Manufacturing Extended Enterprise (an End User, a Customer and a Supplier), will be developed and carried out. It is planned to organise workshops, to participate in conferences and to disseminate results of all these developments, on their different phases, during the whole period of duration of the project (January 2002-December 2004) and of course after the termination of that period, in order to keep the industrial manufacturing community informed about the progress of the project. At the time this article is being written the project is still at the initial stages so it is
believed it will be important to keep track of these dissemination actions. All the information about
events and published results will be available at http://www.kflow.org.

8. Conclusions

The K-FLOW project proposes a problem solving approach, based on the share-of-knowledge
paradigm, for the integration of manufacturing enterprises, down to shop-floor machine level, with
users of the EE.

Special attention is given to the continuously enhanced participation and implication of workers
within the entire production process based on the share-of-knowledge paradigm, as well as the
evolution of their role, skills, work conditions and work contents. This coincides with the EU
employment impact policies.

The aim is to provide the right knowledge at the right place, in the right form and at the right
time.

The innovation provided by the K-FLOW project to the European manufacturing industries as
well as to the European workers, may be summarised as follows:

- Development of a platform where users of an EE will share the same knowledge management
  area and will be fully integrated down to the shop-floor machine level.
- Development of an open, XML-based Knowledge-Flow Configurator which will dynamically
define the knowledge management process for the whole EE, what knowledge, at what place, in
what form and at what time will be provided.
- Development of a Knowledge-Flow Engine, which will be giving the pace to all the system by
  continuously executing the knowledge flow process defined by the K-FLOW Configurator.
- Development of a Knowledge-Flow Portal with two access doors: a Human-to-Machine Door,
to implement the access point of any corporate or web portal, and a Machine-to-Machine Door,
to manage the access point via workstations at machine, section, plant and enterprise level of a
manufacturing enterprise.
- The development of three novel sets of strategies, models and methodologies to continuously
  enhance the integration of the manufacturing enterprises within the EE through the K-FLOW
  platform.

The European Manufacturing Enterprises will be the principal beneficiary of the results obtained
from this project. With K-FLOW, where the operators with their experience and the collaboration
with customers, suppliers and other entities will play a key role, they will earn in competitiveness
and will see how their production, productivity, quality rates and service are improved, and costs,
lead time and time to market reduced.

9. References

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