UNIVERSITÀ DEGLI STUDI DI VERONA

SUBMISSION FORM "*JOINT PROJECTS 2011*"

A) TITLE OF THE PROJECT

Title of the project or acronym
Integrated traceability and real-time process verification applied the production of flour from organic grains from stone mills (E-FLOUR)

B) DURATION

[X] ONE YEAR ☐ TWO YEARS	Starting on: October 1st 2011

C) TYPE OF RESEARCH

INDUSTRIAL RESEARCH	☐
COMPETITIVE RESEARCH	[X]
BASIC RESEARCH	☐
INNOVATION OF STRUCTURES OF RESEARCH	☐

D) SCIENTIFIC AREA, KEYWORDS

AREA CUN (click here)	*Area 09 – Ingegneria industriale e dell'informazione* *Area 07 - Scienze agrarie e veterinarie*
SSD related to the project	ING-INF/05 Computer engineering
Classification ISI-CRUI (click here)	Computer Science & Engineering Food Science/Nutrition
Keywords (click here)	**1.** Process model **2.** Traceability **3.** Semi-structured temporal data **4.** RFID tag **5.** Workflow **6.** Food microbiology **7.** Food

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ATECO classification (click here)	10.61 - Lavorazione delle granaglie.
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Personnel Cost for the realization of the project	4,836.09 Euro

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Personnel Cost for the realization of the project	9,032.00 Euro

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Personnel Cost for the realization of the project	Euro 0

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Monthly Personnel Cost	2,793.33 Euro
Personnel Cost for the realization of the project	Total Euro: 10,475

G) ABSTRACT

The main objective of the project is the integration of automatic identification through interactive labels, traceability in the production process of different flour cereals, monitoring of the environment and the monitoring of nutritional and microbiological quality of the raw cereals. The exploitation of such integrated information for the real-time verification of the business process. In particular, the project will cover the following aspects.

Antico Molino Rosso, the company involved in this project, is a small but lively reality of the milling industry, that encourages farmers to grow organically a wide range of old varieties of cereals and is characterized by the use of the grindstone (*macina a palmenti*) in order to preserve nutritional properties of flours. In addition to a meal by the proposed innovative product line is the yeast from three different types of dough.

Design of a methodology of **integrated traceability** to introduce in the business process the operations of automatic identification and monitoring of the environment and of equipments. Creation of a **Data Fusion Engine** for the collection of such information and their organized storage. This information can be used by the traditional information system, made available on several communication channels and used for the generation of alarms in case of anomalies in the business process.

Design of a methodology and creation of a SW component for the **real-time verification of the evolution of the business process** starting from its formal description and by using the sequence of information collected by the Data Fusion Engine related to automatic identification and monitoring of the environment and of equipments.

Application of the concepts of integrated traceability and real-time verification to the **production of flour from different cereals and natural sourdough**. In particular, the project addresses the automatic data collection to minimize human actions in the automatic identification and monitoring of the environment and of equipments.

Data Fusion Engine and SW component for the real-time verification of the evolution of the business process will be obtained as **extensions of existent Workflow Management Systems** whose capability in term of adaptability and exception handling will be exploited.

H) MOTIVATION

The traceability of raw materials and finished products within the food production processes is a necessary condition to guarantee an audience of citizen-consumers more aware and educated ready to understand and accept products of superior quality products.

Today some concepts and methodologies are affecting business processes and transportation:

- **Automatic identification and traceability**: automatic object identification during production, transport and selling through low cost techniques such as bar codes and RFID tags.
- **Sensor networks**: low cost embedded systems connected through fieldbus or wireless networks capable of collecting environment data, e.g., temperature and humidity, or status information from equipments.

As shown in Figure 1, currently we can notice the lack of an integrated use of these technologies in

business processes; for instance:
1. a failure signal from an equipment generates directly an acoustic alarm;
2. bar code or RFID reading is directly connected to the computer for invoice generation.

The same technologies could be employed in a more integrated way; for instance, a **failure detection** on the equipment, together with the **automatic identification** of the object elaborated by the equipment in that moment, could allow **production quality assessment** which is a much more advanced functionality with respect to the simple acoustic alarm.

Another example comes from the industrial production of flour and sourdough. The production process consists of different phases characterized by several check point on raw material quality (nutritional quality and presence of chemical residues or microbiological contaminants) and final products (long-term stability of nutritional and microbiological quality of the flour and sourdough). Today, even with automatic identification, the fulfillment of such requirements depends on the good experience of workers and, in case of errors, bad products are detected at the end of the process with waste of time and money.

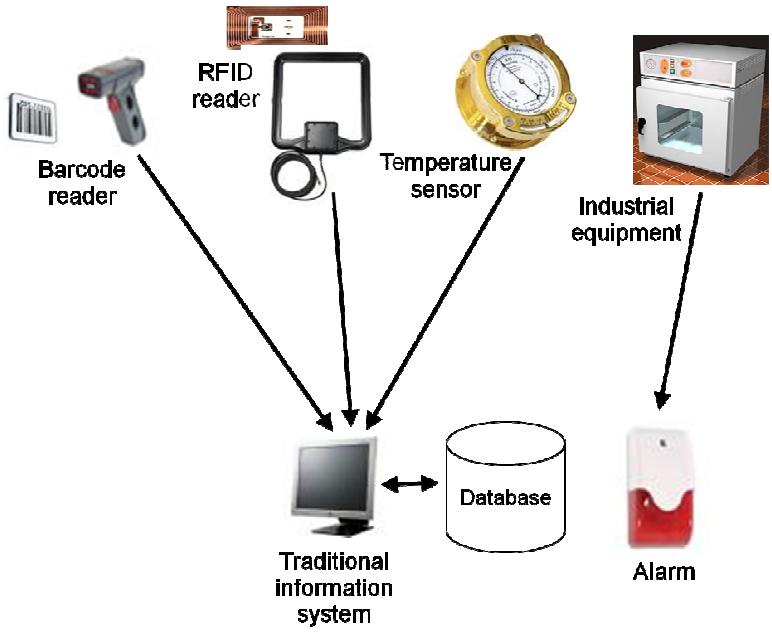

Figure 1. Automatic traceability and sensor networks in a traditional context.

What is missing in the architecture shown in Figure 1 is:
1. a **higher automation level in automatic identification and monitoring of environment and equipments** to avoid error-prone human readings;
2. a methodology and a software component to **merge data** coming from automatic identification and monitoring of environment and equipments; such data could be used transparently in the company for many tasks (e.g., invoice generation, quality assessment, failure notification);
3. a methodology and a software component for the **real-time verification of the business process** starting from its formal description and data coming from automatic identification and monitoring of environment and equipments.

Filling these gaps would bring a high improvement in manufacturing and logistics.

In particular, food production could be highly affected by these gaps due to the following requirements:
1. strict fulfilment of constraints on time and environmental parameters;

2. several production lines in same facility with heterogeneous phases and constraints;
3. limitation of human actions to avoid contamination;
4. long production time which makes the quality assessment economically unsustainable if it is performed at the end of the production process.

The project goals aim at filling these gaps as described in the next Section.

I) OBJECTIVES

The main goals of this research project can be summarized as follows.

Design of a methodology of **integrated traceability** to introduce in the business process the operations of automatic identification and monitoring of the nutritional and microbiological quality of the raw materials (flour and sourdough), monitoring of environment and equipments, as well. Creation of a **Data Fusion Engine** for the collection of such information and their organized storage. This information can be used by the traditional information system, made available on several communication channels and used for the generation of alarms in case of anomalies in the business process.

Design of a methodology and creation of a SW component for the **real-time verification of the evolution of the business process** starting from its formal description and by using the sequence of information collected by the Data Fusion Engine related to automatic identification and monitoring of the environment and of equipments.

Application of the concepts of integrated traceability and real-time verification to the **production of different flours and sourdough starter**. In particular, the project addresses the automatic data collection to minimize human actions in the automatic identification and monitoring of the environment and of equipments.

Data Fusion Engine and SW component for the real-time verification of the evolution of the business process will be obtained as **extensions of existent Workflow Management Systems** whose capability in term of adaptability and exception handling will be exploited.

Figure 2, compared with Figure 1, emphasizes the innovations brought by this project.

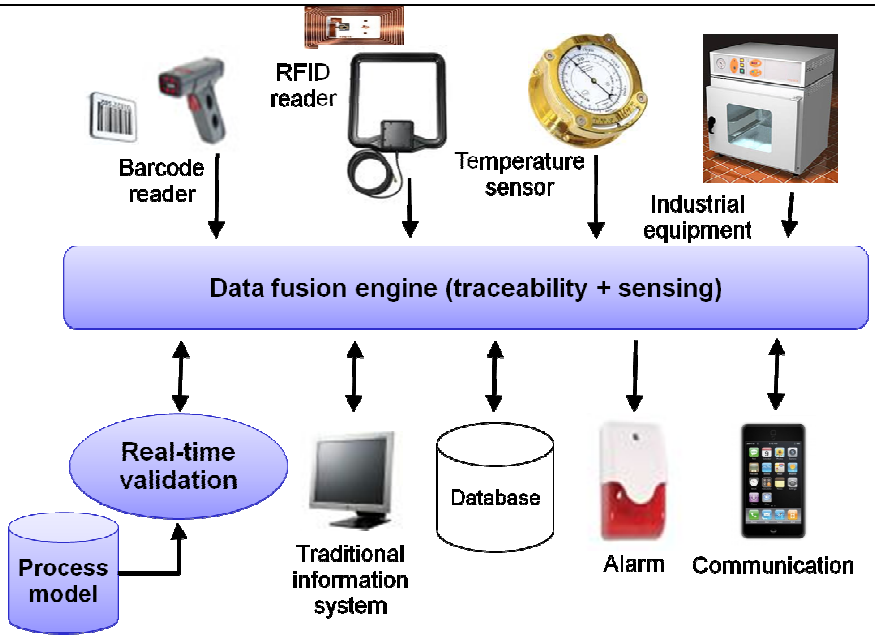

Figure 2. Proposed architecture for integrated traceability and real-time process verification.

J) STATE OF THE ART, BACKGROUND AND REFERENCES

The project is based on the concepts of automatic identification, sensor networks, process modeling of flour and sourdough starter production, food safety and quality.

Automatic identification covers the techniques for object identification through bar codes and RFID tags [1]. One of the most important standard for information sharing and interoperability in this field is developed by EPCGlobal [2].

Sensor networks are made of low-cost low-power embedded systems; they can sample data from the environment at a very fine scale and transmit information towards traditional networks to be elaborated [3].

Process modeling is a methodology to formally describe a business process where tasks are assigned to agents which can be either software components or people or a combination of both [4]. The Workflow Management Systems (WfMS) are computing systems aiming at improving business processes through the automatic assignment of tasks to agents and the information management inside the business organization [5].

For what it concern **food quality and safety**, food products from conventional agriculture usually have higher concentrations of chemical residues while organic agriculture products have higher concentrations of biological toxins such as mycotoxins from mould [6]. Therefore **monitoring the level of mycotoxin contamination** with sensitive and reliable methods, such as the Immuno-chromatography [7], is essential in order to select the safest grain batches and provide safe products. After grain selection also the milling method is a fundamental aspect in order to produce excellent quality flour with high nutritional properties. Particularly, the **cold milling using a grindstone** allows the preservation of essential molecules from the grain germ such as the vitamin E (tocopherol) [8]. Moreover vitamin E has strong anti-oxidant properties and it act as natural preservative for flour [8].

Since moulds can grow on it, mycotoxins are also important risk factors in the mother yeast production for sourdough bread (fermented flour with a complex ecology of yeast and lactic acid bacteria). On the other hand some lactic acid bacteria present in the mother yeast are able to naturally inhibit mould growth [9] and also degrade mycotoxins in the sourdough [10]. The microbiological monitoring of populations in this product is therefore essential in order to provide safe and high quality mother yeast.

See the last part of Section K for further details on the state of the art.

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K) DESCRIPTION *(limit of 20.000 ch.)*

1. Main project innovations

Integrated traceability

The project aims at designing of a methodology of **integrated traceability** to introduce in the business process the operations of automatic identification and monitoring of the environment and of equipments. Furthermore, the project will create a SW component named **Data Fusion Engine** for the collection of such information and their organized storage. This information can be used by the traditional information system, made available on several communication channels and used for the generation of alarms in case of anomalies in the business process.

Currently, the operations of automatic identification and monitoring of the environment and of equipments are disjoined and their information are not considered basic resources of the enterprise information system as the database, network services and printers. For example:

- to count pieces on a transport belt bar codes or RFID tag are used but the counting result is

displayed locally; eventually an employee is committed to transfer this information to the central information system;
- to speed-up the invoice generation a bar code reader is connected directly to the computer which generates invoices;
- environmental sensors and equipment monitoring generate data to be displayed locally; rough alarms are generated in case of failure without the possibility to set complex signaling rules.

Even in case of introduction of RFID tags, they are often read manually as for bar codes. The insertion of an RFID reader in a gate or in a equipment door could allow to detect that in a given time, a given piece has been moved or is operated by a given machine. The insertion of an RFID reader in the door of a fridge or of maturing room could allow to know how long a product stayed there.
The integration of automatic identification, environment and equipment monitoring could allow to exploit the synergies among the different information flows. For example:
- piece counting and invoice generation could rely on the same source of automatic identification;
- the same source of automatic identification, used for invoices, can be re-used for a new activity (e.g., inventory);
- staying time in fridge and maturing room can be detected and correlated with the parameters of those environments to assess the correctness of the operation (e.g., cold chain must not be interrupted);
- environmental parameters and events (e.g., power outage) could be correlated with the requirements of the involved objects;
- when an equipment failure is detected, the quality control system can recover the affected object;
- equipment failure signaling function could take into account the failure importance, the time of the day and the active people (eventually the phone number or the email address of the person is recovered by the information system);
- the information system should not be changed when new equipments are inserted or replaced since the Data Fusion Engine gives an abstract view of them.

Real-time verification of business processes

The project aims at designing a methodology and creating a SW component for the **real-time verification of the evolution of the business process** starting from its formal description and by using the sequence of information collected by the Data Fusion Engine related to automatic identification and monitoring of the environment and of equipments.

Quality control is traditionally performed statistically by human operator and fault products are often detected at the end of the process leading to waste of time and money.
The innovation brought by the project on this aspect is directly based on the concept of integrated traceability previously described. By merging information on object identity, operation on a given equipment or storage in a fridge, status of the equipment and of the fridge, events like power outage, etc., the story of all the objects (not a random subset) can be known. By comparing the evolution of a given object with its ideal model, errors can be detected in real-time without waiting the end of the process. This verification function could even give hints to human operators to prevent errors.

Evolution models are strictly related to process modeling which has been used traditionally to design processes with good properties and to assign tasks to operators. **The innovation of this proposal consists in applying Workflow Management Systems (existent and extended) to the real-time and automatic validation of business processes through information coming from automatic identification and environment/equipment monitoring.** This way, errors like mis-

ordered phases, wrong time, equipment failures can be early detected.

Real-time process verification will be a function of the Data Fusion Engine but it cannot be implemented without knowledge of the specific process to be monitored. Nevertheless, manual writing of this component is a tedious and error-prone activity. For this reason, in this project a tool will be created to take as input the formal description of the process (given through an abstract well-known language) and to generate automatically the source code of the verification component to be inserted in the Data Fusion Engine. Data Fusion Engine and SW component for the real-time verification of the evolution of the business process will be obtained as **extensions of existent Workflow Management Systems** whose capability in term of adaptability and exception handling will be exploited.

Production of flour from different cereals and natural sourdough

The project will apply the concepts of integrated traceability and real-time verification to the **production of flour from different cereals and natural sourdough**. In particular, the project addresses the automatic data collection to minimize human actions in the automatic identification and monitoring of the environment and of equipments.

Currently this kind of production has the following critical issues:
- strict fulfillment of constraints on time and environmental parameters;
- several production lines in same facility with heterogeneous phases and constraints;
- limitation of human actions to avoid contamination;
- long production time which makes the quality assessment economically unsustainable if it is performed at the end of the production process.

These issues could be solved by this project through:
- the use of the Data Fusion Engine;
- the introduction of automatic identification and the insertion of RFID readers in fridges, workstations, air cabinets, etc;
- the automatic sensing of environmental parameters like temperature and humidity;
- the automatic measurement of the output of laboratory equipments (e.g., for the food quality parameters);
- the formal description of the different production lines and the corresponding real-time verification.

2. Methodology

To achieve each objective the following methodologies will be adopted.

Concerning the integrated traceability, the following items will be addressed:
- requirements and architecture of the Data Fusion Engine
- guidelines for the insertion of RFID readers in the most common equipments, workstations and laboratory equipments
- guidelines for the monitoring of the environment and equipments through sensor networks

To obtain general and reusable results, different production scenarios will be considered with emphasis on the industrial microbiology and logistics/transport. The Data Fusion Engine will be implemented in the opensource EPCGlobal-compliant package named Fosstrak [1].

Concerning real-time process verification, it will be a component of the Data Fusion but it cannot be implemented without knowledge of the specific process to be monitored. Nevertheless, manual

writing of this component is a tedious and error-prone activity. For this reason, in this project a tool will be created to take as input the formal description of the process (given through an abstract well-known language) and to generate automatically the source code of the verification component to be inserted in the Data Fusion Engine. Data Fusion Engine and SW component for the real-time verification of the evolution of the business process will be obtained as **extensions of existent Workflow Management Systems** whose capability in term of adaptability and exception handling will be exploited.

The application of developed tools and methodologies on the production of flour and sourdough starter will be used to validate general results in a critical aspect of an integrated traceability procedure and when possible also on the continuous monitoring in-line. The Department of Biotechnology and the Antico Mulino Rosso will play an important role using the Data Fusion Engine, modelling the production process to create the checker and adding the automatic identification and monitoring in the production system and the analytical measures. Analytical measures will focus mainly about chemical and physical characteristic as well as mycotoxins contamination in order to evaluate the quality of the raw material. In this phase instrumentation provided by the industrial partner will be employed such as: INFRATEC (FOSS NITSystem) in the near infrared and on solid phase for nutritional property analyses and immuno-chromatography to analyse presence of mycotoxins (Rosa Incubators, Cham, USA). In presence of mycotoxin contaminated batches the mould which caused the contamination will be identified by DNA based molecular methods and. The stability and the vitamins content, in particular vitamin E, in the flour will be analysed in out-sourcing by specialised external laboratories.
For the mother yeast the stability and the composition of the microflora will be monitored by classic methods as well as innovative culture independent approaches such as DGGE. The primary objective is to ensure the absence of bacteria potentially harmful for human health. Another objective is the characterization of the microflora in order to highlight the presence of positive bacteria such as lactic acid bacteria which can naturally inhibit the growth of mould.

The application of project solutions to the production of flour from different cereals and natural sourdough will be used to validate such results in this particularly critical field. In this context, Dipartimento di Biotecnologie and Antico Molino Rosso srl will play a decisive role in the use of the Data Fusion Engine, the introduction of automatic identification and environment/equipment monitoring in their plants, the modeling of their business processes and the generation of the verification module.

3. Impact

Project results will affect positively industrial fields such as manufacturing and logistics with a significant impact on the local area of Verona. Some examples follow.

Industrial Partner
The potential impacts for the Industrial Partners are:
- the availability of a prototype tailored for the management of different data from different production critical points. The prototype will be evaluated for the required period and eventually will be integrated into the normal production process.
- Enhancement of the nutritional content in terms of flour produced and the value of a niche product, but well defined as the sourdough.
- The return image from the collaboration between company and university in a field so new, that will be claimed by both sides, resulting in amplification of the impact on potential customers.

Industrial microbiology
Companies involved in industrial microbiology could exploit project results in the production of microbial starter cultures for agriculture (e.g., plant food and plant protection products) and food

preparation (e.g., yeast for wine, beer, yogurt, cheese and meat). Many of these companies rely on the experience of their workers to keep quality high. Project solutions could increase the efficiency and competitiveness of these companies but increasing product portfolio and quality.

Food production
Food production consists of phases and constraints on temperature and humidity for each phase. Many production methodologies contain maturing and fermentation phases very similar to the microbial production, even more complex for the size of the rooms and the direct impact on human safety. In the area of Verona and its neighborhood (Pianura Padana and Alpi mountains) there are several companies devoted to the production of wine, yogurt and other milk derivative, and meat. Project results could increase the efficiency and safety of these processes.

Logistics and transport
Automatic identification through bar codes and RFID tag is already a fundamental asset in companies devoted to warehousing and transport of goods. Critical issues in this context are the assignment of the correct vector and theft. The use of temporary employees does not allow quality control based on human experience. In the area of Verona, at the center of important communication pathways, there are several companies involved in logistics and transport which could benefit from project results and their extensions (e.g., the introduction of localization as a new input for the Data Fusion Engine and the real-time verification component).

4. State of the art

The project is based on the concepts of automatic identification, sensor networks, process modeling as well as food safety and quality.

The concept of **automatic identification** covers the techniques for the object detection through bar codes and RFID tags [2][3]. In 1999, the Uniform Code Council and EAN International teamed with Gillette and Procter & Gamble to fund the Auto-ID Center at the Massachusetts Institute of Technology. The center changed the equation by working with private industry to develop an RFID tag that would be very low cost when manufactured in high volumes. That way, companies could put tags on everything they own and then connect them to the Internet through a secure network. The Auto-ID Center's contribution went beyond trying to create an inexpensive tag. It developed the Electronic Product Code (EPC), a numbering scheme that makes it possible to put a unique serial number on every item manufactured. It developed a way for tags and readers to communicate (the air interface protocol) and designed a network infrastructure that stores information in a secure Internet database. A virtually unlimited amount of data associated with a tag's serial number can be stored online, and anyone with access privileges can retrieve it.
The Auto-ID Center handed off its technology to a non-profit organization called EPCglobal, which has created a second-generation air interface protocol and is developing the network infrastructure now called the EPCglobal Network to enable companies to share data in real time [4].

The concept of **sensor network** was established in the last decade to refer to low-cost, low-power, low-rate networked embedded systems capable of acquiring data from the environment and transmitting them towards traditional networks to be processed [5][6][7].

Process modeling consists in the formal description of the business process in which tasks are assigned to agents (human being or SW components) [8]. The Workflow Management Systems (WfMS) are automated systems aiming at improving business processes through the optimal assignment of tasks to agents and the management of business information [9][10][11]. Most of commercial tools for workflow design provides advanced solutions for process modeling and analysis [12]. The Workflow Management Coalition (WfMC) founded in 1993 proposed a standard

reference model for the development of WfMS [9]. Recently the WfMC joined the initiative of Object Management Group (OMG) about the process modeling called Business Process Management Initiative (BPMI) [13][14]. The most famous packages for process modeling, like MEGA [15] and Aris [16], allow to model business processes with the definition of the corresponding agents and tasks. An opensource implementation of Workflow Management System is YAWL [17].

For what it concern **food quality and safety**, food products from conventional agriculture usually have higher concentrations of chemical residues while organic agriculture products have higher concentrations of biological toxins such as mycotoxins from mould [18]. Therefore **monitoring the level of mycotoxin contamination** with sensitive and reliable methods, such as the Immuno-chromatography [19], is essential in order to select the safest grain batches and provide safe products. After grain selection also the milling method is a fundamental aspect in order to produce excellent quality flour with high nutritional properties. Particularly, the **cold milling using a grindstone** allows the preservation of essential molecules from the grain germ such as the vitamin E (tocopherol) [20]. Moreover vitamin E has strong anti-oxidant properties and it act as natural preservative for flour [20].
Since moulds can grow on it, mycotoxins are also important risk factors in the mother yeast production for sourdough bread (fermented flour with a complex ecology of yeast and lactic acid bacteria). On the other hand some lactic acid bacteria present in the mother yeast are able to naturally inhibit mould growth [21] and also degrade mycotoxins in the sourdough [22]. The microbiological monitoring of populations in this product is therefore essential in order to provide safe and high quality mother yeast.

5. References

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L) WORKPLAN AND GANTT CHART

The project consists of three work packages as follows.

WP1 Integrated traceability
Design of a methodology of **integrated traceability** to introduce in the business process the operations of automatic identification and monitoring of the environment and of equipments. Creation of a **Data Fusion Engine** for the collection of such information and their organized storage. This information can be used by the traditional information system, made available on several communication channels and used for the generation of alarms in case of anomalies in the business process and to provide information to consumers.

This WP consists of the following tasks:

T1.1 Requirement analysis and design of the architecture of the Data Fusion Engine.

T1.2 Implementation of the Data Fusion Engine.

T1.3 Design of methodologies to perform automatic identification and monitoring without human intervention.

In this WP the main effort will be given by the Dipartimento di Informatica with the support of the Dipartimento di Biotecnologie and Antico Molino Rosso srl for the analysis of requirements and of the methodologies to perform automatic identification and monitoring without human intervention.

WP2 Real-time process verification
Design of a methodology and creation of a SW component for the **real-time verification of the evolution of the business process** starting from its formal description and by using the sequence of information collected by the Data Fusion Engine related to automatic identification, chemical-physical food parameters as well as monitoring of the environment and of equipments.

This WP consists of the following tasks:

T2.1 Analysis of requirements and choice of the language/tool for process modeling; analysis of the nutritional and microbial quality of flour and sourdough and their stability; identification of the

most relevant food quality parameters to be monitored by the Data Fusion Engine.

T2.2 Design and implementation of the tool for the automatic generation of the process verification component starting from the process description.

In this WP the main effort will be given by the Dipartimento di Informatica with the support of the Dipartimento di Biotecnologie and Antico Molino Rosso srl for the analysis of requirements for the choice of the language/tool for process modelling.

WP3 Demonstration and verification of results

Application of the concepts of integrated traceability and real-time verification to the **production of flour from different cereals and natural sourdough**. In particular, the project addresses the automatic data collection to minimize human actions in the automatic identification and monitoring of the environment and of equipments.

This WP consists of the following tasks:

T3.1 Formal description of the process.

T3.2 Generation of the process verification component.

T3.3 Implementation of the prototype.

T3.4 Project verification by analysing the quality of the produced flour and sourdough (performed by the Dipartimento di Biotecnologie or by an external service).

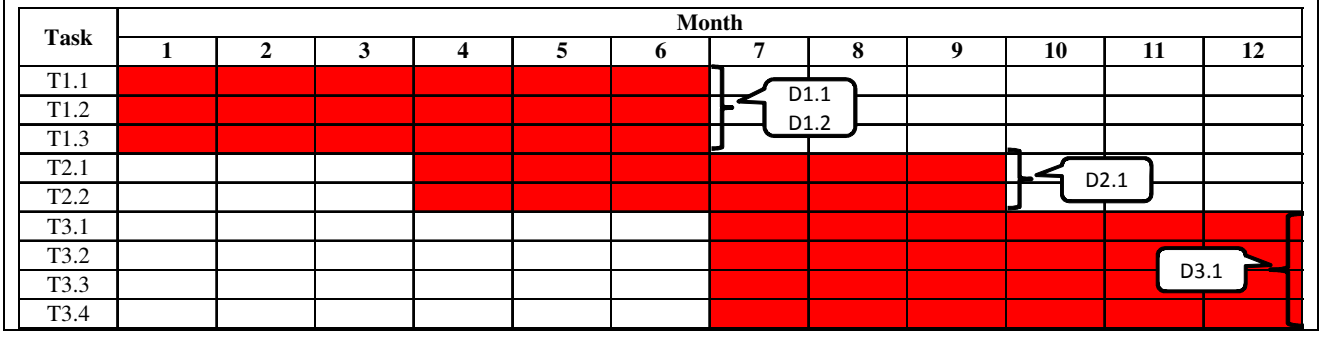
In this WP all the project partners will be involved with almost the same effort:

- The Dipartimento di Informatica will give support for the use of tools developed in WP1 and WP2; it will address the interconnection of the production and laboratory equipments for data collection; it will install and connect sensors bought on the market.
- The Dipartimento di Biotecnologie will perform bio/chemical/physical analysis on quality and stability of final products for project validation.
- The industrial partner will support the creation of the prototype for the demonstration and validation of project results.

The effort (in person month PM) of each Research Unit in each WP is subdivided as follows.

	Dipartimento di Informatica	Dipartimento di Biotecnologie	Antico Molino Rosso Srl	Total PM
WP1	3	1	0.75	4.75
WP2	3	1	1	5
WP3	3	3	2	8
Total	9	5	3.75	17.75

Gantt diagram with deliverable deadlines



M) AVAILABLE STRUCTURE AND EQUIPMENT

1) Antico Molino Rosso Srl

Analytical weighter; INFRATEC spectroscope (FOSS NITSystems, Sweeden); ROSA Incubators for immono-chromatographic measurement of mycotoxins (Charm, USA).

REMARKS. The INFRATEC spectroscope (FOSS NITSystems, Sweeden) is a fundamental equipment for this research project; it has been recently bought and part of its value (i.e., 5,525 Euros) is used to co-fund the research project.

2) The laboratory of the Dipartimento di Informatica consists of several Windows and Linux workstations for SW development. It has also:

- a high capacity file server hosting all home directories
- two computers for high performance computation
- a network server to host web pages, wiki, the document repository and the source code version repository.

All the servers are protected with a periodic backup policy. HW and SW components concerning the topics of this project are:

- Gumstix Embedded PC
- Smartphone I-Mate JAMin with Texas Instruments OMAP850 200 MHz processor
- Smartphone HP iPAQ 214 with Marvell PXA310 da 624 Mhz processor
- Development kit by Texas Instruments for sensor networks consisting of 7 CC2431 nodes
- Development kit by Texas Instruments for sensor networks consisting of 10 CC2530 nodes
- Development kit by Arduino 2009 with Atmega328 for sensor networks
- Development kit for sensor networks consisting of 4 Modules SOC XBee XB24-BCIT-004
- 3 RFID readers at 125hHz for Arduino board
- 1 RFID reader at 13.56MHz HF with serial interface
- 1 RFID reader at 13.56MHz HF with SDIO interface
- 2 RFID tags at 125hHz - 30mm adhesive disk
- 2 RFID tags at 125hHz - 12mm disk
- 100 RFID tags at 13.56 MHZ HF Rectangle ICODE EPC Paper Tag Passive
- Development environments for sensor node by Texas Instruments, Arduino and XBee
- A license for Matlab/Simulink/Stateflow

3) The Laboratory of Food Microbiology and Biotechnology of the Dipartimento di Biotecnologie is endowed of advanced equipment for the phenotypical, biotechnological and genotypical characterization of microbial strains for application in the areas of agriculture, food and biotechnology. Laboratory equipment includes:

- Laminar flow cabinets;
- centrifuges;
- refrigerated super- and ultra- centrifuges;
- PCR equipments;
- agarose and polyacrylamide gel electrophoresis systems;
- equipment for pulsed field electrophoresis (PFGE);
- DGGE apparatus;
- a system for the digital acquisition of images;
- fluorescent microscope;
- spectrophotometer (UV-vis);
- Fluorimeter;
- Real Time PCR;

REMARKS. The value of these HW and SW resources was already amortized and therefore it is not exposed among the project's costs.

N) EXPECTED RESULTS

The expected results of the project are:

1. A SW component named Data Fusion Engine embedded in a EPCGlobal-compliant platform
2. Guidelines on the use of automatic identification and monitoring of environment and equipments in the business process
3. A SW tool which takes as input a process description (in abstract and well-known formal language) and generates the verification component of the Data Fusion Engine
4. A prototype addressing the production of flour from different cereals and natural sourdough based on the specification given by Dipartimento di Biotecnologie and Antico Molino Rosso srl.

Results will be delivered as follows:

WP	Name	Title	Type	Deadline
WP1	D1.1	Data Fusion Engine	Code	M6
	D1.2	Guidelines on the use of automatic identification and monitoring of environment and equipments in the business process	Document	M6
WP2	D2.1	Generator of the verification component	Code	M9
WP3	D3.1	Description of the prototype for the production of flour from different cereals and natural sourdough	Document	M12

The **Dipartimento di Informatica** has the scientific interest in extending the current state of the art of traceability also in relation with embedded systems and communication networks. The responsible of the research unit collaborates with a spin-off of the department which may be interested in the commercial exploitation of project results.

The **Department of Biotechnology** has an interest in monitoring the spread of the main fungal contaminants of grain, thus highlighting the possible relationships between plant variety and frequency of specific species of molds, in order to bring out the potential susceptibility to specific fungal diseases of cereals. It is also relevant to characterize the microflora of the sourdough starter, focusing the study of the interaction between different microbial species present in it.

The **Antico Molino Rosso** is a small but vibrant reality of the milling industry, which is characterized, in particular, the use of the millstone and the fact of raising awareness and encouraging farmers to cultivate a wide range of organic of ancient varieties of grains (wheat, oats, barley, rye and einkorn), including some salvaged from the past (saragolla wheat, durum wheat, Senatore Cappelli). The recovery of the traditions is also reflected by the fact that it has included in the catalog three different types of sourdough.

The participants have **technical and economical capabilities** to face the challenges of this project and they show significant complementarities related to know-how. In particular:

- The unit at the Dipartimento di Informatica has strong capabilities in the context of information systems, in the integration of heterogeneous and distributed software components, and in the context of embedded systems (i.e., sensors, actuators, and networks)
- The unit at the Dipartimento di Biotecnologie has strong capabilities in the context of microbiology applied to food and agriculture.
- Antico Molino Rosso already tested product traceability in the past and it can provide information about its production processes to set the requirements and to build the final demonstrator.

O) TECHNOLOGY AND KNOWLEDGE TRANSFER

PATENT	☐
SPIN OFF	☐
OTHER Organization of a workshop to present project results to companies interested in increasing the efficiency of their business processes. Dipartimento di Biotecnologie will allow to reach companies in the fields of industrial microbiology and food production (e.g., wine, yogurt, bread, etc.). Dipartimento di Informatica will allow to reach companies in the fields of manufacturing and logistics. Attending to the main exhibition and meetings of the field: Partecipazione ad **importanti fiere del settore agro-alimentare** come: • Salone del Gusto 2012 by Slow Food Association • Fiera Sana, the most important exhibition regarding the organic agriculture Dissemination of project results will also be performed through different media, e.g., web pages, poster, brochure.	[X]

P) PROGRESS MEASUREMENT CRITERIA

Project results will be evaluated through the application of integrated traceability and real-time process verification to the production of flour from different cereals and natural sourdough; the following criteria will be considered:

- **Efficiency**. The efficiency of the solution will be measured as the increase of controllability of the process quality regarding the early detection of errors and faulty products.
- **Robustness**. The robustness of the solution will be measured as the decrease of need of human intervention for process control.
- **Scalability**. The scalability of the solution will be measured as the verification time as a function of the number of types and instances of products.
- **Accuracy**. The accuracy of the solution will be measured as the accuracy in the automatic identification and in the measurements coming from environment and equipments.
- **Reactivity**. The reactivity of the solution will be measured as the latency to detect errors in the process.

Project results will affect positively industrial fields such as manufacturing and logistics with a significant impact on the local area of Verona. Some examples follow.

Industrial microbiology
Companies involved in industrial microbiology could exploit project results in the production of microbial starter cultures for agriculture (e.g., plant food and plant protection products) and food preparation (e.g., yeast for wine, beer, yogurt, cheese and meat). Many of these companies rely on the experience of their workers to keep quality high. Project solutions could increase the efficiency and competitiveness of these companies but increasing product portfolio and quality.

Food production
Food production consists of phases and constraints on temperature and humidity for each phase.

Many production methodologies contain maturing and fermentation phases very similar to the microbial production, even more complex for the size of the rooms and the direct impact on human safety. In the area of Verona and its neighborhood (Pianura Padana and Alpi mountains) there are several companies devoted to the production of wine, yogurt and other milk derivative, and meat. Project results could increase the efficiency and safety of these processes.

Logistics and transport

Automatic identification through bar codes and RFID tag is already a fundamental asset in companies devoted to warehousing and transport of goods. Critical issues in this context are the assignment of the correct vector and theft. The use of temporary employees does not allow quality control based on human experience. In the area of Verona, at the center of important communication pathways, there are several companies involved in logistics and transport which could benefit from project results and their extensions (e.g., the introduction of localization as a new input for the Data Fusion Engine and the real-time verification component).

Q) CURRICULUM VITAE

Name First Name	**Annex n.**
Davide Quaglia	1-EN
Sandra Torriani	2-EN
Gaetano Mirandola	3-EN
Federica De Fanti	4-EN

TOTAL COST OF THE PROJECT AND FINANCIAL PLAN

TOTAL COST OF THE PROJECT (in euro)						
Description of cost items	**1st year**	**2nd year**	**Total**	**Financial contribution by Antico Molino Rosso**	**Financial contribution by Departments**	**University financial contribution**
New purchases of durable equipment	2000.00		2000.00	0	600.00	1400.00
Department/Centre durable equipment	0		0		0	
Enterprise durable equipment	5525.00		5525.00	5525.00		
Consumables	1531.91		1531.91	0	1531.91	0
Temporary employees	31916.00		31916.00	9316.00	0	22600.00
Subcontracting	2784.00		2784.00	2784.00	0	0
Travel and subsistence	10500.00		10500.00	10500.00	0	0
Meetings and seminars organization	1400.00		1400.00	1400.00	0	0
Department/Centre permanent employees	13868.09		13868.09		13868.09	
Enterprise permanent employees	10475.00		10475.00	10475.00		
TOTAL COST OF THE PROJECT	**80000.00**		**80000.00**	**40000.00**	**16000.00**	**24000.00**

COSTS DETAIL : Description

New purchases of durable equipment	Purchase of HW devices for data collection and communication.
Consumables	Purchase of material for microbial cultures (medium, pipes, filters, other consumables)
Temporary employees	Activation of a research grant; temporary employee with ICT know-how by the industrial partner
Subcontracting	Microbiological analysis, chemical analysis (vitamins) and organoleptic analysis
Travel and subsistence	Meetings and exhibitions: *Salone del Gusto 2012* (The most important exhibition of Slow Food Association), *Fiera Sana* (The most important exhibition on organic food).
Meetings and seminars organization	Organization of a workshop to present project results; preparation of dissemination material (web pages, poster, brochure)

R) CERTIFICAZIONE RISORSE MESSE A COFINANZIAMENTO

Il sottoscritto Coordinatore Scientifico, dott. Davide Quaglia, del progetto di ricerca congiunto dal titolo "Tracciabilità integrata e verifica di processo in tempo reale applicata alla produzione di farine da cereali biologici macinati a pietra (E-FLOUR)" presentato all'Università di Verona nell'ambito del Bando di Ateneo per la realizzazione di progetti congiunti con Enti ed Imprese del Territorio "*Joint Projects 2011*"

DICHIARA

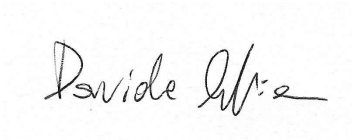
- che il progetto presentato non si sovrappone nei contenuti a progetti di ricerca già precedentemente finanziati dall'Ateneo;
- di aver ottenuto in via anticipata, da parte dei Responsabili Scientifici e dei Rappresentanti Legali delle Unità di Ricerca partecipanti al progetto, adeguata attestazione circa la disponibilità e l'utilizzabilità delle risorse (comprese quelle del personale e per valore d'uso delle attrezzature esistenti) messe a cofinanziamento;

CERTIFICA

la disponibilità e l'utilizzabilità delle seguenti risorse complessive messe a cofinanziamento da parte dei soggetti proponenti (Dipartimenti/Centri ed Imprese/Enti) presso le Unità di Ricerca partecipanti

Soggetto proponente/Unità di Ricerca partecipante al progetto	Risorse finanziarie utilizzabili a cofinanziamento	Valore d'uso delle attrezzature esistenti	Valorizzazione del costo del lavoro del personale strutturato partecipante	Totale Cofinanziamento
Dipartimento di Informatica	1131,91	0	4836,09	5968,00
Dipartimento di Biotecnologie	1000,00	0	9032,00	10032,00
Antico Molino Rosso s.r.l.	24000,00	5525,00	10475,00	40000,00

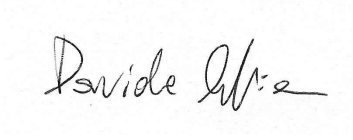
Firma del Coordinatore Scientifico



Data 30 giugno 2011

Per la copia da depositare presso l'Ateneo e per l'assenso alla diffusione via Internet delle informazioni riguardanti i progetti finanziati e la loro elaborazione necessaria alle valutazioni; D.lgs. 196/2003 del 30/06/2003 sulla "Tutela dei dati personali".

Firma del Coordinatore Scientifico



Allegati:

- curriculum vitae dei Responsabili Scientifici e del personale strutturato
- Scheda Segnalazione Referees