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# ON UBIQUITOUS INTEGRATED COMPUTING

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*Abstract:* Ubiquitous integrated computing makes possible new workflow processes and business models which can meet the challenges from the fast growing digital convergence. An *integrated information framework architecture* is proposed, to cope with business challenges to merge and integrated data across domain boundaries. Sensor-data are captured and mapped onto a common (standardized) format where semantic web technologies enable seamless and invisible data-fusion. The proposed architecture raises several technological challenges. Efficient and reliable sensors that can operate in hazardous environment are required. Extended use of sensors may generate vast amount of data, and efficient data filtering, integration and reasoning are needed to benefit from the expanded data collection.

*Keywords*: Integration, Ontology, Semantic Web, Ubiquitous Computing, Reasoning

## 1. Introduction

There is a strong need from the industry to make ubiquitous integrated computing available in the near future, in order to revise workflow processes and realize new business models to meet the challenges from the fast growing digital convergence. The aim is to facilitate information sharing across any network, any device, with relevant content and context in a secure and reliable manner. This implies *unified data processing* by modelling and mapping data into common standards with semantic annotation, extensive data review and validation to ensure high *data quality and relevance*, exchanging and sharing data in a secure network, data fusion and aggregation along with automated reasoning, and visualisation using graphical presentation technology. A project group, with partners from both academia and the industry, is appointed to answer the need for more sophisticated ubiquitous integration technology and solutions.

A prototype framework will be built as a testbed for concept demonstration with plugin-modules for domain specific requirements. It will be based on open standards and technologies. The testbed will provided a vital tool to facilitate concept validation and workflow process refinement in order to lower operational costs and enable provision of advanced integration services. Having a testbed to test the full value chain, ranging from sensor data collection to visualisation of data to appropriate actors is of great importance. We can develop and demonstrate new technology faster to gather new knowledge and research results. The framework may be reused in many industry domains, and four applications areas will be used for illustrating the concept of data integration across domains: *Smart-OilField*, *Smart Home Energy Management*, *Environmental Monitoring*, and *Tele Healthcare*.

As oil productions form the Norwegian continental shelf diminishes, new technologies can be applied to improve the recovery rate from existing fields. One approach is to apply the concept of Integrated Operations (IO) to facilitate more efficient information collection, aggregation and sharing. Currently, generation 1 (IO G1) is being developed, offering only simple application-to-application integration. In the proposed generation 2 (IO G2), full data integration across multiple applications domains, real-time processing and automated reasoning is expected. To fully explore the potential of IO G2, many workflow processes must be revised.

To allow exploration and production in the high north where the environment is fragile, a more efficient and convincing environmental monitoring system has to be in place to prevent pollution. A *real-time monitoring system* can greatly reduce the risk of environmental incidents by reporting frequently and enabling more reliable decisions by correlation data from multiple sources and domains.

In state-of-the-art healthcare systems, healthcare will be provided outside health institutions – on the move or at home – and this requires the use of sensors in a reliable and user-friendly information system. An extended use of sensors and an efficient integration of data are expected to have a great impact on both real-time therapy treatment and the ability to study, analyse and compare treatments off line.

The rest of the paper is organized as follow: Section 2 gives a brief state-of-the-art. Section 3 describes the purposed integrated information processing model. Furthermore, section 4 describes different demos which are to be implemented. Section 5 identifys and focus on different challenges raised by the proposed model and in section 6 we summaries and conclude the paper.

## 2. State-of-the-Art

Many enabling technologies for ubiquitous integrated computing, like sensor technologies, wireless communication, semantic web services and context-aware intelligent computing and visualization, have become mature enough to be applied in industrial and daily life applications. Hence, the grand vision of information sharing among any network, any device, with relevant content and context in a secure and trustworthy manner is now within a realizable range. Ubiquitous computers, networks, and information are paving a road towards a smart world in which computational intelligence is distributed throughout the physical environment to provide trustworthy and relevant services to people. Thus ubiquitous intelligence will change the computing landscape because it will enable new breeds of applications and systems to be developed; the realm of computing possibilities will be significantly extended. By embedding digital intelligence (smart things) in everyday objects, our workplaces, our homes and even ourselves, many tasks and processes could be simplified, made more efficient, safer and more enjoyable. A smart thing can be endowed with different levels of intelligence; they may be context-aware, active, interactive, reactive, proactive, assistive, adaptive, sentient, perceptual, cognitive, and autonomic.

Sensors and their networking technologies have the promise of enabling ubiquitous sensing and communications [1]- Physically distributed near the object being sensed, the sensor technology provides new methods to observe and act on the world, e.g. microhabitat monitoring, structural- and environmental monitoring systems. Industrial applications use extensive instrumentation and now increasingly with more rapidly deployed sensor networks. Advances in reducing senor cost and size imply that they can be inexpensive and small enough to be pervasive. The fact that these devices can communicate means that they can cooperate and relay data to remote users, operating unattended. Also, the emerging Short-range Wireless technologies, such as high data rate Bluetooth, Wireless USB, and low data rate ZigBee, etc. offers easy access to information and communication infrastructures, facilitates seamless connectivity amongst a host of computing, communication and sensing devices that collaborate.

The Semantic Web facilitates the connection of different services, and enables automation of processes, which at presents need to be carried out by humans. Searching, requesting, execution, and payment for services can be accomplished without the need of human interaction. As W3C states; the overall goal of the semantic web is to create a universal medium for the exchange of data. Semantic technologies, like XML, RDF, OWL etc., enables description and connection of data and resources in new and sophisticated manner. Ontologies are used to design models/interpretations of the world, and give an understanding on how different things (data, resources etc.) are connected and related. This information/knowledge can further be distributed, made available and autonomous interpretable by other units. The fully potential can only be reached when data can be exchanged and processed by autonomous tools as well as humans. The idea is that programs of tomorrow must be able to share and process data despite that they have been designed totally independent. The best examples on this idea are probably in the area of social networks, like *facebook.com*, where different applications are integrated in a seamless and invisible manner.

## 3. System Architecture

Currently, integration in mainly focused on ad hoc application-to-application integration. Many integration services already exist in high-end and specialized application areas such as airplane autopilots, military unmanned aircraft (drones), and Formula-1 race cars, but the real challenges are to move to integration of data across application domains and disciplines in a generic environment, this is the hearth of the vision for this project.

A generic integrated information processing model is proposed to provide ubiquitous data integration. Its architecture is illustrated in Figure 1, and the pattern of a general application using the framework can be described as follow: Sensor data and other data are captured, passed through a communication infrastructure, and then mapped into a common (standardized) data format with semantic annotations (metadata). Then data fusion is performed by the middleware by means of correlation, pattern matching, filtering and aggregation of data from multiple data sources and domains. The data fusion process may also involve automated reasoning based on logical rules and polices, enabling assisted mapping, and be able to utilize the semantic layer through web-service interfaces. A seamless infrastructure for data sharing across domains and from any source to any destination is essential for a large-scale digital environment involving many communication organizations. With the proposed framework, large amount of data can be aggregated and dealt with in real-time and decision making can be done automatically, assisted by pattern matching, data correlation and reasoning.

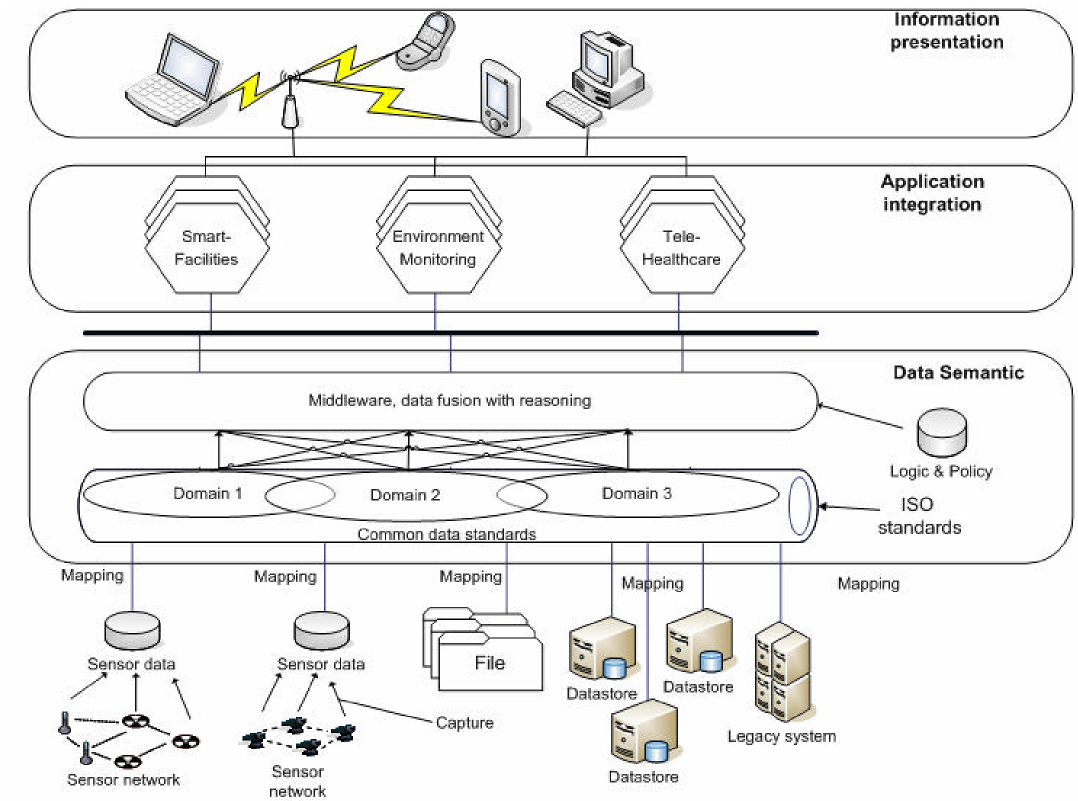


Figure 1: Integrated information processing model

A generic autonomic middleware platform to enable information integration across application domains, where information from a wide range of systems and networks can be collected and aggregated based on logic rules and polices is to be developed. The autonomic middleware provides self-management to cope with the scale and complexity of advanced computing systems and networks, and is classified as follows: the infrastructure, where the self-management properties apply to the network topology and autonomous components, and the applications integration, where semantic data fusion and automatic reasoning and application data is relevant.

The infrastructure is concerned with:

- Self-configuration – components are installed and configured according to predefined policies;
- Self-optimization – reconfiguration due to changing conditions and policies;
- Self-healing by replacing components that fails;
- Self-protecting by detecting and recovering from attacks.

Self-management is especial essential in systems with multiple sensor networks, do to the sheer size of the system. Additionally, data integration across organizational boundaries yields challenges with respect to availability and configuration, as interdependencies between services may render other services (partially) unavailable. This need mandates a self-healing mechanism [2].

The application level is concerned with dat a fusion, i.e. the process of combining data from multiple sources such that the resulting information becomes more accurate, more dependable, and can be combined and viewed in new ways that are more valuable as a comprehensive whole then separate. To achieve this, sensory data need to be collected, correlated, translated and fused before presentation to the application. This is especially true in large-scale collaborative sensor networks exhibiting complex emergent behaviour patterns.

The communication engine in the platform will be based on a distributed event-based system using a publish/subscribe approach over a uniform interface offering a combination of primitives from both traditional reliable communication and probabilistic techniques such as gossip-based protocols. Probabilistic protocols are necessary to handle the sheer volume of real time data generation by multiple sensor networks, and can be used for broadcasting, aggregation and failure detection, etc. The pub/sub platform will offer several innovative features including facilities to enable decentralized reasoning, correlation, filtering, and aggregation.

The distributed publish/subscribe platform will offer primitives for filtering, aggregation, correlation and automated reasoning. Reasoning can be combined with pattern recognition and other modules. Building on these components, we will develop a semantic middleware layer that is able to collect and process information from sensor networks, to process that information and make it available t o the application layer for consumption.

The suggested infrastruct ure provides the necessary tools for achieving ubiquitous sensing and communications that enhances applications such as 24-hours data availability at remote sites, and sensing at sites with harsh conditions. The acquired data will be further associated with machine-understood standardized metadata which maps into the semantic layer.

## 4. Demos

A number of demos are to be built to demonstrate the comprehensive use of the integrated information process model. These demos will be based on the proposed process model and demonstrate the added value of data integration in different business domains. Focus is on use of new tools for remote control and monitoring, integration between business domains and real-time simulation and optimizing of key work processes.

### 4.1. *Smart-OilField*

Modern oil and gas industry is to a large extent a knowledge and information industry, and it is commonly agreed that the capacity of handling large amounts of information has a key impact on both added value and the ability to protect the natural environment. At present, exchange of data demand vast human interaction to ensure information-consistency. Improving the industry's ability to gather, structure, transmit, process and shar e information can make significant contributions to productivity and environment protection. When processed in real-time, precise and accustomed representation of data can give valuable information. Facilities are m oving to subsea, and automation and integration of data processing are essential for controlling and providing situation awareness such that they can be used efficiently. Equipping different equipments and installations with sensors may give valuable information about the operations that was not previously feasible.

There is already an extended use of sensors on drill-rigs and in their surroundings. Wireless sensors are already, to some degree, installed and implemented to capture data from the different parts of the rig, but there is still a lack of real data integration. Real-time sensor data and other (historical) data must be fully integrated and coordinated across domain boundaries, and made available in a seamless and secure manner. Real-time sensor data from the well will be analyzed and compared with stored expert-data to predict the optimal drilling plan on the fly for the well. Drilling equipment will be tagged with RFID sensor for identification and localization, and integrated with other data sources to generate logistic plans. Information is accessed directly at its source, ensuring up to data information. Integrating this information with the daily drilling report containing drilling data such as production volume and productive vs non-productive time into a resource planning toll will allow significant improvement on scheduling of maintenance, identifying resource consumption, and to automate resource allocation. Early fault detection and on-demand maintenance planning will reduce production loss, having great economic benefits. Integrating weather forecasts, equipment arrival delays, dependence between operations and so on will further improve the planning process.

### 4.2. *Smart Home Energy Management*

The proposed model can be used to realize energy-management concepts. Alarm services use wireless sensors in the home combined with a gateway node to send alarm notifications to the alarm company over the Internet. This same (movement) sensors can be used to switch the lightning and heating on/off depending on the room being in use or not. This can be combined with wireless sensors incorporated in light/heating switches. Other types of sensors may also be integrated into such a solution, e.g. light sensors can be used to automatically dim or increase the lightning. Configuration of sensors can be based on simple policy descriptions, and the configuration can be done through a portal on the TV screen, a mobile phone or on a computer. The alarm can be (de)activated through a mobile phone application and location-awareness can be used to automatically launch the alarm application. Furthermore, automatic meter reading can be implemented by means of wireless sensor communication to the gateway node, enabling much finer granularity on the power-usage reading from residential homes. This can be used to increase pricing during peak-hours, giving homeowners an incentive to manage their power consumption accordingly. The system can offer usage statistics on an hourly basis, viewable through the TV screen. Energy companies can also obtain much better usage statistics to assist in making investment and service/repair decisions.

### 4.3. *Environmental Monitoring*

The framework can form the base of an environmental monitoring tool, enabling data acquisition, processing, interpretation, and evaluation of marine environmental effects of offshore industry activities. The tool can integrate information form known environmental risk models, databases (e.g. EnvironmentWeb), metreology, oceanography, AIS positioning system for ship traffic an other relevant data sources which can make the environmental monitoring effective for users. The tool can improve our understanding of the potential harm the pollution has on marine environments and to provide data that will serve to better protect marine life.

At present, environmental monitoring is done by primitive means, e.g. reporting CO2 emission is totally based on estimation and not on measured facts. There is demand from government and industry to have a senor-based solution that provides real-time factual reports. For instance, measuring air intake and burning temperature on oil rigs (or gas-based power plants) and integrating these values into models form the basis for computing actual CO2 emissions; hence, emission taxation could be based on actual emission rather than guesstimates.

An important feature of the monitoring system is the application of e-fields technology such that all recorded measurements are available for online processing. Data can be analyzed at an onshore expert centre using a custom built data management and modelling system to advise the users on the correct course of action at all times. Such advances information sharing and modelling techniques enable the users to forecast/predict the short-term as well at long-term environmental effects of offshore activities.

### 4.4. *Tele Healthcare*

The main research challenge in tele healthcare is to build sustainable and interoperable health information systems and services. A sustainable tele healthcare system is characterized by being adaptive to changes in the environment and at the same time providing the required functionality to end-users. Interoperability is a key factor in achieving sustainability. The overall research challenge for a tele healthcare system can be broken down into three sub-challenges:

- it must be able to utilize external information from other information systems and sensor systems in an effective manner;
- it must provide information to external information systems and services in an interoperable manner;
- it must be robust and adaptable to rapid changes in usage patterns, information need and system concerns like security and performance.

Cross-domain exchange and processing of medical data can result in more accurate and totally information representations, contribute to better understanding on the patients conditions, and increase the changes of correct treatment. Sensor data make feasible remote supervision and treatment of patients. E.g. the patient can be located at home embedded with sensors to capture vital data. Data can be dispatched to the hospital where medical personal can supervise, control, and perform remote treatment on the patient.

In addition to assist and improve real-time patient treatment, this ability to gather and integrate data makes possible offline analyzes and comparison of treatments. Such post-analyzes are important to understand the outcome of different treatments, and improve procedures. E.g., data from resuscitation involves clinical information like demographics and therapeutic events, recordings of cardiac activity of the patient, impedance signals carrying information on therapy. Identifying and analyzing dissimilarities between treatments contribute to the overall comprehension on outcome of treatments, and may influence recommendations of therapy procedures. The proposed integrated information processing model will ease and automate reporting and registration of data, and constitutes a foundation for improved and more reliable data analyzes.

## 5. Challenges

The potential benefits of the ubiquitous information processing model depend on several factors. To make possible seamless and automatic communication of data and information across domain boundaries there need to be a common agreement on how to understand and interpret data. Standards on data modelling and structuring need to be developed. Sensors and sensor technology are developing rapidly, but there are still a number of challenges to be defeated, e.g. efficient sensor location, hazardous environmental strain on sensors, and efficient filtering of sensor data.

The information processing model can only be reaped if the underlying security is strong enough to withstand the inevitable attacks, and also strong enough to remove any linger doubt in the intended end-uses with respect to privacy etc. This is particularly important for e-health applications, where patient privacy and confidentiality, integrity and availability of health records are crucial – just as no one wants their prostate problems aired in the tabloid press, neither do they want to die in the hospital waiting room because their file is unavailable. The importance of security is equally evident in the Integrated Operations scenario – no operator will allow a competitor full access to their data if that means relinquishing control over it.

### 5.1. *Semantic Data Models, Ontology Mapping, and Simulation*

The development of autonomous middleware for an integrated information processing model depends on the ability to enable knowledge sharing between distributed heterogeneous data sources such as sensor networks. So fare, semantic approaches to this problem show promise by resolving heterogeneity by letting the data sources use a common ontology. Such common ontology offers the ability to work with data from disparate sources as if they were located in a central repository.

Developing a semantic layer by using ontologies provides a consistent interface to upper layers. Applications that understand and interpret the same ontologies can communicate despise that that they where design independently. Instead of having one distinct mapping for each application-to-application communication, it is only needed for the applications to map to a common ontology (CO). Ref. Figure 2. In the last year we have seen an increasing development and use of such ontologies, but this is still in the initial phase. The challenge is to build intelligible and reasonable ontologies.

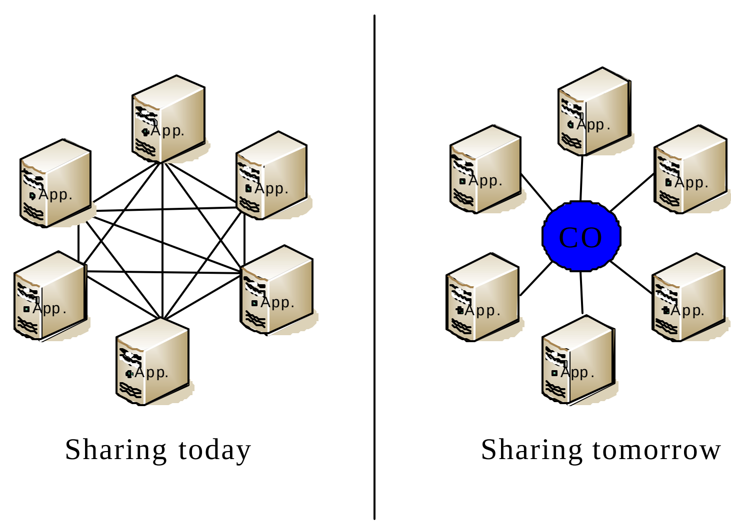


Figure 2: Data integration - Vision

Data from different sources can be feed into simulation tools, to improve and reduce decision-time. For instant, the oil and gas industry wish to decrees the average time-to-decision to approximately 4-5 seconds. This demand for simulations tools to, on-the-fly, predict future outcome/progress. See Figure 3Historical data are feed into a simulation tool to predict further processes. Filtered (to strip off irrelevant data) real time data are added, to concurrently update and adjust the prediction. Enriched with this real time data decisions can be made on-the-fly.

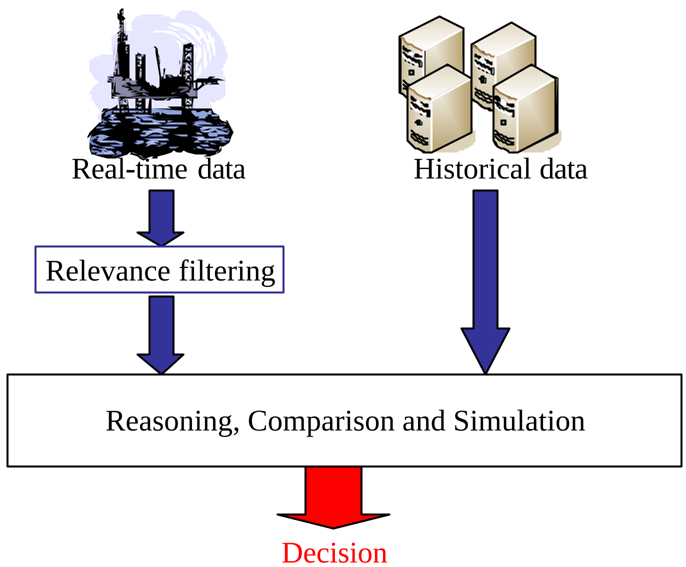


Figure 3: Real-time simulation and optimization

**5.2.** ***Sensor Technology and Data Collection***

Wireless sensor and actuator networks (WSAN) are based on the random deployment of large number of tiny sensor nodes and actuators into or very close to the phenomenon to be observed. They introduce many application areas such as tactical surveillance by military unattended sensor networks and elderly and patient monitoring by body area networks etc. They are in essence ad hoc networks with additional and more stringent constraints. They need to be more energy efficient and scalable compared to conventional ad hoc networks. Wireless mesh networks (WMN) are another member of ad hoc networks domain aiming at application areas such as infrastructureless network scenario for developing regions, and low cost multi hop wireless backhaul connections. Actually, ad hoc networks can be considered as subset of WMN because they also provide a wireless backbone for internetworking the other mesh, ad hoc or infrastructure based networks such as Internet, IEEE 802.11/15/16, cellular, WiFi, WiMAX, and WiMedia networks. WSAN and WMN offer security challenges due to limited power capacity and lack of central authority and availability of various access technologies compared to the typical ad hoc network nods.

RFID tags may be used to provide automatic and reliable identification of objects, such as people, animals or cars. Some tags can also store data. Application areas today are manly in logistics, ticketing and access control. An increasing number of usage areas are expected, particularly within the transport and health sector. An important feature would be to monitor the environment of the transported goods and how they are treated. In these cases RFID tags with integrated sensors (e.g. temperature, humidity, acceleration or shock) could provide increasingly useful. The challenge is to acquire RFID data and deliver it to the semantic middleware in an integrated and secure manner. In some areas, e.g. oil and gas, RFID tags need to tolerate harsh conditions, like high temperature and pressure, and the challenge is to develop RFID tags that can withstand hazardous environmental strains.

Underwater senor networks have many potential applications. For instance, seismic imaging of undersea oilfields is a representative application that may imply significant economic benefits over traditional technology, helping to improve resource recovery. However, underwater communication models are not yet completely available, where communication is hampered by temperature, salt content, and other ocean factors. Technology challenges include: Micro senor based sensing; Underwater and near sea surface communications and networking; Node localization and time synchronization; Data correlation, association, aggregation, fusion, and querying.

Passive measurements have been around for a while; the technology is moving toward applications where collective action properties enable new types of operations. As important as monitoring is, autonomous reaction to the environment will be the ultimate hallmark of distributed sensing. An established and stable platform based on distributed senor networks allows data stream coming from the distributed instruments to act in a collective manner. Putting intelligence into the instrument embedded in the field is the only way to ensure practical performance for real-world demands. Once that occurs, the applications for this wireless technology are truly as endless as projected.

In a pattern recognition framework, measurements derived from one or more signal/image sources are collected and integrated into feature vectors. Thus, the individual features in the feature vectors will represent specific system properties. The main objective of the pattern recognition system will be to identify the state of the system. The proposed generic framework should have problem independent and flexible functionality: for defining and expanding a classification system where the various states of the system can be coded e.g. allowing the annotation of a recorded signal. Furthermore a class-definition and data extraction module should enable the user to define criteria for extracting and grouping data according to what the pattern recognition system is supposed to identify. It should be possible to export extracted data to a software environment that facilitates the design of feature extraction strategies and the pattern recognition system. Likewise, it should be possible to import a designed feature extraction and pattern recognition system into the framework.

In a sensor cluster, i.e. a collection of several different sensors, signal processing is important for filtering, aggregating, and communication of the usually large amount of raw data from the sensors. The sensors can be standalone sensors or distributed sensor networks (DSN). If the distance between sensors and main system is small and the bandwidth of the communication channel is large enough, processing may be postponed and performed in the main system rather than at sensor level. A complete measurement system includes both the sensor network and the main system, as well as infrastructure for signal processing and communication. The following issues give interesting signal processing and communication research opportunities: It will be important to improve the signal by *noise reduction* or by amplifying the information carrying components of the signals. In DSN an interesting new topic is distributed adaptive filtering, where focus will be on developing *generic distributed adaptive filters.* The use of source coding in a DSN framework presents new challenges as a result of the entities being communicated possessing both temporal and spatial correlations. In DSN, communication is a crucial point as it implies power consumption and one of the main goals of DSN is being able to operate for extended periods of time on small batteries. One active research strategies (routing, protocol design) maximizing the communication capacity for a given level of available energy. In applications for surveillance, environmental monitoring, and safety both in private homes and industry, video cameras are part of the sensor system. Given an image sequence (video), how can we describe the motion of objects and background?

Context-awareness is used to determine if actions should be taken in a given context, e.g. many ubiquitous computing applications rely on sensor networks in which the sensors geographical located is important. Yet, the sensor themselves may not know their exact position. Fitting each sensor with GPS receiver would be expensive and would also lower the lifetime of their batteries considerably. One challenge would be to infer the approximate position of the sensors based on other information and then using that sensor information in spatially aware applications.

### 5.3. *Safety, Reliability, Security, and Privacy*

The full benefit of cross-organizational data sharing, correlation and data fusion can only be attained when security and fault tolerance mechanisms are in place that allows the data owner to control access, yet retaining the availability and usability of the data. There is a need to provide security mechanisms that allow sharing of data and interaction between diverse organizations, thus enabling true data integration and cross-referencing without sacrificing confidentiality or integrity; and without reduced availability due to malicious intent. Cross-domain data may yield new information that even the information owners were unaware of. Increased interconnection of data across organizational boundaries will significantly enlarge the attack surface.

Queries need to be made across data regardless of the community in which it originates, while enforcing adequate security to prevent information theft. The user on ontologies and reasoning mechanisms makes it possible to reason about information in new an sophisticated ways that has not been possible before. This ability to reason about information allows more subtle attacks [3], thus demand for focusing on security in the development of ontologies. We need to protect RDF and RDFSchemas, and we need mechanisms to control the creation of statements about resources and other statements. Ontologies may have security levels attached to them. The challenge is how to use ontologies for secure information integration. How can information be managed, integrated, and exchanged securely?

Over the past years there have been proposed several security related standards for web applications; like XML, WS-security/trust/policy, SAML, and Liberty Alliance. These standards assume a well-established web of trust among business-to-business partners [4]. In an open homogeneous and dynamic network different entities relying on different security mechanisms and security policies should be able to make connections on the fly. This autonomous coupling of multi-domain, homogenous systems and the increased ability to reason about information creates new security challenges, thus demand for fresh thinking when it comes to security and security solutions. E.g. there is a need for reasoning about security at a semantic level [5]. Security ontologies makes a foundation for services to reason about other entities security-related properties, thus make them able to determine if they can cooperate, and under which conditions.

The semantic web implies that there will no longer be physically isolated data, and online data are more vulnerable to theft and disclosure. Business critical data must be protected, while still remaining accessible to those that have a legitimate need for them. This implies that a trust infrastructure must be established, and that identity federation will be needed for cross-domain AAA. This must in turn be linked to security policies. There has been little research addressing authentication specific to the semantic web. Most access control and trust research simply assumes that authentication is present. Existing certificate schemes that may be used in the semantic web includes X.509 [6] and PGP (Pretty Good Privacy) [6].

Role-based access control policies (RBAC) can be used as a basis for access control in knowledge management [7]. The challenge is to create a new RBAC form allowing for some user exploration without providing a carte blanche. A different approach is to use policies for defining access control [4, 8], where each entity specifies policies regarding authentication, access control, privacy etc.

When the semantic web becomes a reality it will be important to device new mechanisms that allow users access to part of information without allowing them to aggregate a complete database. This applies to both privacy-related data, but also confidentiality in general. Furthermore, the users of semantic web will be vulnerable to profiling based on the information they access, and new mechanisms are needed to prevent this.

Continuous information availability is a challenge when operating over sparsely connected infrastructures. To this end, we need to leverage routing mechanisms, redundant paths, and component to ensure highly available resources where this is required, and this need to be viewed in relation to the self-healing mechanism of the autonomic middleware. Self-protecting is also necessary to proactively detect and recover from malicious attacks on the infrastructure. Strong reliability guarantees can be provided by means of replicated objects or a transaction system.

We need to identify the security challenges inherent in the semantic web, and propose architectures for semantic web deployment that ensures the security of the semantic content. The overarching motivation for the semantic web is information sharing, and thus we need to establish what kind of information is to be shared, how information can be combined, and how this can be tracked through the information lifecycle. One of the fundamental principals in the proposed model is the use of open standards, and standardized technologies. Upcoming and new web-service security standards from both W3C and OASIS should be considered.

## 6. Conclusion and Further Work

Many enabling technologies for ubiquitous integrated computing have become mature enough to be applied in industrial and daily life applications, and the grand vision of information sharing is now within a realizable range. Currently, integration is mainly focused on ad hoc application-to-application integration, but the real challenge is to move to integration of data across application domains and disciplines in a generic environment.

A generic prototype framework is to be built as a testbed for concept demonstration with plugin-modules for domain specific requirements. Sensor-data are capture and mapped onto a common (standardized) format where semantic web technologies enable seamless and invisible data-fusion, reasoning and simulation to enrich and improve information representation and accompanying decision making. A generic testbed, like this, is desired by many industries to demonstrate the concepts, verify ideas and methods, and to visualize the potential of future work processes and business models. The framework may be reused in many industry sectors like energy (oil, gas, and electricity), environment and healthcare.

A present, the recovery rate from oil field is approximately 30-40%. By applying *Smart-OilField* technology an increase of 5-6% is estimated, with considerable economic benefits. The urgent need for skilled labour due to economic growth can be alleviated with the technology developed, as it has significant potential to relieve such labor for less mundane tasks.

Energy management can reduce emission; real-time environmental monitoring will enable faster response to pollution; enable direct reporting to government; and remote sensing and control will reduce the need for traveling to monitored sites for physical observations.

The proposed model raises several challenges that need to be dealt with Ontologies and integration tools need to be further developed to make feasible reasonable and valuable data fusion. Furthermore there is a need for good simulations - and representation tool to make use of this "new" integrated information.

Even though the sensor technology has evolved rapidly in the past years there are still challenges to overcome before sensors can be used to a fully extend. Sensors are to be used in hazardous environments, and need to tolerate harsh strain.

The full benefit of data fusing can only be attained when security and fault tolerant mechanisms are in place. For the purposed model to be adopted we need to ensure proper information security, privacy and integrity as well as a fault tolerant infrastructure.

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