Contract No. IST 2005-034891

# Hydra

**Networked Embedded System middleware for Heterogeneous physical devices in a distributed architecture**

# D9.2 Building Automation domain requirements

**Integrated Project**
**SO 2.5.3 Embedded systems**

**Project start date: 1st July 2006** **Duration: 48 months**

**Published by the Hydra Consortium** **25 May 2007 - version 4.0**
**Coordinating Partner: C International Ltd.**

**Project co-funded by the European Commission within the Sixth Framework Programme (2002 -2006)**

**Dissemination Level: Confidential**

**Document file:** D9.2 Building Automation domain requirements v3.0.doc

**Work package:** WP9 – User Applications

**Task:** T9.3 Develop user application two

**Document owner:** Jesper Thestrup (IN-JET)

**Document history:**

| Version | Author(s) | Date | Changes made |
|---|---|---|---|
| 1.0 | Christine Ludwig (C-LAB) | 09-03-2007 | Initial version |
| 2.0 | Christine Ludwig, Siegfried Bublitz (C-LAB), Nuno Costa (INNOVA) | 12-04-2007 | Changes and restructuring of the document |
| 3.0 | Jesper Thestrup (IN-JET) | 21-05-2007 | Major restructuring, added content related to professional applications |
| 4.0 | Heinz-Josef Eikerling | 25-05-2007 | Final version submitted to the European Commission |

**Internal review history:**

| Reviewed by | Date | Comments |
|---|---|---|
| Siegfried Bublitz | 25-05-2007 | Minor corrections |
| Heinz-Josef Eikerling | 25-05-2007 | No fixes. Demonstrator description and related requirements will have to be done in D9.5, since the initial scope of the document has been changed. |

**In Memoriam**

**This deliverable is dedicated to Christine Ludwig**

## Index:

# 1. Introduction

## 1.1 Background

The Hydra project develops middleware for networked embedded systems that allows developers to create ambient intelligence applications. System developers are thus provided with tools for easily and securely integrating heterogeneous physical devices into interoperable distributed systems.

The middleware will include support for distributed as well as centralised architectures, cognition and context awareness, security and trust and will be deployable on both new and existing networks of distributed wireless and wired devices that typically are resource constrained in terms of computing power, energy and memory. Hydra middleware will be based on a Service Oriented Architecture (SOA), to which the underlying communication layer is transparent.

The middleware will be validated in three application domains: Building automation, healthcare and agriculture. The HYDRA middleware can be used in building automation applications, e.g. for building automation, energy management, facility management or total management of technical components and infrastructure.

## 1.2 Purpose and context of this deliverable

The objectives of WP9 are to demonstrate and validate user applications in three different domains using the Hydra middleware. As such, WP9 is structured as follows:

1. Derive initial domain specific requirements for end-user applications based on the Hydra middleware.
2. Define and describe demonstration use cases, which will address the user requirements.
3. Build the use cases for inclusion in the first, second, and third demonstrators (M12+M24+M36).
4. Test and validate the demonstrators with users.
5. Feed back user responses and validation results to next step in the iterative phase.
6. Close the loops with the final demonstrator (M48).

This deliverable will define the domain specific requirements to be included in the second set of user applications based on the Hydra middleware, which will focus on the building automation domain. It will hence address step 1 and 2 of this process. The following steps will be defined in the following and will be detailed in relevant deliverables.

Domain specific requirements for the building automation and the agriculture domains are presented in *D2.3 Healthcare domain requirements* and *D2.4 Agriculture domain requirements* respectively.

## 1.3 Requirements engineering

The user-centric software development (UCD) process in the Hydra project incorporates requirement engineering processes that follow the principles of ISO 13407 "Human-centred design processes for interactive systems". The user-centric design approach implies an iterative approach with cycles that allow the project to advance from initial specifications and prototypes via experience and evaluation to updated specifications and improved prototypes.

To kick off the requirements engineering process, vision scenarios for the healthcare domain were first developed using the IDON method with contributions from experts in healthcare systems and medical devices. The scenarios developed this way are visions of future deployment of Hydra enabled systems providing coherent, comprehensive, internally consistent descriptions of plausible futures and are fully described in *D2.1 Scenarios for usage of Hydra in 3 different domains*.

From the vision scenarios, technical scenarios were derived focussing on the detailed workflow of developer users in Hydra enabled environments and addressing technical questions referring to the middleware, both at device level and at runtime. The technical scenarios were evaluated by focus groups of developer users and a large number of requirements were gathered using the Volere template.

The functional and non functional requirements thus derived were finally integrated and generalised to form a package of developer user requirements specifications that was fed into the architectural definition. The full description of the requirement gathering process and the collected requirements is found in *D2.5 Initial Requirements*.

The complete set of functional and non functional requirements (including security and socio-economic requirements) finally formed the basis for the initial architecture proposed in *D3.3 Draft of architectural design specification*.

It is important to note that the present domain specific requirements are not new requirements in relation to the comprehensive set of requirements already gathered and reported in *D2.5 Initial Requirements*. All domain specific requirements are already included in the Volere template. Hence, the domain specific requirements constitute a subset of requirements that are most relevant to the specific domain. This exercise can be helpful in the requirements engineering process for prioritising, resolving conflicts and filtering for demonstrations of the large number of requirements gathered.

### 1.4 Demonstrator cycles

A total of four iteration cycles is planned in the Hydra project. Each cycle leads to a demonstrator in a new domain, while the previous demonstrator is being updated. The first cycle is the demonstrator in the building automation domain. In the next cycle a demonstrator in healthcare is added, while the building automation demonstrator is augmented. In the third cycle a demonstrator for the agriculture domain is added and the two other domains are augmented.

The goal of this procedure is not to focus only on the evolution of the demonstrators but on the refinement of scenarios, requirements, specification of the middleware and its implementation. This iterative process ensures a gradual approximation to the final middleware.

The first demonstrator will be the "proof-of-concept-demonstrator" of the Hydra middleware. It will be based on use cases and scenarios from the building automation domain. The deliverable *D9.5 Concept demonstrator* provides a full technical description of the first demonstrator including the scenario to be demonstrated, the sequence diagrams, and the technical solution chosen.

Demonstrator two will focus on demonstrating the Software Development Kit (SDK). This demonstrator will aim to demonstrate how a developer user can build an application using the Hydra SDK. The main setting of the second demonstrator will be the healthcare domain, but new aspects of the building automation scenario will also be demonstrated. The deliverable *D9.6 SDK demonstrator* will provide a technical description of the second demonstrator. It will be updated with new knowledge and new facilities in subsequent iterations following the progress of the project.

Demonstrator three will focus on demonstrating the Device Development Kit (DDK). This demonstrator will aim to demonstrate how a developer user can enable a device for networking using the Hydra middleware. The main setting of the third demonstrator will be the agriculture domain, but new aspects of the building automation and the healthcare scenarios will also be demonstrated. The deliverable *D9.7 DDK demonstrator* will provide a technical description of the third demonstrator. It will be updated with new knowledge and new facilities in subsequent iterations following the progress of the project.

At the end of the project, a complete Hydra middleware platform capable of demonstrating the use cases and scenarios in three different user domains will be available.

## 1.5 Scope of this deliverable

The document starts with an introduction to the building automation domain and its specific challenges imposed on applications for this facility management, smart home, remote control and monitoring, remote metering, etc. Chapter five describes some of the trends and challenges, which among other things, were discussed during the scenario workshops, and looks at the state of the art in commercial solutions available today.

In chapter five actors and target users are described and an initial set of domain specific requirements for applications based on Hydra middleware in the building automation sector is derived from the work in task T2.1 *Scenario thinking*. Moreover, both generic and specific requirements are derived from the vision scenarios and correlated to the Volere based requirements.

Finally, the chosen vision scenario "The Beehive" is provided in chapter 7 for reference.

# 2. Executive summary

## 2.1 The process

The user-centric software development (UCD) process in the Hydra project implies an iterative approach with cycles that allow the project to advance from initial specifications and prototypes via experience and evaluation to updated specifications and improved prototypes.

From the vision scenarios, technical scenarios were derived focussing on the detailed workflow of developer users in Hydra enabled environments and addressing technical questions referring to the middleware, both at device level and at runtime. The functional and non functional requirements thus derived were finally integrated and generalised to form a package of developer user requirements specifications that was fed into the architectural definition. This deliverable will define the domain specific requirements to be included in the second set of user applications based on the Hydra middleware, which will focus on the healthcare domain. It is important to note that the domain specific requirements are not new requirements in relation to the comprehensive set of requirements already gathered and included in the Volere template.

A total of four iteration cycles are planned in the Hydra project. Each cycle leads to a demonstrator in a new domain, while the previous demonstrator is being updated. The first demonstrator will be the "proof-of-concept-demonstrator" of the Hydra middleware. It will be based on use cases and scenarios from the building automation domain. Demonstrator two will focus on demonstrating the Software Development Kit (SDK). This demonstrator will aim to demonstrate how a developer user can build an application using the Hydra SDK. The main setting of the second demonstrator will be the healthcare domain, but new aspects of the building automation scenario will also be demonstrated. Demonstrator three will focus on demonstrating the Device Development Kit (DDK). This demonstrator will aim to demonstrate how a developer user can enable a device for networking using the Hydra middleware. The main setting of the third demonstrator will be the agriculture domain, but new aspects of the building automation and the healthcare scenarios will also be demonstrated. Details of all demonstrators are found in the corresponding deliverables.

At the end of the project, at complete Hydra middleware platform capable of demonstrating the use cases and scenarios in three different user domains will be produced.

## 2.2 The building automation domain

The term “Building Automation” covers a great many distinctive market and technology segments with a diverse set of end-user and developer user requirements. The term also covers both professional and private consumer end-users.

The field of Intelligent Buildings, Intelligent Homes and Building Management Systems (BMS) encompasses an enormous variety of technologies, across commercial, industrial, institutional and domestic buildings, including energy management systems and building controls. The function of Building Management Systems is central to “Intelligent Buildings” concepts: its purpose is to control, monitor and optimize building services, e.g. lighting, heating, security, CCTV and alarm systems, access control, audio-visual and entertainment systems, ventilation, climate control, etc.. Even time and attendance control and reporting (notably staff movement and availability). The potential within these concepts and the surrounding technology is vast, and peoples’ lives are changing from the effects of Intelligent Buildings developments on living and as well working environments.

In the professional segment, there are several topical themes such as “Industrial Services”, “Facility Management” and “Total Management”. For the purpose of a maintaining a strict and rigorous methodology, we aim to establish a clear definition and a technical, contractual and business framework for these terms.

In order to increase business value, product companies have increasingly been looking for other, related products and services. If the products are used as part of a complete installation involving various manufacturers’ products, system integration is a valuable proposition seen with the customers' eyes. It provides a single point of responsibility and increases the likelihood of success. Added value can also be derived from long term planned, preventive and predictive maintenance and value added services such as remote monitoring and compliance monitoring and documentation. All of these products and services adds value to the company's product offerings and, to most companies, represents a reasonable balance between risk and value. We will use the term "Industrial Services" for these activities.

In the consumer market, technology is often used as a routine or a daily application, so that people are not really thinking about what they are doing. In order to increase the success of a new technology it has to be ensured that the technique can be easily integrated into the daily life of the user.

Hence a smart home is often a completely networked, both internal and external controllable house which is electronically secured and equipped with different features and based on self-learning software. This software is setting up user profiles based on the behaviour of the different users and is automatically disposing resources at that times when they are expected to be needed by the users. But of course it is possible that the user is able to manually control any process in the house at any time – the software is also learning from that. A smart home is at the moment not yet a real intelligent home.

This more widespread use of smart home technology has been enabled by the standardization of control networks, the creation of a standard communication protocols, and by a broad range of sensors in Europe. Single solutions in the smart home sector have now reached a phase of development in which further development steps are taking place, but in which no radical innovations are necessary any longer.

## 2.3 Domain specific requirements

A Hydra target group consists of all active or potential manufacturers, developers, customers and users of an application. The target groups can be further differentiated by a classification following relevant criteria such as demographic or psychographic ones. The different actors identified in this way will have different expectations and will see the usefulness of the Hydra middleware from different perspectives. In other words, their requirements will be different. The identified actors are:

- Developer user
  - Smart Home application developer
  - Manufacturer of consumer devices
- Facility Manager / service provide
  - Smart Home application provider
- End user
- Home owners
- Demanding home owners
- Seniors
- Disabled persons

The functional user requirements specifications include the most important aspects of user expectations in building automation applications. The ten experts concluded that the following specific requirements were most relevant for their domain:

**Functionality**

The demand for increased functionality will be backed by an increasing number of public requests that will only be available in electronic form and which could be facilitated by automatic monitoring and metering (i.e. compliance, resource consumption reporting, etc.). All systems must be flexible, adaptable, configurable, scalable and modifiable in order to take advantage of networking. The systems must also be easy and simple to use for the end-user. Various forms of wearable computers will increasingly be available for executing applications. For mobility and ease of use, it can be assumed that all end-users will have and be able to use mobile phones and PDA's. Although additional functionalities in appliances and devices normally will lead to higher product costs and use costs, the additional development costs to add new functionalities to products through interoperability with other manufacturers' devices are low.

**Networking**

The increased need for networking of products and devices is beyond any reasonable doubt and the market will respond with a strong growth in products that able to communicate and interact. This will lead to an increased appearance of interoperability standards where device drivers, interfaces and applications may need a third party certification to be acceptable for other manufacturers when used for networking applications. New standards may be needed for this, but their scope and form is still unknown. The end-users will normally assume that the systems will function properly in their intended operating environments but system malfunction in interconnected products may need to be legally regulated. In order to minimise system malfunctions, preventative measures, which can predict and prevent malfunctions, will increasingly be needed. Prevention of malfunctions may also require that devices can be upgraded automatically.

**Privacy and security**

Building automation devices will need to have security features installed that can prevent any kind of intended and unintended misuse and the specific security model must be established as part of the development process. However, the responsibility for system security is not always clearly defined or assigned to specific actors, and the security model can either be centralised or distributed across the network. However, access rules will be commonly understood and accepted among end-users. Manufacturers will wish to have open remote access to their own systems on end-users' premises for maintenance, upgrade and service delivery. Hence, manufactures will (as a consequence of their brand name) be able to impose some access control models and authentication schemes on end-users. Authorizations will probably handled by third party authorization bodies, but other trusted authorization methods may emerge.

**Power**

End-users will increasingly demand products that use less energy, which can be seen as being in conflict with the increased demand for extended functionality. In some cases smart home devices will be able to use new types of renewable energy sources thereby decreasing the need for traditional energy. Systems will e.g. be extendable with energy producing devices like solar panels forming parts of the network.

**Design**

Most devices and appliances are today equipped with simple touch pads for easy interaction, but it may be too limited for serious interaction in the future where user interaction increasingly will take place using multimodal interfaces. Generally, devices and interfaces must be designed according to ergonomic principles and especially socially and physically disadvantaged end-users should be supported with other modalities for easier interaction.

**Business models**

Manufacturers will use preventative maintenance and remote service monitoring to increase customer loyalty and create new services. Manufacturers will increasingly offer both products and services in value enhanced bundles and need new business models for this. Smart home technologies are generally affordable and smart home appliances will have a high value propositions. Other manufacturers will explore the market by introducing new products and services with similar propositions and utilising the networking capabilities.

# 3. Building automation domain overview

The term "Building Automation" covers a great many distinctive market and technology segments with a diverse set of end-user and developer user requirements. The term also covers both professional and private consumer end-users.

The field of Intelligent Buildings, Intelligent Homes and Building Management Systems (BMS) encompasses an enormous variety of technologies, across commercial, industrial, institutional and domestic buildings, including energy management systems and building controls. The function of Building Management Systems is central to "Intelligent Buildings" concepts: its purpose is to control, monitor and optimize building services, e.g. lighting, heating, security, CCTV and alarm systems, access control, audio-visual and entertainment systems, ventilation, climate control, etc.. Even time and attendance control and reporting (notably staff movement and availability). The potential within these concepts and the surrounding technology is vast, and peoples' lives are changing from the effects of Intelligent Buildings developments on living and as well working environments.

In this chapter we aim at providing an overview of the very diverse market for building automation applications and we try to identify a set of common (or mega) trends and challenges affecting the requirements for the Hydra middleware. The exercise can be helpful in the requirements engineering proves for example for prioritizing the identified requirements, resolving conflicting requirements and for filtering of the large number of requirements.

## 3.1 The professional segments

In the professional segment, there are several topical themes such as "Industrial Services", "Facility Management" and "Total Management". For the purpose of maintaining a strict and rigorous methodology, we need to establish a clear definition and a technical, contractual and business framework for these terms.

From a business perspective, the main difference between Industrial Services, Facility Management and Total Management has primarily been the "management" element and the greater responsibility that goes with it. In this respect management shall be understood to include technical work process and human resource issues and also legal, ethical, health and safety and social issues. The value offerings that businesses and service providers may consider can thus be grouped in a structure as shown in figure 2.

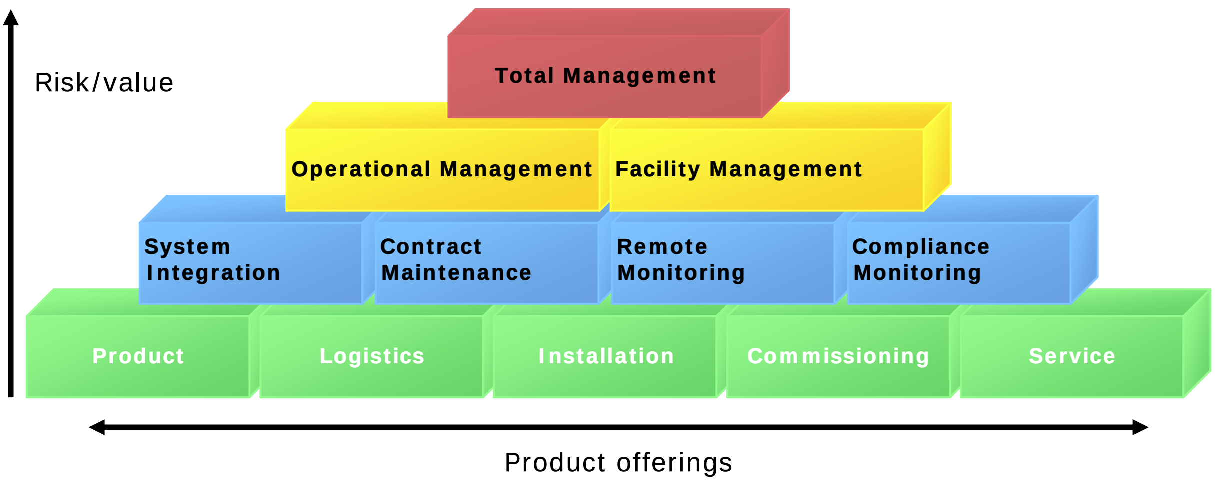


Figure 1 Risk and added value in product offerings

Traditionally, more involvement in management issues means greater value potential, but also greater risk. Firms need to balance the risks and the business opportunities stemming from the value creation process of assuming increasingly greater management responsibility (read: liability).

Product companies traditionally initially expand their business horizontally at the lowest level. They provide logistics support for their customers, perform installation and commissioning of their products and offer various degrees of basic services. All of these offerings are closely related to the firms own products and will not greatly increase business risks; neither will it add significant value to the business processes over and above keeping the customers happy and maintaining a competitive position in the market. Except for maybe the products themselves, companies may choose to provide any offering in co-operation or alliance with business partners.

In order to increase business value, product companies have increasingly been looking for other, related products and services. If the products are used as part of a complete installation involving various manufacturers' products, system integration is a valuable proposition seen with the customers' eyes. It provides a single point of responsibility and increases the likelihood of success. Added value can also be derived from long term planned, preventive and predictive maintenance and value added services such as remote monitoring and compliance monitoring and documentation. All of these products and services adds value to the company's product offerings and, to most companies, represents a reasonable balance between risk and value. We will use the term "Industrial Services" for these activities.

When firms seek to go further in creating value offerings for their customers, it inevitably involves some degree of management and thus greatly increases responsibility and risk. "Operational Management", "Facility Management" and "Total Management" involves companies' taking over large portions or even all of the management responsibilities previously vested with the owner and operator of manufacturing operations or process facilities.

Firms offering these services need to be solidly rooted in the particular area they wish to operate in, in order to contain the risks within reasonable boundaries. Hence the professional players in this business segment can offer serious business propositions with very high added value. Not so professional or inexperienced players can still get involved by teaming up with smaller professional players and offer bundled services.

The business activities are aiming at absorbing outsourced tasks relating to the whole lifecycle from installation and commissioning over maintenance to end-of-life retirement and replacements of components and complete installations as well as new value added services such as remote monitoring and compliance services (the two lowest levels in the hierarchical structure in Figure 1).

## 3.2 The non-professional segment

The usage of technology is depending on the demands of the society. Normally, technology is used as a routine or a daily application, so that people are not really thinking about what they are doing. In order to increase the success of a new technology it has to be ensured that the technique can be easily integrated into the daily life of the user.

In order to increase business value, product companies have increasing been looking for other, related products and services. If the products are used, as part of a complete installation involving various manufacturers' products, system integration is a valuable proposition seen with the customers' eyes. It provides a single point of responsibility and increases the likelihood of success. Added value can also be derived from long term planned, preventive and predictive maintenance and value added services such as remote monitoring and compliance monitoring and documentation. All of these products and services adds value to the company's product offerings and, to most companies, represents a reasonable balance between risk and value. We will use the term "Industrial Services" for these activities.

The lifestyle is determined by the ideals of the individual. These ideals are also of high importance regarding to daily routines and determine the attitude in consumption of the individual. The decision whether to invest in a new technique or not is therefore also depending on the individual lifestyle and its indicators.

The acceptance of a technology is depending on a life-long process of user's behaviour and attitude on new techniques. Factors which influence these attitudes and behaviour are:

- The attitude against technology in parent's house
- The occupation and education
- Financial background
- Social background (friends, culture and region of living)

From all of these indicators, it can be said that smart home acceptance is very high in the following end-user segments:

- DINKS, Dual-Career-Families
- Men
- Higher educated persons
- Persons with a high acceptance of new technology
- Persons with a higher or medium income

The dramatic increase and awareness of energy use concerns, and the advances in cost-effective technologies, energy efficiency is rapidly becoming part of the domestic residential construction sector. For lighting, energy savings can be up to 75% of the original circuit load, which represents 5% of the total energy consumption of the residential and commercial sectors.

Energy savings potential from water heating, cooling, or hot water production, can be up to 10%, which represents up to 7% of the total energy consumption of the domestic residential and commercial sectors.

Experiences from studies in Austria suggest that potential heating and cooling energy savings are up to 30% in public buildings[1]. Even allowing the fact that the buildings in this study may have been those with particularly high energy usage, the figure is impressive.

Security systems are mostly part of smart home systems. A break-in is a dramatic experience for most people because of the material lost on the one side and also because of the lost of privacy they feel. Another reason for advanced security systems is that some insurance companies vary in the prices between houses with security alarm services and those with none. So some insurance companies actually provide a discount on a homeowner's insurance policy that can range from 5% to 25%, if a property is protected by a home security system.

But security systems are not only limited to alarm systems in case of a break-in. They can also protect people against break-ins by light-on-movement systems or simulated occupancy.

Another aspect of security systems are for example baby monitoring systems like baby-TV or the prevention of domestic accidents.

Smart home technology assists in monitoring patients in their homes. Earlier, they would need weeks of hospitalization and examinations prior to the correct diagnosis or to monitor any variances. A sensor attached to the skin would allow the patient to stay in his or her home while the home gateway would transfer all information directly to the hospital or to an ambulance station. A procedure actually facilitating a better basis for diagnosis since the measurements will reveal the patient's condition in his or her normal everyday routines – rather than the atypical behavioural patterns of hospitalization. Other smart home systems can support elderly or sick people by fulfilling tasks in their every-day life and help to avoid dangerous situations like regulating the oven, switching off a forgotten iron or reminding them to take their medicine etc. The smart home technology could without doubt improve the traditional care for the elderly.

In order to enhance and improve resident's lifestyle, it is possible that smart home applications overtake several routine functions around the home. Applications thinkable are for example the automation of lighting functions, heating, air condition etc. Central locking is another feature which enhances the convenience as well as the security of home residents.

[1] EU2 Analysis and Market Survey for European Building Technologies in Central & Eastern European Countries - GOPA

# 4. Trends and challenges in building automation

## 4.1 Industrial services

Industrial Services are closely related to manufacturers' products and no separate market analyses exist for these services. However, several estimates show that the Industrial Service market could be as high as 3-4% of the total industrial market and could be as much as €60-70 billions annually.

The activities within Industrial Services, which are relevant to Hydra middleware, are related to all aspects of monitoring and maintenance of technical equipment and machinery used in business environments, either directly in any kind of manufacturing process or as supporting machinery for infrastructures such as commercial, buildings, supply, support, and logistics systems. The following life-cycle related activities can be identified:

New business models among the manufacturers often include services such as system integration, preventive and predictive maintenance, remote monitoring and compliance monitoring, all of which required new and improved functionality in the products, both existing and new.

New offerings will also include value added services based on bundling of manufacturers' products, system and service integration as well as a new level of intelligence in the products to be used for remote monitoring and compliance monitoring and documentation. As an example, a pump with build-in monitoring capabilities, will have remote communication channels that can be used for transmitting other information like meter readings or compliance data. Such information will represent value propositions to completely new business partners such as utility companies and health inspectors.

Security and privacy issues are focused on maintaining operational availability, integrity and confidentiality in the day-to-day operations of the organisation. The ISO-17799 and related standards sets out guidelines for the security polices to be adopted for organisations.

Legal and regulatory issues concerning Industrial Services are not very different from the issues relating to marketing and delivery of traditional products. However, eBusiness services have important issues related to privacy, legal interception, ownership of location data and access to content. These issues must be adequately addressed by service providers, equipment manufacturers and customers and users. The application of performance monitoring and work surveillance measures is regulated in the EU Directive on Data Protection (Directive 95/46/EC). These and other issues are dealt with in *D2.3 Initial standards and regulatory watch report*.

## 4.2 Facility Management

CEN defines Facility Management[2] as "an integrated process to support and improve the effectiveness of the primary activities of an organization by the management and delivery of agreed support services for the appropriate environment that is needed to achieve its changing objectives", where primary activities are "activities that constitute the distinctive and indispensable competence of an organization in its value chain". Facility Management is thus a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology.

Facility Management can be re-conducted to two main types of demand: 1) related to space and infrastructure (e.g.: cleaning) and 2) related to the people and organisation (e.g.: security, logistics, etc.). Hence traditionally Facility Management is closely related to buildings and the preventive and remedial upkeep of building components (HVAC, electrical, plumbing, elevators, carpentry and painting), sometimes excluding janitorial and grounds maintenance. However it is increasingly common for companies to outsource a larger part of their non-core business activities as a means of

[2] prEN 15221:2005 Facility Management - Terms and definitions

encouraging greater business flexibility. The flexibility derives from the ability to shift core resources with greater ease. Outsourcing targets are no longer confined to cleaning and catering but involve complete process facilities such as water purification plants, cold stores, logistics and many other areas that previously were accepted as “core-activities”. Facility Management is not confined to business-oriented activities such as manufacturing. Public services (water supplies, emergencies, buildings, sports arenas, etc.) are typical targets for Facility Management.

In the Hydra context we use the term “Facility Management” to also include the business activities related to “Operations Management” and “Total Management” including process equipment, installations, buildings, infrastructures, services and all other material activities needed to fulfil a specific business or technical goal. The Term “Facility Management” thus covers the two upper levels of the hierarchical structure in figure 2.

Facility Management was initially focused on non-strategic areas as property management and property maintenance. Today, the Facility Management sector is a large and complex industry, comprising a mix of in-house departments, specialist contractors, large multi-service companies, and consortia delivering the full range of design, build, finance and management. As the actors become more and more experienced and knowledgeable, the expansion into Operational Management and Total Management including the management of an increasingly broad range of tangible assets, support services and people skills is progressing.

Experts see terrorism and security related issues as an important area of concern extending at least through 2010. Europe and Asia have unfortunately had to deal with issues of terrorism for a long time and incidents of terrorism have been frequent. European facility managers have thus developed both strategic as well as hands on tactical knowledge of how security challenges are handled at the facility level.

As of middle 2005, oil prices had risen more than 20% from the year before making energy prices the driver of a potential steep increase in intelligent building installations. Hence as the world is experiencing a peak in oil production and a continuing rise in the need for energy, the trend to enable the rise of the true “smart building is becoming more and more obvious. Experts seem to feel the time is finally “right” for the rise of the intelligent building (IFMA 2005).

The generally accepted definition of Intelligent Building technologies are “…integrated technological building systems, communications and controls to create a building and its infrastructure which provides the owner, operator and occupant with an environment which is flexible, effective, comfortable and secure”. Facility managers are pushing building automation systems vendors to transform today’s closed technologies into Web-enabled applications running over IP networks. Facility managers are driving building automation systems by demanding more-open systems. The open architecture approach means widespread acceptance and sharing of hardware and software designs, standards, and protocols and is seen as being critical to the successful spread of intelligent building technology. It will lead to a greater interoperability of various systems.

In a scenario in which energy costs are increasing, a greater utilisation of building automation systems to manage costs and utilisation is expected, but efforts to improve indoor air quality are also an integral part of many intelligent building initiatives.

Legislation and environmental standards; health and safety regulations and global trends towards improving indoor air quality standards are all significant drivers of Intelligent Buildings technologies, which can contribute directly to the reduction in energy use, and thus greenhouse gas emission, in commercial, industrial, institutional and domestic residential sectors.

Government Initiatives around the world are also driving the development and adoption of Building Management Systems technologies. For example the UK Carbon Trust allows Enhanced Capital Allowance (ECA) to be offset against taxation on energy efficient systems, which enables savings of around 30% for all energy-related Building Management Systems and Intelligent Buildings equipment and the associated installation and design costs.

Another area of significant resource expenditure has been in the addition of wireless networks (WiFi). A survey conducted by the Wireless LAN Association and NOP World Technology showed that the average payback for a wireless installation is about nine months. The survey also concluded that the average wireless user is 22% more productive than his or her wired counterparts. Productivity benefits are quantified at 48% of the total return on investment of a wireless network.

One theme that emerges repeatedly among facility managers is the move from “property management” to “infrastructure management”. Several studies of commercial and public buildings indicates that only about half of all the problems encountered is due to building problems with the balance being due to equipment, control and system problems. The benefits to facilities and to facility managers who grasp the potential of the intelligent building technology are thus potentially enormous. Facility managers are now embracing for “transformational technologies” that completely reshape their markets such as the convergence of technologies that make building intelligence possible.

The inclusion of integrated services in Facility Management introduce new important issues related to privacy, legal interception, ownership of location data and access to content that should of concern to service providers, equipment manufacturers and developer and end users. We are also beginning to see extensive national regulation, such as anti-spam provisions, data security and privacy laws including general surveillance practice in different countries as well as implication from the proliferation of electronic commerce on the traditional regulatory framework for trade and commerce.

The ISO-17799 and related standards sets out guidelines for the security polices to be adopted for organisations. These and other issues are dealt with in *D2.3 Initial standards and regulatory watch report*.

### 4.3 Smart homes

Cook and Sajal [1] define Smart environment as "a small world where all kinds of smart devices are continuously working to make inhabitants' lives more comfortable". Smart environments aim to satisfy the experience of individuals from every environment, by replacing the hazardous work, physical labour, and repetitive tasks with automated agents.

So a smart home is a completely networked, both internal and external controllable house which is electronically secured and equipped with different features and based on self-learning software. This software is setting up user profiles based on the behaviour of the different users and is automatically disposing resources at that times when they are expected to be needed by the users. But of course it is possible that the user is able to manually control any process in the house at any time – the software is also learning from that. A smart home is at the moment not yet a real intelligent home. But by the ongoing development and integration of artificial intelligence it will be the aim, that the house can make its own reliable, complex and self-contained decisions without any user intervention.

To increase the comfort of the user is the aim for nearly every smart home development. But on the other side the user should not have the feeling that they are dependent or even monitored by the technique. In fact, the user should have the feeling that simple tasks and functions are now overtaken by the smart home like turf cutting, automatic ordering and delivery of groceries and other things of the everyday life. Therefore, the smart home owner will have more time to do important and more interesting things.

The move of Smart Technology from the commercial to the residential market is now a well defined trend. The first smart home apartments housing have sold out and new property development projects are constantly being commissioned. According to Hugh Whalley, Product Manager for Siemens Smart Home Technology, “Smart Home Technology is already a very affordable reality in the residential market, with smart homes on sale from around £150,000.” Parks Associates expects that 145 million homes worldwide will have installed wired and wireless home networks in 2010. According to European Commission, around 90% of all existing buildings have inapplicable or ineffective controls; many of those require complete refurbishment of control systems. So the estimations for Building Management Control Systems for new build and major refurbishment, all sectors, suggest market adoption of:

- Heating controls 70%.
- Hot water system controls 90%.
- Air conditioning controls 80%.

Most concerns against the smart home technology are because of the fear to loose one's privacy. This is for example a topic of several movies and is from time to time covered in the media. Clear statements concerning this issue have to be made by adjudication because these concerns should not overlay the advantages and benefits being offered by the smart home technology.

Possibilities and challenges in the smart home sector have become a research topic during the last 10-15 years but the idea behind this is quite older. It started with the first building control systems installed in the Rockefeller Center in the 1930s and with the first air-conditioning systems installed in public and private homes in the 1920s. After these very early and rudimental steps in the direction of an intelligent home, main steps in the development towards a concept to increase user's comfort in living and working in a building have been made during the last decades.

In the beginning of the 1990s, the electronic industry developed a semi-intelligent control of components, equipments and features, known as EIB – European Installation Bus. Plugs, interior- and exterior lighting, jalousies, cookers and other systems and components have been instructed to fulfill specific tasks at pre-defined times by an EIB-net. This system has been comparable to clock-timers. The external control of these components was done by an interface and the software PCanywhere (for example). At that time, the term "Smart Home" has already been used, although it was mainly depending on user's actions. Without any user's interaction, these types of smart home buildings in the 90s would have been as inactive as common buildings.

The rapid development in the 90ies in the ICT market, the multimedia sector, the medical area and of course the World Wide Web enabled quite a new range of further developments and innovations. User comfort, security, energy efficiency, and increasing living conditions by the usage of information technologies have become requirements for the usage and the market success of all technical investigations.

Since 2000, bigger steps have been made in the smart home development. Several solutions and concepts have been presented since then. Most interesting projects in this area are the InHaus in Duisburg/ Germany (coordinated and pushed by Fraunhofer, Germany), the FutureLife-Haus in Zuerich/Switzerland, the CiscoSystemsHome in London/Großbritannien, the T-Com House in Berlin/ Germany and the EHII in Tokio/Japan.

So 'Smart Home' has become an alternative term for an intelligent residential building, or an intelligent home. A few years ago these concepts have been considered futuristic and fanciful. Now they have become reality. These terms are now commonly used to define a residence that uses a control system to integrate the residence's various automation systems.

Integrating the home systems allows them to communicate with one another through the control system; thereby enabling single button and voice control of the various home systems simultaneously, in pre-programmed scenarios or operating modes.

The development of smart home systems does focus on how the home and its related technologies, products, and services should evolve to best meet the opportunities and challenges of the future.

In the private home sector most smart home applications are targeting to support people to do their daily chores. These are mostly easy but boring activities for the individual and can easily be overtaken by a machine or robot. Those are for example functions like vacuum-cleaning or daily tasks like the control of the heating, the opening and closure of windows etc.

Other smart home solutions are focused on information and communication and are supporting the users need for entertainment. For example, chats can be supported by other family members living at other places using big screens.

Some applications are targeting an improved security of the inhabitants. These applications can include protecting systems like baby-TV systems as well as alarm systems or also alert functions if an accident is happening inside the house.

At least, smart home applications support the mobility of their inhabitants. They are able to control general functions of the house like heating etc. while they are away and can prepare everything for a nice return.

### 4.4 Progress due to standardisation

Since the beginning of the automation and control in the building sector, a lot of developments and innovation have taken place.

In the early phases of building automation, most techniques have been developed for office buildings or factories. For nearly ten years, developments in smart home technologies for the private user have been started as well. Of course, these developments focused on high-level buildings, but nowadays smart technology has also become popular in private homes and is sometimes integrated as a standard in prefabricate houses.

This more widespread use of smart home technology has been enabled by the standardization of control networks, the creation of a standard communication protocol and by a broad range of sensors in Europe.

By the integration of three different standards (EIB; BatiBUS, EHS) and a range of stand-alone solutions has been created a common standard, the KNX-standard, which is compatible to the EIB-standard and which have become a norm in Europe. Many devices from different suppliers have been introduced to the smart home market in the meantime, so that a lot of different smart home applications are available today.

For example, via KNX it is possible to link and combine divided systems like heating, air-condition, electric power supply, garden irrigation, security systems like video cameras, alert systems, locking systems and fire control systems.

Concerning the lighting, another standard (DALI) has been accomplished in order to manage the digital control of lighting systems. It is only responsible for the lighting, which means that it is composed easier than KNX. But there is no problem to combine it with KNX at all.

KNX can also easily be connected with a central computer. This computer is capable to control similar components of the house automation system and can be used for example as a gateway for the telephone system or for the internet. All devices can then be controlled via phone or internet by the user (for example the regulation of the heating).

The United States and some Asian countries have now set up KNX as a standard as well, so that it is just a question of time until KNX will become a worldwide standard (which means that the demand for KNX components will increase as well, which will lead to a broader range of KNX-components and suppliers).

All in all it can be stated, that KNX has become the basic for the development of smart home technology. Because of its standardization and the easy implementation it has been achieved on the market. In Europe, ca. 100.000 homes have been equipped with KNX or compatible systems during the last years. KNX is raising comfort, security and the efficiency of the usage of energy for homeowners and is quite flexible in case of renovation or rebuilding.

### 4.5 Stand-alone solutions

Single solutions in the smart home sector have now reached a phase of development, in which further development steps are taking place, but in which no radical innovations are necessary any longer. The next real progress would be the comprehension of artificial intelligence in smart home solutions.

Difficulties in the smart home sector are momentary caused mainly by the profit orientation of the several market players. Each supplier is developing his own solutions, which means that there exist a range of stand-alone applications but no real integrated system which combines the several applications and is supplier-independent.

## 4.6 Commercial solutions already on the market

In the Industrial Service area, dynamic value creation will be a key parameter for future competitiveness, when firms need to integrate products and services to a significantly higher degree than what is seen today. Further, companies are increasingly facing the need for complying with increased user centred demands requiring much more focus on intelligent solutions where for example the complexity is hidden behind user-friendly interfaces.

Suppliers will need to handle their products whole lifecycle from installation and commissioning over maintenance to end-of-life retirement and replacements of components and complete installations. Hence the focus on long term planned, preventive and predictive maintenance will increase.

A very large number of solutions exist on the market today aiming at providing remote services and applications in the industrial area. Most of the solutions are product or manufacturer specific but there are an increasing amount of solutions being offered by independent suppliers.

Both of the worlds two dominant electrical components suppliers, Legrand and Schneider Electric offers a wide range of components for building automation and building management. A brand of Schneider Electric, Square D in the UK, is a supplier of electrical distribution, protection and intelligent control solutions. Other large suppliers of network infrastructures and building automation infrastructures, for both private homes and commercial buildings, have networking infrastructure components on the market. Establishment of communication infrastructures in building automation is highly customer specific and is often done by independent system integrators or installers.

#### 4.6.1.1 Siemens Building Technologies

Siemens Building Technologies is one of the providers of complete, standardised technical infrastructure for security, comfort and efficiency in buildings.

Siemens' building management system, APOGEE[3], is an integration platform, spanning diversified core systems and standard protocols. APOGEE has an open architecture and the integration platform is compatible with all related industry standard protocols. APOGEE offers the advantages of controlling all systems and equipment with one workstation.

APOGEE is used in various industrial settings and a wide range of facility system integration tasks such as:

- System-to-system communication, to develop a single platform and a site-wide control interface that may include multiple core infrastructure systems for fire and life safety, security and lighting
- Control HVAC equipment, chillers, boilers, dampers, valves, etc.
- PLC & SCADA
- Industrial Control
- Laboratory Controls
- Elevators
- Power Management
- Tanks and Generators
- Gas Detection and Particle Measurement

APOGEE system controllers are the traffic centres of the APOGEE Building Automation System. They organize the signals that go to and originate from equipment (sensors, actuators, drives, equipment controllers, etc) and translate the signals into data that can be instantly viewable, programmable and actionable at the controller, through powerful control and reporting software, or remotely through the Web.

APOGEE and its native BACnet solutions provide powerful control functionality and features for a wide range of building automation possibilities. It also offers integration options for a wide array of proprietary and standard protocols.

[3] www.siemens.com

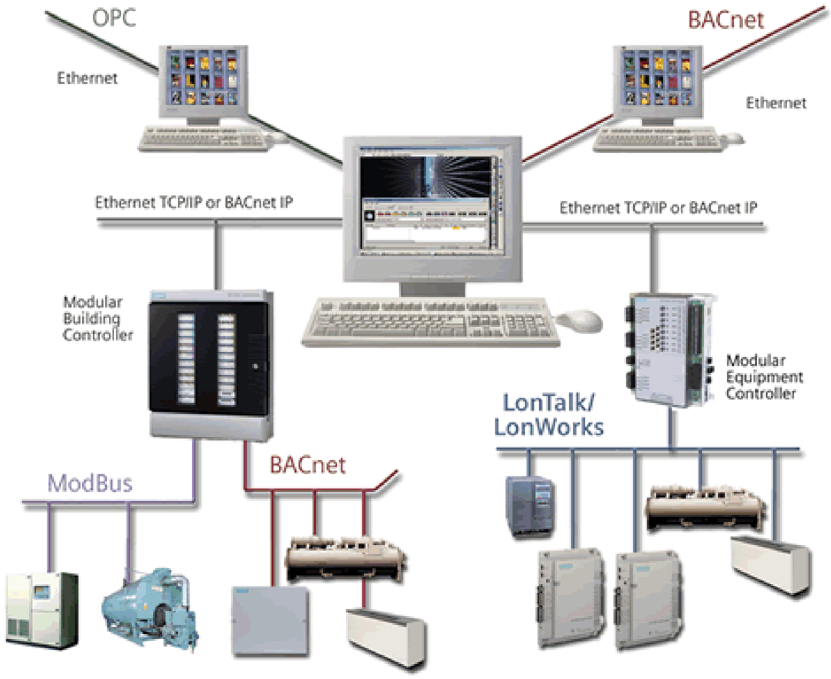


Figure 2 Siemens' APOGEE Building Automation and Integration system

#### 4.6.1.2 AutomatedLogic

Automated Logic's WebCTRL[4] is a building automation system, offering an intuitive user interface and powerful control features. WebCTRL can be accessed from anywhere in the world through a standard web browser, without the need for special software on the workstation.

WebCTRL, is a BAS solution, which was designed from the ground-up as a Web Services platform. The diagram in Figure 3 illustrates the internal organization of the WebCTRL server:

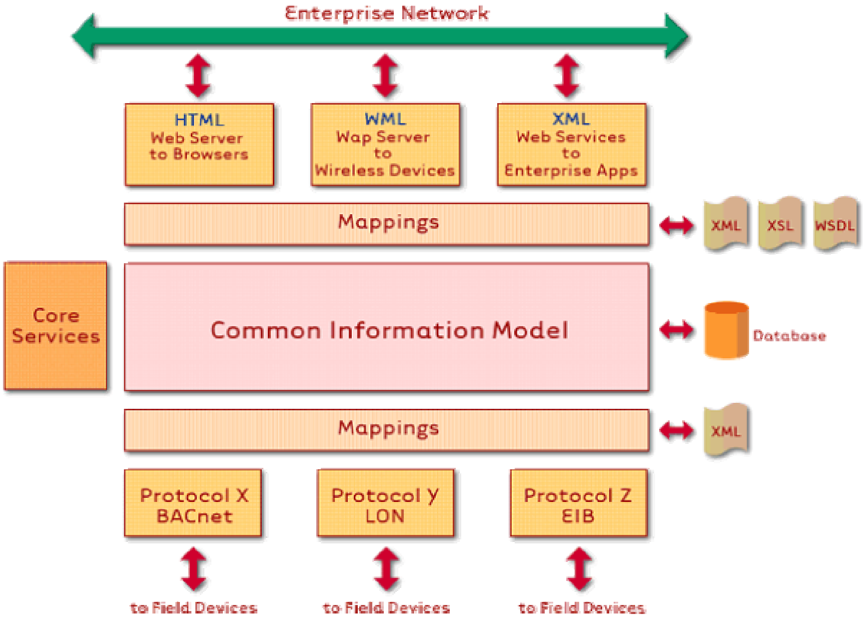


Figure 3 Automated Logic's building automation server

[4] www.automatedlogic.com

The WebCTRL has many similarities to the Hydra middleware platform. It uses Web Services to provide the basic functionality and it uses an Information Model (Domain Model) to describe objects and interrelationships. However, it does require a server installed at location instead of the middleware approach taken by Hydra.

## 4.6.2 Relevant research projects

### 4.6.2.1 SIRENA

The SIRENA (Services Infrastructure for Real-time Embedded Networked Applications)[5] project intends to create a service-oriented framework for specifying and developing distributed applications in diverse real-time embedded computing environments, including industrial automation, automotive electronics, home automation and telecommunications systems. SIRENA will develop a set of common services to address this common denominator, complemented with domain-specific services for each of the target domains. Schneider Electric is leading the consortium.

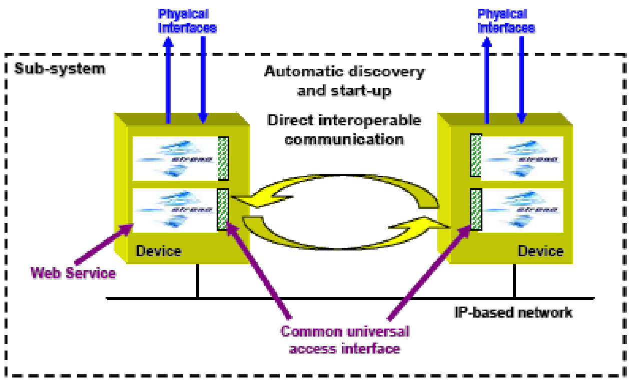


Figure 4 SIRENA service structure

The SIRENA project applies a service-oriented architecture (SOA) for building autonomous yet interoperable systems of heterogeneous and distributed devices. In a SOA, communicating entities are loosely coupled, by virtue of the fact that a service's functionality is exposed at its boundary, in terms of service "contracts" (interfaces) together with schemas describing the documents exchanged in a standardized, platform-agnostic format.

Thus, the implementation of the service is fully opaque and may be modified without the service's users being affected.

### 4.6.2.2 VAN

The objective of the VAN "Virtual Automation Networks" project[6] is to adopt, modify and extend common office communication/IT solutions according to industrial standards in areas as security, wireless, safety, and real-time. - aiming at real knowledge-based, intelligent, agile manufacturing enterprises. A Virtual Automation Network is a heterogeneous network integrating wired and wireless field level communication networks, Local Area Network, Internet, and wired or/ and wireless telecommunication systems.

The network also has to enable widely distributed application programs to co-operate and fulfil common control applications. An end-to-end connection through a heterogeneous network has to guarantee a location awareness, required scalable real-time behaviour, security and privacy, a very high degree of intrusion protection, and safety. A SIRENA target scenario is the "Industrial System Environment" as shown in Figure 5. Again, the VAN approach is device integration and not a client/server infrastructure.

[5] http://www.sirena-itea.org/Sirena/Home.htm
[6] www.van-eu.eu

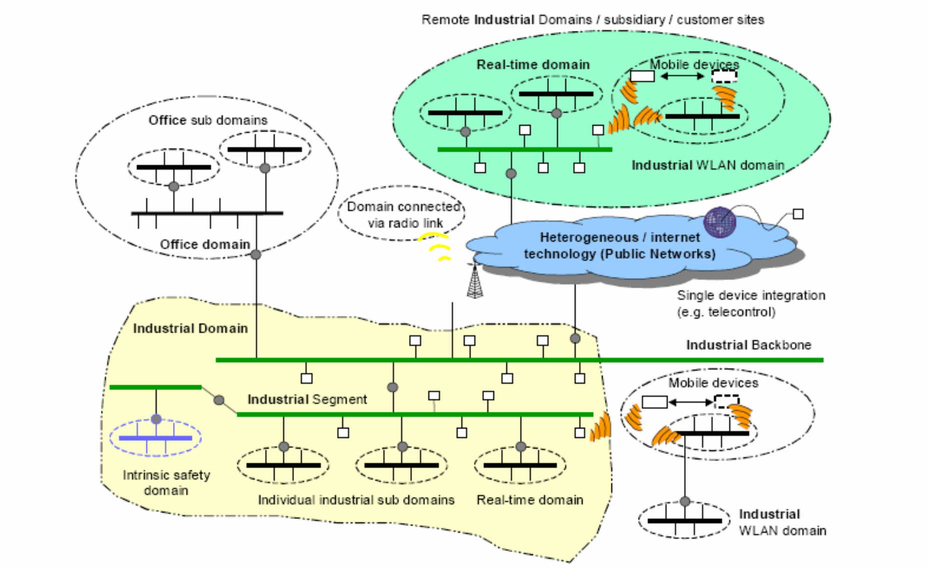


Figure 5 VAN industrial systems environment

### 4.6.3 Smart homes

A large number of companies are offering components and infrastructures for smart home concepts and home entertainment for private homes and do-it-yourself markets. These companies represent a wide variety of different actors of different sizes and strengths. The companies can be divided into five technical solutions:

This area is mostly peer-to-peer communication and contains a vast number of remotely controllable devices, which potentially could be connected to Hydra enabled devices and thus become part of a Hydra application. The US web shop www.smarthome.com has thousands of connected devices on a variety of different platforms in their catalogue; everything from door openers and rain alarms to automatic cat and dog feeders is available. Both of the worlds two dominant electrical components suppliers, Legrand and Schneider Electric offers a wide range of components for building automation and building management.

A brand of Schneider Electric, Square D in the UK, is a supplier of electrical distribution, protection and intelligent control solutions.

# 5. Domain specific user requirements for buildings

In this section, we deduct the specific technical requirements for the building automation domain. We set off by identifying all possible actors and analysing the future vision scenarios created by the external experts. We then deduct specific requirements from the scenario thinking process and from the scenarios themselves.

During a full day workshop, ten external domain experts discussed the most critical applications for ICT technology in building automation in the future, how existing automation equipment and subsystems can be improved and what type of new and better networking and integration tools could be developed to improve concepts like intelligent buildings,, energy sustainable buildings, smart homes and remote metering, just to name a few applications. The main focus was on smart homes and the manufacturers' viewpoints prevailed.

The time horizon was set for year 2015, which participants felt was suitable when discussing future trends and developments in the building automation domain.

## 5.1 Actors and target users

In order to derive domain specific requirements for the design process, it is useful as a first step to define the main target users that will develop and eventually utilise building automation applications supported by the Hydra middleware.

A target group consists of all active or potential manufacturers, developers, customers and users of an application. The target groups can be further differentiated by a classification following relevant criteria such as demographic or psychographic. The aim is to create actor segments that are sufficiently homogenous to render synchronized behaviour in all relevant aspects (usage patterns, buying behaviour, etc.) while at the same time sufficiently large to be economically viable for exploitation.

The different actors identifies in this way will have different expectations and will see the usefulness of the Hydra middleware from different perspectives. In other words, their requirements will be different.

### 5.1.1 Developer user perspective

The Hydra middleware will allow developers to develop high-performance intelligence applications for heterogeneous physical devices and is thus extremely well positioned to help develop users meet most of the challenges.

It is necessary that requirements and needs of all stakeholders and users of building automation applications are met in the design process. The needs of the users must be determined and these needs must be reflected in the overall design.

#### 5.1.1.1 Smart Home application developer

The application developer user is responsible for the design and development of smart home applications. He has to develop them with respect to user needs and usability design aspects and in the Hydra project of course by the usage of the hydra toolkit. The developer has to be in close contacts with end-users and consumer equipment manufacturers. The needs of all these stakeholders must be reflected in all areas of the design process. There are several iterations in the design process, so that the initial design may be modified considerably in the process. Necessary changes must be identified quite early, so that it is easy to adapt the system.

The design process must be divided into different steps; to describe scenarios and use cases helps the designer to determine how the technology can benefit the person in the different situations. The needs of the stakeholders inform the design process and determine the level of interaction that is required between the user and the technology.

#### 5.1.1.2 Manufacturer of consumer devices

In the private end-user market for smart home applications, typically heating systems, household devices and alert systems are combined in order to make life much smarter for the user. Therefore manufacturers of household devices have to follow trends and challenges in the smart home domain and must prepare and equip their devices for an easy and seamless integration and implementation into typical smart home environment.

### 5.1.2 Facility Manager / service provider perspective

Facility Manager / service provider In bigger companies, hotels or in resident parks, a facility manager is operating the building automation system with the building-specific necessities.

In general, these buildings are quite complex and furthermore it is electronic and application infrastructure. The systems have to deal with a lot of different functions (locking systems, heating and lighting systems, air condition etc.) and specific requirements have to be regarded for the several blocks of the building. For example, in the production hall, other building automation systems are installed than in office centres.

The facility manager will be especially trained and skilled in accordance to the specific building automation system he is responsible for.

Therefore it is not that important that the system is easy to use because the facility manager is working with the system as a more or less full-time job. But on the other side, these people generally technically not very experienced, so the systems have to run quite stable. Because of the complexity of these building automation systems, it is important that this system can be monitored and easily operated and it must at least be understandable for the facility manager.

#### 5.1.2.1 Smart Home application provider

The smart home application service provider is offering smart home systems to the end-user. They install the system at the end-user’s home and have a direct contact to the user of the system. They are aware of the combination of the different end-user devices and the specific demands and wishes of each customer. It is their task to adapt generic smart home applications running on different devices to the specific requirements of home owners, company buildings, owners of resident parks etc.

### 5.1.3 End user perspective

Understanding the needs of end users and integrating those needs into development projects lies at the heart of producing effective medical devices.  Measuring and fulfilling user requirements during medical device development will result in successful products that improve patient safety, improve device effectiveness and reduce product recalls and modifications.

#### 5.1.3.1 Home owners

The end-user is the target user of all smart home applications. This can be private end-users as home-owners on the one side. In the commercial sector the integration of smart home applications in company or factory buildings is getting more and more popular because of the possibility of energy savings and cost reductions by smart working applications. In between these two forms of target users are owners/ inhabitants of resident parks in which smart home applications are installed. For hotels the implementation of smart home applications is also quite attractive. In this two cases, the role and all tasks of the target user and the usage of the system must be shared between the owner of the resident park/ hotel and the guest/ hirer.

In order to derive user-oriented requirements for a user-centred design process, it is necessary at a very first step to define main target users for the later utilization of smart home applications.

That way a target group consists of all active or potential customers and users for an application. The target groups are differentiated from each other by a classification following relevant criteria. These criteria can be for example demographic or psychographic criteria. The aim is to create segments that are as homogenous as possible themselves and as heterogeneous as possible against each other.

Relevant target groups for smart home applications are:

1) Demanding home owners
2) Seniors
3) Disabled persons

#### Demanding home owners

Demanding home owners are sophisticated users of smart home applications which main demands focus on security, entertainment and convenience topics for smart home applications.

Characteristically for this type of users is that they dispose of a high income, that they are used to get the best that's available on the market at the moment, they are not very price-oriented against a high quality-orientation and they are quite demanding and sophisticated once they have decided to install or integrate a certain solution.

The typical demanding home owner is around 35 years old, well-educated and used to new kind of techniques and solutions.

Smart home applications for this type of user must therefore be easy and convenient, must be of a very high quality and stability, added value must be presented to him and the system must meet his demands of entertainment, convenience and security.

On the other side, it is not that important that the applications have quite simple user interfaces or is quite simple in general because this user is normally used to deal with techniques in different application domains.

#### Seniors

Seniors are an important user group for smart home applications. In contrast to the demanding home owners, their motivation for the installation of smart home networks at their private homes is to deal with the restrictions in activity and as well with their mental prostration. Smart home applications can help to overtake daily routine tasks and can also overtake memory functions like automatic switch off the iron or the oven if it is not used for a pre-defined time-line.

On the other side, seniors have a high demand for security issues. Smart home applications addressing and increasing the safety of the home are also of high importance for seniors.

Another interesting feature is emergency alert systems. This will secure that in case the inhabitant has an accident inside the house or has broken down; the system will recognize that automatically and will inform other family members or an ambulance.

Smart home applications for seniors must meet another group of requirements than for demanding home owners. Seniors need very strong user guidance through the system. The system must be very easy, self-explanatory and intuitive to use. The symbols, icons and terms used in order to choose a program or to deal with the system must be very easy to understand. Technical terms and specific items have to be avoided as far as possible. The user interface must be adapted to the specific physical requirements of elderly people: So screens have to be maximized, instructions etc. must be quite readable and buttons should not be too small.

#### Disabled persons

The requirements and demands of disabled people are comparable to those of the seniors. The motivation of disabled people to investigate in smart home applications is to get the chance to live in their own houses keeping their privacy at the best way.

Smart home applications are able to support disabled people in fulfilling specific tasks. For people with physical handicaps it is even hard to fulfil normal daily issues as to clean-up the house, to control heating and lighting, to cook their meal etc. Smart home applications can overtake some of these tasks or can help to fulfil them by the disabled in overtaking critical steps of the process.

The interface of smart home applications must be adapted to the specific handicaps of the disabled. In case of visual impairments, screens and fonts must be adapted to be able to be read by these people as well. In case of physical handicaps it can be necessary that buttons and user interfaces must be arranged or created in a user-specific way.

## 5.2 Requirements derived from the scenario thinking process

During the workshop, a large number of environmental factors were recorded, discussed and subsequently analysed. The discussion revealed several high-level generic requirements for future applications and systems. These requirements will be addressed in the Hydra middleware so that it will allow the development users to develop exactly such innovative applications that are needed.

The functional user requirements specifications include the most important aspects of user expectations in building automation applications. The ten experts concluded that the following specific requirements were most relevant for their domain:

**Functionality**

The complexity of networked system requires a logical and structured access to the devices and information sources in the network. A systemic approach will thus prevail for systems concepts, including logical and ad-hoc connected components. The big challenge will be to develop methods that can avoid information overflow in large groups of networked devices.

The demand for increased functionality will be backed by an increasing number of public requests that will only be available in electronic form and which could be facilitated by automatic monitoring and metering (i.e. compliance, resource consumption reporting, etc.).

All systems must be flexible, adaptable, configurable, scalable and modifiable in order to take advantage of networking. The systems must also be easy and simple to use for the end-user. However, it is uncertain how open these systems will be for end-users to be able to make their own programming, which programming languages and standards will be in force (and dominate the market). In any case, the end-user will most likely be responsible for using the devices/products correctly according the defined guidelines and instructions issued by the manufacturer.

Various forms of wearable computers will increasingly be available for executing applications. For mobility and ease of use, it can be assumed that all end-users will have and be able to use mobile phones and PDA's. However, the use of these devices is not always suitable for all end-users or all applications.

Although additional functionalities in appliances and device normally will lead to higher product cost and use costs, the additional development costs to add new functionalities to products through interoperability with other manufacturers' devices are low.

**Networking**

The increased need for networking of products and devices is beyond any reasonable doubt and the market will respond with a strong growth in products that able to communicate and interact.

This will lead to an increased appearance of interoperability standards where device drivers, interfaces and applications may need a third party certification to be acceptable for other manufacturer when used for networking applications. New standards may be needed for this, but their scope and form is still unknown.

System reliability is crucial for widespread user acceptance. Since the complexity of networks increase rapidly with increasing number of devices, there is a need for clear division of responsibilities between the different manufacturers. The end-uses will normally assume that the systems will function properly in their intended operating environments but system malfunction in interconnected products may need to be legally regulated.

In order to minimise system malfunctions, preventative measures, which can predict and prevent malfunctions, will increasingly be needed. Prevention of malfunctions may also require that devices can be upgraded automatically.

**Privacy and security**

Building automation devices will need to have security features installed that can prevent any kind of intended and unintended misuse and the specific security model must be established as part of the development process. However, the responsibility for system security is not always clearly defined or assigned to specific actors, and the security model can either be centralised or distributed across the network. However, access rules will be commonly understood and accepted among end-users.

In smart home applications, it can generally be assumed that the domestic environment is trusted and secure with built-in firewalls where consumers are able to configure and manage security issues themselves However, manufacturers will wish to have open remote access to their own systems on end-users' premises for maintenance, upgrade and service delivery. Hence, manufactures will (as a consequence of their brand name) be able to impose some access control models and authentication schemes on end-users. Authorizations will probably handled by third party authorization bodies, but other trusted authorization methods may emerge.

Authorities may also enact legislation intended to allow the authorities to access personal data information residing on smart home networks (home land security).

**Power**

End-users will increasingly demand products that use less energy, which can be seen as being in conflict with the increased demand for extended functionality.

In some cases smart home devices will be able to use new types of renewable energy sources thereby decreasing the need for traditional energy. Systems will e.g. be extendable with energy producing devices like solar panels forming part of the network.

**Design**

Most devices and appliances are today equipped with simple touch pads for easy interaction, but it may be too limited for serious interaction in the future where user interaction increasingly will take place using multimodal interfaces. Generally, devices and interfaces must be designed according to ergonomic principles and especially socially and physically disadvantaged end-users should be supported with other modalities for easier interaction.

**Business models**

Manufacturers will use preventative maintenance and remote service monitoring to increase customer loyalty and create new services. Manufacturers will increasingly offer both products and services in value enhanced bundles and need new business models for this.

Smart home technologies are generally affordable and smart home appliances will have a high value propositions. Other manufacturers will explore the market by introducing new products and services with similar propositions and utilising the networking capabilities. Overall, this makes the homes more attractive to owners and tenants.

## 5.3 Generic requirements derived from the scenarios

From the scenarios, the following high-level user requirements for Hydra enabled devices can be derived:

**The "Walking the dog" scenario** *(in which a system integrator is working for a public utility)*

- Interconnectivity, standard interfaces, centralised control, large number of devices, and scalability

**The "The Beehive" scenario** *(in which a system integrator operates within facility management)*

- Interoperability, decentralised control, fault tolerant, heterogeneous networks, accountability

**The "Easy does it!" scenario** *(in which a developer user develops systems for non-technical end-users)*

- Self configuration, hiding complexity, cognitive applications, central monitoring, flexible trust models

**The "Daredevils"** *scenario (in which end-user can program smart home applications)*

- User controlled interoperability, self configuration, media, runtime application programming

All of these generic requirements have been checked for consistence and mutuality against the technical requirements reported in *D2.5 Initial requirements*.

## 5.4 Specific requirements derived from the scenarios

The scenarios provide the framework for the iterative requirement engineering as described in *D2.5 Initial requirements*. From the scenarios and storylines, a systematic formalisation of all relevant user requirements and subsystem functional, security and societal requirements was derived.

A number of technical requirements can be derived directly from the scenarios and the scripts contained therein. The following table list the generic and specific healthcare requirements, which have been identified in the four scenarios. The requirements are reflected, either directly or indirectly, in the technical requirements reported in *D2.5 Initial requirements*.

| No, | Scenario fragments | Derived requirements | Impact |
|---|---|---|---|
| | **1.1 Walking the dog** | | |
| 1 | *The pumps have over the years become increasingly intelligent.* | Runtime applications must be able to use existing applications embedded in devices. | Runtime view |
| 2 | *Other systems are logging operating data and handles error conditions.* | Applications must be able to recover from perceived or real fault situations | Runtime view |
| | | Applications must log data of performance | |
| 3 | *Even before Jaap joined Redenbeek, several product lines had been equipped with various kinds of remote interfaces.* | Devices must be accessible through a multitude of remote interfaces | Device view |
| 4 | *…intelligent functionalities can be made remotely available for external services, customers and other manufactures* | Runtime applications should facilitate external web service integration | Runtime view |
| | | Integrity of devices to be maintained | Device view |
| 5 | *using new and emerging interface standards* | Devices must have standardised communication interfaces | Device view |
| 6 | *Jaap now wants to use the Hydra SDK module for LabVIEW to develop the Hydra middleware* | Hydra SDK to operate on a Labview platform | SDK |
| 7 | *The HIS system interfaces with a large number of local and national measuring systems, widespread sensor networks, low altitude aerial and satellite based meteorological and oceanographic surveillance systems* | Applications must be able to interface to highly heterogeneous systems in terms of data structure, timing, bandwidth and availability | Runtime view |

| No. | Scenario fragments | Derived requirements | Impact |
|---|---|---|---|
| 8 | *Applications are being developed that automatically collects data and information from these systems, cross-correlate the information using models and historic data and performs real time predictions of tide levels in each sector under RWS authority* | Applications must be able to semantically locate necessary data sources, and repositories<br>It should be possible to perform real time predictions based on external models | Runtime view |
| 9 | *… eventually fuse data for automatic operational control of unmanned sluices and water levels in dams and polders* | Intelligent data fusion should be facilitated based on real-time information | Runtime view<br>Device view |
| 10 | *…to provide the necessary security for the systems to avoid terrorist and similar malign attacks* | The system must be able to have its own security model at runtime | Device view<br>Runtime view |
| 11 | *The external requestor must present the necessary credentials before obtaining the information and there must be a trust model for how these credentials are evoked and maintained* | The security model should be based on credentials<br>Identity management system is part of the trust model | Runtime view |
| 12 | *comprehensive logging and authorisation systems… for tractability and accountability* | The system must have secure logging of access and actions performed | Runtime view |
| 13 | *…the developers have serious problems with computing power and especially the burden of constrained memory space* | The network must have facilities to overcome memory constrains | Device view<br>Runtime view |
| 14 | *Redenbeek can deliver e-Business services directly to new customers* | The business models must be sustainable | Business models |
| | **1.2 The beehive** | | |
| 15 | *applications must have extensive provisions for all sorts of services* | Applications must be self configurable and have service discovery capabilities | Runtime view |
| 16 | *capable of learning from the individual user's behaviour and to create suitable user profiles for monitoring of adverse consumption patterns* | Applications must be able to store use patterns and monitor complex user behaviour | Runtime view |
| 17 | *remotely access and control things, when away from their homes* | Devices must be remotely accessible by end-users | Device view |
| 18 | *maintenance jobs are automatically distributed* | Applications must include workflow management possibilities | Runtime view |

| No. | Scenario fragments | Derived requirements | Impact |
|---|---|---|---|
| 19 | *automatically recognised and cleared by the security clearance system* | The security system must have context aware capabilities | Runtime view |
| 20 | *personalised environment in terms of access to equipment and data sources* | Applications must support context and location aware capabilities | Runtime view |
| 21 | *...decides to buy technical support directly from the Siemens support centre in Germany* | Applications must have provisions for negotiation and optimisation | Runtime view |
| | **1.3 Easy does it!** | | |
| 22 | *Healthcare applications are automatically created or launched according to needs and are fully interoperable with the residents' networked devices,* | Devices (with embedded systems) are self configurable and applications must have semantic discovery capabilities for these devices | Device view<br>Runtime view |
| 23 | *... they really don't notice them* | Complexity should be hidden through intuitive interfaces and automatic features | Device view |
| 24 | *...the system is able to find and automatically interface to telephones, hearing aids, or any other device* | Automatic and semantic device discovery | Device view |
| 25 | *...systemised prioritising scheme in place which automatically calls on the next nurse...* | Application must be intelligent and support workforce management, including automatic alarms | Runtime view |
| 26 | *...automatically identifies and securely sends the request to the Park View Homes diabetes care centre* | Devices must be able to communicate intelligently with external services | Device view |
| 27 | *The alarm and communication application provided by the manufacturer automatically adjusts itself to the available resources.* | Applications should be able to adjust to resource constraints in devices and networks | Runtime view |
| | **1.4 Daredevils** | | |
| 28 | *... choice is either to use an ID card or a biometric device. To enhance security, any of these devices must used in combination with his newly acquired voice recognition system* | The security system must be user configurable and include biometric devices | Device view |
| 29 | *...uses voice input to access his electronic cookbook* | Multimodal user interfaces must be supported | Device view |

| No, | Scenario fragments | Derived requirements | Impact |
|---|---|---|---|
| 30 | *…so that he gradually could build a knowledge base of personalised cooking habits to augment the online cooking book* | Data persistence must be present for intelligently knowledge indexing and retrieval | Runtime view |
| 31 | *…tosses his clothes into the washing machine, which determines the ideal cycle from the RFID's in the clothes.* | Context sensitivity should be provided to devices | Runtime view |
| 32 | *The manufacturer has developed a large program of self-configurable sensors with wireless connection* | The application must be able to handle large sensor networks with resource constrained devices | Device view<br>Runtime view |

# 6. The building automation vision scenario

After careful study and with a view to the completeness and complementarity of the total universe of technical requirements, "The Beehive" scenario was chosen for application development.

Parts of this vision scenario will be used throughout the project to be incorporated in technical user scenarios, which in turn can provide demonstration of the progress of the project and the use of the Hydra middleware in the healthcare domain. At different iteration levels, various aspects of the scenario will be made available for demonstration as defined in the technical scenario. The precise content of healthcare applications in each demonstrator will be determined during the course of the project and will depend on the availability of which Hydra components are available for implementation and demonstration at the time.

The aim is that the final demonstrator (M48) will be capable of providing a demonstration of a full developer user technical scenario, which will be able to generate applications such as those foreseen by domain experts in the vision scenario.

## 6.1 "The Beehive" scenario

NCC is one of the largest building companies in Denmark. They operate globally, but have large contracts with the Danish government for building housing projects. One such project is the "Krøyers Plads" housing complex in centre of Copenhagen. This project consists of 5 apartment blocks with at total of 120 apartments. In addition, the project contains a medium sized shopping mall with a fitness complex and two social service centres e.g. a kindergarten and an activity centre for the old people. The project was designed by the Dutch architect Erik Van Egeraat and is renowned for its highly unusual architecture. The first apart-ments were ready in late 2014 and the rest are being finished in the coming few months.

The management of the housing complex is in the hands of ISS, Europe's largest facility management company. ISS manages buildings and facilities all over the world. The technical control centre in "Krøyers Plads" was originally planned as a central facility located in one of the blocks from where, a team of six caretakers could monitor all the technical installations. With the emergence of many new control systems based on Hydra middleware, it is foreseen that most systems will be able to work together and perform intelligent, interoperable tasks so that no human intervention is required. Consequently, the central control centre has been abandoned and the rooms transformed into a community day care centre.

Being responsible for the technical and building maintenance, ISS will undertake to specify the advanced monitoring systems for control and maintenance of technical installations such as electrical distribution, heating and cooling systems, water supply and wastewater. The actual applications for controlling the building and the installations will be designed by TAC Danmark, a market leader in system integration and Building Automation. As facility manager, ISS has clearly stated that they are not interested in how the system works, as long as it lives up to the requirements specification. This is a proven business model, which both ISS and TAC are comfortable with.

Klaus Jensen is the lead engineer in TAC's system integration unit and responsible for the "Krøyers Plads" project and is a very experienced in all aspects of system integration. Today, system integration is mostly performed through dedicated TAC networking applications that connect various subsystems through a central control platform. With the emergence of the Hydra middleware and a common, open interface standard, Klaus expects to be able to develop effective applications operating directly on the network itself, utilising the interoperability of the connected systems. Last year the International Device Interoperability Verification (IDIC) body was inaugurated, so in the future, Klaus and his colleagues will probably only use systems and devices certified by IDIC.

TAC applications must have extensive provisions for all sorts of services, such as meter reading, so that the consumption of electricity, water and heating can be remotely read from each apartment and automatically transferred to the administrative system. TAC applications need further to be capable of learning from the individual user's behaviour and to create suitable user profiles for monitoring of adverse consumption patterns, which may indicate faulty installations. This kind of embedded intelligence is one of the reasons that Klaus has selected the Hydra middleware, because he sees great potential in letting the large constituency of manufacturers develop a wide range of useful and interoperable solutions, and letting TAC develop only the customer oriented application.

TAC applications should also have extensive end-user features allowing residents to remotely access and control things, when away from their homes e.g.: in-house lighting, burglar alarms, camera surveillance, booking of laundry room, control of heating, supervision of windows, doors, stove, etc. A major concern here is how the user will be authenticated, which credentials to use and how the trust model should be developed.

The newest service to be requested by ISS is a vendor access system that requires all authorised vendors, subcontractors and service organisation to access the building management system through a new authentication procedure. The purpose of this is to have a better security in the maintenance process, including the integrity of logged data, e.g. water temperature, which is required by law. There has been an example of data being lost during service, which is not very welcomed by the Danish Building Inspections Bureau. ISS also wants to use the system to check accuracy of the service costs they are being billed under the current service contract.

John Hansen is a senior service technician with Siemens Denmark, the main vendor of the electrical power automation and climate control installations. Since ISS is not prepared to accept responsibility for the correct use of interconnected devices and products, John has a full time job looking after the service contract that Siemens has entered into with ISS. When John starts his day, all service and maintenance jobs are automatically distributed on available service technicians and downloaded to their mobile devices in their cars. All the building systems automatically locates the manufacturers central maintenance systems and reports faults and corrective actions taken, so John can immediately get updated information from the Siemens system.

Today John needs to perform maintenance on the “Krøyers Plads” heating system. When John arrives at the apartment building, he is automatically recognised and cleared by the security clearance system to enter and move around freely in the building complex. The standard TAC system comes with access control based on identity card authorisation, but ISS have chosen to utilise a more intelligent system based on a distributed security model and individualised authentication provided by a mix of trust entities and third party authorisation. Although the basic trust model is an integral part of the TAC system, the choice of security model can be completely independent.

All systems in the building interoperate, not only in respect of access control, but it also to provide John with a specific personalised environment in terms of access to equipment and data sources.

John has now received all data on his mobile web tablet about history and service records for the heating system. From Siemens' own database, he has also downloaded the product information and tutorials he needs, so he can go directly ahead and perform the maintenance. Every device is available to him and he has the possibility to perform different kinds of tests, check the current status and to upgrade software components, if needed.

As he goes through the procedures, one heat exchanger does not perform as he expects it to. He can see in his service record that the Siemens support centre in Germany remotely updated the software 2 weeks ago, so he assumes that there might have been some problem with the operating conditions of this device. Instead of trying a range of different approaches, he decides to buy technical support directly from the Siemens support centre in Germany. The support is ordered and within 3 minutes, a service support person from Siemens is online with John and the device.

After the successful completion of his work, John checks his web tablet again and heads off for another job. He finds life much easier now, because the intensive decision support provided by all the systems gives him time to think through the really important and critical elements in his job. He finds this very un-stressing.

# 7. References

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