Chapter 3
Service Robotics

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Abstract In this chapter, a classification of service robotics technology within the digital home is established. This is followed by several examples of the different categories of service robots. The classifications include vacuuming and cleaning, gardening and lawnmowers, personal robotic assistants, telepresence, teleassistance and health, entertainment, home security and privacy and robotic learning categories. Some of these are analyzed and their parts described using SysML formal, open and standard notation. Finally, a brief note about the synergies between professional service robots and home service robots is included.

3.1 Introduction

The integration of computer and human activities has allowed computer science to push the boundaries of technology and today there are more than 6.5 million integrated units in use worldwide in 2007. This figure, as seen in 2008 edition of World Robotics report, and is estimated to rise to 18 million units by 2014 (Gomez 2008). Accordingly, the subset of home service robotics is expected to have 18 million robots by 2011 (IFR/WorldRobotic 2008).

The development of service robots (Schraft and Schmierer 2000) started in the late 1950s and early 1960s with the first industrial robot known as Unimate designed by George Devolop and Joe Engelberger (Mellon Carnegie 2010). Joe also designed Unimation and was the first to market with this machine, earning him the title of "Father of Robotics." By the 1980s, modern industrial arms had already increased their skills and performances through microcontrollers and modern programming languages.

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These advances were achieved thanks to large investments in automotive companies. Since its beginnings, robotics has been limited to very small and isolated areas apart from the automotive industry, such as the defense or space sectors. In the past decade, because of the economic boom of the 1990s, this has extended into some of the fastest growing fields such as aviation and pharmaceuticals (Barrientos 2002).

With its tremendous growth and widespread use in most prosperous sectors, the production of robots has been optimized, resulting in a significant reduction of costs. It is encouraging that robots have extended to several sectors: construction, agriculture, tourism and ITC among others. A wide range of robots aimed at this particular area is also being developed and marketed at the same time as the industrial ones.

Expectations are high because of a number of factors. These include a robust public acceptance of the first commercial robots, the wide acceptance of IT in general, and familiarity of the population with robots in the workplace, along with a sufficient level of technology at an affordable price. All the evidence implies that robots will become common, and having multiple robots in every home will be as frequent as finding several computers in the same house.

Service robots do not have a precise definition; however, the International Federation of Robotics (IFR International Federation of Robotics 2010) decided to define them as "*robots that work in an autonomous or semiautonomous way to develop useful services, oriented to the well-being of humans and work teams, excluding the repetitive or tedious tasks.*" The International Service Robot Association (Pransky 1996) defines service robots as "*machines that interact and think with the objective of increasing the abilities of the human being and his productivity.*" Both definitions have some intrinsic ambiguity, but are the best found in the current literature. For instance, could an industrial robotic arm be considered a service robot? It is an open question to be answered by applying the definition of a robotic platform rather than from only a technological perspective.

Kawamura et al. (1996) preferred to define service robots as "*sensor-based mechatronic devices that perform a useful service in the activities of humans.*" According to this definition, service robotics stand somewhere between industrial robots and space robots.

The EUROP (European Robotics Technology Platform) (Wendel and Bischoff 2009) distinguishes five areas of application to classify the different types of robots:

- Industrial: Work, partner and logistic robots.
- Professional Service: Work, collaborator, logistic, monitoring, exploration and education robots.
- Domestic Services: Staff, logistic, monitoring and education robots.
- Security: Staff, logistic, monitoring and exploration robots.
- Space: Work, collaborators, logistic and exploration robots.

Currently, robots are being developed for most human environments, and they are becoming generally available because of price reductions. Therefore, the new

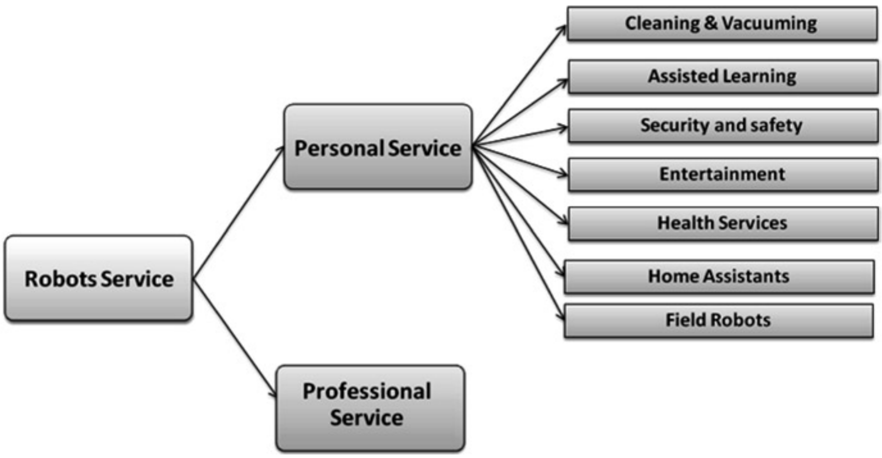

Fig. 3.1 Home service robotics – body of knowledge

category of personal service robotics can be analyzed. The following subsections categorize them and give the most representative examples based on the market, the science and the author's subjective criteria (Fig. 3.1).

3.2 Personal Service

3.2.1 Cleaning and Vacuuming

The main part of the personal robotics market share is held by the vacuuming robots of IRobot. They are the best example of how an application can push the limits of manufacturing and devise a robotics solution to a common problem. The following examples show three different approaches to the same problem.

3.2.1.1 Roomba and Scooba

The Roomba series is the biggest product line for robotic vacuuming within a private home (Jones 2006). Its robots, from series 500 (IRobot 2010), are focused on the house environment and are the best selling service robots with approximately seven million units sold.[1] They have become more and more autonomous over

[1]This figure has not been verified by the manufacturer, but the data were gathered directly from a presentation from the manufacturer.

Fig. 3.2 IRobot Roomba 563

Fig. 3.3 IRobot Scooba

recent years, and with more characteristics. Nowadays, IRobot also has the 600 series for inmotic and industrial environments.

These robots clean up to four rooms in a pseudorandom way, which is an effective compromise between cost and reliance on artificial intelligence. Figures 3.2 and 3.3 show a Roomba 563 Pet series and the Scooba (the floor cleaning version of the Roomba).

ICreate has also been developed for the US market, which is the research platform for IRobot (Fig. 3.4).

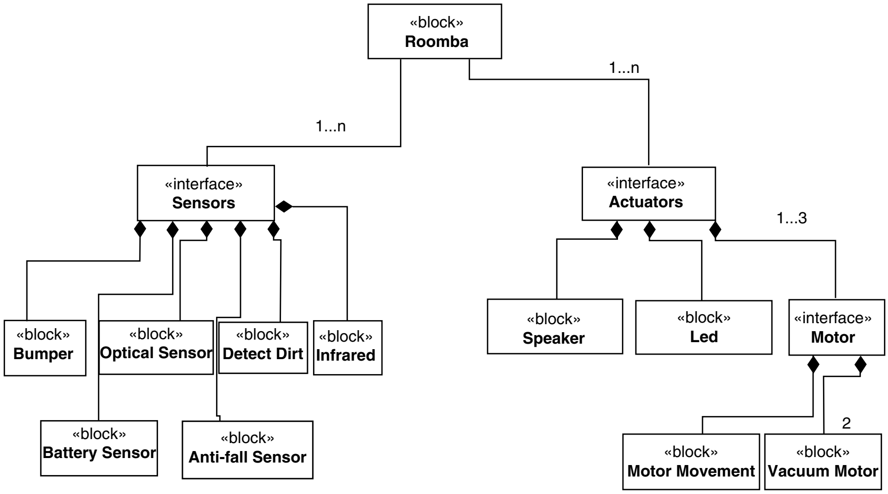

Fig. 3.4 IRobot Roomba SysML block diagram

Notes About Development with Roomba Robots for the Digital Home

I Communication protocol
Given the advantages offered by UPnP (Santana 2005), this was the protocol chosen for service robots such as Roomba. UPnP works with an architecture that provides point-to-point connectivity to give users the possibility of automatically obtaining dynamic IP addresses.

II Microsoft Robotics Developer Studio and Player/Stage in the IRobot Roomba case
The processes performed by robots require constant interaction between software and hardware elements, so it is often necessary to combine the knowledge of both to carry out the development. This can be achieved by using simulation techniques; Microsoft Robotics Developer Studio and Player/Stage are both open platforms (one free but not open source in the concept definition) that can help with the task. They provide Roomba robots with two platforms for control and simulation.

3.2.1.2 Mint Automatic Floor Cleaner

As stated in the above subsection, the navigation algorithm for the Roomba series is pseudorandom. To avoid unclean spots and to reduce operation time, new products have been arriving in the market with improved navigation algorithms and systems. Mint (Mint Evolution 2010) is one of the two that will be described in this section.

Mint's navigation algorithm comes from NorthStar navigation (North Star Evolution Robotics 2010), which makes this robot a more efficient navigation platform than the IRobot alternatives. However, it also mops so it could fit better the expectations of the final user if he or she has a wooden floor (Fig. 3.5).

Fig. 3.5 Mint

Fig. 3.6 IClebo smart

3.2.1.3 IClebo Cleaning Solutions

Another option in the competitive market of vacuuming solutions is from Yujin Robotics (Yujin Robot 2010). With one low cost and a different intelligent solution, the IClebo platforms are viable alternatives for vacuum cleaning.

The IClebo Home is not that different from the IRobot technologies, but the IClebo Smart robot is really a more powerful alternative to the IRobot and Mint combined. The disadvantages of these products are their size and weight but depending on the use, it would be a good idea to have a big dirt deposit chamber (Fig. 3.6).

Fig. 3.7 Aquabot Pool Rover

3.2.1.4 Pool Cleaners

Another interesting application for automatic cleaning is the swimming pool cleaning. Different manufacturers compete in this segment using contrasting approaches. The Aquabot (Aquabot 2010) manufacturer is another alternative with its Aquabot Pool Rover (Fig. 3.7).

3.3 Green, Agricultural and Lawnmowing

The second most popular application for home robotics is automatic lawn mowing. Like vacuum robots, lawnmower robots focus their services on a specific application. The robotic platform infrastructure behind it is similar to that of vacuuming systems, but it is designed for outdoor work, as can be seen by comparing the Roomba SysML block diagram and the LawnBot SysML diagram. The presence of markers to help the robot fix its working area was initially its main limitation. Modern robots are now more context-aware, and their sensors and localization systems allow them to autonomously navigate inside their working areas. Common to all solutions in this subset is the presence of safety systems to avoid people or animals (Figs. 3.8 and 3.9).

Despite the large and growing markets for service robotics in homes and smart cities, enormous research continues on autonomous machinery for applications to agro-farming tasks.

3.3.1 Green Botics

IRobot and other manufacturers are starting to consider efficient energy management as an important feature in their products. The DH Compliant standard set by

Fig. 3.8 Friendly Robotics LawnBot (Robomow 2010)

Fig. 3.9 KA LawnBot (LawnBott 2010)

its robot manufacturer's consortium, similar to efforts seen in Europe, is also being applied to the same problem and finding the same solutions. The challenge is huge, but it is a must for any manufacturer seeking an opportunity in the modern robotic home environment.

3.4 Home Personal Robotic Assistants

Although they are not yet in the mainstream, different applications for home personal robots are resulting from the research efforts of a number of private and public initiatives. As with any type of social skills (Breazeal 2004), robotic platforms must try to interact with humans in unstructured environments, and they have done so with some success. These kinds of platforms are Human-shaped and are being developed to ultimately replace the human majordomo or maid. They have also developed some interoperability software services to equip any home robotic platform with some intelligence, energy management and localization systems according to the DH Compliant protocol. The following robotic platforms are serious attempts to achieve that final goal.

3.4.1 Examples

Personal Robot from Willow Garage, the PR2 (Cousins 2010; Willow Garage 2010) is a robotic platform for research and education. Its main characteristic is the use of ROS (the open source operative system, which is a fork from a Linux distribution with real time and other robotic framework utilities). It has been used for automatic plugs into electric walls as well as for experimenting in different unstructured scenarios present in a house (Fig. 3.10).

In the near future, linked to a price reduction, it may be possible to find another interesting alternatives for home personal robotics. The FutureBot (Futurerobot 2010), a restaurant and museum assistants from Futurerobot (Fig. 3.11).

Fig. 3.10 PR2 from Willow Garage

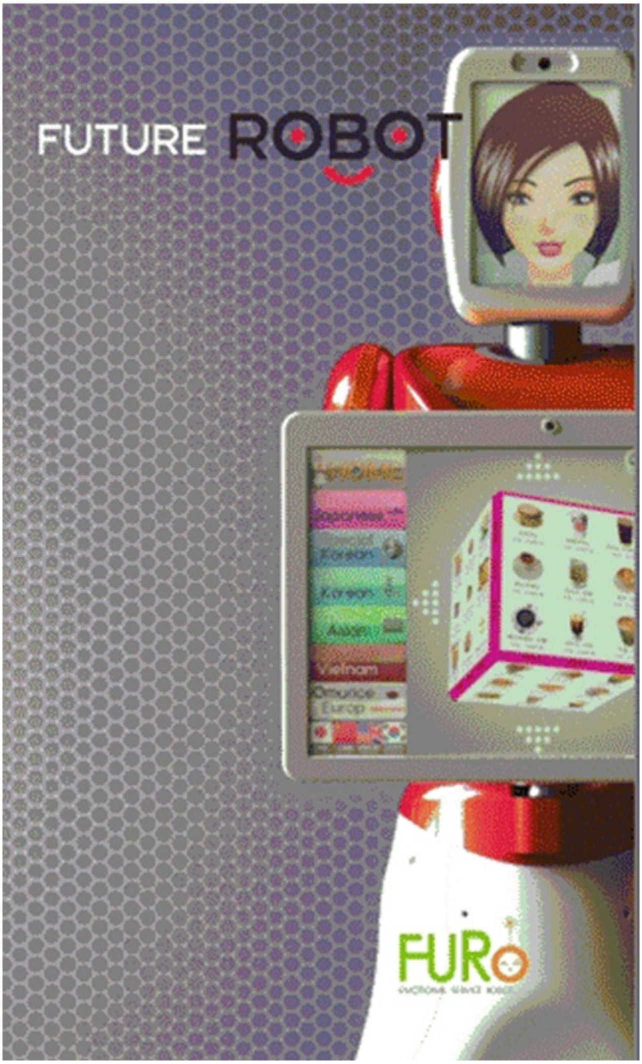

Fig. 3.11 FURO from Futurerobot

The **Sacarino** project (Cartif 2010) has been used inside the DH Compliant consortium's interoperability efforts (at the date of publication still protected by an NDA contract).

Moreover, it is fair to mention the **Honda Asimo** (Honda 2010) and similar solutions for other two-legged robots such as Reem-B from Pal-Robotics (Pal Robotics 2010) and others (Fig. 3.12).

Asimo will require an entire book for itself, and it does not fit the category of home robotics because of its company's price policy (Fig. 3.13).

Fig. 3.12 Honda Asimo (Sakagami et al. 2002)

3.4.2 Home Robotics Interoperability: DH Compliant Services

Software services in a network environment have their own role in house robotic assistants. Digital Home Compliant is an initiative led by Ingenium, University of Oviedo, Domótica Davinci, University of Sevilla, Cartif and Movirobotics that aims to achieve an interoperability virtual device based on DHC-Protocol and UPnP. It has several services to help a robot interoperate with other robots and with home and building automation services. For instance, DHC-groups (for house services cooperation), DHC-Energy (for green energy management), DHC-Intelligence (for business rules developments and machine learning), DHC-Localization (to get the position of a device) and DHC-Security&Privacy (to help the user in managing its privacy and protecting its home).

The architecture of DHC is depicted in Fig. 3.14.

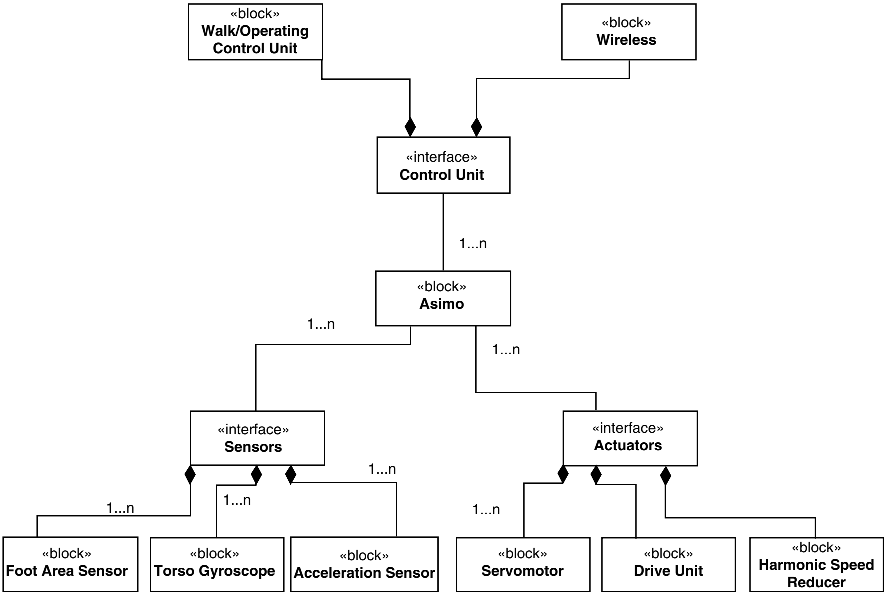

Fig. 3.13 Asimo SysML block diagram

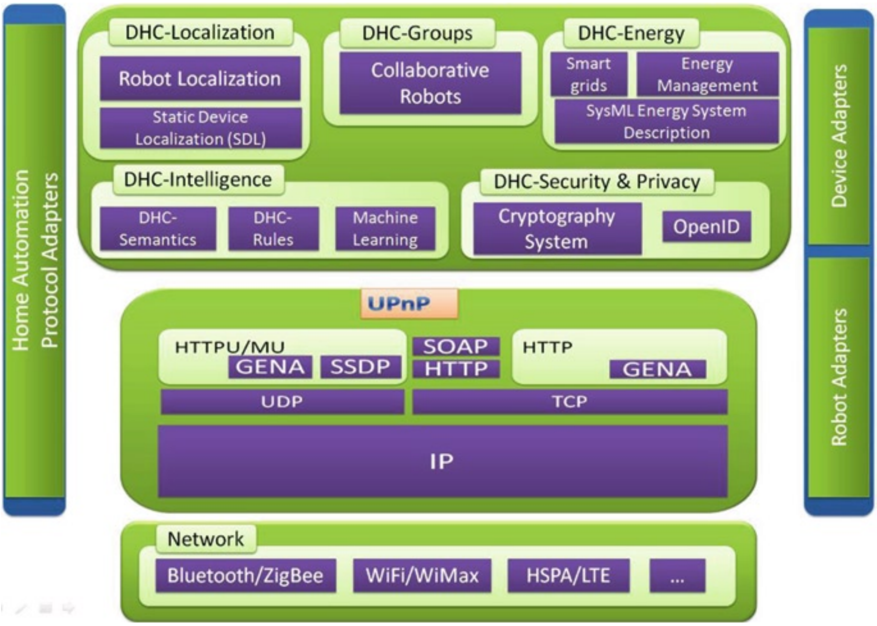

Fig. 3.14 DH Compliant architecture

3.5 Telepresence, Teleassistance and Robotic Health Services

The concept of telepresence (Graf et al. 2004) has been widely developed by modern research and market applications. It reflects the idea of being in two places at the same time, and mixes the power of ITC with robotic mobility, helping the owner sense and act remotely through the teleoperation of these platforms through a network (nowadays that means the Internet). Three examples of these platforms follow.

The most cost effective option for telepresence is the Rovio Wow-Wee (Begum et al. 2010; WowWee 2010). This is a cheap alternative, but incorporates an indoor navigation system based on an infrared vision recognition system. Its robot wheels are multidirectional and it can be compared with a 4 × 4 in the automotive sector. Its main weak point is that it does not have a camera at the height of a human face. However, its moving camera has tried to satisfy that need (Fig. 3.15).

Despite the price, it is of interest to analyze the Anybots QB telepresence solution (Fig. 3.16).

The final alternative shown is the Rovio competitor, the Spykee (Spykee World 2010) (Figs. 3.17 and 3.18).

3.6 Entertainment

Automatisms were already available when robots started to be used as entertainment tools (Karakuri 2010) or to perform magic tricks. Modern entertainment robotics applications for the digital home are linked with robotic toys. Moreover,

Fig. 3.15 Rovio Wow-Wee

Fig. 3.16 Anybots QB

Fig. 3.17 Spykee

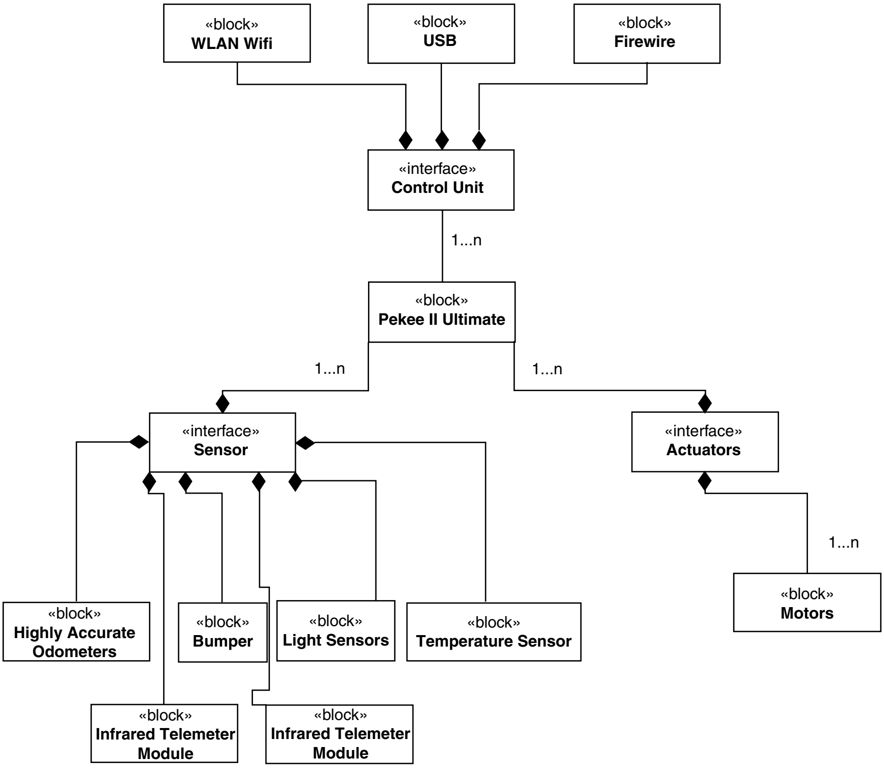

Fig. 3.18 Spykee SysML Block diagram

they have developed platforms intelligent enough to interact with their owners (Kerstin et al. 2003). They have also developed kits for adults who discovered that they enjoyed learning how to use them and how to build variations of their own. Of course, there are other entertainment robots, such as those for shopping malls, theaters and so on. But they are outside the scope of this book.

3.6.1 Playing

There is an enormous variety of robotic toys presenting many benefits and innovative approaches in amusement and assistive technology for children with autism. Failures in this area will help other robotic toy developers understand the fact that this market has not only typical high-technological device constraints, but also limited budget constraints for customers.

Fig. 3.19 Wow-Wee Tribot (Marco et al. 2010)

3.6.1.1 Tribot

From the WowWee (WowWee 2010) company, this robot explores several social interactions with children and is a good platform to introduce elementary programming concepts to youngsters. Its remote control is the perfect excuse to show how to program the device with a highly intuitive interface (Fig. 3.19).

3.6.1.2 Robotic Teddy Bear

From the MIT Media Lab, the Teddy Bear (Matsumaru 2009) is a platform for developing health solutions (MIT media lab 2010). Examples of those health applications of that robot are autism treatment or old people care. Of course, the research in personal health appliance should have also synergies with those robots.

3.6.1.3 Pleo

> "In all science, error precedes the truth, and it is better it should go first than last" Hugh Walpole

Technicians who develop robots sometimes make mistakes, just like any other human. One of the most frequent mistakes is losing focus on solving market needs, confusing the fulfillment of a customer's expressed desires with the beauty of a particular technique. While understanding the ease of humanizing a

Fig. 3.20 Pleo robot toy

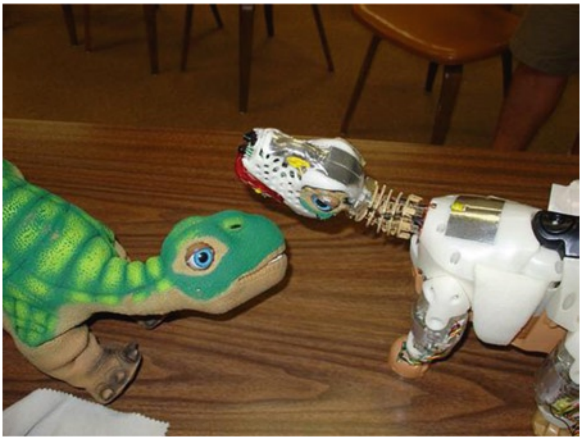

Fig. 3.21 Boe Bot

device, one can lose sight of the fact that developing a product without clearly understanding the needs of the customers could lead to failure. The same principle applies to not understanding that a $600 toy is not a toy; no matter what the Pleo functions were. The Pleo toy had those problems; and consequently, it failed (Fig. 3.20).

3.6.2 Robotic Kits

This section explores some robotics kits that are having enormous success in South Korea in terms of developing new applications for sumo or martial arts robot games (Robobuilder 2010). Examples of these kits include Robotis and RoboBuilder (Figs. 3.21 and 3.22).

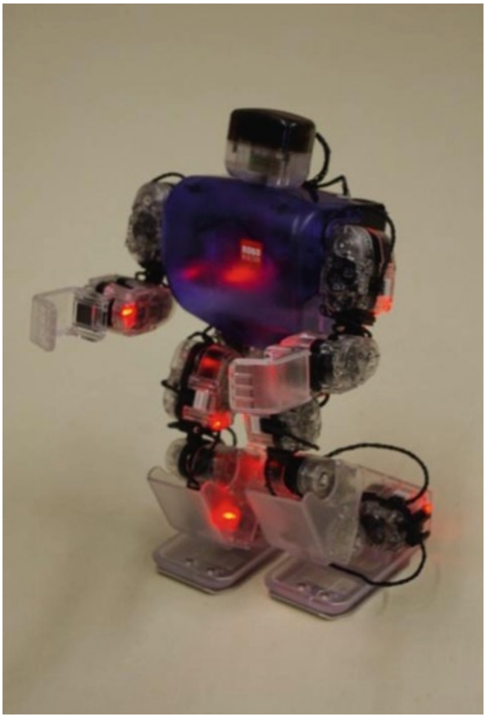

Fig. 3.22 RoboBuilder

3.7 Security and Safety Robotic Services

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3.7.1 Home Security

Home security is a problem with no widely accepted solution. Therefore, there are many opportunities to achieve a marketable solution for mainstream sales. It is remarkable that some attempts today in this category can be used inside buildings and homes to provide better protection and surveillance. It is impossible to describe all the security platforms that have been developed for this purpose, so a few examples will be considered as potential future home security devices. The following five potential robotic platforms could play a role in home security (Figs. 3.23–3.28).

It is not only in homes that security robots play a role, but also the defense sector has been a ready market for many solutions. If these become affordable (and they will), they will have an even more expanded role in our smart cities and societies of the future. Examples include Predator (General Atomics 2010), Big Dog (Wooden et al. 2010; Boston Dynamics 2010) and the Samsung surveillance unmanned vehicle (Samsung 2010).

Fig. 3.23 IRobot PackBot

Fig. 3.24 Pointman robot

3.7.2 Privacy Considerations

All technologies have some risks, and service robotics is no different. Therefore, the importance of understanding and managing these questions is crucial. Inside the digital home, a key question is that of privacy and the openness of traditionally protected space in homes.

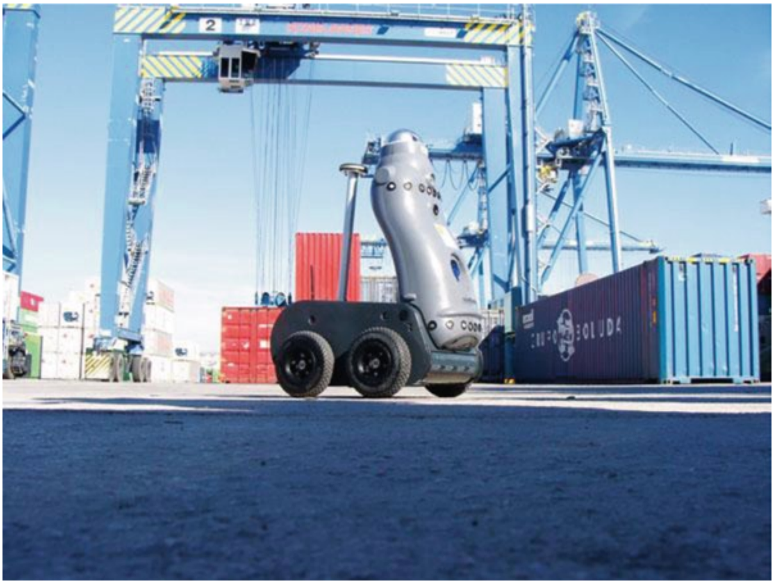

Fig. 3.25 mSecurit

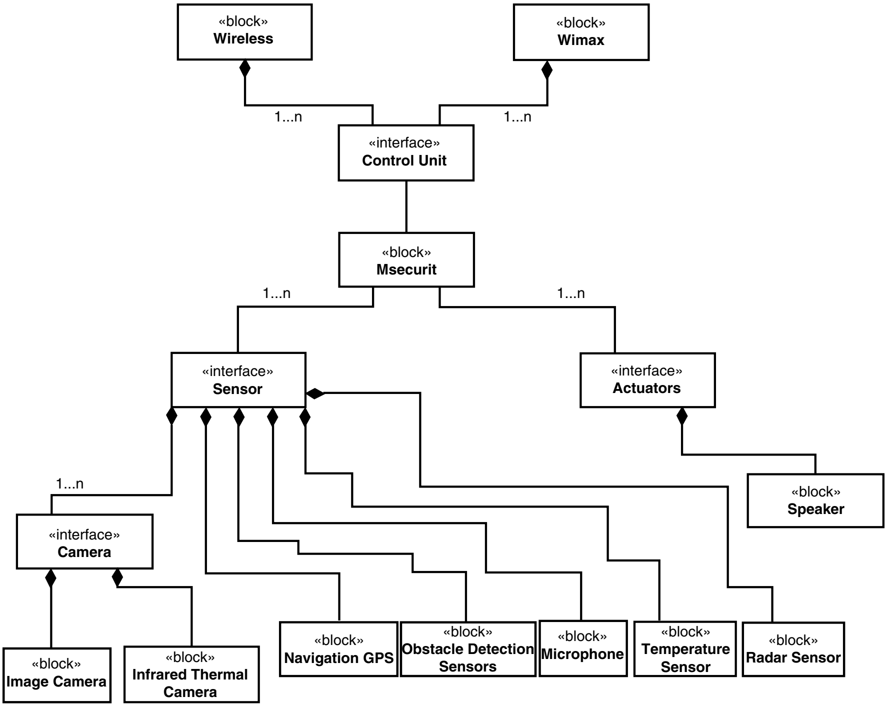

Fig. 3.26 mSecurit SysML block diagram

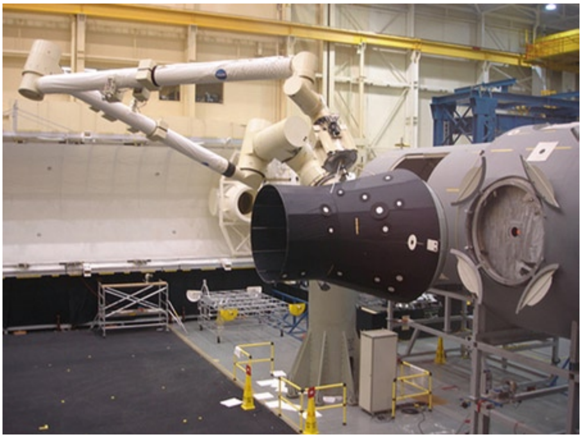

Fig. 3.27 Canadarm2 (Mamen 2003)

Fig. 3.28 Ultra light unmanned aerial vehicle (UAV)

An interesting approach to this problem can be obtained from a comparison with privacy management inside social networks or O.S. security policies. This might show how the intentions of users have to be prioritized over any other consideration within their own home. The right to have control of your home is not only a primary feature of privacy acts of different countries, but exists in the upper range of laws and norms of any democratic legal system, such as constitutional or root law books.

Therefore, it is of high importance to manage this feature carefully if digital home robots are to be effective.

3.8 Home Robotic Assisted Learning

Learning is a lifetime task, from childhood to adulthood. Science and technology benefit from the visualization and motivation a robot gives students in the areas of physics, mechanics, electronics, computer science, and other similar disciplines. Furthermore, mobile phones connected to our houses and robots allow us to satisfy both our random curiosity and our ongoing learning needs. E-learning is outside the scope of this book, but there exist different robotic software and hardware that represent good examples of robotic learning solutions.

For example, the Lego NXT Mindstorms is the best attempt at a cost effective and powerful platform for robotic facilities. In addition, it has an enormous deployed base so it can be seen as the *de facto* standard in the learning robotics area (Fig. 3.29).

Of course, there are hundreds of problems that admit of robotic solutions, but we would like to mention one more that is only a software platform. This is the suite for robotic programming and simulation from National Instruments Lab View (NI LabVIEW 2010) (Fig. 3.30).

Fig. 3.29 Lego NXT Mindstorms

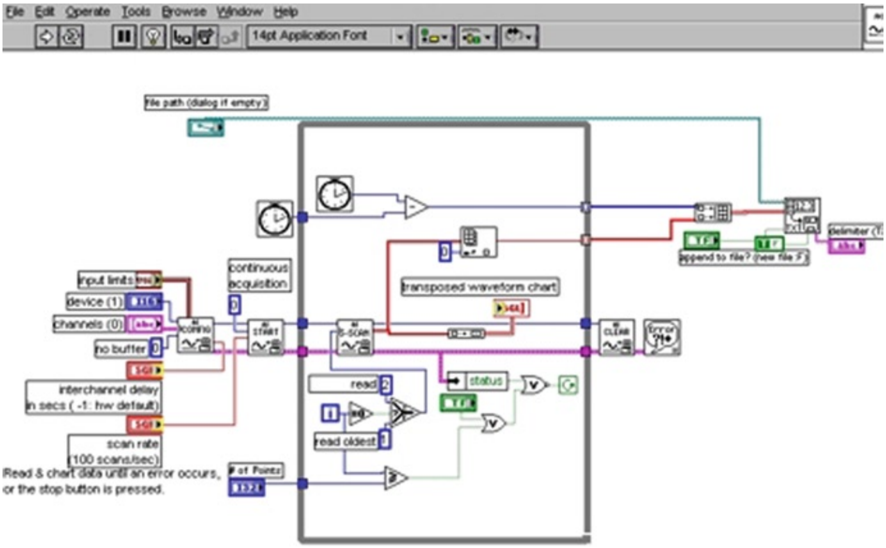

Fig. 3.30 National instruments lab view

3.9 Other Service Robotics in the Professional and Home Environment

The fields of professional service robotics, automated logistics and industrial robots will create enormous synergies with the digital home. Here it will be the same situation as in security robotic solutions. They will be the leaders and the pushers for new technologies that will came to the mainstream when the expected price reduction occurs.

3.9.1 Professional Service Robots

Professional service robotics is the branch of service robotics with the best growth forecast, since the industry is already using solutions similar to home robotics but in a different context. The aim of professional service robotics is to enhance the ability of people to perform tasks required by their jobs. The current professional robotics strategy is to replace or cooperate with the worker on tasks involving high risk or tedious tasks using intelligent robotic co-workers or teleoperated robots under constant human supervision. However, other solutions are being developed to give a greater capacity to activities that demand important physical skills or if operators are disabled. There is no doubt that, in the unstoppable search for the lowest costs and maximum benefit, a more profitable way to use professional robots instead of cheap workers from underdeveloped countries will be found (Fig. 3.31).

Fig. 3.31 Corobot

The main application fields of professional service robotics are the following. All have enormous potential within the digital home robotics context:

- Field and outdoors (agriculture, forestry, mining, etc.);
- Autonomous transport (fleets of vehicles, driver assistance, etc.);
- Professional cleaning and the inspection of different kinds of infrastructures (buildings, ships, pipelines, bridges, etc.);
- Construction and demolition;
- Logistics (logistical tasks in hospitals and offices and the delivery of mail/food/ medicine, logistics in workshops, etc.);
- Underwater applications (exploration of the marine fund, inspection and repairing of pipes, etc.);
- Medical robots and rehabilitation; and
- Emergency situations (natural disasters such as fires, earthquakes, floods and human disasters such as bombings, explosions in chemical plants, energy, etc.) (Figs. 3.32 and 3.33).

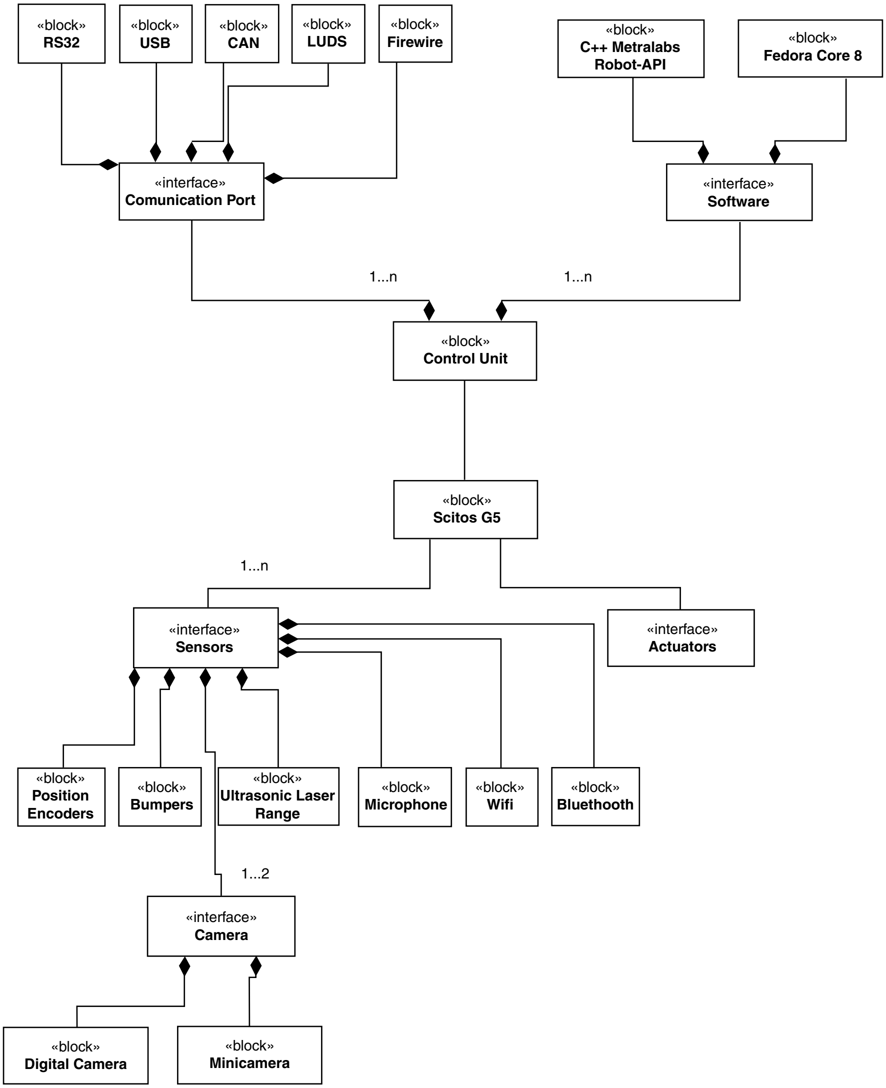

Fig. 3.32 Scitos GT SysML block diagram

Fig. 3.33 RobuCab from Robosoft