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An approach to the standardization of the Robotic Technology

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***Abstract* — The robotic technology is becoming mature and people start agreeing on the need for defining common related standards. The emergence of such standards could benefit the development of robotics in many ways; however the broadness of the field and the different expectations may hinder the process. While there have already been several isolated attempts to standardize in some specific areas of robotics, we believe that the set up of a general standardization framework for robotics will be necessary in order to issue consistent standards.**

***Keywords* — Standardization, Robotics, Model, Framework, Object Management Group.**

1. Introduction

As the market of Robotic Technologies is expanding from the manufacturing industry toward lighter, more general and more human friendly applications such as entertainment, security or healthcare, many companies are working on developing their own solution. However, developing a Robotic System is still a difficult, long and costly task that requires a high degree of expertise and often results in solutions with too few added-value functionalities to gather wide interest from potential end-users.

To address those issues, many organizations including mainly universities and research laboratories but also some companies have been working on developing Robotics Development and Integration Platforms that provide a consistent environment and adequate tools for the development of their robotic systems [1-16].

While this has helped bringing some robots to the market like Aprialpha [17] from Toshiba or making others popular to a wider public like Aibo[18] or RoboSapiens [19], the range of their application is still limited to basic functions such as entertainment or communication, and the fact remains that all those different platforms are not interoperable.

As it becomes obvious that one company alone will hardly be able to support the burden of the development of a complete robotic solution, the emergence of open standards that will enable the integration of components from several specialized companies becomes of paramount importance for the durable development of the robotic market.

2. The Need for Standards in Robotics

Although one could find many reasons why standardization for the robotics field is convenient, we will address the main reason why it will be necessary for a large scale development of the technology.

A. Technology re-use

Software reuse is not a problem intrinsic to robotic systems. In other fields such as business software, the emergence of component based standard technologies has greatly facilitated the development of the industry.

Nowadays, transfer and reuse of software designed specifically to control robotic systems is difficult, and often impossible due to the diversity of hardware and software involved. Most of the time, an important software integration effort is necessary to reutilize software developed by different organization (or even different sections of the same organization). Using a common standard which clearly defines the functionalities and the external interfaces of each component will relieve the robot makers from the burden of the development of a complete robotic system and let other

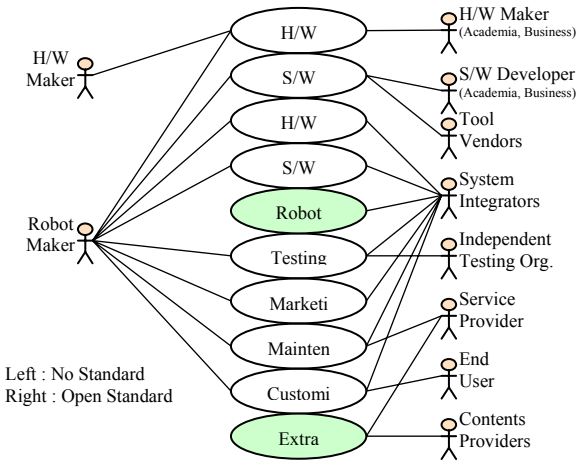


Figure 1. Use case of a robotic system development. When an open standard exists, the burden of development can be shared amongst several actors and new possibilities emerge.

business actors emerge such as specialized components developer, tool vendors or other service providers. We can then expect that sharing the financial profit generated by the development of a robotic system will be compensated by the expansion of the market.

B. System Level Functionalities

When working on a robotic system, most designers and developers only focus on the internals of their system (which is usually already complex enough) and fail to include in their design the functionalities necessary at a higher level, where the system becomes a sub-system, part of another bigger system such as administration, deployment and so on. A development framework based on a standard addressing these issues will help enforcing practices and design policies facilitating the integration of robotic systems.

C. Conformance

While common standards are essential to incorporate different robots with varying electronic devices into the same intelligent network, they are also needed to develop certification program that will ensure the quality and the safety of the robots put on the market, wiping out models that fail to meet basic criteria. From a consumer point of view, this would give the assurance that a robot will not harm him/her and generate more trust in the technology. From a vendor point of view, this would help setting up a legal framework clearly defining the duties and the limits of responsibilities of each actor and so as to protect them against eventual abusive legal action from a user after the misuse of a the robotic system.

3. Challenges when designing standards

Understanding that standardization in the field of robotics is necessary unfortunately does not make the task of defining the standards any easier and people who will take the charge of this process will have to face many challenges.

A. A broad and complex field

When developing a robotic system, one have to deal with many technologies ranging from pure control theory at the lowest levels gradually up to artificial intelligence, via several communication and information processing paths, all applied using software engineering practices, and that is, besides all the mechanical and electrical aspects. The physical characteristics of a robotic system can have a large variation including mobile robots, humanoid robots, pet robots, manipulator robots, robot house, micro robots, etc. In the same way, the span of robotic system applications is very broad, including communication and entertainment robots, life style support robots, rescue robots, intelligent transportation, surgery robot, and so on. With such diversity, it is still not at all clear what and how to standardize in the robotic technology.

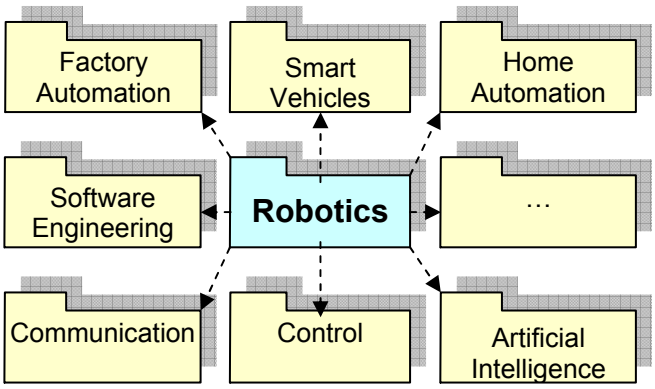


Figure 2. The Robotics Technology has a very broad scope both concerning the technologies it relies on as well as the applications it can be applied to.

B. An early technology

It is only the recent advances in hardware and software technologies that has made the development of service robotic systems possible and presently, there are still new developments pouring out every day. Moreover, the robotics research going on around the world is still simply too much disparate for anyone to accept and adopt one consistent code as the base for a complex robotic system, which has so far prevented from the emergence of a de facto standard.

C. Different Expectations

While researchers can see a standard platform as a way to build and demonstrate innovative robotic systems by developing new experimental concepts on top of already available technology or simply by replacing a low performing component by a new one including all the newest algorithms and optimization. The openness and flexibility provided by the standardization are, in this case, of prime importance.

A robot maker, one the other hand, while still interested in the flexibility and vendor independence allowing it to build robot easily by integrating standard components and developing its own components that will provide it with a competitive advantage, will also want a way to protect its intellectual property and make sure that the product that has been developed and delivered will not be modified in the way that could alter its performances and safety. In that case, the potential openness provided by a standard can become a potential threat, unless the standard specifies for an efficient management of what is open and what is not.

4. A Reference Standardization Framework

As of today, nobody has been able to give a clear definition of the concept of robotic system nor been able to state where the scope of Robotics starts and where it ends. Moreover, as approaches to develop robotic systems can greatly vary between organizations, it often happens that a very same concept is referred by different appellations. We feel that in those conditions, pursuing a standardization activity is bound to end up with overlapping, unfocused and inconsistent standards.

In order to deal with the complexity of the standardization of Robotics and before attempting to start any actual specification work, a thorough preparation of the process is therefore necessary.

As a first step, we believe it will be necessary to identify and classify the different areas of robotics in which we intend to pursue a standardization activity so as to establish a clear cartography and a common terminology of the technology that would become a reference during the discussions.

To help us in classifying these areas, we introduce the notion of robotics standardization space. This space comprises three dimensions which represent the level of abstraction, the level of functional abstraction and the specialization of each area.

The highest level of abstraction is the "Model Level" where the concepts, semantics, usage paradigms related to robotics are standardized. These concepts can then be mapped to the "Platform Level" in which standards specify how to apply the concepts defined at the model level to a particular technology (like communication protocols, concrete interface definition…). The platform level standards can then be mapped to the "Implementation Level", at which the standards APIs to support the development of components in any given platform are defined. The lowest level of abstraction is the Physical Level in which standards concerning hardware are defined (like the connection between two mechanical components).

The level of functional abstraction roughly corresponds to the typical multi-tier architecture found in most robotic systems and that consists of the Hardware Abstraction Layer and the Information Abstraction Layer, the Task Execution Layer, the Deliberative Layer and the Application Layer.

Finally, in each layer of functional abstraction, we define areas that are specific to each application of any given robotic system and that are therefore optional. For instance, a standard related to Navigation Technology is important for the development of mobile robots but is irrelevant in the case of a robot house.

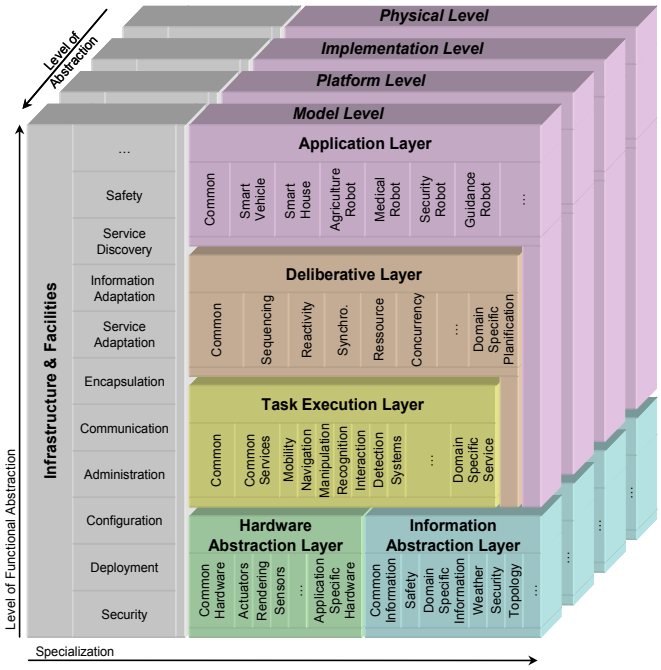


Figure 3. A clear and common high level decomposition of the major functional categories constituting robotic systems would help focusing on specific areas of standardization and avoid overlapping of the different efforts.

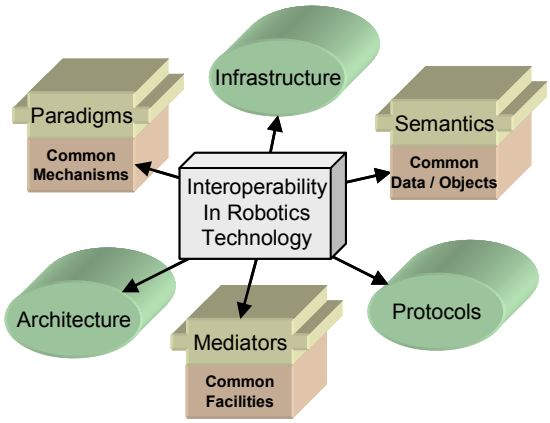


Figure 4. To ensure interoperability between components in a robotic system and between robotic systems standards must address Infrastructure, Architecture and Protocol issues.

The ideal case would be that the infrastructure be common to all types of application and at all level of functional abstraction. However, different infrastructures, or subsets, may turn out to be necessary at different level of functional abstraction.

Based on this classification, it will be possible to set up working groups responsible for elaborating standards focused on well defined areas, and which will address all the aspects necessary to ensure the interoperability of robotics systems in their area, as well as assure the liaison with other organizations involved in the standardization of a related field.

5. Existing standardization efforts

As of today, there is no established standard covering service robotics. However, we can mention several past and present efforts to move in this direction.

One of the most closely related efforts was certainly the Robotics Engineering Task Force (RETF) [20], lead by Intel™, and whose goal was to specify reusable, interoperable software technology for mobile robots. Unfortunately, after having issued a couple of early draft specifications, their activity seems to have definitively ceased.

Looking at other related domains, the Society of Automotive Engineers (SAE) [21] has evolved hardware and software specifications so that various subsystems can communicate with each other within any given robot.

A presently active effort is the Joint Architecture for Unmanned Systems (JAUS) [22] working group. JAUS is a component-based, message passing architecture for the domain of unmanned vehicles. In short, it is a set of standardized messages and component behavior enabling internal and external communication between unmanned systems. Supported by the SAE Generic Open Architecture, JAUS had been largely military in usage and implementation but will also be open to non-military use.

In the domain of industrial robots, the ISO TC184 has issued guidelines concerning safety [23], performance criteria test methods [24] and graphical user interface programming

[25], as well as nomenclatures for coordinate systems and motion [26].

We can also mention more general standardization activities such as, the Open Service Gateway Initiative (OSGi) [27] or the Open Resource Interface for the Network (ORIN) [28].

All these activities, although either too domain oriented or too general, could nevertheless be a good source of inspiration for a robotics standardization activity.

6. Robotics Standardization within the OMG

About a year ago, we started a standardization activity concerning the Robotics Technology within the Object Management Group organization [29]. We believe that the OMG provides us with the adequate environment to pursue this activity for several reasons. First of all, the OMG is a consortium that has been involved in creating standards related to the computer industry for more than 15 years and is the home of the Unified Modeling Language (UML) [30], the Model-Driven Architecture (MDA) [31] and the Common Object Request Broker Architecture (CORBA) [32] which are all widely accepted and implemented within the industry. Also, as an independent and non-technical organization, it provides an open membership and adoption process where specialists in the field from member organizations can freely and equally provide inputs and vote on technology issues while guided toward a generally accepted consensus. Finally, although it is the home of CORBA, the OMG issues standard at a high level of abstraction based on models that can then be mapped to any existing technology.

Following the approach mentioned above, we are presently trying to gather information related to the robotic technology that will help us identify the recurrent functional / architectural patterns in existing robotic systems so as to establish a common cartography of the robotic technology, as well as determine the areas that actually need standardization and their respective priorities. In order to do so, we have issued a formal OMG Request for Information [33] requesting anyone with practical knowledge in the field to share their experience and opinion. The responses to this RFI will be used to populate the robotics standardization space mentioned above and help us initiate working groups that will focus on the standardization activities that are the most relevant. Eventually, we expect to be able to issue standards at the Model Level and Platform Level, which are the most needed to ensure the interoperability of robotic systems. As responses from anyone in industry, government or academia are welcome, we invite you take part into the process.

7. Conclusion

Standardization in the field of Robotics will be necessary for the large scale popularization of the technology and a wide spread of its applications outside factories, like public places, offices or homes. The non-emergence of established consistent “de facto” standards will require a formal standardization process that must be thoroughly prepared and focused in order to generate a general consensus between the many actors involved.

Ultimately, the success of our effort will depend on the active collaboration of all the potential players involved in the robotic business at an international level who may provide relevant inputs and feedback into the process. Moreover, the large amount of work necessary before we can expect the emergence of a global standard in Robotics will require time and man-power to be achieved and securing the long-term funding of such activity will certainly be one of the major non-technical issues.

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