



robuBOX™

Seamless Building of Microsoft® Robotics Studio-based, Industrial-Grade Service Robots



ROBOSOFT® S.A.

<http://www.robosoft.fr>

DRAFT 10

Summary

The robuBOX™ aims at making faster and cheaper the development of industrial-grade service robots for professional use, in fields like transport, cleanliness, security or health.

This document describes the innovative concept of robuBOX™ developed by ROBOSOFT. We describe all the flexibility of this concept, at both hardware and software levels, and demonstrate why the robuBOX™ plus Microsoft Robotics Studio is the state-of-the-art solution for all designers and integrators of service robots.

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Building industrial-grade service robots

What is service robotics?

"A service robot is a robot that operates partially or fully autonomously to perform services useful to the well-being ... of humans and equipments. They are mobile or manipulative or a combination of both."

[Definition of The International Federation of Robotics]

Service robotics is becoming one of the fastest growing businesses: the ageing population leads to less workers and more demanding services to people. Service robots help human beings in their everyday life for basic services such as transport, cleanliness, security, care and others.

Market opportunity

Since the beginning of the millennium, the process to robotize services to people has started, the same way than manufacturing automation took place in the 70s. But the market opportunities are much bigger, because of wider scope and associated huge needs. A few examples among others:

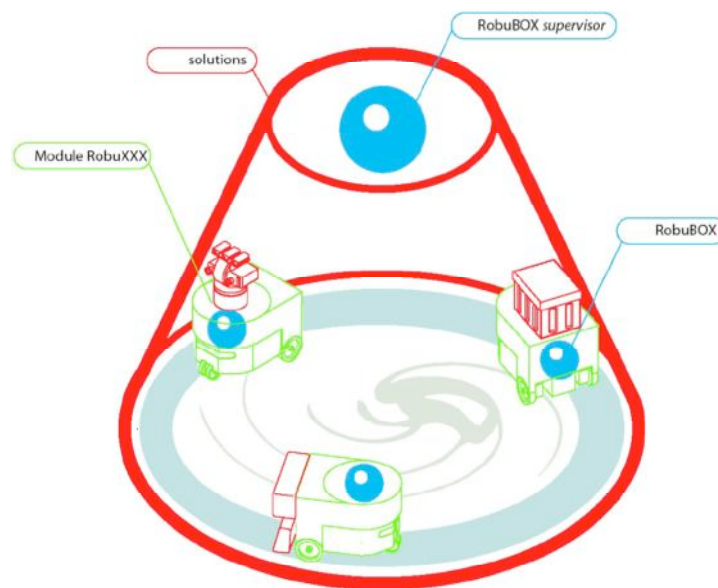
- Automatic shuttles for transport of people over short distances (a few km). Typically, all public sites are concerned : hospitals, museums, airports, malls, theme parks, factories... to link parking lots or to move inside the site;
- Automatic transport of goods, such as containers, boxes, parts... in the same sites;
- Surveillance of these sites;
- Floor cleaning, currently done with vacuum-cleaners and scrubbing machines driven by operators. There are millions of square meters cleaned everyday all over the world which call for cost reduction and flexibility;
- Window cleaning, also done by hanged operators, in hazardous conditions. Some large and/or modern windows even preclude manual cleaning...
- Robotic assistance to elderly and handicapped persons, whose number is growing everyday, while less and less nurses are available.

Technical challenge

The technical challenge lies in the diversity of potential applications in various different fields and kinds of users. There are 3 levels for such challenges (see figure):

- **Robotic Solutions** (red), for final customers, who have to implement customized systems meeting their specific requirements. For instance a fleet of robots transporting people from a parking lot to a site;
- **Robotic Modules**, for integrators (green), who require off-the-shelf mobile robots. Their challenge is to define and build the right mobile configuration, made of dedicated robotized vehicles;
- **Robotic Hardware and Software Technologies** (blue), also called control-systems, which all together implement 80% of the service robot intelligence. It includes hardware and software for these robots and target industrial manufacturers willing to conveniently robotize their products (vehicles, cleaning machines, etc.).

The overall technical challenge is to propose horizontal hardware and software technologies, common to most of service robots applications, which are generic enough to be used at the 3 identified technical levels, by end users, integrators and vehicles manufacturers. Moreover, all these technologies should be state-of-the-art, integrating latest advances and providing for full openness and robustness.



Industrial challenge

The industrial challenge is to make industrial-grade robots at market acceptable price levels, within a given timeframe while reducing the overall development and manufacturing risks. However, to build complex task-specific mobile robots, developers have to deal with challenging issues. Among others:

- Dealing with the increasing number of sensors and actuators required by the robot to manage its environment: its “ears”, “eyes” and “hands”.
- Dealing with the ever increasing computing power necessary to implement sophisticated control algorithms. Often, a distributed approach, made of several boards connected together is an efficient but complex solution.
- Developing and implementing robust and reliable real-time control algorithms, mapping the potentially complex behavior of the service robot. Software bugs in this domain may lead to unexpected stops of the robot and to unacceptable or even critical situations for a robot having to operate 24 hours a day by itself.
- Reducing development time, by not “re-inventing the wheel” for each new robot. They have to find a way to leveraging proven hardware and software developments while providing openness and drawing from the power and new capabilities of recent advances.

Managing complexity and ensuring reliability while drastically reducing development time and costs let no way to developers: they have to build from a multi-level, structured and modular (component-based) approach. Exactly as nobody would today build a full-featured computer from scratch, robotics developers must find the adequate hardware and software bricks to play with.

The Microsoft® Robotics Studio framework

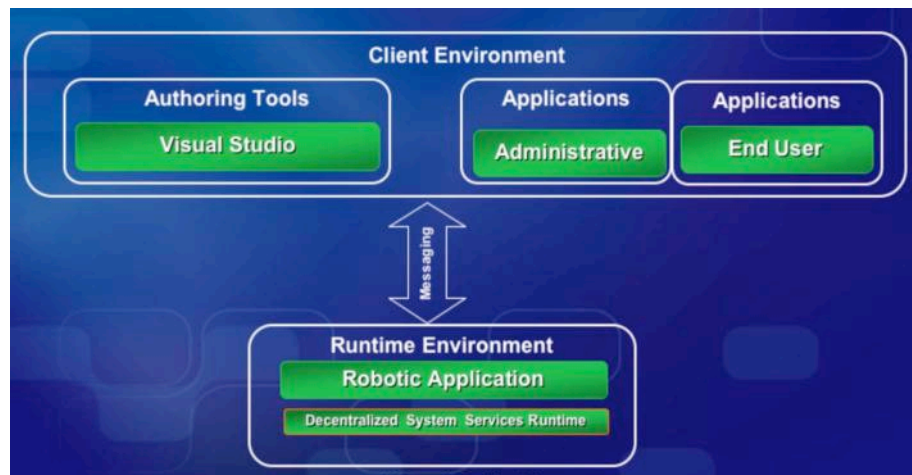
Purpose and Scope

The Microsoft Robotics Studio is an extensible framework amplifying and extending Microsoft Visual Studio to make it easier to develop and debug software for robot scenarios. Its main features are:

- A runtime that scales across multiple hardware devices and platforms
- Support scenarios for single robots, multiple robots, and robots operating with other computing technologies

The development tools include:

- Powerful robotics authoring, including development and simulation environment
- Visual programming editor
- Simulation
- Concurrency debugging
- Target Microsoft OS and potentially other embedded environments

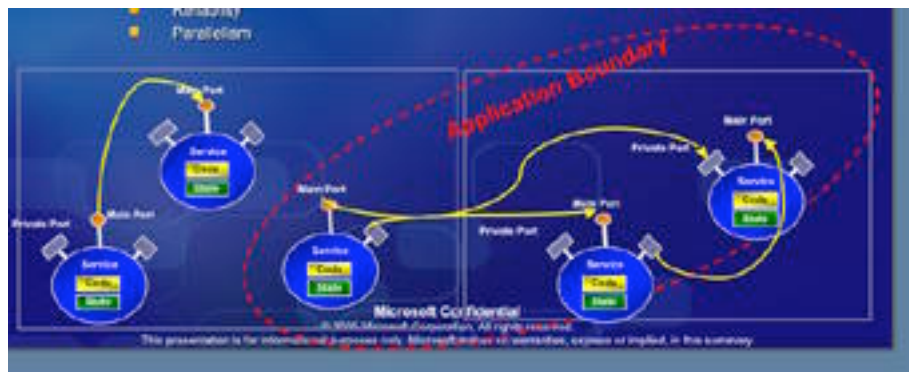


Principles

The basic principle is to divide a robotic application into communicating web services, which can run on any CPU of the control system.

Applications are assembled from a sea of loosely-coupled, services concurrently executing across machines.

- Interactions described via service contacts
- Services form pair-wise, session-less couplings
- Protocols are simple request/response, or subscriptions
- Separation of state from function
- Provide isolation between components
- Reliability
- Parallelism



Robotic application projects are first class citizens. Other features:

- Scales with programmer skill
- Helps beginners with drag/drop programming
- Assists advanced developer with service orchestration
- Conceptually consistent with conventional programming languages
- Context based toolbox
- Support Rapid Application Development via visual programming, simulation and visualization.
- Supports programming of distributed scenarios
- Extensible to support other hardware

Benefits

The Microsoft Robotics Studio leverages – and seamlessly integrates with – ROBOSOFT robuBOX™, providing:

- For red business – Solutions: Fast and cheap integration/customization of robots
- For green business – Modules: Capitalization of algorithms and software developments, making them easier and cheaper to integrate
- For blue business – Technology: Generic robotic algorithms

But a robot is not only software: mechanical part and application software are needed to obtain efficient and robust service robots, as professional expect them. That is why ROBOSOFT expands Microsoft Robotics Studio tools with:

- Validated multi-purpose off-the-shelf modules (mainly mobile platforms), which can be customized and integrated using Microsoft Robotics Studio
- Dedicated hardware for service robots. The robuBOX™ can be used by designers to build the controller of their service robots
- Technology libraries (robotic algorithms), compatible with modules and robuBOX™
- Application software (vertical applications), specific to application fields, such as CyberCars, cleaning robots, transport robots ...

ROBOSOFT robuBOX™: seamless building of industrial-grade service robots

What is robuBOX?

The robuBOX™ concept is resulting from hundreds of man-years of public and private Research & Development.

The robuBOX™ is a set of generic hardware and software modules used to build control systems for any type of service robot. The robuBOX™ comes with proprietary libraries and services compatible with Microsoft Robotics Studio including:

- Robotic sensors acquisition and pre-processing (laser, ultrasounds, inductive wire for guiding, gyro, vision ...)
- Generic Robotic algorithms: torque/speed/position control loops, path generation and tracking, collision detection and avoidance, localization ...
- Applications algorithms, such as CyberCars libraries (platooning, crossing, overtaking ...), floor cleaning, fleet management ...

Bridging technological value and business requirements

Any service robot controller can be built using one or several robuBOX™, in various and customized configurations.

The distributed nature of such complex control systems fits the Microsoft Robotics Studio concepts, allowing robot manufacturers to focus on their value by working on business requirements.

In such conditions, using robuBOX™ makes much easier and faster the design of customized robot controllers.

robuBOX™ product range

The 3 types of following robuBOX™ can be combined to build any complex robot controller:

robuBOX™-Lite



Based on ARM processor, the robuBOX™-Lite performs low-level (control loops, data pre-processing...) requiring critical real-time functionalities. It runs Windows-CE, and allows managing critical real-time tasks such as data acquisition, signal pre-processing or low-level control.

robuBOX™-Standard



Multi-purpose robuBOX™, based on standard x86 processor and running Windows XP or XPe. If real-time functions are implemented in lower levels (for instance intelligent speed controllers are used), the robuBOX™-Standard can be a good solution to power a simple robot. The robuBOX™ Standard is the simplest way for integrators, since all developments can be done using standard and widespread software development tools from MICROSOFT.

robuBOX™-Remote



Based on a laptop/desktop computer running Windows XP, windows server... with dedicated I/O. This robuBOX™ is appropriate for remote Man Machine Interface or Fleet Management.

robuBOX™ architecture and key technology choices

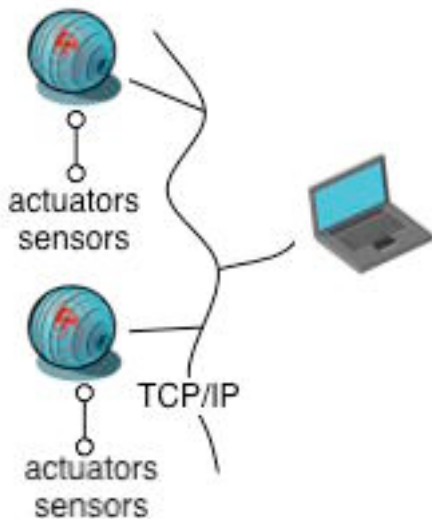
The robuBOX™ modular concept allows implementing simple robot controllers to very complex architectures for sophisticated service robots. We describe below the most common configurations.

Single controller for standalone robot



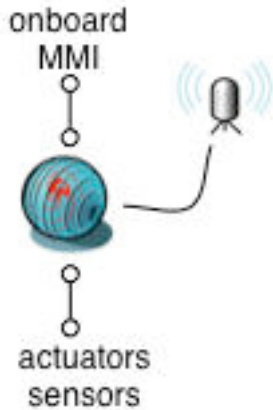
This is the simplest controller, made of a low-cost robuBOX™-Lite. This is the final architecture for simple robots manufactured in large quantities, which need simple MMI (Man-Machine Interface) and no communication with other devices.

Twin controller with laptop for standalone robot



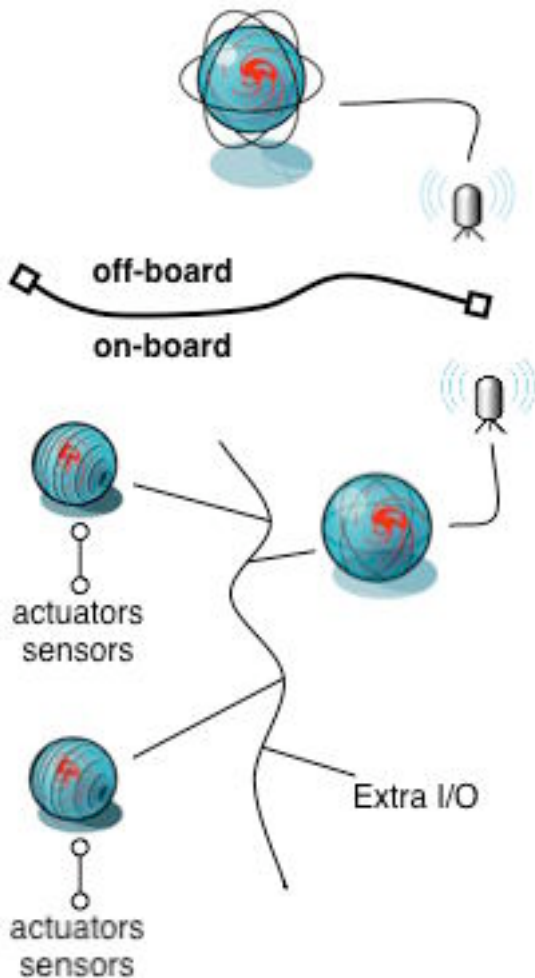
This type of controller is useful for complex mobile robots (needing more than 1 controller), on which a simple laptop is used to control the motions. In this case, a MMI can be implemented on the laptop to control the motions of the robot (speed, steering ...). The laptop can also be used to communicate through a Wifi channel for instance.

Single controller for communicating robot



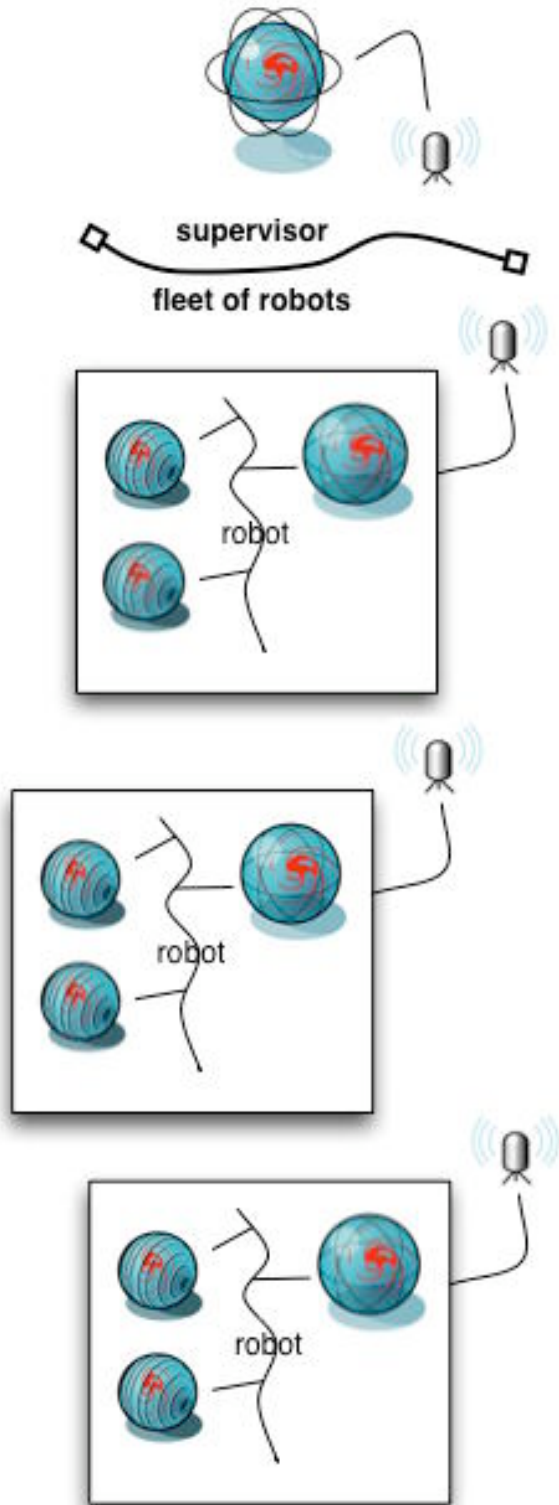
If the standalone robot requires a remote MMI and/or communication capabilities, an extra Wifi channel is needed. This configuration meets the requirements of remote-controlled robots like EOD robots.

Intelligent distributed controller



Among all the possibilities is using intelligent I/O and servo-controllers. If critical real-time functions (control loops and axes synchronisation) are implemented in the servo drive, a robuBOX™-Standard can control as many axes as needed networked by as many robuBOX™-lite as needed, running standard non real-time Windows. Integration and developments are then much easier.

Fleet of complex multi-processor robots



The main advantage of the robuBOX™ concept is its flexibility which allows short hardware and software development times, even for complex distributed architectures. In this case, each robot has several robuBOX™-Lite for real-time and interfacing functions, a robuBOX™-Standard for communication and onboard coordination. A robuBOX™-Remote is used for fleet management.

robuBOX™ at work: examples and business cases

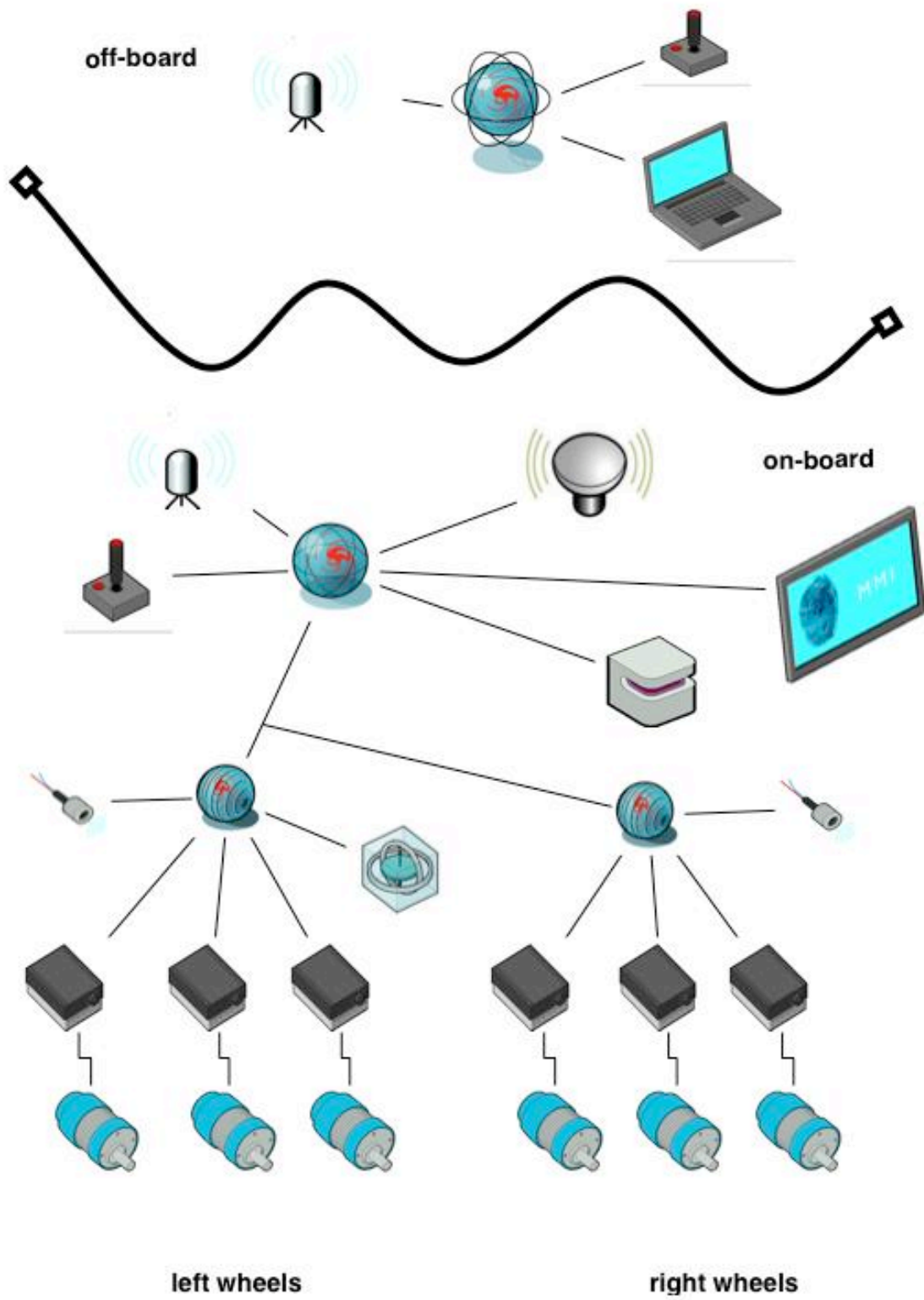
Dual-mode EOD and investigation robot



Many EOD and investigation robots combine remote control and autonomous modes.

With exceptional obstacle-crossing capacities compared to its size, the robuROC6 offers a real solution for reconnaissance, monitoring and safety operations while minimizing human risks.

The highly innovative concept of customized loads allowing adaptation of the load to the context of operations opens multiple application fields. Thus equipment such as video cameras, transmission systems and sensors can be very easily installed on the robot to customize it to the type of missions it will have to carry out.

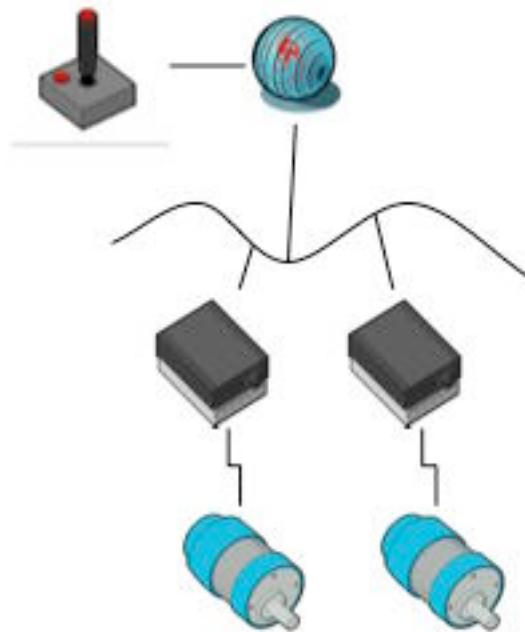


Intelligent wheelchair and simple vehicles

An intelligent wheelchair can be controlled by a robuBOX™-Lite, controlling the 2 motors. Such a device also needs a simple Man-Machine Interface and a joystick to be driven. The flexibility of the robuBOX™ allows connecting miscellaneous sensors allowing intelligent behavior, such as obstacle detection, automatic motions, tilt limitation ...

The parameters (maximum speed, turning radius, joystick data filtering ...) of the wheelchair can also be customized depending on the type of disability: to do that, any laptop can be connected, and a dashboard appears in a web page, displayed by any web browser.

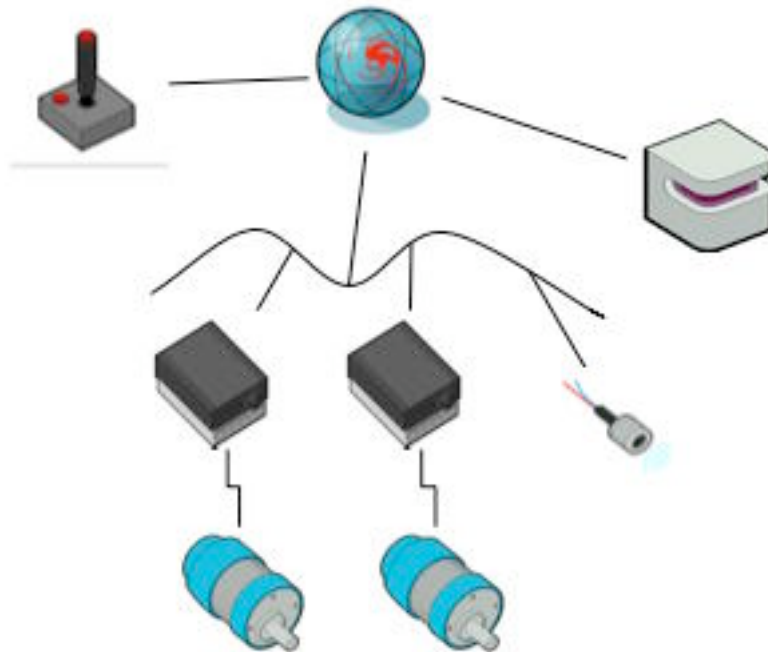
This scheme applies to any simple vehicle, like a golf car, to which automatic capabilities would improve its use.



Automatic vacuum cleaner



In this type of application, the robot is built using distributed CAN-based components (power amplifiers, I/O, sensors ...). In such a case, there is no need to implement critical real-time functions in the robuBOX™, because they run inside intelligent components. The laser, used for both safety and localization is directly connected to the robuBOX™. That is why the robuBOX™-Standard (running Windows or XP) is enough, and gives all the required flexibility to customized the system and add extra functions. An extra Wifi channel, connected to the robuBOX™-Remote, allows implementing and coordinating a fleet of vacuum-cleaners cooperating to automatically clean large areas.

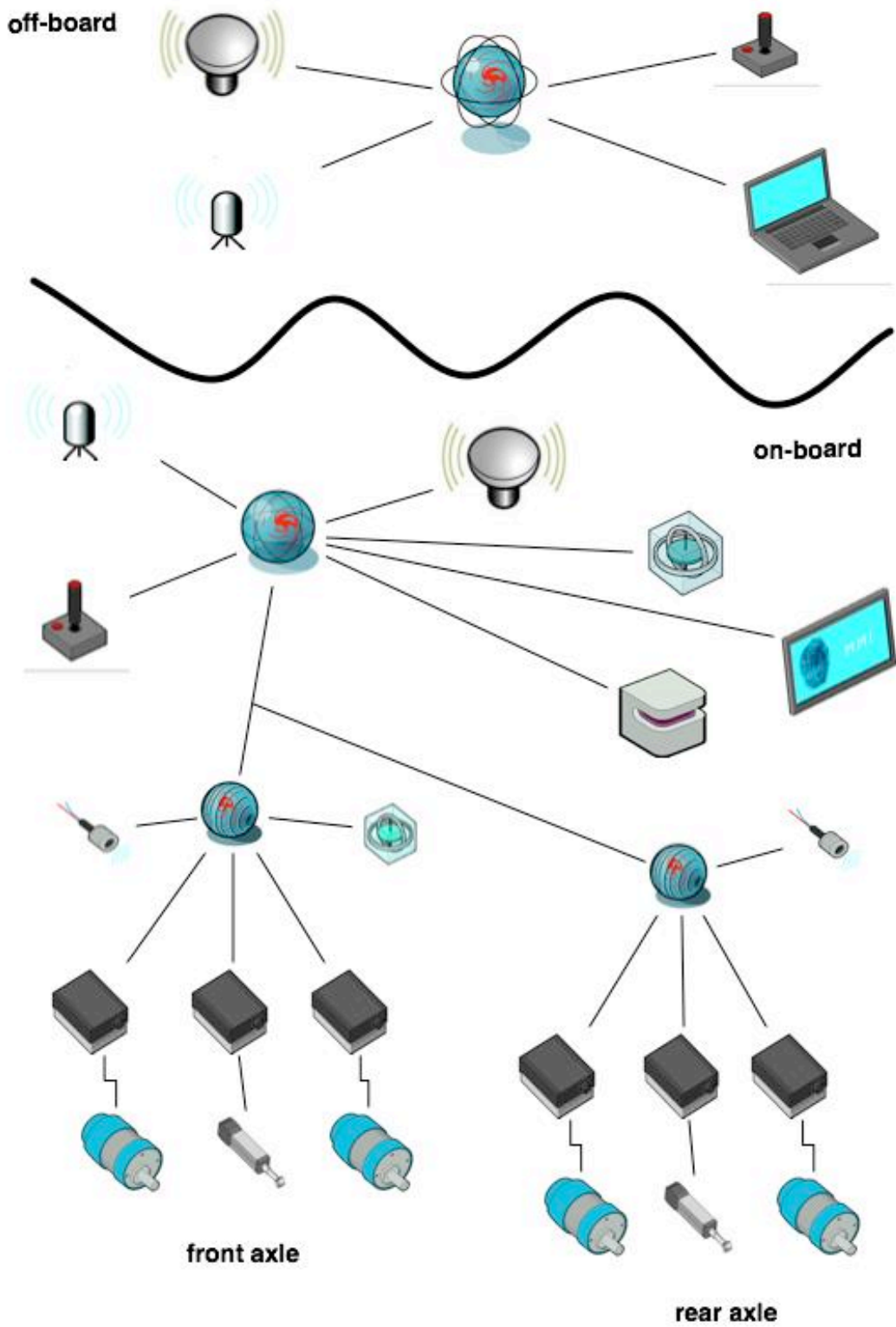


Automatic cab shuttle



The *robuCAB*[™] is a mobile robot, not a traditional electric vehicle. It has been designed so that all of its functions (throttle, braking, steering, etc.) are computer controllable. Sensors on the vehicles control all of these functions by furnishing real-time information to the automatic control system. It uses the “drive-by-wire” concept developed for aircrafts, which eliminates all elements of mechanical transmission such as steering columns, drive shafts, connecting rods, etc. This vehicle is quite modular and customizable to take into account not only the varying nature of the passengers but also environmental factors such as climate, safety,

etc. It is the basic component for complex Cybernetic Transport System (CTS), where fleets of automatic vehicles transport people from locations to locations, in taxi mode (on-demand) or shuttle mode (scheduled trips, like buses).



Conclusion

In this Whitepaper, we have presented the result of several hundreds of man-years of public and private Research & Development: the robuBOX™ innovative concept is a real breakthrough in the way to design and produce cost-effective, industrial-grade service robots. The Microsoft Robotics Studio empowers developers, offering them the way to seamlessly develop and maintain sophisticated robotics applications.

From stand-alone wheelchairs to fleets of surveillance, cleaning or transportation robots, ROBOSOFT robuBOX™ opens huge and exiting business opportunities to industrial integrators and manufacturers.

About ROBOSOFT

ROBOSOFT is one of the worldwide leaders of service robotic solutions. Thanks to its high level skills in all scientific and technical fields, ROBOSOFT develops and supplies since 1985 developmental and modular solutions for transport, cleanliness, security, health and research applications.

ROBOSOFT clients include operators of large buildings and sites open to the public (hospitals, airports, museums, shopping centres, train/bus stations, campuses, amusement and other parks), service providers (urban transportation entities, cleaning companies, security services), integrators operating on those markets and public and private research laboratories.

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