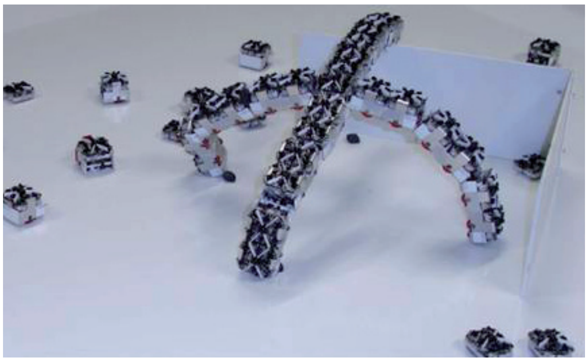
Replicator
FP7 - 216620

Robotic Evolutionary Self-Programming and Self-Assembling Organisms

Symbricator Hard- and Software Architecture

Replicator and Symbrion Synergy

The Symbrion and Replicator projects investigate and develop novel principles of adaptation and evolution for symbiotic multi-robot organisms based on bio-inspired approaches and modern computing paradigms. Along those approaches such robot organisms will consist of super-large-scale swarms of robots, which can dock with each other and symbiotically share energy and computational resources within a single or distributed artificial-life-form. Furthermore, whenever convenient these swarm robots will dynamically aggregate into one or many symbiotic organisms and collectively interact with the physical world via a variety of sensors and actuators. Those paradigms which are enriched with means for embodiment and emergence



A vision of a Replicator

of swarming features, will enable such artificial organisms to autonomously manage their own hardware and software organization. Artificial robotic organisms will become therewith self-configuring, self-healing, self-optimizing and self-protecting from both hardware and software perspectives. All this will lead not only to extremely adaptive, evolve-able and scalable robotic systems, but also will enable robot organisms to reprogram themselves without human supervision and for new, previously unforeseen, structure and functionality to emerge. In addition, different symbiotic organisms may co-evolve and cooperate with each other and with their environment to tackle various industrial, manufacturing, medical or rescue problems.

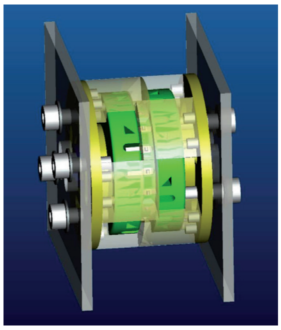
Both both projects differ in specific targeted objectives:

Symbrion	Replicator
Platform for exploring artificial evolution and pervasive evolve-ability	Intelligent, reconfigurable and adaptable "carrier" of sensors (sensor network)
Extremely powerful computational on-board resources	Sensors- and communication-rich platform
Support for artificial immunology and embryology	High-reliable in open-end environment
Large number of light modules	Medium number of heavy modules

Although the projects head each for their own objectives, they share common hardware and software architectural objectives. The Replicator specific requirements boil down to the need for a large number of sensors, human-independent way of power harvesting as well as the capability of local and global localization and mapping of the organism itself and its environment.

Hardware Architecture

The mechanical functionalities of the assembled organism need to be deeply related to the hardware structure and functions of its basic composing modules. Many basic functions have to be taken into account in order to achieve satisfactory performance of the robotic organism, in particular locomotion capability; docking mechanism; lifting/bending capability.



Two docking elements in connection

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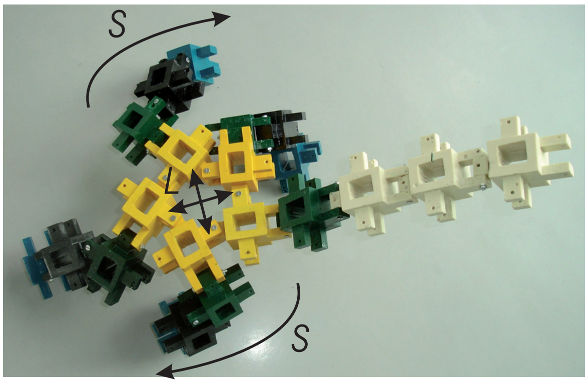
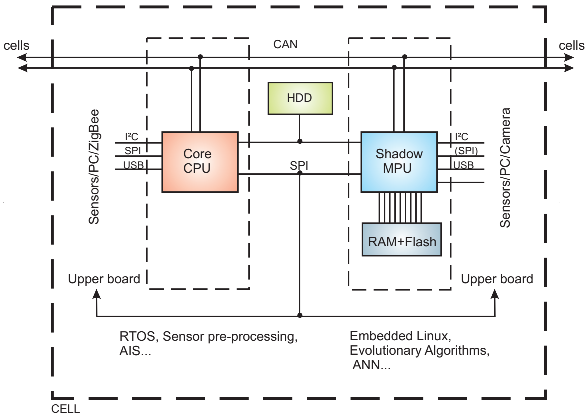


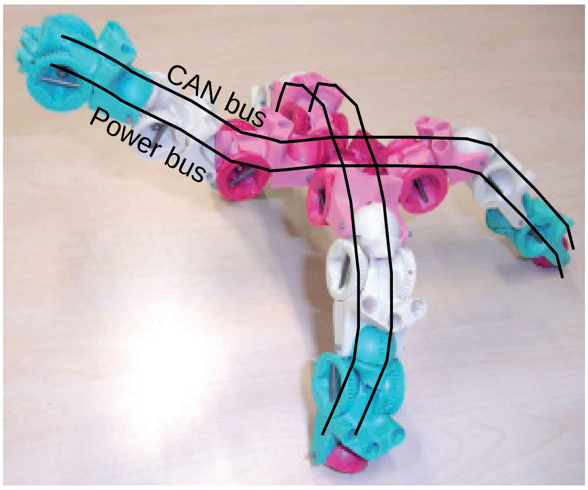
Top-view on the unsymmetrical scorpion, central modules (yellow) built a ring. Deforming this ring, different movement of legs can be created

The electronic functionalities depend on the mechanical structures and functions an organism has to fulfil. As merging all necessary components on one board is not possible, several small modules, so-called cells, need to be distributed across the organism. Each cell should have its own functionality. Thereto, tasks are divided amongst cells – this allows a lot of possible configurations for homogeneous or heterogeneous robots.



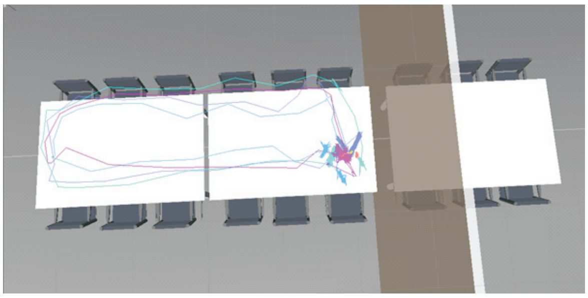
Electronic design principles for one single cell

The communication within and amongst boards should be possible. Thereto, a common wired bus system is used for both message and energy exchange amongst micro-robots in the organism.

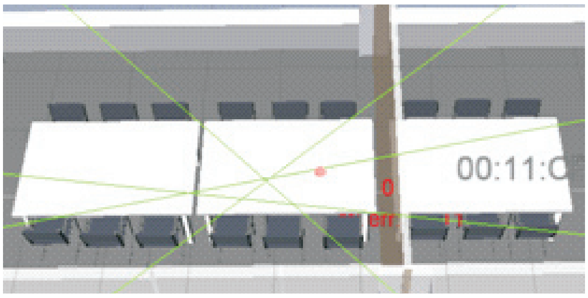


Principle of sharing common bus for communication and for energy

Sensors represent very important components of the overall hardware design and should provide the individual robot basic localisation and mapping abilities. Thereto, a 3D real time location system based on existing wireless communication network technologies and a vision system distributed across the micro-robot are used.



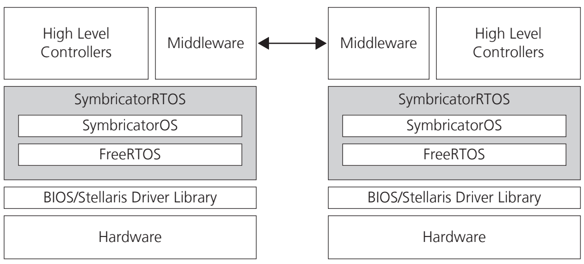
2D view showing the computed angle of arrival (green lines) and the time difference of arrival curves (blue hyperboloids)



3D view of the room

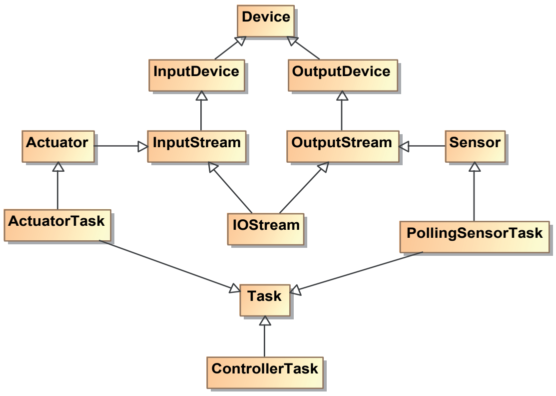
Software Architecture

Novel software development principles underlying robotic organisms, such as those for self-configuration, self-adjustment and self-learning, will be investigated. The principles will allow the organism adapting to the changes occurring at micro-robotic and multi-robot hardware structure and functional levels as well as at environmental morphodynamic levels. Each part of the hardware needs a driver that allows the higher software system to manage it. Most of the drivers are provided by the Stellaris Driver Library. Above the drivers, the SymbricatorRTOS is composed of the



Software Architecture

FreeRTOS layer that provides the Real-Time System, and the SymbricatorOS layer that implements the low-level controller. Above the SymbricatorRTOS, there are the Middleware layer, which defines unified interfaces and communication services when the robots aggregate into a more advanced multi-cellular organism, and the High Level Controllers, which are in charge of the different behaviours (evolutionary, learning, adaptive etc.) of the single robot and of the aggregated organism.



General structure of the SymbricatorRTOS

This enables the robotic organisms entrained by their own and environmental morphodynamics to let emerge new functionalities, to develop their own cognitive sensor and control structures and to work autonomously or cooperate as a collective in uncertain situations without any human supervision, e.g. to rescue people. This shared software architecture is exploited in the embodiment and the emergence of advanced cognitive sensor fusion and self-organized control modules of the organism.

Background Information

Web: http://www.replicators.eu
http://www.symbrion.eu

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