Development and Experimental Evaluation of a Software Framework for the Lily Robots

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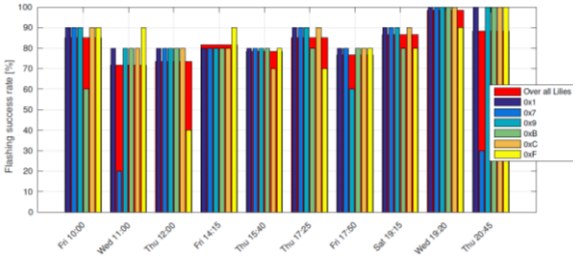
The existing firmware framework, used for the Lily robots is based on the open source uracoli radio library. In this project the framework in use was revised in matters of know an unknown problems and limitations concerning:

1. Over the air upgrade of the application of the Lily robots
2. EPM Neighbourhood discovery

The over the air application upgrade is performed with the *wibohost.py* script from a PC, that is sending the application image via a serial connection to the radio host. This central radio host is processing the application image and sending it in a broadcast to the Lily nodes. In a preliminary test, a flashing success rate of 33.75% was identified.
The transfer of the project, originally existing as an AVR-GCC Makefile project, to the Atmel Studio IDE (AS), that has a rich set of hardware debugging features, and the implementation of a logger functionality on the *wibohost.py,* provided the insights needed, to identify the serial connection as the error source, that caused the corruption of data sent from the PC to the host.

An additional HEX line checksum check was implemented on the radio host. This check allows to inspect the individual integrity of every line of data received from the PC. Below the evaluation of a set of verification tests is shown.



Over the air application upgrade of 6 Lilies during different times of day with the improved firmware. Average over all Lilies in red.

An overall application flashing success rate of 82.5% could be achieved. The tests also showed that the traffic on the 2.4 GHz radio channel has a major influence of roughly 15% on the application flashing success.

In a second step, the EPM neighbourhood discovery procedure was investigated. In longer experiments (~20 min), a dead lock situation of the inter Lily communication on the inductive channel was observed. No communication to the neighbour Lily or any newly latched Lily could be observed from that point on.
The EPM communication of the Lilies is based on a cyclic scanning of the neighbourhood for possible communication partners. Apart from this active discovery, the Lily switches continuously among its four EPM channels, to listen for an incoming message.
Using the hardware in loop debugging feature of AS, the error source could be determined as the appearance of an unforeseen situation in the state machine of the robot. The flags for the normally exclusive states of being a communication initiator (when scanning) or a responder were found to be activated at the same time. In this situation, the Lily does not change the EPM channel anymore and it loses its ability to reply in a communication.
In a suite of 5 tests, each lasting one hour, it could be shown that the correction of this firmware problem eliminates the total interruption of the EPM communication to 100%.

On the other hand, these tests have revealed, that the neighbourhood discovery procedure exhibits a substantially lower success rate, than what is expected by design. To date it is unclear to what extent the spreading in performance on the inductive channels and the asymmetric communication in terms of communication approach and reply per channel, has a deterministic reason, generated by the firmware, or is induced by a fluctuation of physical characteristics of the respective pairing of two given EPMs.