The Combechem MQTT LEGO™ Microscope.

A grid enabled scientific apparatus demonstrator.

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Introduction

In previous work, it has been shown that the provision of remote monitoring can help to improve the quality of results, and the efficiency with which they can be collected. Giving the scientist the ability to also control their experiment remotely is an extension of this.

Why LEGO?

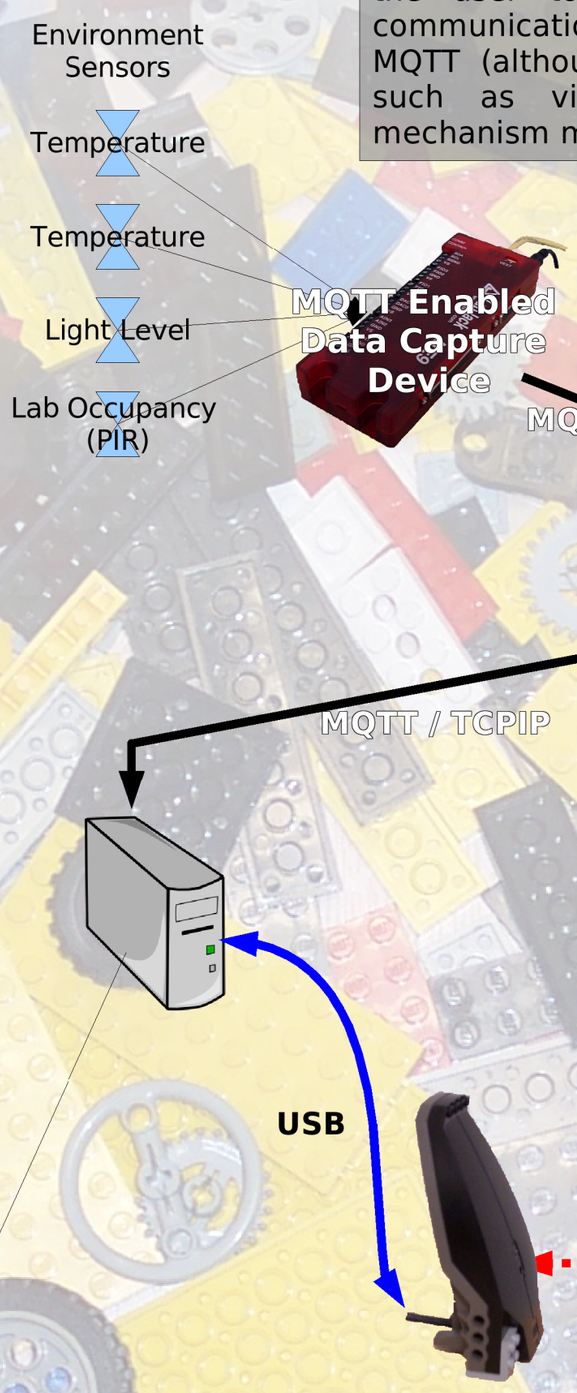
The experiment available to this group involves a high power laser. To ensure the safety of the chemists working on the experiment, emission by the laser should only be allowed under certain conditions, hence to test these principles a “safe”, sandbox needed to be found. LEGO provides us with a familiar, “physical sandbox” which can be used to demonstrate various technologies. LEGO Mindstorms provides us with a programmable microcontroller for LEGO components. The Mindstorms RCX also provides some sensor connections, the data from which can be merged with those from traditional sources, using a Message Broker.

Why MQTT?

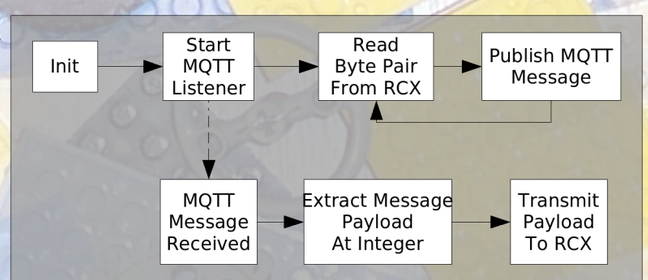
This group has prior experience of using MQTT, and an IBM Message Broker to implement reliable, efficient message distribution systems, hence it was logical for existing technologies to be reused.
Other message passing technologies are available from both commercial suppliers, open standards, and from within the UK eScience community. It would be interesting to see a comparison of the various message passing systems.

Delayed Delivery:

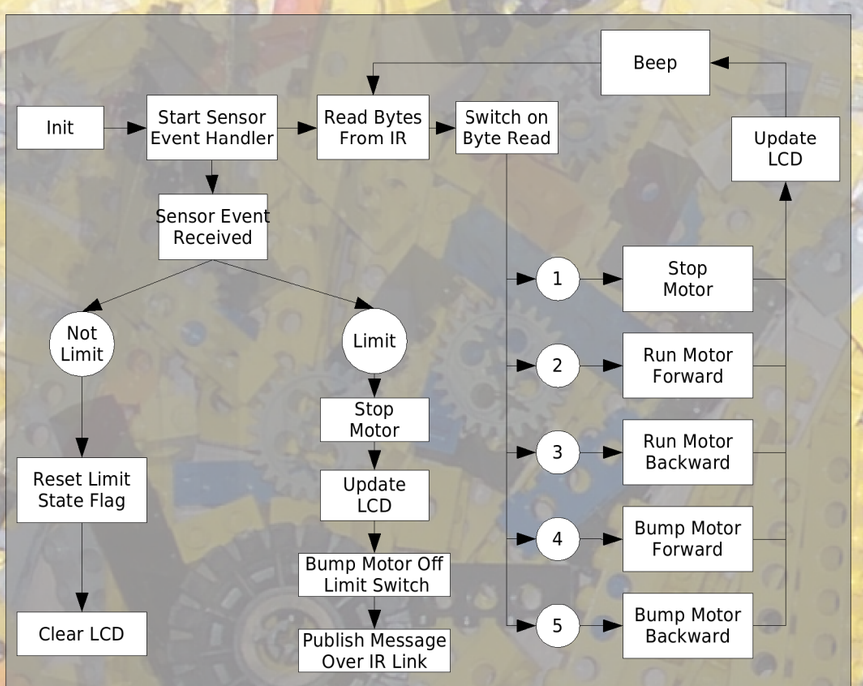
In previous work (Laboratory Monitoring) it was important that measurements always get through. When controlling apparatus this isn't always the case. Initial placement of the IR Transmitter made the link un-reliable. The control messages coming from the user were sent using MQTT's Resilient mode, meaning that they were stored until delivery was possible by the broker. However this meant that when the link re-established the RCX received a backlog of messages and acted on them – ie unexpectedly moving the sample tray. Had this been in control of the laser system, a potentially dangerous situation could have occurred



The client interface presents the user with a summary of the laboratory and experiment conditions (as derived from the apparatus and environment sensors).
It also provides a mechanism allowing the user to trigger events. All this communication can take place over MQTT (although for some applications, such as video, a parallel delivery mechanism may be better suited).



The PC connected to the LEGO IR Tower provides a bridge between network based MQTT messages, and an application specific “MQTT-lite”. This aims to provide only relevant parts of the MQTT standard, without including un-necessary bloat. This methodology is suited to embedded systems, where resources may be limited.



Code running on the LEGO RCX receives control messages over MQTT, and signals from directly connected sensors. The motor outputs are then toggled based on this. Messages are also sent over MQTT to alert the user of sensor conditions.

Conclusion.

LEGO provides an effective (and fun) way to prototype remote control and sense systems. It allowed us to discover a number of features of brokered message passing that could have lead to a dangerous situation had the technology been implemented directly onto the experimental rig. It has highlighted the benefits of task analysis (had we fully analysed the 'experiments' behaviour, we should have realised that resilient messaging was the wrong choice in this case), and of having independent electromechanical interlocks; the control system should be prevented from changing experiment status when someone is working on the rig.

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