The Design of a Tangible Underlying Control Architecture and Foundational Control Application:

A case study in developing a Mixed Reality application for the remote control of lighting in the VR-lab

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The VR-lab is a facility located in the University of Twente occupied with supported decision making in design processes and developing new configurations with VR-tools. The lab is deployed with a large variety of tools and systems which facilitate its use as a multifunctional research department. Nevertheless, the gradual expansion and change of these technologies has led to a complex collection which provides difficulties to control to its full potential.
Therefore, the objective of this assignment is to *Design a tangible underlying-control architecture and foundational control-application.* Tangible in this context means that the underlying architecture should allow for constant change, development and expansion of the devices for control- and the tools and systems to be controlled. Foundational refers to the fact that the application which has been created should allow for expansion of its functionalities and potential implementation on multi-platform devices. For feasibility reasons, the decision was made to perform a case study by *Developing a Mixed Reality application for the remote control of lighting in the VR-Lab* to complete the assignment within the given timespan. Nevertheless, the result of the case study should be in line with the main research objective of this assignment and should function as starting point.
There was chosen for the lighting due to the fact that it is one of the most complex systems in the lab, which provides the most potential which is currently not being used.
Developing for the HoloLens 2, the latest Mixed Reality headset, is in line with the research objectives of the VR-lab and a Mixed Reality application offers extensive capabilities as a control application.

The lighting is currently controlled through Obsidian Onyx, a program designed for controlling stage-lighting which has a built in operating system to be able to alter and control the parameters of each individual lighting fixture. However, due to the complexity of the program the light is generally only controlled through a tablet which offers the possibility to switch the lights on and off.
The communication between the tablet and Onyx is done through an extension of Onyx called Onyx Manager (OM). OM offers three possibilities for the remote control of Onyx: through the Web, Telnet or UDP. The current control system uses the web-remote. The UI on the tablet is a web page, with embedded hyperlinks for on-and-off buttons. These hyperlinks trigger the dispatch of specific command codes which control the lights. Each command code refers to one specific set-up for the lighting and has to be manually programmed into Onyx. This provides a lot of work, making Onyx not the ideal operating system for the lighting. However, the scope of this assignment is not to find a suitable alternative for Onyx and to focus on the greater goal Onyx was solely kept as a potentially replaceable workaround to make the prototype function.

As the project should provide a tangible underlying control architecture, directly sending UDP or Telnet signals from the HoloLens would not be suitable. As it would assume that current and future technologies are all able to receive and read these signals. Therefore, the HoloLens should transmit a

suitable signal which could be received by an intermediary receiver, which would convert the signal to a specific signal that a specific technology can read.
As this protocol, Message Queuing Telemetry Transport (MQTT) was adopted. With MQTT, publishers can send messages with a specific topic to subscribers, which are subscribed to a specific topic. The communication is supplied by a broker, which forms the intermediary between the two clients. The advantages of MQTT are that it is light-weight and works on top of the TCP/IP transportation protocol, which ensures message delivery. Also, it is very easy to add additional publishers and subscribers to the network.

The application that was built on the HoloLens 2, incorporates several functionalities that highlight the possibilities and advantages of VR. Input of the application will trigger an output in the lighting.

It was aimed to make a functional application. However, some attention has been paid to aesthetics and the main problem with this assignment was that these two goals constantly interfered with each other. So this application does provide a substantiated basis for control, but it requires a lot more research to find out whether it would allow implementation on a large basis.