Master's Thesis Engineering Technology

2017-2018

Comparison of a Wired and Wireless Networked Control System using XBee antennae and LabView

Steven Abrahams

Master of Energy Engineering Technology

Introduction

The demand for wireless applications is also in the industry an ever-growing fact. The research presented in this poster focuses on wireless controlled network systems and investigates the viable solutions for wireless communication in an industrial setting. The wireless communication creates several problems such as finding the optimal sampling period, preventing message delay, avoiding message dropout and lowering power consumption.

The proposed solution uses XBee antennae for the wireless communication and LabVIEW to program the control loop. This choice was made because XBee antennae are low power-consuming and LabVIEW gives much flexibility and control over creating a control loop. Since it was not possible to close the control loop via the physical connection, it was decided to investigate whether a satisfying conceptual solution using XBee would be possible.

The control loop

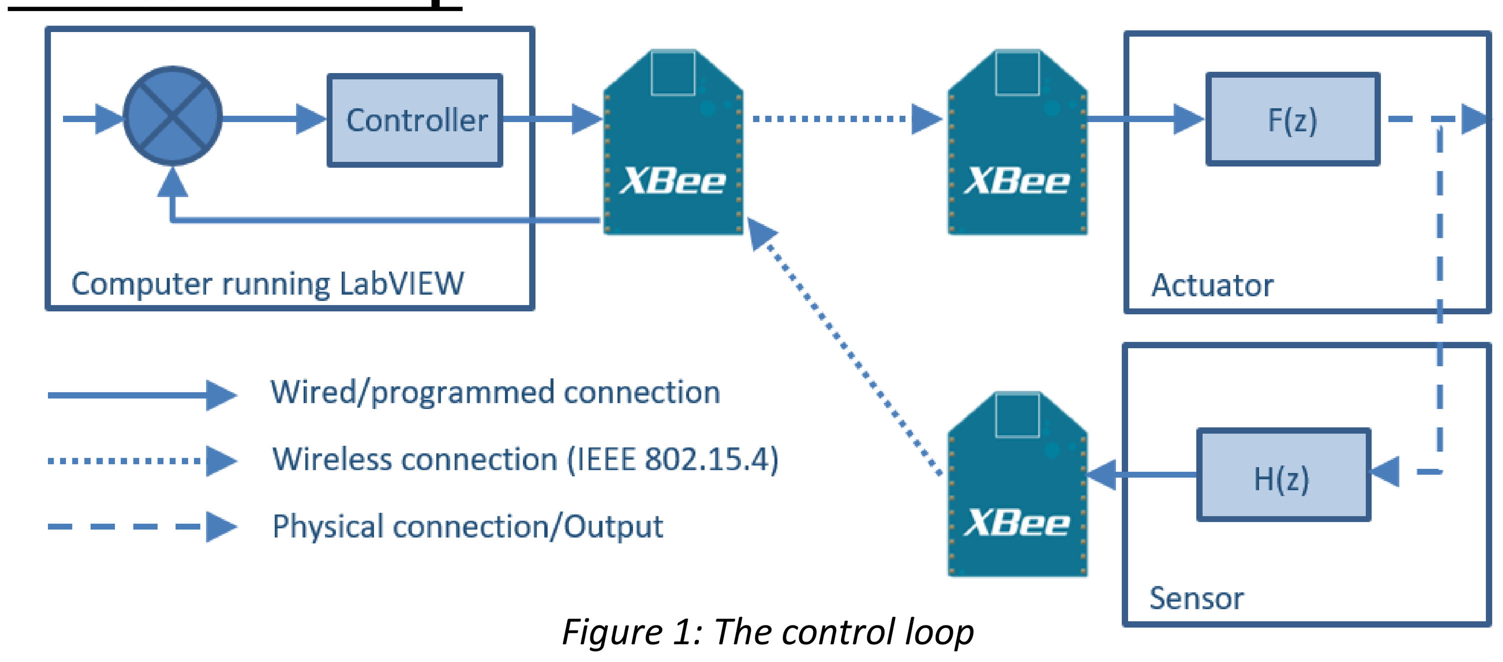

Figure 1: The control loop

This figure illustrates what the control loop should look like. The setup used for the experiments is the same without the physical connection between the actuator and the sensor. The computer is running LabVIEW which compares the data from the sensor with the setpoint and contains the controller. The computer is connected over USB to the XBee that sends and receives the data to/from the XBees connected to the to translate the data being received and converts it to the correct output. For the sensor it was also necessary to use an Arduino for its ADC since the ADC of the XBee had a significant offset that threw off the data.

Interference with WiFi

The XBee antennae use the IEEE 802.15.4 protocol for communicating. This protocol can work on several different frequencies. In the case of the XBee this frequency is 2,4GHz which is the same frequency as WiFi. To check if there would be interference an experiment was held in which a high quality video was downloaded at ± 5 Mbps while the XBees tried communicating at 10 Hz. Meanwhile the message dropout was checked in LabVIEW. The test pointed out that there is a large interference between the two protocols as the dropout rose up to 60 %.

XBee ADC vs. myDAQ

Figure 2 shows the difference between the signal transmitted through XBee and through a wired connection using a NI myDAQ. The difference is very significant for low voltages but becomes smaller the higher the voltage is. This error is unacceptable and should be eliminated. The error seems to be linear so it can be eliminated in LabVIEW by applying a linear model to the received data. Another solution is to use a different ADC.

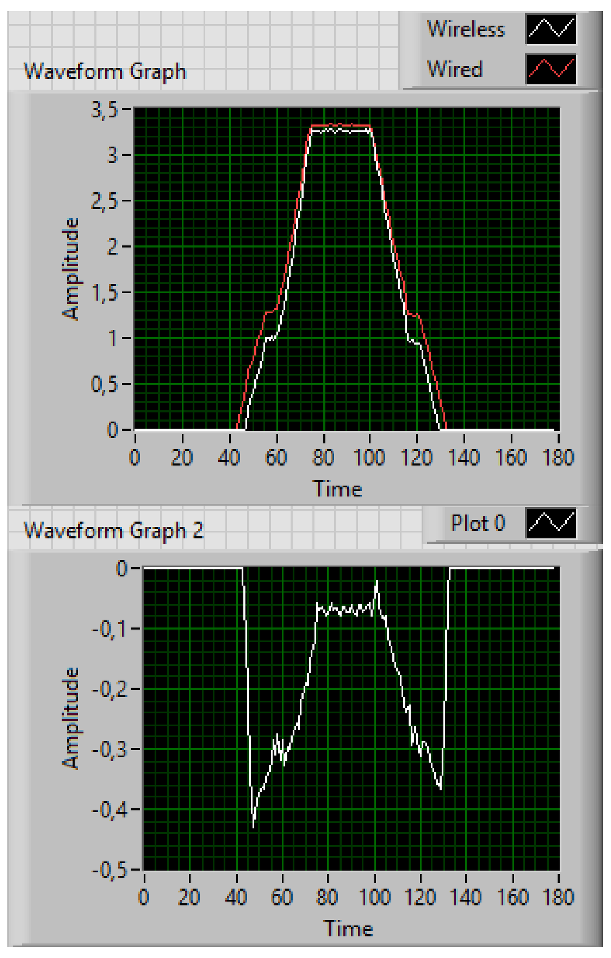

Figure 2: XBee vs. myDAQ

XBee + Arduino's ADC vs. myDAQ

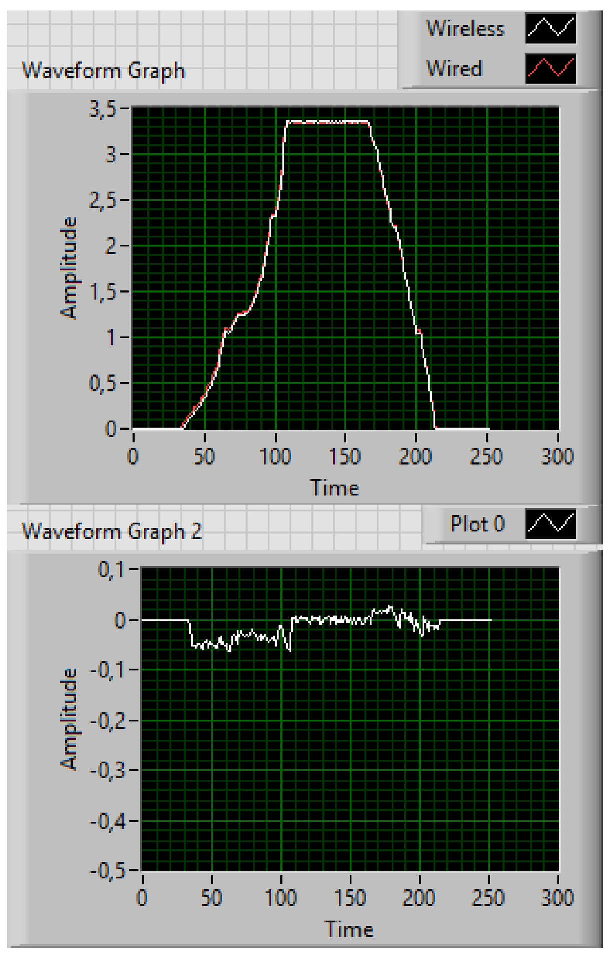

Figure 3: XBee+Arduino vs. myDAQ

With a different ADC the difference between the signals is significantly smaller. For this experiment the ADC of an Arduino was used while the XBee transmitted the data to the computer. As can be seen in Figure 3 the results already look more promising. Depending on the needed precision for the application an Arduino will suffice. If more precision is needed, again a different and more precise ADC can be used as the XBee is capable to send up to 256 bytes in one payload as shown in figure 4.

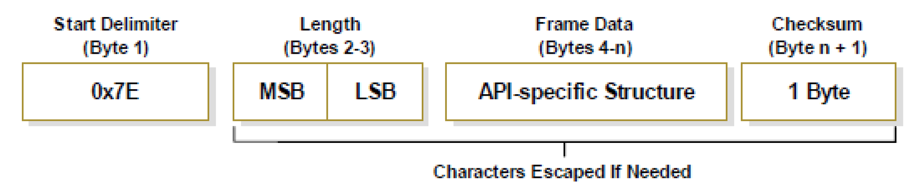

Figure 4: Frame structure of payload

Message Delay

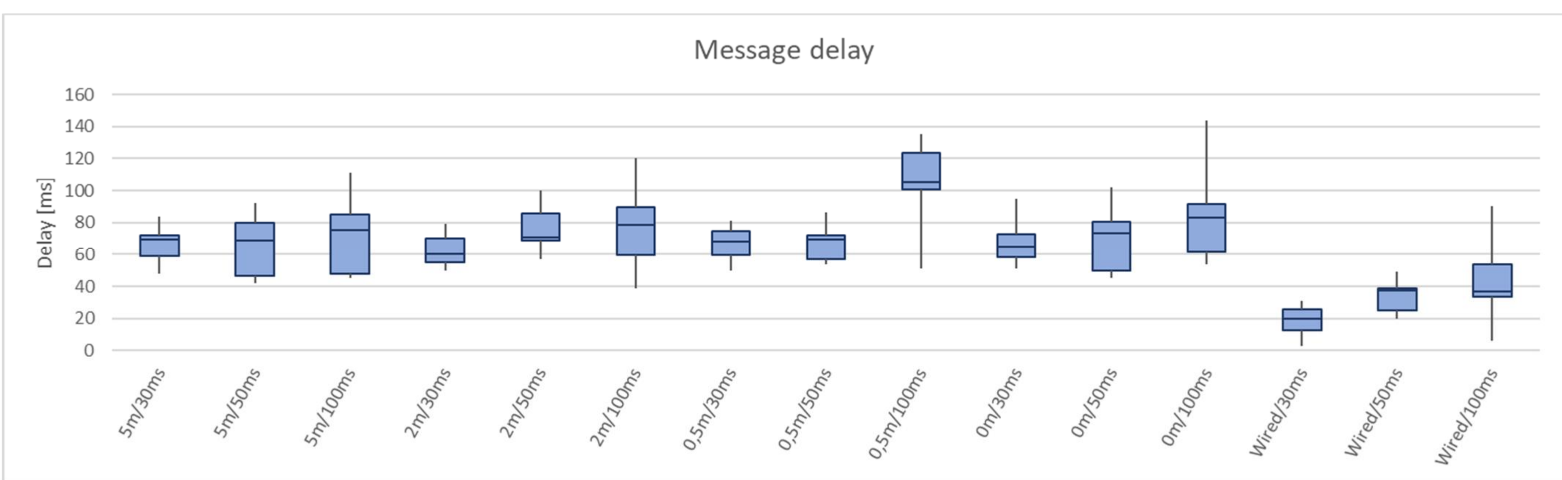

Figure 5: Message delay

One of the important parameters is the message delay. To measure this an experiment was designed in which the time between a trigger and its return was measured using an oscilloscope. If a message delay is present it will create a phase shift which limits the control bandwidth and therefore the closed-loop stability. In the case of the XBees the message delay will cause a problem. Figure 5 shows the boxplots resulting out of the experiment. The data is very inconsistent. There are many outliers and there is no trend in the median. It is clear that there is a delay in both the wired and wireless connection. This delay is caused by both the processing speed of the computer and the sampling period. In case of the wired connection the delay is much lower but the deviation in all cases is significant nonetheless. This makes it hard or even impossible to anticipate the delay because of the inconsistency.

Conclusion

In conclusion it can be said that there were many problems using XBee for wireless communication. But most of these problems can be solved. First the interference can be avoided by using different XBees that work on a different frequency. In Europe this is 868 MHz. The second issue at hand is the ADC, but this also can be solved by using a more precise instrument to measure the data needed. And finally the message delay causes the largest problem. Since the operating system of the used laptop interferes with the real-time working of LabVIEW another solution has to be added. To secure the real-time working a NI myRIO can be used. If all these solutions are applied the control loop can be a success.

Supervisors / Cosupervisors: Prof. Dr. Ir. Isidro Calvo and Prof. Dr. Ir. Johan Baeten / Prof. Dr. Ir. Oscar Barambones

eman ta zabal zazu
UPV EHU

UHASSELT

KU LEUVEN