Master Thesis:
Stable Communication Over a Wireless Network Under Heavy Load

A Goal Document for Master's Thesis work

by

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1 Introduction

When transmitting important data over a wireless connection it is important that the data arrives in a timely manner. The medias used in a network should meet all the requirements which the user imposes upon it. A dependency should be enforced upon all the components in a network to ensure the stability of the entire network.

2 Backgound and motivation

Uniti is a newly founded company that is developing an electric vehicle which will be driven autonomously. In a couple of months Uniti will showcase the advancements in their development, by hosting a demostrational event with a live demo of their cars functional properties. Uniti estimates that around 5000 people are going to be attending this event. However, they want to make sure that the event works as planned even if 10000 people attend. Furthermore they estimates that roughly 10% of the people attending the event will actively be using devices that can put any sort of load on the network.

During this event the development of their car is not supposed to be finished, but rather supposed to be far along enough to showcase its electric-only propulsion and autonomous features.

Today Uniti uses a UDP stream for communication between the vehicle and external devices, this is not really ideal as UDP-applications most likely suffer from package-loss, errors, or duplication. This is fine for some applications but for some applications it could be critical to miss out on certain information. Furthermore it is also desireable to use a protocol which is designed with, the application of the data which is transferred, in mind.

Uniti has expressed the need for a better solution for communicating with the vehicle. This solution is supposed to let the vehicle be both monitored and in worst case controlled via outside devices.

3 Project aims and challenges

The goal of the thesis is to evaluate the connection using 4G and WiFi in combination with a selection of protocols for handling the communication between Uniti's vehicle and external devices. This connection should be able to handle both media streaming and the transmission of control signals such as Stop and Start.

For our thesis we will be investigating the compatibility of setting up this connection with both 4G and WiFi as well as with four different protocols focused on either streaming video or transmitting discrete signals.

For streaming video we will test both the Real-Time Transport Protocol (RTP) and Real-time Messaging Protocol (RTMP). For sending discrete control signals we will work with Stream Control Transmission Protocol (SCTP) and Multipath Transmission Control Protocol (MPTCP).

The different protocols will be tested through using readily available implementations and integrating them with Rosbridge.

This results in eight cases that we are going to investigate.

Uniti have requested that the solution should work even if there are on avarage 1000 active devices interfering with the network in proximity to the demo.

Our transmission of discrete signals has to be guaranteed to arrive with a worst-case latency of 50ms. Finally video transmission should work with an average latency of around 100ms.

4 Approach and methodology

Our thesis project will be executed through a couple of stages.

1. During the first stage we will work on a rough implementation of our connection using the Rosbridge package to communicate with the Robot Operating System (ROS). ROS is the operating system which drives the core functionality of the Vehicle. At this stage we will implement the remaining part of the connection using basic protocols over WiFi.

2. The second stage of our project will be focused on making our implementation work using the different protocols specified. This will probably be our most time-consuming stage as not all the protocols have native support for Linux and rosbridge.

3. The third stage of our project is centered around making sure the connection works well over both the Wi-Fi Setup and the 4G Setup. This will be done by performing several stability tests. Where we will bring our test platform into environments where we can test over a long period of time. This will allow us to measure how the performance of the proposed protocols depend on the load on the wireless networks in the test area. These environments will be places heavily populated by network activity, in the Wi-Fi case this can be a large office park i.e. Ideon, for LTE (4G) it will be places more populated by people, such as train stations or arenas.

4. The final stage will consist of evaluating the results from the third stage to deduce which solution is best suited for the task with the constraints imposed on it by Uniti.

5 Previous work

The main field of this thesis is latency and response time and there are quite a lot of mechanisms and methods specifically for the measurement of both. These could be used in chain and used to calculate the latency of the video stream.

The protocols that are to be used have allready been specified in their respective standards.

RTP: Real-time Transport Protocol

Real-time Transport Protocol has a history as one of the more popular protocols for media streaming. It is one of the most well-documented application layer protocols. [1]

RTMP: Real-time Messaging Protocol

RTMP is n extension on RTP that mainly improves on latency and has support on most plattforms. This protocol seems to specify itself in areas that are benificial to this project. [2]

MPTCP: Multipath TCP

MPTCP is an experimental improvent of TCP allowing for multiple ip-adresses and high transfer rate. This will be useful in the case where WiFi and 4G connection is available. [3]

SCTP: Stream Control Transport Protocol

SCTP is a protocol that is message based like UDP, and ensures reliable, in-sequence transport of message with congestion control like TCP. [4]

The work that we will be doing will be placed within a ROS node and integrated with Uniti's vehicle. As they have been working with ROS and ROS nodes they can supply direct help with installation and development issues. The ROS community is also quite active and should be able to provide support.

6 Advancements and Outcome

The outcome from this thesis work is made up of two parts, implementation and the test results.

The implementation will be the final ROS node that we deem most suitable based on the test results.

The test-results from the different implementations of the connection between Uniti's vehicle and external devices could be used as a basis for decisions regarding implementation of similar wireless application and which protocol and connection media that should be used.

We will use the test results to extrapolate the more general characteristics of the different protocols and mediums under more severe loads. Then we will analyze what sets them apart at a lower level, to be able to more generally discuss which protocol and medium is more suited for specific tasks. This will give us a basis for which protocols that is to be used in our final implementation of the connection. However it should be noted that, as the characteristics of the protocols are estimated rather than measured for higher loads, some inaccuracy is to be expected. Thus some caution is adviced regarding decisions based upon the results from these tests as they might not reflect accurately enough how the protocol performs under very heavy loads.

7 Resources

We will work with our thesis at Uniti's office in Lund where Uniti will provide us with the resources necessary to complete this thesis work. Below is a list of agreed upon resources that will be provided.

Workstations Stationary computers to work on.

Laptop Just like a stationary computer this will be used to produce code on.

Test platforms Uniti provides two test platforms that will be available during the course of the master thesis work. One full size test platform (denoted as `Mule`) and one small size test platform (denoted as `Robot`)

- `Robot` The small size test platform. This will run the same ROS-core as the real product on weaker hardware and will allways be available for use by us, so no planning and coordination with the rest of the team at Uniti is needed. Some parameters may need to be tweaked before moving to full size testing, but the general functionallity will not be affected by the size difference in our case.
- `Mule` The full size test platform. This will run on hardware that will be very similar or equal to the hardware that will be present in the vehicle at the demo. The rest of the team at Uniti will be working and testing on this platform during the course of the master thesis work so some planning and coordination with the rest of the team will be necessary to be able to perform the tests on the full size model. This should however not be to much of a problem as most of the testing can be done on the small size test platform.

TOBY-L210 Long range radio module. 4G with 3G/2G fallback.

EMMY-w163 Short range radio module. WiFi.

EVK-L2x Evaluation kit for TOBY-L2x

EVK-EMMY-W1 Evaluation kit for EMMY-w1x

source code Current source code.

During our thesis work, we will work by integrating our ideas into Uniti's current source code. Network tests and simulations will be performed with the help of Uniti's equipment.

References

[1] Rtp: A transport protocol for real-time applications. Technical report, Network Working Group, 2003.

[2] Adobe's real time messaging protocol. Technical report, Adobe, 2012.

[3] Tcp extensions for multipath operation with multiple addresses. Technical report, Internet Engineering Task Force (IETF), 2013. RFC6824.

[4] Ed. R. Stewart. Stream control transmission protocol. Technical report, Network Working Group, 2007. RFC4960.

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