

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 Background 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 their advancements in their development, by hosting a demonstrational 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 peripheral 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 a couple of different mediums of wireless network transmission to and from Uniti's vehicle, as well as evaluating a couple of different protocols for sending both video data and more discrete signals as in Start or Stop.

For our thesis we will be investigating the compatibility of setting up this connection both with 4G and WiFi Transmission. Furthermore we will also

look into implementing both Real-time Transport Protocol (RTP) and Real-time Messaging Protocol (RTMP) for sending video data.

We will also look into implementing a connection for the discrete control signals using either Stream Control Transmission Protocol (SCTP) or Multipath Transmission Control Protocol (MPTCP), to ensure that the time critical control signals reach the vehicle within a desired time. This results in eight cases that we are going to be investigate.

Uniti have requested that the solution should work even if there are on average 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 steps.

During the first stage we will work on a rough implementation of our connection using the rosbriidge 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.

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 rosbriidge.

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 analysis tests. Where we will bring our test platform into environments where we can perform test over a long period of time to measure the load average depending on activity in the area. These environments will be places heavily populated by network activity, in the wifi case this can be a large office park i.e. Ideon, for LTE (4G) it will be places more populated by normal people, such as train stations or arenas.

The final stage is the evaluation step where we will use the larger test module to simulate heavy loads on the network to generate test data. The test data is then used to deduce which solution is best suited for the constraints set upon the project 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 already been specified in their respective specification.

### **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 an extension on RTP that mainly improves on latency and has support on most platforms. This protocol seems to specify itself in areas that are beneficial to this project. [2]

### **MPTCP: Multipath TCP**

MPTCP is an experimental improvement of TCP allowing for multiple IP addresses 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 peripheral 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.

The theoretical knowledge used within this project will be rather easy to verify the success of, seeing as the implementation of the different protocols and integration with different wireless medias will provide feedback easily. Something that is harder to verify by oneself is whether or not a certain solution is safe in terms of network security or whether or not it is stable under heavy loads, as these things require larger experiments to verify.

## 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 functionality 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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