LogDynamics
International Graduate School

The Efficiency of M2M Protocols in Mobile Networks for Logistical Processes

Employing Machine-To-Machine (M2M) communication can help in increasing the efficiency of logistical processes. Especially for perishable or valuable goods, the environmental conditions during transport or storage have to be supervised in order to guarantee a certain quality at the end of the supply chain.

During transport from source to destination, goods may react very sensitive to changes in their environmental conditions, such as temperature, humidity, vibration, or gas concentration. Once the mentioned parameters differ from a certain, optimal transport/storage value, the goods may experience severe changes in their quality. Hence, a supervision of the environmental conditions – and taking actions on undesired values – is beneficial. Considering this supervision, communication engineering aspects are becoming more and more important to realize optimum and reliable connectivity to and within the transport unit during the entire shipping.

To realize this supervision, a Wireless Sensor Network (WSN) can be used within the cargo container for gathering, e.g., temperature, humidity, and gas concentration. Since most of the devices in WSNs have low bandwidth, scarce memory capacity and limited processing capability, the currently available Internet Protocol (IP) based application protocols (HTTP, FTP, etc.) are not suitable for those kinds of networks. Furthermore, the application protocols that work in the WSN should be able to integrate with IP based networks, which are used for the communication between the container and the host computer.

Currently, at the University of Bremen, the so called “Intelligent Container” project deploys such a system for supervising a cargo container. The architecture of this system consists of a WSN, a Freight Supervision Unit (FSU), and a telematic device (see figure 1). The FSU is the main computing device which acts as a border router for the WSN and manages the different kinds of communication with the host computer. On the host computer, a backend software is used for monitoring and evaluation of transport conditions.

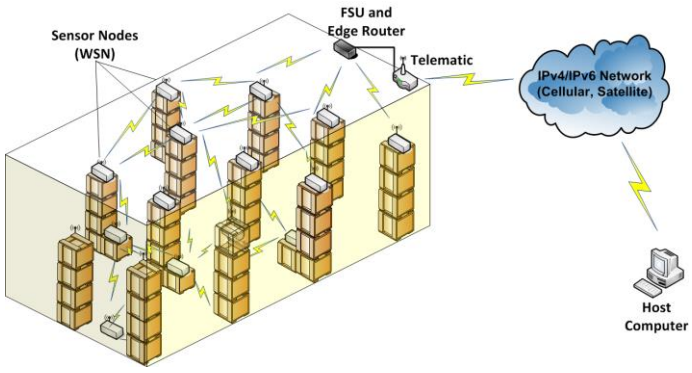

Figure 1: Architecture for Supervising a Transport Unit

An important aspect to realize such a system is a reliable end-to-end connection (also called Machine-to-Machine (M2M) connection). In this particular case, endpoints are sensor nodes in the transport unit and a host computer in the warehouse or company. Especially under the aspect of the spatial distance between those endpoints, high requirements are expected from the wireless connection and its protocols.

To comply with these requirements, the Internet Engineering Task Force (IETF) has proposed a Working Group Internet-Draft called Constrained Application Protocol (CoAP). The aim of this working group is to realize the Representational State Transfer (REST) architecture in a suitable way for those kinds of constrained networks. The main goal is to design an optimized web protocol which is similar to HTTP and fulfils requirements such as small message overhead – which reduces packet fragmentation –, asynchronous message exchange and built-in discovery.

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Due to the absence of mobile networks on sea, the supervision is mostly covered by satellite links, whereas several options are conceivable during land transportation. Available options on land are for example Universal Mobile Telecommunications System (UMTS), Long Term Evolution (LTE) or Wireless Local Area Network (WLAN). Nevertheless, the availability of those wireless networks is highly dependent on the current location of the transport unit. In places such as warehouses, production plants and trans-shipment centres, WLANs with their high data rates are mostly present and can be used to ensure a reliable connectivity to the transport unit.

However, most of the time, the goods are transported on the road or on the rail where no WLANs are available. In those locations, cellular networks are becoming more attractive for logistical processes. Although cellular networks provide a significant advantage with their area-wide coverage, they are also implying several drawbacks in terms of M2M communications.

Research Problem and Objectives

Considering the above mentioned logistical processes, a particularly undesired case is the overly rapid ripening of fruits within a transport unit, e.g., a cargo container. This can be either caused by environmental conditions above the limits or by damaged organic conditions of some single fruits. The latter is due to the fact of the production of particular gases of those particular fruits which are emitted during the ripening process. In turn, this leads to a slow but steady chain reaction within a cargo container. In the worst case, the entire shipment might get spoiled and rendered inedible afterwards. Consequently, this causes not only economic but also ecological harm and needs to be avoided.

Another undesired case is when fruits are not reaching the expected ripening state during the shipment. In this case, the fruits need to be stored in a reefer at their destination for a specific time which also leads to several other economic issues, regarding for example capacities of the warehouse or waste of energy.

Due to these challenges, a system is desired which allows a seamless and detailed supervision of the cargo container during the entire transport process. Additionally, the system shall give the manufacturer the opportunity to regulate and control the ripening process of the goods remotely.

The objective of this work is to investigate, develop, and evaluate a concept for establishing a M2M connection between two given endpoints. The main focus lies in the communication between two endpoints of an M2M transmission link by using the above described CoAP protocol operating on a cellular network, e.g., Long Term Evolution (LTE). Both of these components are still in an early development and deployment. Hence, experience concerning reliability, performance and feasibility of M2M using LTE are not available yet.

By using LTE for communication, its capability of carrying high data rates needs to be taken into account. Since LTE has a packet-oriented transmission scheme and was originally designed to serve cellular devices with data rates of up to 100 Mbit/s, the utilization and integration of M2M connections with their rather low data rates and small packet sizes needs to be investigated and analysed. Carrying low amounts of data over links with high capacities leads to a waste of bandwidth within the given transmission channel. From this consideration another question arises in terms of user load: How does the cellular network perform when these small packets are not only transmitted by single users (machines), but continuously by many endpoints at the same time? Therefore, the feasibility of using the CoAP protocol for M2M connections in combination with LTE needs to be investigated and evaluated. In the same context, parameters such as round-trip times for a periodical message exchange shall be measured and optimized in a feasible manner.

Another important point to address is the integration of CoAP into existing protocols such as HTTP. A translation from HTTP to CoAP and vice versa is usually done by a so called Proxy. A Proxy acts as a bridge between two protocols and translates their message structures to comply with the corresponding data structures of both protocols. By integration of proxies into an existing network it needs to be investigated, where the location should be and how their presence influences the overall performance. In particular in mobile network architectures as they are present in LTE, it is important to choose these locations carefully and to allocate the available resources properly. As a result, a concept and architecture for the usage of CoAP in conjunction with LTE shall be developed and evaluated to point out the ideal usage of those components in the existing network architectures.

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