A Study on network virtualization technology in home network

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In recent years, network appliances such as tablets and Wi-Fi connection is achieving widespread adoption in the home. Along with the increase of network appliances in the home, a typical user is now able to freely add new devices to the home network. As the number and type of devices connected to the home network increases, there are new needs that cannot be fulfilled by simply connecting all the devices in the same broadcast domain. For example, in the HEMS, it is a common scenario to connect the energy controller and energy related devices to separate network different from the home network that is not directly accessible using the IP protocol. Furthermore, the HTIP protocol which was developed for the management of the home network requires that basic information is gathered using the LLDP protocol over Ethernet frames. However, in recent years, the is an increase in machines that use the 6LoWPAN protocol which does not utilize Ethernet frames. In order to implement similar functionality for these devices, a framework that can transmit Ethernet frames over IP is necessary. Therefore, the purpose of this study is the introduction of virtualization technology with desired properties in a home network that can achieve these needs.

Due to the differences in implementation and operation layer, a large variety of virtualization technologies currently exist. Therefore, a survey on virtualization technologies that can realize the needs stated above was conducted. Tag VLAN, GRE, VXLAN, GENEVE were all examined and compared in the context of the home network. The results of this comparison showed that, in terms of cost and deployment percentage, the introduction of GRE or a combination of GRE and tag VLAN is the best candidate solution currently. Moreover, an example home network was created that reflects the design of a home network with virtualization technologies in mind. The target devices for this example network configuration are devices that implement HTIP, HEMS related devices and devices that are expected to be added by a typical user for visualization purposes. Other devices are deemed to be out of scope. For this example network configuration, the necessary configuration settings in regards to GRE and GRE plus Tag VLAN for each device were considered. In order to clarify the requirements for the remote management of network devices connected in the home, use cases covering common usage patterns such as device installation, moving a device to a different place, service operation and troubleshooting have been created. These use cases were examined thoroughly and new use cases were also created. Presently the number of such use cases has risen to 31 use cases.

From these use cases, a certain number of them were selected to be evaluated in terms of adaptability to virtualization technologies. As selection criteria, cases that involve a large variety of actors and processing procedures were selected from each category. As a result, 13 cases were selected.

The HTIP protocol which can be used to obtain home network topology information is defined in JJ.300.00. This document also includes a processing example where the GRE protocol is used as an encapsulation protocol. This processing example is included in the example network configuration of this research, and it was adapted for use with GRE and GRE plus Tag VLAN virtualization technologies. The non-ethernet datalink medium used in this adapted example was SLIP. Also, devices that already implemented the functionality of an HTIP Manager and End Terminal were used and the device information that was communicated during the operation of the HTIP protocol was gathered. Furthermore, Manager-bridge and the End-device-bridge were prepared. These bridge devices provide bridge functionality for transferring the HTIP packets sent from the HTIP devices over a specific network interface. The bridge device implementation in this research was achieved by combining one HTIP bridge and one HTIP device into a new HTIP device. The results of packet capture show that with the introduction of GRE or GRE & TagVLAN it is now possible to send and receive LLDP frames between the new HTIP devices in a non-ethernet environment.

Through this research, the functionality for all the devices present in the home network that is necessary for the introduction of virtualization technologies were identified. In addition, for each example network configuration, the possibility of increasing the number of network interfaces of a device was considered, and the configurations necessary for each virtualization technology to achieve this were evaluated in terms of ease of use. Furthermore, the standard used for ECHONET Lite is defined by TR-1043, and the bandwidth consumption rate by transmission and reception of the LLDP packet in one set of the HTIP implementation device at the time of using GRE encapsulation for every standards of these was shown. The selected 13 cases were evaluated for their adaptability when using GRE and GRE plus TagVLAN. In the use cases that begin with the operation of the CE device, notifications such as IP address using the LLDP broadcast domain are necessary, but due to the use of a non-Ethernet protocol this procedure cannot be performed. During startup, GRE configuration for the Configurator and the CE device is necessary. Thus, a different mechanism from sending and receiving LLDP frames is necessary in order to communicate information such as IP addresses. Furthermore, the results of this research show that, with the introduction of virtualization technologies, it is possible to send and receive LLDP frames and collect device and network connectivity information from connected devices that do not use Ethernet frames. With the use of enterprise network virtualization technologies in the home, it is possible to fulfill the needs of complicated scenarios without the use of extra network devices or network cables, in a low cost fashion.