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ENHANCED NETWORK SLICING FOR INDUSTRIAL AND ENERGY PROTOCOLS

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ABSTRACT

With the development of industry 4.0 and the recent evolution of the substation automation, as prescribed at least by the International Electrotechnical Commission (IEC) 61850 Standard, the network is becoming one of the key element of these trends. Network design and network architecture are becoming more and more complex and leading to challenging problems and issues, such as network security, multiplication of unmanaged broadcast domains, and bandwidth limitations. Recent tools have been introduced to help network engineers visualize different industrial Internet of Things (IIoT) protocol flows and characterizations for devices connected to the network. However, visualization is not enough and any help in the design and configuration of the network would be a great differentiator. Techniques herein provide for the ability to utilize sensors to build a network map of industrial and power data flows. The network map can then be used to configure different network slices with guaranteed bandwidth and flow isolation.

DETAILED DESCRIPTION

Network visualization tools have been developed that provide for the ability to analyze and visualize all industrial (IIot) flows in a network utilizing different protocols, such as Modbus or Fieldbus protocols. Such tools can be extended to consider substation automation protocols, such as IEC 61850 Sample Values (SVs), Generic Object Oriented Substation Events (GOOSE), Manufacturing Message Specification (MMS), Distributed Network Protocol 3 (DNP3), and/or the like.

With the increasing number of devices attached to these networks, network segmentation or network slicing is a key solution that may improve network management and limit the broadcast domain. However, such network segmentation is a very complex task that is typically by a network designer/engineer and can be a source of numerous problems.

Provided herein is a solution that involves utilizing a network visualization tool to analyze industrial protocols and devices in order to draw a map of an active network. Through the map, clusters of devices can be isolated per industrial protocol. For instance, from the map, it can be determined which industrial devices subscribe to the same Fieldbus flows and the bandwidth used by such devices. In the case of IEC 61850, the analysis of SV/GOOSE flows can be utilized to develop a similar picture for substation networks. As the configuration of manufacturing chains or the design of a subsystem does not change very often, the network vision that results from such analysis is accurate.

Once the mapping/analysis is performed, clusters can be further mapped to network slices with the right sizing of the bandwidth and use of microsegmentation to isolate nodes that need to talk to one another. Several methods to implement the network slicing may be used, such as virtual local area networks, (VLANs), Time-Sensitive Networking (TSN), or Committed Information Rate (CIR) mechanisms.

This solution adds a concept of a Manufacturer Usage Description (MUD) microsegment, whereby an industrial node can express that it only talks to other nodes that play the roles 'a', 'b', and 'c'. With the visualization tool, the protocols that the devices speak and their roles within the protocols can be analyzed. Thus, this proposal enforces that only the roles described in the MUD form can be connected together (note that this is an abstraction that says for instance "one controller and only one controller of type X" but does not say which controller exactly). The identification of a controller can be discovered by the tool dynamically, and then the position can be occupied and the micro segment can be marked as complete and isolated.

Analysis of the flows can be periodically performed to ensure that any changes in the behavior of devices can be taken into account, such that clusters and the network slicing can be modified accordingly.

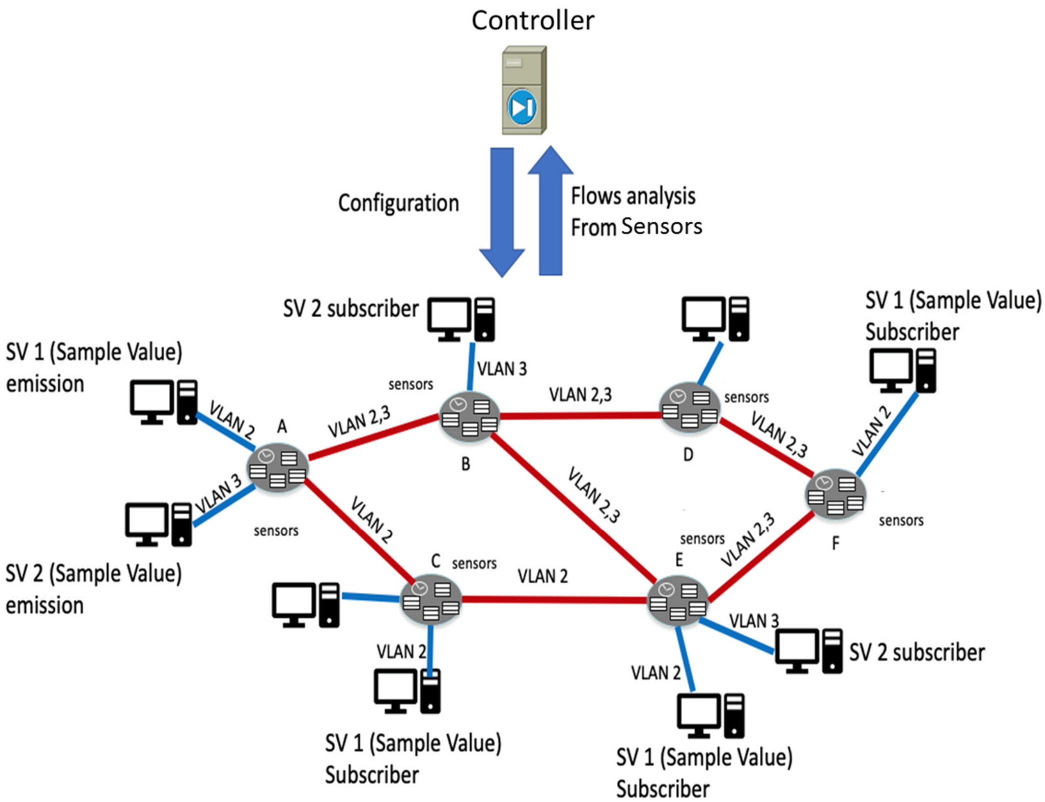

Figure 1: Example Networking Environment

Consider an example networking environment, as shown above in Figure 1. During operation, the sensors can gather all the flows going through the network and send this information to the controller that is running the network visualization tool. The controller can then computes a network topology based on VLANs and sends back the VLAN configuration to the switches. The isolation and the guaranteed bandwidth could be realized by using a TSN or CIR mechanism.

One implementation for the techniques of this proposal may involve utilizing an 802.1Qbv mechanism, as illustrated below in Figure 2.

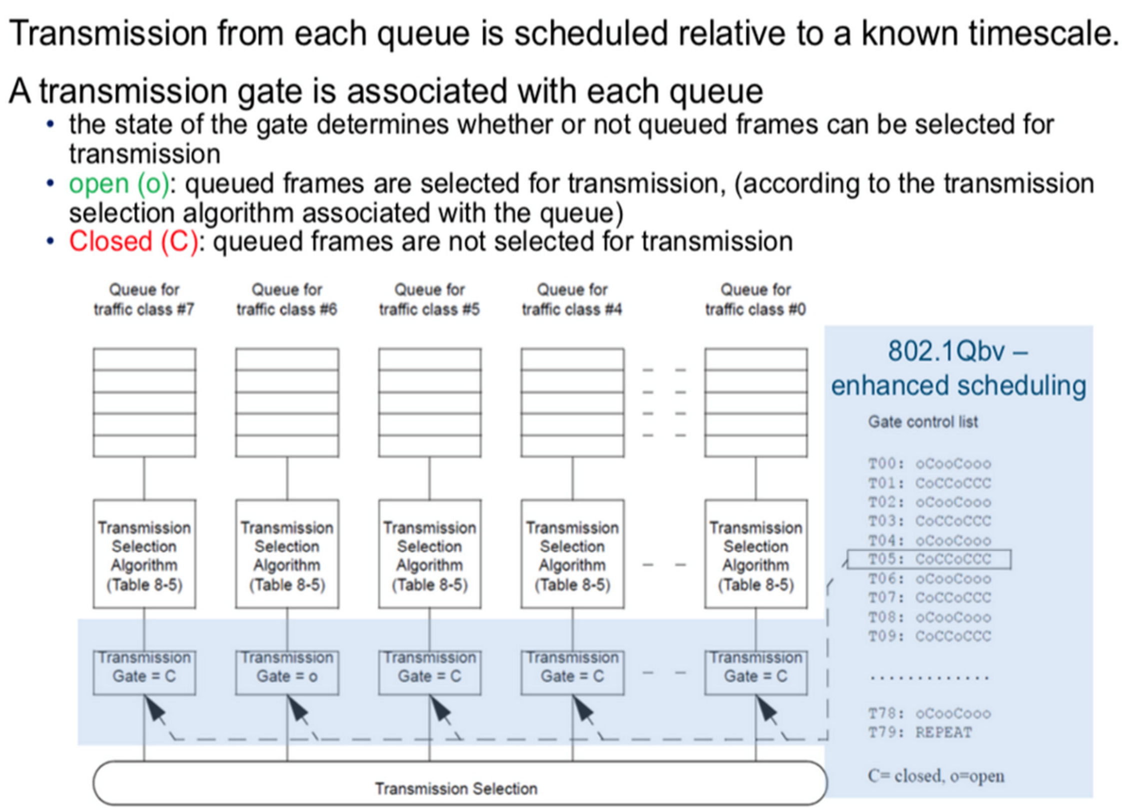

Figure 2: Example 802.1Qbv Implementation Features

Using the mechanism as illustrated in Figure 2, access to the media can be partitioned in order to provide a dedicated bandwidth to a specific Queue. Such a mechanism can be implemented at each egress port and the time gate schedule can be computed to give each VLAN an associated bandwidth, such as, for example, example 10 megabits per second (Mbps) for VLAN 2 and 30 Mbps for VLAN 3.

This solution can also be used with peristaltic scheduling. Either way, the solution bounds the use of the outgoing link for each "flow," which is really a slice. Thus, this solution, guarantees is a perfect isolation of the flows to provide that the flows get the same bandwidth regardless of the pressure by other flows. This is not the case with best effort queuing and fair share in which the bandwidth typically goes down with the amount of competing flows.

In summary, techniques herein provide for the ability to utilize sensors to build a network map of industrial and power data flows. The network map can then be used to configure different network slices with guaranteed bandwidth and flow isolation. By analyzing the dynamics of existing traffic, the approach focuses on bandwidth and isolation requirements that are automatically gathered. Such techniques also provide for an innovative implementation using network slicing based on TSN and 802.1Qbv.