Demonstrating the Multi-Hop Capabilities of the HaRTES Real-Time Ethernet Switch

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I. Introduction

Ethernet is becoming the *de facto* standard networking technology for a vast area of application domains, including industrial and factory automation systems, computerized machinery and cars. Many of these applications have specific requirements, namely in terms of temporal determinism, that cannot be efficiently fulfilled by Common Off-the-Shelf Ethernet technology. This scenario motivated the development of the so-called Real-Time Ethernet (RTE) protocols, such as TTEthernet, Profinet, and Ethernet POWERLINK, which are modifications and/or extensions of the base Ethernet technology and enable real-time traffic. Despite that these RTE protocols follow different strategies, they offer, in general, good performance levels and strict timeliness guarantees. However, they have been designed to handle static requirements, because they are based on static resource allocation policies.

However, many real systems are dynamic, due to e.g. including different subsystems that operate sporadically, enduring operational mode changes according to environment stimuli, or handle a variable number of requests from other subsystems. Additionally, the traffic types are heterogeneous, comprising fixed (e.g. elemental sensors) and variable-bit-rate (e.g. compressed real-time video streams) sources. Using conventional RTE protocols on these systems requires massive over-provisioning, leading to a poor resource utilization. In many applications, e.g. cars, the use of over-provisioning is becoming problematic due to intrinsic bandwidth limitations (cars are an harsh environment and currently only 100Mbps Fast Ethernet is used) and an increasingly high bandwidth demand, resulting from the widespread adoption of multimedia/infotainment systems, video-based Advanced Driver Assistance Systems (ADASs), etc.

II. The HaRTES switch

The Hard Real-Time Ethernet Switching protocol (HaRTES) switch [1] is a modified Ethernet switch, based on the Flexible Time-Triggered (FTT) paradigm. It is based on a master-slave technique, where the Master module contains the scheduler, admission control and QoS management services. Real-time services are accessed via suitable reservation mechanisms. These services include creating and removing message streams, as well as changing their properties. The traffic is scheduled online, thus eventual changes made to the message set are reflected at the system level, thus making this system suitable to support the open and dynamic systems, above described. Moreover, all the change requests made to the message set are screened by the admission control and QoS blocks. Only the ones that don't compromise the timeliness of existing reservations are accepted, thus ensuring a continued real-time behavior.

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III. The demonstration

Nowadays, switched Ethernet networks are often used in complex systems, that encompass tens to hundreds of nodes and thousands of heterogeneous signals. Such scenarios are far beyond the capability of a single switch. This observation fostered the investigation of techniques to allow the use of multi-hop topologies based on HaRTES switches, reported e.g. in [2]. Recently, the HaRTES switch hardware prototype was extended to support such multi-hop topologies. Implementation aspects and validation results regarding end-to-end worst-case response time are reported in [4], while this demonstration shows the ability of the system to cope with dynamic scenarios.

Multi-hop HaRTES networks preserve the essential features of single-hop HaRTES networks. In this demo we demonstrate some of them, namely: isolation between isochronous and sporadic traffic, dynamic reconfiguration and traffic policing. The experimental set-up, depicted in Figure 1, is derived from [3], consisting of two switches (H{1,2}), 3 ADASs cameras (CAM{1..3}), a periodic sensor (S), a PC simulating a faulty node with a babbling idiot behavior (PC) and a supervisory node with HMI (SUP). A high-resolution hardware sniffer (SNIF) is connected between H2 and SUP, to allow the precise capture of arrival packet timestamps. SUP is the consumer of all message streams. It displays the 3 video streams, as well as relevant information regarding them (bandwidth and frames per second). It also displays the jitter suffered by the isochronous source (S) and enables managing online the QoS assigned to the cameras. It will be shown that i) the faulty node PC does not affect the reservations of the other message streams; ii) the QoS of the cameras can be dynamically changed without mutual interference; iii) the isochronous traffic maintains its regularity, even during reconfigurations.

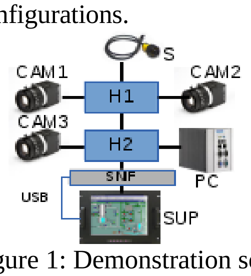

Figure 1: Demonstration set-up

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