Demonstrating an Ethernet switch enhanced with hierarchical scheduling

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I. Introduction

The complexity of Networked Embedded Systems (NES) has been growing steeply, due to increases both in size and functionality, and is becoming a major development concern. This situation is pushing for paradigm changes in NES design methodologies towards higher composability and flexibility. Component-oriented design technologies, in particular supported by server-based scheduling, seem to be good candidates to provide the needed properties.

As response, we developed a multi-level hierarchical server-based architecture for Ethernet switches that provides composability and supports online adaptation and reconfiguration [1] [2]. This framework exhibits the following features: 1) A hierarchical architecture that supports server composition and virtual real-time channels, providing temporal isolation (composability in the time domain); 2) Analytical tools for guaranteed real-time behavior; 3) Simple interface to adapt and reconfigure servers during runtime.

II. Hierarchical server-based traffic scheduling

The hierarchical server-based traffic scheduling framework has been presented as a way to provide composability of real-time channels that handle communications in each output port of an Ethernet switch. This framework can be organized as a hierarchical structure of entities, represented as an inverted tree (Figure 1A). Each branch of the tree represents a server that handles a portion of the total bandwidth assigned by the parent server.

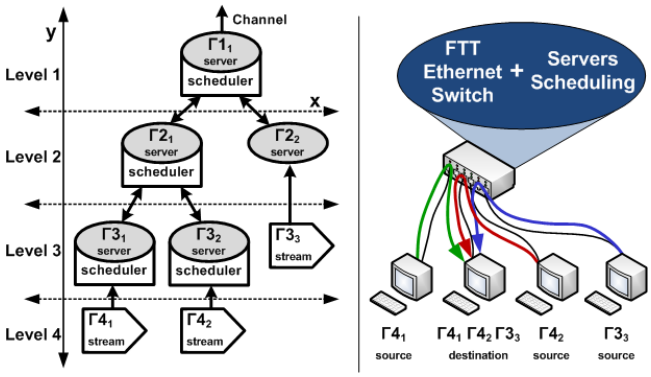

Figure 1. A) server hierarchy and B) demo setup.

The hierarchical server framework herein presented supports both server adaptation (the server attributes such as capacity and period may be adapted online) and hierarchy reconfiguration (servers may be added, moved to different branches or even removed). Each change request is subject to a schedulability analysis algorithm, which rejects every request that may compromise the system timeliness, therefore continued real-time behavior is inherently guaranteed.

As evidence, a prototype implementation of the hierarchical server-based traffic scheduling framework has been deployed on the FTT-enabled Ethernet switch to manage the asynchronous traffic. This is an instantiation of the FTT (Flexible Time-Triggered) communication paradigm in a customized Ethernet switch [1] [2].

III. Demonstration

Due to its practical relevance, the demonstration is focused on the composability in the time domain, predictability and reconfigurability of real-time channels. For that the server structure depicted in Figure 1A is created to handle the data flows represented in Figure 1B. With this setup the following demonstrations will be made: **Temporal isolation**: stream Γ_{4_1} is monitored while the traffic generation pattern of the other two streams is varied. (e.g. an babbling idiot scenario); **Timeliness**: the response time of stream Γ_{4_1} is monitored while the traffic generation pattern of the other two streams is varied. The maximum response time of the monitored stream should be verified independently of the load pattern of the other streams; **Reconfigurability**: stream Γ_{4_1} is monitored while the associated server attributes are changed, e.g. the budget is increased. The observed traffic pattern should evolve according to the new attributes, whenever the change request is found feasible and thus accepted by the system.

IV. Conclusions

This demonstration will show the effectiveness of the hierarchical server-based traffic scheduling framework in addressing the requirement of complex NES, supporting namely, composability in time domain, dynamic reconfiguration and timeliness guarantees. For that, we will use our own software and hardware.[1]

References

[1] R. Santos, A. Vieira, R. Marau, P. Pedreiras, A. Oliveira, L. Almeida, and T. Nolte, "Implementing Server-based Communications within Ethernet Switches," in *Proceedings of 2nd International Workshop on Compositional Theory and Technology for Real-Time Embedded Systems*, December 2009.

[2] R. Santos, M. Behnam, T. Nolte, P. Pedreiras, and L. Almeida, "Schedulability Analysis for Multi-level Hierarchical Server Composition in Ethernet Switches," in *Proceedings of the 9th International Workshop on Real-Time Networks*, July 2010.

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