Enhancing the Performance of Distributed Real-Time Systems

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Abstract

Advanced embedded systems can consist of many sensors, actuators and processors that are deployed on one or several boards, while having a demand of interacting with each other and sharing resources. Communication between different components usually has strict timing constraints. There is thus a strong need to provide solutions for time critical communication. This thesis focuses on both the support of real-time services over standard switched Ethernet networks and the improvement of systems' real-time characteristics, such as reducing delay and jitter in processors and on communication links.

Switched Ethernet has been chosen in this work because of its major advantages in industry; it supports higher bit-rates than most other current LAN (Local Area Network) technologies, including field buses, still at a low cost. We propose using a star network topology with a single Ethernet switch. Each node is connected to a separate port of the switch via a full-duplex link, thereby eliminating collisions. A solid real-time communication protocol for switched Ethernet networks is proposed in the thesis, including a real-time layer between the Ethernet layer and the TCP/IP suite. The network has the capability of supporting both real-time and non real-time traffic and assuring adaptation to the surrounding protocol standards.

Most embedded systems work in a dynamic environment, where the precise behavior of the network traffic can usually not be predicted. To support real-time services, we have chosen the Earliest Deadline First scheduling algorithm (EDF) because of its optimality, high efficiency and suitability for being used in adaptive schemes. To be able to increase the amount of guaranteed real-time traffic, the notion of Asymmetric Deadline Partitioning Scheme (ADPS) is introduced. ADPS allows distribution of the end-to-end deadline of a message, sent from any source node in the network to any destination node via the switch, into two sub-deadlines, one for each hop according to the load of the physical link that it must traverse.

For the EDF scheduling algorithm, the feasibility test is one of the most important techniques that provides us with information about whether or not the real-time traffic can be guaranteed by the network. With the same computational complexity as the feasibility test, a method has been developed to compute the minimum EDF-feasible deadline for a real-time task. The importance of this method in real-time applications lies in that it can be effectively used to reduce the response times of specific control activities or limit their input-output jitter. To allow more flexibility in the control of delay and jitter in real-time systems, a general approach for reducing task deadlines according to the requirements of individual tasks has been developed. The method allows the user to specify a deadline reduction factor for each task in order to better exploit the available slack according to the tasks' actual requirements.

Keywords: Switched Ethernet, real-time communication, EDF scheduling, reduction of delay and jitter.