Guest Editorial Special Section on Communication in Automation—Part II

THE special section on "Communication in Automation" presents relevant research works concerning selected aspects about the adoption of digital communication techniques for interconnecting devices and equipments in advanced control systems. This second part (the first one has been published in the February 2008 issue of the IEEE Transactions on Industrial Informatics) completes the section. In the present issue, three papers are presented, which deal with techniques and mechanisms for enhancing performance and dependability of control networks. In particular, they address the design and dimensioning of large-scale CSMA-based control networks, the exploitation of priority-based medium access control protocols to achieve increased real-time performance in sensor networks, and a fault-tolerant orthogonal solution for clock synchronization in CAN networks.

Large building automation systems often rely on CSMA-based control networks like LonTalk. In such case, a major drawback is that the quality of service provided by the communication network and, consequently, the reliability of the whole building automation system depend directly on the amount of traffic exchanged over the different network segments. Network performance engineering can be profitably employed to verify the correct design and dimensioning of building automation networks. It combines performance analysis and diagnosis methods to evaluate the effective network utilization, and allows design errors to be discovered before the overall system is deployed. Therefore, it can save the engineering costs caused by either the overdimensioning of the communication system or the need for redesigning it.

The paper "*Diagnosis and Consulting for Control Network Performance Engineering of CSMA-based Networks*", by Joern Ploennigs, Mario Neugebauer and Klaus Kabitzsch, develops a diagnosis model based on fault trees that is able to assess the coherence of the huge amount of information resulting from performance analysis, and hence to identify design errors. Besides enabling fault causes to be quickly traced back so that proper solutions can be easily derived, this approach can also help the user to better understand the network design, by providing him a clear view of the fault behaviour. Moreover, additional consulting tools are provided that implement best practice strategies, useful for supporting the user in parameterization activities.

At present, the availability of small and inexpensive sensing devices provided with a digital communication interface enables large sensor networks to be also used for feeding real-time control systems. Unfortunately, the need to send a huge amount of data being measured by sensors over networks that are often characterized by a low data rate, may have a serious negative impact upon the timing behaviour of the control loop.

The paper "*A Scalable and Efficient Approach for Obtaining Measurements in CAN-based Control Systems*", by Björn Andersson, Nuno Pereira, Wilfried Elmenreich, Eduardo Tovar, Filipe Pacheco and Nuno Cruz, presents a solution to the problem described above. The authors propose a system where sensor measurements are described by means of an approximate representation − an interpolation of sensor measurements as a function of space coordinates. A priority-based medium access control (MAC) mechanism, such as the one adopted by the Controller Area Network (CAN) protocol, is then used to select the sensor messages that carry the highest information content. This means, that the most significant data from a large number of sensor measurements can be conveyed with relatively few messages. Such an approach greatly reduces the time required for obtaining a meaningful snapshot of the current environment state; hence, it may be suitable to support the timing requirements of real-time feedback control loops.

Besides being appropriate to interconnect devices in low-cost applications, the CAN protocol is currently also targeting marketing niches with hiher technological requirements. The reliability level reached by CAN technology makes many researchers believe that it can also be adopted for the interconnection of devices in control systems with dependability requirements. However, the suitability of the CAN technology to address these challenging applications strongly depends on the ability to integrate a number of already available solutions into a single, comprehensive architecture. Clock synchronization certainly plays an essential role in such a kind of systems. Therefore, a solution is needed able to fulfil all the expected requirements on dependability, cost and accuracy.

The paper "*Orthogonal, Fault-tolerant and High-precision Clock Synchronization for the Controller Area Network*", by Guillermo Rodriguez-Navas, Sebastià Roca and Julián Proenza, discusses the importance of clock synchronization in upcoming CAN-based critical systems, and describes a novel solution to provide this kind of service. The proposed approach exhibits a significant number of advantages: while providing a very high accuracy degree, it keeps low communication and computation overheads. Moreover, mechanisms to provide fault tolerance have been included as well. Unlike previous approaches for clock synchronization, this proposal is designed to be orthogonal to the rest of the system. Thus, it can be incorporated directly into the existing CAN systems, without the need to replace any component; in this way, the additional implementation costs are kept low.

Finally, the process of publishing a special section like this one has required the help of several people. Again, we would like to express our gratitude to all of them: the authors, for their contributions and their co-operation in promptly replying to the reviewers' comments; the reviewers, for their careful reviews and comprehensive comments; and, finally, the editorial team, for their guidance in preparing and finalizing this special section.

GIANLUCA CENA, *Guest Editor*
Italian National Research Council, IEIIT-CNR
10129 Torino, Italy (gianluca.cena@polito.it)

FRANCISCO VASQUES, *Guest Editor*
Faculdade de Engenharia da Universidade do Porto
4200-465 Porto, Portugal (vasques@fe.up.pt)

Gianluca Cena was born in Torino, Italy, in 1966. He received the Laurea degree in electronic engineering and the Ph.D. degree in computer engineering from the Politecnico di Torino, Italy, in 1991 and 1996, respectively. In 1995, he became Assistant Professor at the Department of Computer Engineering of the Politecnico di Torino and, in 2001, he joined the Italian National Research Council (CNR) as a Senior Researcher. Since 2005, he has been Director of Research with the Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni (IEIIT-CNR), where he is engaged in research activities concerning communications in manufacturing and automotive environments.
He is the author of many technical papers in the area of computer communications. His current research interests include industrial communication systems, wired and wireless protocols and real-time networks. He is also active in the international scientific community working on these subjects, and served as Program Co-Chairman for the 2006 and 2008 editions of the IEEE Workshop on Factory Communication Systems.

Francisco Vasques (M'00) was born in Porto, Portugal, in 1964. He received the "Licenciatura" degree in electrical engineering from the University of Porto, Portugal, in 1987 and both the MSc and PhD degrees in computer science from LAAS-CNRS, Toulouse, France, in 1992 and 1996, respectively. Since 2004, he is Associate Professor of the University of Porto. His current research interests include real-time communication systems, factory communications, fault-tolerant systems, and real-time system architectures. He served as Program Co-Chairman for the 2000, 2004 and 2006 editions of the IEEE Workshop on Factory Communication Systems. He is author or coauthor of more than 75 technical papers in the area of real-time systems and factory communications. He is Associate Editor of the IEEE Transactions on Industrial Informatics since 2007.