Invited Session Proposal for IFAC World Congress 2008: "Virtual Automation Networks"

Organizers: Peter Neumann and Ulrich Jumar

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Description and Scope: For the last 20 years a lot of effort has led to the decisive usage of digital communications in distributed computer control systems within both the factory and the process domain. The proprietary communication systems within SCADA systems were supplemented and partially displaced by Local Area Networks, Fieldbus systems and Sensor/Actuator Networks. At the same time, Ethernet won the battle as the most used communication technology within the office domain resulting in low component prices caused by the mass production of these components. Nowadays, there is a large community inventing and introducing Ethernet-based communication systems to be used in the industrial automation domain, e. g. in the harsh environment, and in a real-time and safety-critical world. However, opposite to that, Fieldbus systems are the most important communication systems used in commercial control installations. Additionally, wireless communication has been introduced in both the office environment and the workshop area in the meantime.

Since there is an economic interest to widely introduce the Ethernet-based and Radio-based technologies, the inventors have to guarantee that the domain-specific requirements can be fulfilled. These requirements are: (1) Guaranty of real-time behaviour; (2) Guaranty of functional safety (this means protection against hazards caused by incorrect functioning including communication via Industrial Communication Systems); (3) Guaranty of security (this means a common security concept for distributed automation using Industrial Communication Systems).

Regarding the real-time behaviour there are different real-time classes: (1) Non real-time applications NRT: diagnosis, maintenance, commissioning, slow mobile applications; (2) Soft real-time applications SRT: data processing in manufacturing and process automation, data acquisition; (3) Hard real-time applications HRT: control applications, fast mobile applications, machine tools; (4) Isochronous real-time applications IRT: motion control. Mostly middleware concepts are used to realise the separation of IRT, HRT, SRT and NRT traffic; migration concepts are available to introduce the data of Sensor/Actuator networks and of Fieldbus-oriented sub-systems into the Ethernet-based systems.

Local Area Networks (LAN) based on both Ethernet-TCP(UDP)/IP and Radio standard IEEE 802.11 has been standardised and widely introduced in the office domain and also in the automation domain, using shared Ethernet as well as Switched Ethernet (star and tree topology). Thus, in an enterprise there exists a common infrastructure for both domains. But there are system-specific limits regarding the real-time behaviour, because most of the solutions use the TCP (UDP)/IP functionality and a middleware above TCP (UDP)/IP to schedule the (soft) real-time traffic SRT and the non real-time traffic NRT.

A lot of research activities and product developments deal with a middleware on top of the MAC layer of Ethernet scheduling the hard real-time HRT and soft real-time SRT/ non real-time NRT traffic to avoid the non-deterministic behaviour of Ethernet. The investigated IRT mechanisms are very important for synchronous data transmission in the Motion Control area.

In the field area, wired Fieldbus systems have been standardised and widely installed in factory as well as process automation. Nowadays, meshed Wireless Sensor/Actuator Networks is becoming high importance, especially in the process automation. Their standardisation is going on. Therefore, the security, safety and integration into the enterprise communications hierarchy are becoming more and more important. Furthermore, an additional engineering discipline has to be considered: the co-existence of wireless networks, which are installed within a workshop area simultaneously.

For geographically distributed control applications, there exist connected remote application functions running in distributed automation devices. The communication endpoints have to be connected by a Wide Area Network (WAN) with deterministic behaviour. From the application point of view, the mechanisms

of the local automation-specific (industrial) communications have to be offered. The mechanisms of the different WAN technologies, providers and Quality of Services have to remain hidden. These requirement leads to “Virtual Automation Networks” covering all kinds of (local/remote, wired/wireless, provider-oriented/provider-less, circuit-switched/packet-switched) communication technologies. The invited session should offer the ongoing activities to investigate and develop the basics for Virtual Automation Networks.

Content of the session: The session will deal with recent activities in Virtual Automation Networks. The contributing papers inform about an actual fragment of a European Integrated Project within the 6th framework.

List of Participants

[1]

Title: Architectural Concept of Virtual Automation Networks”

Authors: P.Neumann, R.Messerschmidt, A. Poeschmann (Institut f. Automation und Kommunikation Magdeburg, Germany; email: peter.neumann|ralf.messerschmidt|axel.poeschmann@ifak.eu)

Abstract: Twenty years ago, fieldbus systems have been developed and are widely introduced in industrial automation installations in the meantime. In the nineties, the Ethernet-based office automation has been successfully introduced followed by the usage of Internet-based applications. As a result, many enterprise-specific hierarchical communication networks are existent in the automation world. The aim of the European Integrated Project “Virtual Automation Networks” is to harmonize the different local and wide area communication concepts, and to offer a unique view on the (end-to-end) communication of geographically distributed automation applications from the automation point of view. This paper presents the basic design and fundamental definitions, the topology, the system architecture and implementations aspects for realizing a Virtual Automation Network.

[2]

Title: “Public network and telecontrol concepts in Virtual Automation Networks”

Authors: J. Lohmeier (Siemens AG Nürnberg, Germany, Automation & Drives; email: joachim.lohmeyer@siemens.com), and T. Werner, R. Messerschmidt (Institut f. Automation und Kommunikation Magdeburg, Germany; email: thomas.werner|ralf.messerschmidt@ifak.eu)

Abstract: This paper describes the aspects for the integration of public networks into Virtual Automation Networks. The aim is to define the integration of public and private networks into the automation environment. Therefore, available technologies, infrastructure components and provider services have been analysed. The main aspects to build automation aware applications using public network services are the following: (1) Real-time capabilities of public networks concerning automation tasks; (2) Telecontrol requirements; (3) Provider Contracts (Service Level Agreements); (4) QoS capabilities and network monitoring from automation side.

The focus of the activities lies on how to seamlessly integrate real-time and telecontrol functionalities into an overall VAN platform. This covers the specification of a telecontrol profile as well as the enhancement of the available IEC 61158 type 10 communication stack that currently does not support telecontrol and the definition of the necessary ASEs (application service element), as defined in the common VAN platform architecture. Future telecontrol systems have to be able to transmit data in both ways: cyclically and event driven. An important aspect is the monitoring of public network behaviour to be able to react respectively. This means, in a broad spectrum of applications using WANs it is not necessary to have real-time cycles in the lower ms range, much more important is to have the certainty that the information arrives in a defined time frame. The ongoing activities established a classification of automation specific cycle time for VANs. According to this isochronous real-time communication is out of scope in Inter-LAN as well as WAN or public network constellations. However, RT communication is required for the whole virtual automation network. During runtime phase, network downtimes are not allowed in closed loop control applications. The network availability is highly demanded. But the infrastructure is mostly non exclusive and the whole path can not be described in detail. Therefore an approach using priority assignments when interconnecting VAN domains to achieve a more deterministic behaviour has been described. The approach is based on QoS classifications of the packets to be transferred as well as the application of appropriate service level attribute definitions used for the service level agreement contracted with a network provider. To have the ability to react on QoS failure scenarios and to have verification against the SLA an online monitoring of the current communication path capabilities is also addressed. Further considered aspects are switching and routing in context of VAN which addresses an approach of network robustness and concepts for alternative paths.

The work presented here established generic concept and models that are future oriented as well as covering current conditions. Further development of the infrastructure and involved devices can be expected. Therefore it is possible that current automation requirements for local networks will in future be increasingly met also by larger network

structures. The concepts described here are still going to be an integral part of those solutions as they comply with the general tendency towards high quality infrastructures.

[3]

Title: “Evaluation of Real-Time Behaviour in Virtual Automation Networks”
Authors: J. Beran, F. Zezulka (Brno University of Technology, Czech Rep.; email: beranj|zezulka@feec.vutbr.cz)
Abstract: Some features of office networks and telecommunication technologies are not tailored to automation needs. Hence, it is necessary to spend significant effort on extensions to meet the requirements of industrial applications. These are mainly preserving real-time behaviour, preserving functional safety, extending system security, and integration of wireless technologies. A part of the activities is dedicated to preserving real-time features of industrial communication when extending the communication scope from a single LAN to multiple LAN communication. In such a case the communication requires routable protocols, e.g. UDP/IP. Our approach to this problem is introduction of established methods of Quality of Service (QoS) resulting in preserving determinism and availability of communication. The aim of our work is to evaluate influence of different network components on the communication determinism, and observe its improvement when employing DiffServ approach. The expected result is to draw a general conclusion of determinism feasibility and provide a solution suitable for industry. Providing this analysis required development of a specialized test bed capable of very precise measurement of QoS metrics, e.g. latency, jitter, bit-error-rat, and packet loss.

[4]

Title: “Wireless network integration into Virtual Automation Networks”
Authors: L. Rauchhaupt (Institut f. Automation und Kommunikation Magdeburg, Germany; email: lutz.rauchhaupt@ifak.eu), and V. Lakkundi. (Brno University of Technology, Czech Rep.; e-mail: vishwas@feec.vutbr.cz)
Abstract: Wireless automation is today an emerging topic. Industrial wireless solutions base on Bluetooth, Wireless LAN, IEEE 802.15.4 or even on proprietary radio technologies. This paper describes the function of different wireless technologies within a Virtual Automation Network (VAN). It is shown how the VAN device architecture is applied to wireless solutions. This includes the definition of generic parameters and exemplary for IEEE 802.15.4 based systems of specific parameters. Finally the purpose of the formal description is shortly explained.

[5]

Title: “Secure Virtual Automation Networks based on a Generic Procedure Model”
Authors: M. Wolframm (Teleport Sachsen-Anhalt, Germany; e-mail mario.wolframm@tsa.de), and H. Adamcyk (Institut f. Automation und Kommunikation Magdeburg, Germany; email: heiko.adamcyk@ifak.eu)
Abstract: Security is a huge topic, however an international standard for automation control systems is missing. The standardisation work is progressing, e.g. within the IEC. It is clear that behind security there are several well-known security objectives such as availability, integrity and confidentiality. It is also clear that the office domain provides thousands of different security solutions. A possible use for automation networks, 1 to 1 or with adaptations, is one task within the European research project “Virtual Automation Networks”. Furthermore VAN sets its focus on IT-Security and thereby on communication security. The use of the brand-new procedure model which is part of the VDI/VDE guideline 2182 was applied. The first time use of this model was a challenge and also a benefit for the project.

[6]

Title: “Engineering Concept for Virtual Automation Networks”
Authors: C. Diedrich (Univ. of Magdeburg, Germany, Institute of Control System; email: christian.diedrich@ovgu.de), and H. Hengster (Schneider Electric GmbH, Automation; e-mail: harry.hengster@de.schneider-electric.com)
Abstract: This paper presents the concept for the engineering of Distributed Control Systems (DCSs) based on heterogeneous communication systems as defined in the European Integrated Project “Virtual Automation Networks”. These heterogeneous communication characteristic has to be faced by the engineering concepts and tools. The VAN project has defined a common engineering workflow as basis for a VAN information model. The information model covers the functional, topological and network view and their relation each other at detailed level. The details are derived from the VAN protocol specifications which are based on the OSI Reference ASE model. The paper presents also the mapping of the engineering concept to FDT/TCI technologies in general which is used to evaluate the information model and the usefulness of the VAN information model and the interaction of the tools with the VAN devices.