Virtual Automation Networks – one way from incompatibility

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Abstract: Paper deals with existing situation in industrial communication. Apart from proprietary serial communication systems exist many standardized fieldbuses. Due to increasing requirements on rapid data transfer and in hope of better transparency of communication in the overall plant control architecture, Ethernet has established as a well known and broadly used industrial communication technology**.** The paper shows one of possible methods for at least partial overcoming of the existing heterogeneity and incompatibility in large highly distributed control applications. The way is virtual automation networks and paper specify requirements and key features of the solution. The most important part of the paper deals with questions of the real – time features of virtual automation networks and the data security in heterogeneous communication environment.

Keywords: fieldbus, virtual automation network, VAN, VPN, openVPN, tunneling

1. INTRODUCTION

Industrial communication systems as fieldbuses, device buses and sensor – actuator buses are reality since more then 20 years ago. The development of industrial communication systems was motivated by invention of distributed computer based control systems, which were used for control of machines, production lines and technological processes. Due to the non- coordinated development of industrial communication systems in 80th and 90th years of the 20th century, there were developed many different communication solutions. Later more then nine industrial communication systems (fieldbuses, device buses and sensor/actuator buses) have been standardized in the IEC 1158 since 1990. Communication systems became one of the most dynamically innovated automation tool as the special industrial buses had to meet demanding requirements on real time and functional safety. However, the industrial communication solutions were mutually incompatible, therefore the users were limited in the choice of communication systems as they had to select the communication subsystem according to the selected vendor or vendor group as the mutual interoperability of heterogeneous systems is very difficult to achieve [Fiedler P, Bradac Z, Zezulka F (2000)]. Consequently producers of distributed I/O devices to cover the market with their devices had to develop and support many various communication interfaces and protocols.

In the meantime due to increasing requirements on rapid data transfer and in hope of better transparency of communication in the overall plant control architecture, Ethernet has established as a well known and broadly used industrial communication technology. Unfortunately the history has repeated itself and there have been standardized more then eleven incompatible Industrial Ethernets standards (standardized by the IEC 61158-2). Moreover additional industrial communication technologies are being developed and applied on the market. Industrial Ethernets are more flexible, more open to other standards, nevertheless it does not represent a uniform fieldbus and therefore does not guarantee any mutual compatibility.

This paper shows one of possible methods for at least partial overcoming of the existing heterogeneity and incompatibility in large highly distributed control applications. The presented solution uses internet as the communication backbone and is a result of 6th FP EU project named Virtual Automation Networks (VAN); this project has been executed from 2005 to 2009 within a consortium of eleven partners. The project consortium defined following requirements on the envisaged solution:

- No new industrial Ethernet (IE) standard has to be developed (market would not accept it).
- Solution shall be based on an existing IE standard, existing standard shall be extended to support new requirements.
- Already existing automation devices with implemented interfaces and profiles of existing successful fieldbuses will be used further and any new communication standard has to accept and integrated in them.
- For configuration and commissioning of the network no very new tools have to be developed; reuse of existing yet enhanced tools is needed.

The proposed solution to enable a uniform, transparent and open communication in a heterogeneous framework consisting of fiedbuses, industrial Ethernets, private LAN (intranet) as well as public networks (TCP/IP based Internet and intranets) are "Virtual Networks".

The presented solution fulfills the requirements listed above and the key features are specified as follows:

- Solution has to go out from the reality of the IEC 61158 standard (no new fieldbus or industrial Ethernet system is to be specified, but existing properties of LANs and industry networks will be utilized for end – to – end communication among entities).
- Virtual Automation Network (VAN) will hide the communication infrastructure so the network will appear as homogeneous with defined communication parameters for given links.
- The connection between geographically distributed automation applications is established using Web – services with the aim to carry out the most appropriate run-time tunnel for the end – to end-communication between entities. During the run time tunnel exists, the data exchange is carried out in the same way as in the local industrial network specified in the corresponding IEC 61158 and IEC 61784.
- Addresses in a VAN network are name based in order to avoid the use of IP addresses or even MAC addresses and enable communication across networks that use network address translation (NAT).

The principal scheme of the virtual automation networks is depicted in the Fig. 1 [Zezulka F., Beran J. (2009)].

The principal scheme consists from several industrial domains with sub domains, office domains, industrial domains with wireless links and communication among geographically distributed industrial plants. The connection between industrial plants can be realized via public networks (internet, WAN). There are used wired as well as wireless links among domains and among devices in one domain ore sub domains. Some domains are real-time domains, the other have no requirements on real time properties.

It was decided to base the solution on extension and enhancement of IEC 61158 Type 10 protocol (Profinet) over other IEC 61158 standards. The communication model of IEC 61158 Type 10 has been extended due to the VAN requirements on real-time, safety and security functions and the need to enable scalable implementation including possibility to transfer data over wireless technologies.

2. PRINCIPLES OF THE VIRTUAL AUTOMATION NETWORKS

VAN network entities

The components for automation functions [Zezulka F., Beran J (2008)] are VAN Automation Device (VAN–AD), VAN Proxy Device (VAN–PD) And the VAN Virtual Device (VAN–VD).

The component for communication only is the VAN access point (VAN–AC). Let us briefly introduce these network entities below.

VAN Access Point (VAN-AP)

Is an entity containing VAN functionality (VAN protocol enhancements) and interconnects connects VAN network segments but it does not contain any automation function or an automation application. It is just a network device. Such device can work as a gateway or router to automation devices which are members in a VAN application context (VAN Domain).

VAN Automation Device (VAN–AD) is an entity which supports VAN services and VAN protocol implementation and at least one automation function or automation application process in the VAN application context.

VAN Virtual Device (VAN-VD)

Is an entity that represents a real device without VAN network capabilities but with at least one automation function or one automation application process in the VAN application context. These virtual devices are members in a VAN domain.

VAN Proxy Device (VAN-PD)

Is an entity that contains a VAN Function Set (VAN-FS) that is realising the VAN Network capability and a Proxy Application (Proxy Function). This device is used as a proxy enabling connection of legacy communication systems and devices to the VAN network.

The principal features, which enable functionality of the Virtual Automation Networks are introduced below.

3. THE OPEN PLATFORM ARCHITECTURE

In order to combine legacy existing automation devices together with new VAN specific automation devices in a