Internet – technologies that are missing

CACH Petr
cach@feec.vutbr.cz
Department of Control and Instrumentation
Brno University of Technology
Božetěchova 2 612 66, Brno,
Czech Republic

FIEDLER Petr
fiedlerp@feec.vutbr.cz
Department of Control and Instrumentation
Brno University of Technology
Božetěchova 2 612 66, Brno
Czech Republic

The industrial communication networks face a serious challenge – how to achieve seamless interoperability of fragmented networks operating on heterogeneous protocols and how to access data from these networks over Internet to fulfill the idea of ubiquitous computing.

Past development of interoperability in the area of industrial automation can be summarized as follows:

1. Devices from different vendors on single network;
2. Unification of meaning of data fields including physical quantities;
3. Creation of more complex networks
    a. Utilization of different media on one network;
    b. Development of inter-networking (protocol translating) gateways

The big question is: "*What is next?*"

1. Introduction

Today we can see that Internet is covering all the Earth. Sooner or later an Internet connection will be available for a reasonable price almost everywhere. The only known limit of present Internet - the lack of IP addresses - will be solved by IP version 6, so the Internet is not declining technology at all. In fact the necessary technologies are developing towards the idea of ubiquitous computing. As the Internet technologies are spreading, there are many attempts to utilize Internet for transmission of automation data too. Almost every vendor or vendor group has developed a method that allows to interconnect their fieldbuses over Internet. However all these solutions share common drawbacks:

- Misunderstanding the philosophy of Internet;
- Attempts to use former (sometimes pretty old) protocols over Internet;
- No attempts to utilize advantages of Internet;
- Only half-opening of the protocols while presenting them as open protocols.

Many people believe that Internet is just a huge network that interconnects many computers. That's wrong. Internet is a network that interconnects networks. Those interconnected networks are called subnets (subnetworks). Every computer that is connected to Internet is primarily connected to a subnet. Even a single computer that connects to Internet using modem or cable becomes a member of some subnet for the duration of the connection. To access the Internet every computer uses an Internet gateway that is present on the subnet. The gateway is the only device directly connected to the outside world – the Internet.

After we accept that Internet interconnects subnets, we can easily find out that the best way to connect arbitrary devices to Internet is to connect them to a network. To a network that can be used as an Internet subnet. So if we want to connect a temperature sensor directly to Internet we have to equip the sensor with communication interface that can connect the sensor to a network which can be connected to Internet. Moreover the sensor has to use Internet compatible protocol.

At present time it seems that the primary goal in Internet based automation is the development of devices that can be connected to Internet - anyhow - and still utilize the old protocols. The proposed idea is that the primary goal should be: *"Let us develop a technology that will enable to connect automation devices to an Internet compatible network, which will form an Internet subnet. Let us develop Internet compatible fiedlbus*

protocol that will fully utilize the advantages of Internet."

To find out what communication technologies have to be developed, it is necessary to define what is Internet compatible network and what is Internet compatible protocol.

2. Internet compatible network

Common for all Internet compatible networks is that there exists a specification defining how to transmit datagrams of Internet Protocol over these networks. All useful data is then encapsulated in the datagrams of IP protocol. So Internet compatible networks are all networks that are able to transmit unaltered datagrams of Internet Protocol (IP protocol). The content of the useful payload, layers below IP protocol and the technology used as physical layer are not important.

3. Internet compatible protocol

If a protocol is Internet compatible it means that the protocol operates above the IP protocol and uses the IP protocol to transport data.

4. Internet compatible technologies

It is obvious that to connect devices to Internet we have to use some Internet compatible technology (network + protocol). You may say: "*O.K that's what we are doing all the time. We have a device that has Ethernet interface and Ethernet is Internet compatible network. The device uses HTTP and FTP protocols that are Internet compatible protocols, so what's all this about?*"

Well, if you have a device that acts as a HTTP or FTP server, then it is O.K. However there is no suitable technology that would enable to connect low cost sensors (or other devices) to Internet. The manufacturers of sensors have following requirements on communication interface:

- low cost;
- low power consumption;
- bus technology (not star technology);
- minimum space requirements.

These days almost all Internet compatible automation devices are equipped with Ethernet interface. The reason is simple - there is no reasonable alternative to Ethernet. However Ethernet is not low power technology, nor it is space efficient and the most used variant 10/100BasedT is based on start topology with active network components (HUBs and Switches).

As an example this paper presents an idea to use CAN 2.0B based networks for transmission of IP datagrams to fulfill the above-mentioned requirements. The CAN is slow (up to 1 Mb/s), however the amounts of data that are being sent from sensors are extremely low. On the other hand the CAN meets the need for low power consumption and low space requirements. The creation of "process area network" based on CAN could bring the Internet to process level while maintaining high reliability and low cost. The CAN/Ethernet gateway can assure real-time processing on CAN, processing of non-real time requirements and many attractive features like encryption and authentication, firewalling, etc.

Another attractive option for some industrial and process applications are wireless communication networks based on Bluetooth, IEEE 802.11 and IEEE 802.16 technologies, that are very fast, flexible and thanks to their wireless nature do not require any cabling thus are suitable for applications that require to interconnect mobile, moving or rotating objects.

5. Application layer protocols for automation

Even with CAN based Internet compatible subnet there is still missing Internet compatible automation protocol. There had been developed many automation protocols in the past, however these protocols had been tailored to specific applications. These "obsolete" protocols are not able to utilize advantages of Internet and most of them are not open. We believe that there is need for new automation protocol, which would fulfill following requirements:

- Fully open technology - the protocol has to be published as RFC document (freely downloadable);
- Utilization of IP addressing scheme (utilization of IPv6 as the IPv4 is obsolete for intended applications);
- Definition of data as physical quantities including units of measurement (as in LonWorks or CANAerospace), which would minimize interoperability issues.

At present time many proprietary protocols for IP networks are under development in various European and foreign countries, e.g. ProfiNet, Ethernet/IP, IDA, Modbus/TCP, etc. Development of protocols performed by competing vendor-group organizations will not lead to solution that could guarantee interoperability among the animus vendor groups. The only way that can lead to development of open, reliable, secure and globally acceptable standard for exchange of sensor/actuator data is unbiased cross-national development based on real needs of the users. The competing vendor groups are biased towards their old protocols and their will to create something new from scratch is quite low. However without globally acceptable standard that would

guarantee global interoperability of automation data the interoperability problems will remain.

However the possibility to start with a new protocol from a scratch provides another attractive possibility. Almost all present automation protocols lack security features, however the need for such features is significant. The advantage of Internet is the wide selection of available security technologies for encryption and authentication. Especially the ability to create encrypted tunnels is very attractive for automation purposes. Encrypted tunnels allow creation of secured wide-area data acquisition and control systems, while keeping computational requirements placed on automation devices very low.

The new application layer protocol should be based on the best ideas selected from all automation protocols. For example the idea of physical quantities based data representation (as in LonWorks and CANAerospace protocols) can eliminate large amount of interoperability issues that are quite common in these days. Protocols designed with interoperability on mind can guarantee that the communicating devices will be able not only to "talk" together (common protocol), but also it is guaranteed that the devices will understand to each other (common interpretation of data structures) as the protocols exactly specify how to store and transmit values of physical quantities, including units of measurement. An apposite demonstration of the significance of the common data interpretation is the unsuccessful NASA mission to Mars with Mars Climate Orbiter in 1999. The official explanation of the crash from NASA was: "*The 'root cause' of the loss of the spacecraft was the failed translation of English units into metric units in a segment of ground-based, navigation-related mission software ...*"

Obviously engineers at NASA and their operation guidelines were not aware of the interoperability issues.

6. Conclusion

The presented paper introduces the key technologies needed for successful penetration of Internet into the area of industrial automation. The era of ubiquitous computing is slowly approaching, however the technology is not ready yet. Missing are low cost, low power IP compatible communication technology, IP compatible application layer protocol with state of the art security features, proven wireless IP compatible technologies and widespread use of IPv6 protocol.

With described technologies the Internet could be used as widely available fieldbus that would allow for applications, which are hard to imagine with present technologies (e.g. global data acquisition systems for weather forecasting, disaster prediction, traffic control, pollution control, remote health status monitoring of persons with medical issues, citizen based remote supervision of environmentally sensitive plants, etc.).

This paper briefly introduces thoughts and ideas that are behind the Expression of Interest (EoI-CZ27) named *Communication and software technologies for embedded, distributed and Internet based automation* submitted in the frame of Integrated Projects of 6th Framework Program.

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7. References

[1] Industrial Automation Open Networking Alliance, http://www.iaona.com

[2] The Industrial Ethernet Book, http://ethernet.industrial-networking.com

[3] Bradáč Z., Fiedler P., Zezulka F., "Heterogenous interconnection of industrial fieldbuse", Proc. of IWCIT99, Ostrava, 1999

[4] Cach P., Fiedler P., Zezulka F., "Sensor/Actuator web oriented interface", Proceedings of PDS2001 IFAC Workshop, Gliwice, Poland, 2001

[5] Cach, P., Fiedler, P., Zezulka, F., Vrba, R., Švéda, M. "Internet based remote I/O". In Summaries of 16th International Conference on Production Research ICPR-16, Praha, 2001

[5] NASA. "Mars Climate Orbiter failure board report release: 99-134", 1999, available on Internet at address http://mars.jpl.nasa.gov/msp98/news/mco991110.html

[6] Vergeest, J. – Horvath, I.: "A fundamental limit of interoperability". In proceedings of 10th Symposium on Product Data technology, Quality marketing Services, Sandhurst, U.K., 2001