Application of Networks in Automotive Production

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Abstract: *This paper deals with the recent questions of information networks related to companies considering levels those. It sketches the management levels and their features and gives some information connected with technological level. At the end of the presentation there is an example, which presents a produced machine with emphasis of its networks.*

Keywords: *information networks*

I INTRODUCTION

In case of the automotive production there are informatical processes integrated parallel y next to the material production. If we are talking about multinational companies the traditional pyramid like structure is transforming. Parts of these companies can be all around the world because of financial reasons. Despite the parts of information, i. e. development or business administration, have to be accessible in all plants independent of geographical location. Nowadays these demands have to be fulfilled at the level of PLC or embedded controller.

II NETWORK LEVELS

Let us consider a multinational company whose has more plant. Those plants have determined production capacities. Top management of this company is in one of the above mentioned plant.

III TOP MANAGEMENT LEVEL

This level is classical business administration network with suitable servers, firewalls and authentication.

IV PLANT MANAGEMENT LEVEL

This level is also classical business administration. Communication between plants and top management is established with help of suitable VPN (Virtual Private Network). Sometimes dedicated communication can be applied.

V PROCESS DATA HANDLING LEVEL

This level is coupled directly to the plant management level. It would be optimal if only one database were in one company, but as for other viewpoints it is impossible.

VI PROCESS CONTROL LEVEL

This level of information is for handling and delivering information of production. Some overlapping can exist with the previous level. At this level it is possible setting up, obtaining service information and reprogramming production devices. Inside communication of production devices belongs to this level.

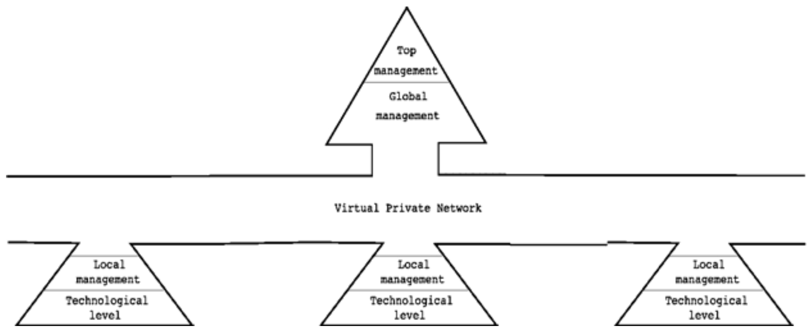

Figure 1
The traditional pyramid like structure

VII NETWORK OF PROCESS CONTROL LEVEL

Question of network at this level is not a closed field of production informatics. Levels above this could be considered as standardized ones.

Process control network has to be fulfilled the following demands:

1. it has to accommodate to production machine,
2. it has to have suitable band width,
3. it has to be reliable,
4. it should accommodate other devices.

Recent 10-15 years many manufacturers developed so called field buses, which work very well under bad industrial circumstances. Their common problem is relative low speed.

If we are watching automotive production system can be electrical or mechanical ones noise protection of field buses is not needed. Environment of these systems rather resembles office environment than we were waiting for. Production environment is always controlled and electrical noise doesn't exceed acceptable level.

Applied controllers in production systems can be PLC-s, PC-s or embedded controllers. Most of the PLC-s have field bus interface such as Profibus, Foundation field bus, CAN bus, etc... New trend is that the above mentioned controllers have Ethernet interface and able TCP/IP communication.

In case of PC Ethernet and TCP/IP are given, but filed bus interfaces can cause problems to designer. Of course these kind of interface cards can be purchased but they are quite expensive. Most often used PC interface is CAN bus.

If we are talking about embedded controller designer's possibilities are not restricted. He has the possibility to design an interface as for demands. If FPGA-s are used libraries can be applied, so implementation needs three four or steps. In case of software level design is not more complicated.

In case of application of embedded systems the widespread interfaces are Ethernet and CAN bus.

Remark: Nowadays embedded systems can have entire operating systems such as Linux and Windows that make controller very flexible.

Practical choice is Ethernet TCP/IP pair. Speed is 100 Mbit/s that means approximately 9 Mbyte/s. This bit rate is enough to communicate to production database (don't forget the whole production line communicates to the database). This speed is enough to reprogram and set up production system, consequently production line can alter without any standstill.

Another advantage TCP/IP communication is applying wireless connection. Considering a manufacturing line, which uses AGVs. AGVs' board computers are able to use production database directly. This can make material flow more flexible.

In case of high level electrical noise optical cable can be used.

For inside communication of machines CAN bus is suitable. Inside communication doesn't need large amount of data, but fast and safe communication is important and CAN bus is good for this aim. Its great advantage is the protocol is established in physical and data link layers, so programmers don't have to deal with it. Bit rate of CAN bus is between 40 Kbit/s and 1Mbit/s. Arbitration filed of CAN bus can contain additional information.

VIII PROTOCOLS

As we mentioned before we suggest for outside communication Ethernet – TCP/IP protocol with 100 Mbit/s bit rate. If we apply PC or PC-like device there available more services. Some possibilities.

- HTTP: it is easy to make GUI. It disadvantage is not really interactive. Its safety level is low.
- SHTTP: see the previous point, but its safety level is high.
- Telnet: it provides a consol. It would be good for configuration activity, but its safety level is low.
- SSH: see the previous point. Its safety level is high.
- Socket connection: A connection can be established with a certain IP address and port.

In our opinion socket server - client bidirectional connection should be the best solution. It is possible to apply safe channel to communicate. This solution allows us to change files and configuration messages. Database messages can use socket connection.

As it was mentioned before CAN bus should be applied for machine inside communication. We have more possibilities, such as:

1 To identify recipient in software way (soft identification). All the devices on the bus read messages and the handler software decides whether the current message is its own or not.

2 To identify recipient in hardware way (hard identification). The message identification is occurred by protocol machine. Message is only read by addressed machine. This way is safer than soft identification.

3 Mixed identification. One part of the address is identified by hardware the other part is done by software. This method is applied when the sender should be identified as well.

The other part of CAN usage we have to choose sending CAN messages. Methods are the following:

1 Event triggered message. If an event occurs current device will send a message. This is the original method of working CAN

bus.

2. Periodic messages (Time Triggered TT). Current device sends a message about its status with a certain periodic i. e. 50 ms.
3. Event periodic messages (ETT). If an event occurs current device will send messages with a given periodic time as log as the event exists.

If we want to get information of single events the first method is good. If we want to monitor a system TT CAN should be applied. In case of special state of a machine I. e. emergency stop the ETT method should be used.

IX A PRACTICAL EXAMPLE

Let us consider a classical electronics production process whose periodic time is 15 seconds, but the current technological procedure takes 50 seconds. That means at least four technological stations are needed. For practical reasons five stations are applied, since:

1. Procedure can be longer because of some technological problems.
2. One of the stations may be broken down.

The fact we have more stations can cause a little scheduling problem. Trivial solution is the first empty station is chosen but other viewpoints exist, for instance:

- Despite stations are manufactured almost the same, during usage their features are changing, i. e. pneumatic chokes are discalibrated, contact nails are getting worn, this make error rate of one or more stations higher.

As for this it is worth collecting data from the station to find stations' optimal rank which determines the optimal scheduling.

To control the current machine we applied so called mixed control contains 6 PC-s and 7 embedded controllers. You can follow the next explanation in the figure.

Five PC-s have to control processing of units. Sixth PC (PC6) has to coordinates all the procedures inside machine. Embedded controllers handling units inside the machine directly and keep contacts to the previous and following machine.

Material handling control has to fulfill the following demands:

1. Ensure movement of units inside machine as for scheduling algorithm.
2. It has to control units processing inside stations.
3. It has to keep contact to processing PC-s.
4. It has to keep contact to previous and following machines.

Operating information between PC6 and embedded cards can be changed via CAN bus with 50 Kbit/s. Embedded controllers have their own CAN interface CAN PC interface is a small CAN - RS232C or CAN – USB 1.2 interface card.

The PC6 and and PC1-5 communicate via Ethernet TCP/IP socket server-client connection. Speed of Ethernet line 100 Mbit/s.

Database communication between the machine and production database is established by PC1-5 via Ethernet TCP/IP protocol. Reason for this we don't want to deal with this part of communication so we don't have to deal with data base queries.

At this point emerges the natural question why we should have used five processing PC-s.

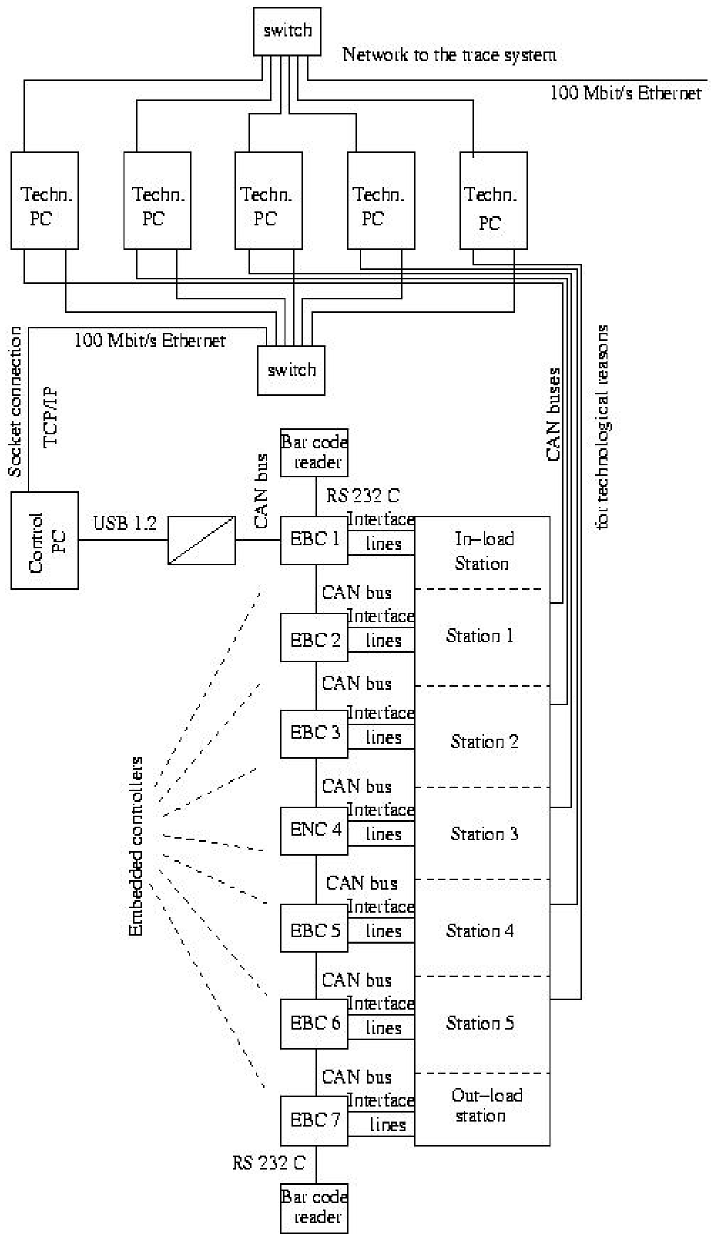

Figure 2
The block diagram of an existing production machine

To tell the truth one PC has enough running capacity to handle all the five stations but company standard doesn't allow us to use one processing PC. These PC-s communicate with units via dedicated CAN bus provided by the customer company. The CAN interface cards are also provided by the customer.

Tasks of embedded controllers are:

- The first EBC controls in-load parts of the machine.
- The second – sixth EBCs control procedure of units.
- The seventh EBC controls out-load part of the machine.

These tasks mean direct motor and pneumatic control.

PC6 main tasks are:

1 It has to provide a GUI for operator.
2 It acts as a gateway between PC1-5 and embedded controllers (in case of usage advanced controllers they can act as gateway as well).
3 It has to attend and calculate material flow and scheduling.

This structure allows quite high reliability, which can be improved low and high level supervising the material flow. These means EBCs control and supervise the current stations, but control PC watches data flow on CAN bus. In case of disturbance this PC is able to recognize this problem and can apply some interventions to correct the emerging problem.

X ANOTHER IDEA OD USAGE NETWORKS IN PRODUCTION LINES

Let us consider the following topic: we have a production line where physical control based on EBCs. The supervisory level is provided by PCs. In the supposed case PCs handle scheduling algorithm, graphics user interface, keep contact with production database and some other tasks, which are important for functioning given machines.

If we observe the load of PCs we may realize this value is not too high usually 30%. That means PCs have a lot of free time. Here emerges the idea it would worth exploiting this capacity. If we want to control the production line in optimal way we should watch the whole line parameters and act to reach this optimal functioning. The question is how we can do that.

Conclusion

The problem is the following: If we try to model the production line we will realize the mathematical model results a very complicated state space. This needs very large computing capacity.

One of the methods to get the above mentioned capacity we use grids. Members of grid can be the supervisory PCs since they have spare time to take part in grid activity and they are using the (same) network. Of course real time tasks have higher priority than grid tasks. Solving the optimizing algorithm we should get following results:

1 Reduce energy consumption of line.
2 Get service information from line.
3 Keep production time of the line.
4 Make longer life time of machines.

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