AN INVESTIGATION OF DIFFERENT DATA BUSES AT ANKA AND THEIR INFLUENCE ON THE PERFORMANCE OF THE ANKA CONTROL SYSTEMS

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Abstract

A variety of data buses with different topologies, protocol conversions and speeds connect the distributed computer components, programmable logic controllers (PLCs) and embedded systems at the beamlines and the storage ring of ANKA[1].

To monitor and evaluate the performance of data buses and gateways some investigations are done. Results are presented, regarding the criteria: data integrity, speed, interoperability, safety and the response time of the ANKA beamline control application SPEC[2].

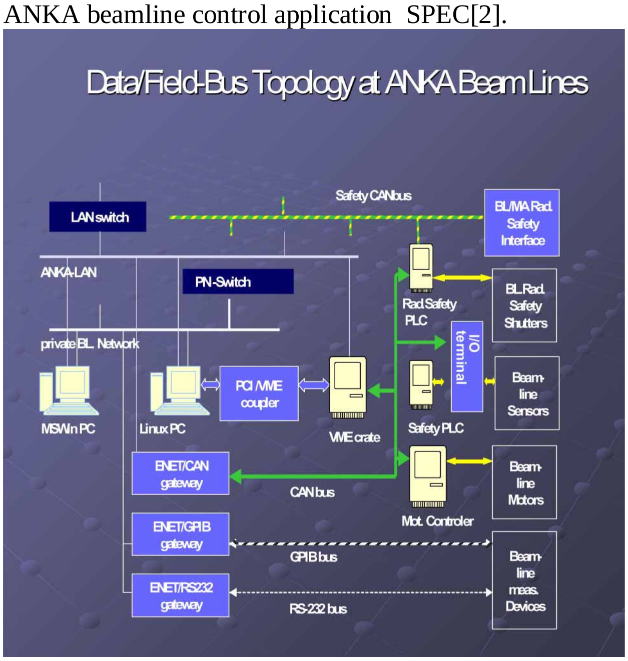

Figure 1: Typical data- and field bus topology of the ANKA beamlines.

MOTIVATION

On one hand field bus to Ethernet converters provides a good measure to bridge larger distances between beamline field and control PCs and to connect the field device layer with the beam line management and scientific data services. On the other hand the most stringent requirement is not to degrade a short response time and high data transmission reliability due to the insertion of additional data communication modules into the networks.

The method of investigation is therefore sending a command sequence from beamline PCs to devices with and without Ethernet/field bus gateways included into the transmission path and to measure response times of data transmission from bus subscribers.

BUS CHARACTERISTICS

The data buses at ANKA are the CAN field bus [3], with the derivative SafetyBus [4], equipped with redundancy features for radiation safety application, the RS232 serial bus and the General Purpose Interface Bus GPIB/IEEE488, present in a variety of measurement devices [5]. The buses differ in their physical properties and usability in the field.

Table 1: Characteristic of field buses used at ANKA beamlines

bus type	Data transfer rate/ max.No. of subscribers per segment	Max.length of bus cable (meters) per segment
RS232	115kbit/sec 2 devices	3 to 30 m
GPIB/IEEE488	Up to 1.5 Mbit/sec 5 devices	20m (4m each)
CANopen/SafetyBus	500-40 kBit/sec 64 devices	100m-3500m
Ethernet	10 MBit to 1GBit/sec unlimited	depends on media

The basic length of bus segments can be extended, using repeater, router, active junction, fiber optics cable link or bus bridge devices. With such devices the transmission speed can be maintained over larger distances by introducing tree- or star topology.

The maximum field bus length for the CAN based SafetyBus to connect beamline radiation safety PLCs with the machine interlock at ANKA is actually 489m with 125 kBit/sec. A bus length of 500 meter should be the upper limit in single line topology to maintain speed performance of safety requests.

In contrary to the not for real time applications optimised Ethernet a field bus is optimised to assure real time behaviour and minimum response time between bus subscribers by highest transmission reliability. A work around for Ethernet can be the introduction of a switched private network (PN) with a restricted number of subscribers at a beamline. The ENET/CAN gateways is set up here mainly as listener to the communication protocol on the field bus side to monitor status information.

The GPIB and RS232 device islands are localized in the beamline fields and need Ethernet gateway support to bridge spatial distance to the beamline PCs.

The overall LAN and the private network of each beamline are physical connected only at the control PCs, which are equipped with two network cards each. The use of beamline PCs with Linux and MS-Windows operation systems allows configuration of ENET/field bus gateways on the private Ethernet with the software tools available for each operating system used at the ANKA beamlines.

TOOLS FOR PERFORMANCE INVESTIGATIONS

- benchmarking Software on a PC,
- integrated hard-, software bus test devices,
- the firmware software application tools of gateway devices.

Gateway configuration tools

The benchmarking tool for Ethernet was the network protocol analyser Ethereal [6], a public licensed software tool for MS Windows and Linux.

Ethereal is used in combination with a PCMCIA/CAN-interface card and a commercial CAN-analyser software on a laptop to test Ethernet socket- and CAN communication in parallel.

The gateway setup is performed with a common RS232-terminal program which makes connection over the serial programming interface to the laptop. The configuration is flashed to the EPROM, the gateway is accessible now by Ethernet connection with one of its command shells.

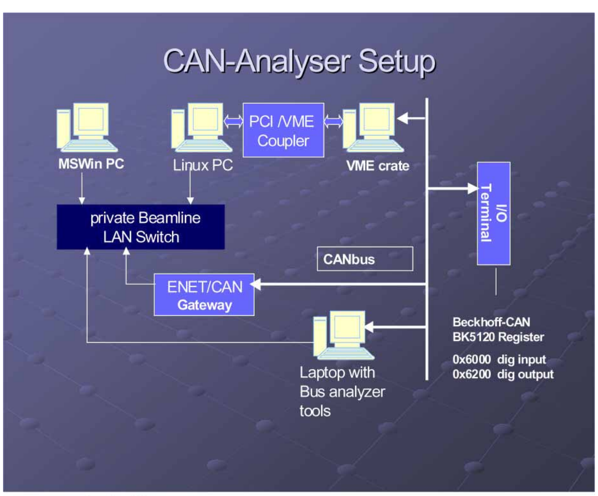

Figure 2: Test setup for CAN bus analysis with laptop and CANanalyser hardware.

The setup of a ENET/GPIB gateway and beamline measurement devices is performed with a National Instruments software tool running under the MS-Windows operating system.

The setup of the N-port RS232 gateway from manufacturer Moxa [7] is done by web browser or telnet connection under the MS Windows or Linux operating system.

SPEC Language

All bus system performance tests under Linux were done with the Certified Scientific Software beamline control software SPEC, which allows a very quick application development due to its easy to learn C-like macro language.

METHODS

The test laptop is connected to the appropriate branch of the beamline CAN-bus and in parallel by hub to the private beamline Ethernet, within the collision domain of the beamline PCs. The network traffic on field- and Ethernet sides is analysed, see Fig. 2.

1. Direct beamline PC/CAN communication*:*
from the beamline PC, write/read commands are send to CAN device registers using the SPEC macro language. The response is traced with the SPEC timestamp function.

2. Indirect communication, Ethernet/gateway/field bus: the software tools supplied with the bus gateway are used, in our case this is a Ether/CAN gateway by the manufacturer Port [8] with a 32bit Linux operating system, a PC-terminal program to set network and device parameters and two interactive command shells to handle up to four CAN-devices. The SPEC application is used to communicate with the CAN devices, wrapping around the command shell tokens.

CAN-bus

A typical method to compare the performance in both cases is to read/ write values to the register of a digital I/O module on the terminal bus (Fig.1) and to measure the average response time.

In a first setup a read/write service data request command is send from the Linux workstation over VME/PCI coupler via CAN-Bus directly to a Beckhoff I/O terminal module or a McLennan PM595 Motor controller, see Tab.2.

In a second setup the ‘direct’ PCI/VME connection is bypassed with the ‘indirect’ ENET/CAN gateway connection, Fig.1. From the SPEC command interpreter the Ethernet gateway is addressed by socket communication, wrapping the ENET/CAN gateway command into shell tokens.

After setting the digital output signal the digital input register is polled, until a change of the value occurs. The time difference is evaluated using the SPEC timestamp function. The spread in set times for one command after a hardware reset of the gateway differs a factor of 10 to 20 between ‘direct’ CAN and E-NET/CAN gateway communication. This is due to the Ethernet broadcast time needed to set up the TCP/IP between PC and gateway.

After having established the connection the read/write response for polling operation is in the same range for both cases and listed in Tab.2

The GP-IB/IEEE488 instrument bus

Due to its short range characteristics the GPIB bus is in use for localized measurement applications. We used the National Instruments (NI) analyser software to send read/write commands to acess beamline measurement devices via GPIB/ENET gateway from the MS-Windows beamline PC. The communication response time is listed in Tab.2.

The difference in performance of SPEC applications using 'indirect' gateway in comparison to a 'direct' communication is within the statistical variation of the data transmission time values measured in both cases. The GPIB communication time is in the range of 0.33 seconds, which a factor 100 larger than the additional Ethernet communication time.

The RS232 bus

The serial RS232 connection is used for actuators like crystal bending devices and even some detector systems like the Roentec at the ANKA Supra-Mini Undulator.

As RS232/Ethernet gateway a N-port RS232 device server [7] with eight serial connections was used. This device can be configured for each port with individual serial transmission parameter settings. Each RS232 port can be addressed by a simple TCP/IP socket communication over a separate port for each RS232. The setup of the gateway is done with web browser or telnet connection. A special feature of the device is its parallel addressability to different IP addresses in the LAN and private networks.

SafetyBus

The SafetyBus [4], a failsafe CAN bus connects the ANKA beamline and the machine interlocks. The Safety Bus is compatible to the IEC/EN 61508 Norm, safety integration level 3 (SIL 3).

The response time on safety requests must be independent on the number of beamlines. The total response time is measured from the setting of a shut down event, to switching off the High Frequency of the ANKA machine cavities.

The response time for beam dump originated by vacuum System request is of major interest at the three ANKA wiggler- and undulator beamlines. This is due to the heat load in the range of $1kW/mm^2$ exerted on the fast shutter which can damage the thin metal sheet of the valve during the time interval between a vacuum emergency close of the valve and the final beam loss by cavity shut down.

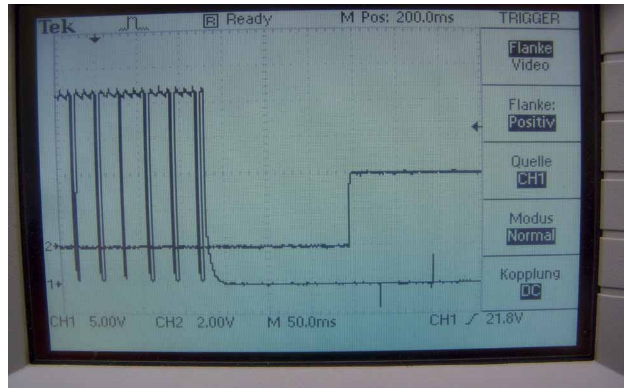

Figure 3: Oscillogram of time delay between setting an emergency stop signal on a beamline hutch (with watchdog pulse, left)

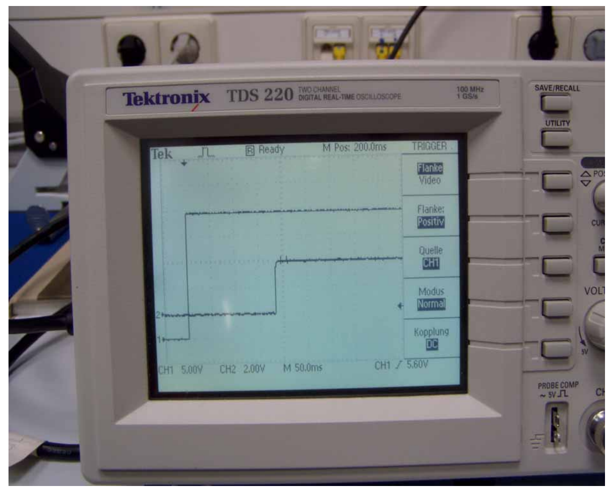

Figure 4: Response of cavity HF interlock beamdump (upgoing signal on the right side).

The time delay is 150 msec. This is the same for the beamline frontend fast vacuum shutter which closes automatically in case of a vacuum leak.

Table 2: Data read/write response times of SULX-data buses and gateways

Source Application	Connection	Register r/w time, 1000cycles averaged
SPEC/Linux	PCI/VME Beckhoff-CAN	2 msec 'direct' comm.
SPEC/Linux	PCI/VME PM 595 motor controller	3 msec 'direct' comm.
SPEC/Linux	ENET/CAN gateway	6 msec 'indirect' comm.
SPEC/Linux	Ethernet 10Mbit/sec	4 msec 'overhead'
SPEC/Linux	ENET/RS232	6 msec
NI-MSWin application	ENET/GPIB gateway	15 read cmds. 16 msec

SUMMARY

The response times of register I/O operations with and without gateways differ in the time scale of milliseconds by a factor of up to 3. So the influence of gateways to the overall performance can be neglected for nearly all applications.

Furthermore there are a lot of advantages by using gateways; First the upgrade odyssey caused by introducing new PC hardware or versions of operating systems can be minimized. Due to the standardised TCP/IP socket communication there is no need to find and install databus specific hardware driver packages. The reduction of PC-interface cards frees resources for detector specific interface boards. Second the length limitation of data buses becomes negligible and the data acquisition has not anymore be located near the measurement devices.

The built in communication features of field-bus gateways allows access to the web. This admits to monitor and diagnose errors in the field from the ANKA facility- and office sites without loss of performance.

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