



Technology overview of present solutions

Report

ATJ-kehitysohjelma

”Ajoneuvon / työkonteen langattomat lähiverkot (ALMA)”

Pauli Mikkonen, Centre for Wireless Communications Kainuu

Jukka Kämäräinen, VTT Technical Research Centre of Finland

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Abstract

CAN-bus with its different higher level protocol variants seems to be a de facto standard these days in machine controls like hydraulics and motor control as well as different sensor readings, diagnostics etc. Ethernet (variants) are in use in some applications, but less so strictly as a working machine main control bus. There are examples of remote machine controls which are realized by wireless radios operating at 433 MHz band and at e.g. 2.4 GHz band utilizing Bluetooth. 2.4 GHz band is however somewhat troublesome because of its wide use and high probability for interference in dense scenarios and is usually left for non-critical transmissions.

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1. Introduction

This report is an overview of buses and wireless solutions working machine manufacturers use today, and what wireless and wired interfaces vehicle computer manufacturers offer in their products. Additionally some answers were received also about future needs and desires for reliable wireless links from working machine manufacturers.

The information for this report was gathered in May 2009 from Internet and directly from working machine manufacturers. That information with their answers can be seen in appendix A. Information about vehicle computer manufacturers and their products can be found in appendix B.

A fraction of manufacturers are included in this report simply because there are so many of them in this global business. That applies to both working machine and vehicle computer manufacturers. Still, main players in Finland and some foreign companies are included.

2. Results of the enquiry

2.1 Field buses in working machines

CAN-bus was originally designed for use in automotive industry. In working machines CAN-bus is used in motor control, hydraulics systems, sensors etc. Since its creation its use has expanded to become nearly de facto standard in working machines practically in less than two decades. Nowadays it is used also in other application areas outside automotive industry. Over the time several higher layer protocols have been developed for different needs and approaches but still utilizing the same physical layer. These include e.g. CANopen, DeviceNet, CANaerospace and J1939.

Ethernet based buses are designed for and used in industrial automation. Their use as working machine main control bus is not common, at least not yet. CAN over Ethernet is used thought.

2.2 Wireless solutions in working machines

Wireless solutions in working machines could be divided in reliable critical ones including wireless control methods, and less critical ones for diagnostics and centralized data collection.

According to information from working machine manufacturers they tend to use 433 MHz band for greater reliability in wireless control and stay away from possibly crowded 2.4 GHz band. The risk for unreliable connection is usually seen to be too high in that frequency band. Some control applications are found to be used with that 2.4 GHz band. Hiab, for example, uses its CombiDrive, a Bluetooth driven remote control unit to control crane mountable on different machines. Bluetooth uses a frequency hopping technique so it has some tolerance for interference.

Less critical communications is usually realized with 2.4 GHz band for low cost, easy implementation and, in WLAN's case, substantially higher data rate. If greater distances are needed implementation is usually done using cellular frequencies.

2.3 Wired and wireless interfaces in vehicle computers

The gathered information about vehicle computers can be seen in appendix B. The results reflect the most used solutions at least to some extent. Most commonly manufacturers offer CAN-bus. Ethernet is also very popular. Different serial ports, digital and analogue I/Os can be found depending on the needs of the customers. Most common short range wireless communications are implemented by Bluetooth or WLAN. More special short range communications needs are typically set by the customers and are implemented as requested with suitable radios. For greater distance GSM/GPRS or faster broadband operator networks are used.

2.4 Wishes and requirements for reliable wireless link

Working machine manufacturers were asked for personal requirements and needs they might have for reliable wireless link, and what kind of wireless solutions they have in use. Some were quite interested in substituting wired bus with wireless but a question arose about the real advantages compared to wired method because the power to operate valves etc. is still needed and it's currently transmitted by wires only. One interesting need points out. How to physically pair different machines or separate parts of a machine, like upper and lower parts of a crane for example? Wireless control bus could make things much easier.

The requirements for wireless technology vary from application to another. Specifications need to be set by the tightest requirements for particular application. In

wireless control bus consideration in the technology selection has to be done on several factors: maximum allowable delay, jitter of delay, transmission rate, frequency band (interference etc.), price, security issues, size of physical devices, power usage, required operation distance, standardization etc.

Working machine manufacturers see the requirements for reliable wireless controls through their own applications. Reliability in general and low delay are seen the most important factors.

3. Conclusions

CAN-bus is very popular these days in working machines. Data volumes in automation applications are increasing as well as number of nodes per machine which leads to more complex systems with increased amount of traffic in the bus. Additionally some safety technologies might require more data traffic capacities. For higher capacities Flexray and Ethernet based solutions could become more common but not likely overthrow CAN-bus completely in near future simply because of its wide use and long life span of working machines. Let alone the fact that CAN-bus may be the best compromise for quite some time. Familiar, well tested technology and easy implementation may simply be enough reason to stick with CAN-bus.

There are some wireless safety critical applications in use. One popular frequency band is the 433 MHz band which is used for wireless control. Wireless link between two CAN-buses is used. There are off-the-shelf solutions for different wireless protocol CAN-bus gateways.

Appendix A: Working machine manufacturers

Tractors, Forest Harvesters and mining machines

John Deere (from Internet)

- tractors
 - o CAN bus to control data

Normet Oy

- concrete spraying equipment for underground mining
- underground explosive chargers
- hydraulic impact hammer for scaling in hard rock
- Utilift scissors lifts for lifting and installations in mining and low-profile tunnelling
 - o CanOpen and J1939 for motor control
 - o radio control to boom and explosive chargers
- requirements for wireless bus:
 - o very reliably, low power, antenna inside of equipment, connectivity to CANopen, low cost

Ponsse

- tractors, harvesters
 - o ArtNet bus

RCM Harvester Ltd

- remote control wood harvester
 - o Remote control by Hetronic technic, 433 ISM band
 - o CAN bus
 - o CAN over Hetronic radio
 - o Send wood measurement and quality evaluation data over radio

Sampo Rosenlew

- combine harvester, wood harvesters
 - o no wireless technologies
 - o CAN bus by Partek (IQAN)
 - o J1939 in motor control
- Interested in new bus technic.
- Need reliable wireless bus

Naarva harvester head

- from Internet:
 - o Naarva pulse harvester can be attached with a radio controlling unit. Radio manufactured by Jay Electronics.
 - o Specification of radio control unit
 - 18 programmable frequencies (433,100 to 434,740 Mhz) for transmitters with "start/stop" button
 - A passive stop shuts down the system if the radio link is jammed
 - A "Start/Stop" function (category B per EN954-1) available with transmitters equipped with "start/stop" button and receivers equipped with "On" relay

Valtra

- www.valtra.fi
- tractors
 - o ISOBUS connecting agricultural machines to tractors.
 - o The ISOBUS system allows the Electronic Control Units (ECU) of the tractor and the implement to communicate and share information via a CAN bus
 - o CAN bus for internal bus on the tractors, for example hydraulic control

Diggers, cranes and trucks

Bronto Skylift Oy, Tampere (Federal Signal Corporation, USA)

- bronto.fi
- hydraulic platforms on trucks, worlds highest personnel platform on truck
 - o CAN based control system by Siemens/Klinkmann
 - o GSM modem through RS-232
 - all data can be transmitted through GSM modem in two ways
 - remote diagnostics and setups
 - sensor readings, calibrations etc.

Hiab (Cargotec) / Cargotec Finland Oy, Helsinki

- cargotech.com / hiab.fi
- smaller loader cranes and trucks in great variability
 - o CAN
 - o Bluetooth in crane remote control unit

Jungheinrich, Germany / Jungheinrich Lift Truck Oy, Kerava

- jungheinrich.com / jungheinrich.fi
- industrial trucks and logistics
 - o CAN
 - o integrated diagnostics system for remote maintenance via modem
 - o RFID in automatic pallet identification system
 - o RFID warehouse navigation unit (optional)
 - RFID in positioning and with the floor topology information e.g. speed limits in certain floor areas

Kalmar (Cargotec) / Cargotec Finland Oy, Kalmar Suomi

- kalmarind.com
- heavy duty materials handling, container lifting (cranes)
 - o CAN
 - o Machine Interface Unit (MIU)
 - GSM, radio modem (depending on need), WLAN
 - o Remote Maintenance Interface (RMI) software displaying reports, analyses, diagnostics etc.

Konecranes Oy, Hyvinkää

- konecranes.com
- wide variety of lifting equipment/cranes, one of the leaders in this field
 - o uses mainly frequency band of 433 MHz for reliable controlling of crane
 - o also 868 MHz band is used
 - o burst radios
 - o reliability requirements set for all possible operating environments
 - o some diagnostics data is also transmitted through WLAN, but nothing control related

Mantsinen Oy, Ylämylly

- mantsinen.com
- material handling machines, mobile harbour cranes and logistic services
 - o CAN
 - controlling valves, sensors, meters, levers etc.
 - o WLAN (not confirmed) wireless camera
 - o radiation sensor is using wireless radio (no precise information)
- possible uses for wireless reliable bus:
 - o control valves, but where the power for them?

- separate and detachable lower and upper “carriage” in handling machines and cranes
- possible requirements for wireless radio:
 - real-time demand? For radiation sensors ~1s, other sensors ~0,1s
 - transmission rate, not so critical
 - reliability, very important – big machines are involved
 - low power, only in wireless sensors, not so important as such
 - size of a fist is enough
 - hidden/visible antennas, has to be impact proof
 - connectibility to bus/HW is case-specific
 - price? no simple answer, the whole package determines the “right” price

Rocla Oy, Järvenpää

- rocla.com
- warehouse trucks, counterbalance trucks, Automated Guided Vehicles (AGVs)
 - CAN in engine control, different sensors, dashboard feedback screens etc.
 - Ethernet in “small scale” in trucks and AGVs
 - WLAN for forwarding diagnostics and data collection from trucks
 - Bluetooth was previously used but was determined to be unreliable
 - WLAN also between central controlling and AGVs
 - to AGVs: general directions
 - from AGVs: status and position information
 - GPRS for single trucks
- Future interest:
 - positioning indoors
 - wireless truck battery charging
 - physically pairing machines together could be easier

Sandvik Mining and Construction AB, Sandviken, Sweden

- sandvik.com
- mining vehicles

- o buses

“CAN and application layer protocols in use. In addition to own old TAS protocol CANopen is main integration platform, and SAE J1939 (between diesel engine and other system). Additionally Ethernet and IP protocol family is used. Certain devices use Ethernet-Powerlink (CANopen over Ethernet). RS-232/485, USB”

- o wireless

“WLAN. Machine is controlled with the help of streaming video from control room. Also machine production and diagnostic data from machine to control room”

- o needs for wireless bus

real-time demand

“Important demand. Remote operations induce <150ms round-trip delay”

data transmission rate

“Important for non-delayed video assisted controlling. Present 54 Mbps is enough but less would be difficult [in this use].”

reliability

“Important when dealing with machine controls. The connection has to be very reliable because disconnection causes production process to stop. Additionally remote operations require uninterrupted change of active access point.”

power consumption

“Not so important.”

physical size of devices

1) “That’s relative but smaller is always better.” 2) “In the future very critical factor because many systems can be installed to older machines which don’t have predefined installation spots.”

encapsulated/visible antennas

1) “Better if antennas are heavily encapsulated, otherwise broken easily. On the other hand encapsulation not necessary if antennas are cheap and easily replaceable.” 2) Underground environment demands separate antennas because the machine always blocks the view to another direction. Two antennas per radio is necessity.”

connectivity to wired bus or directly to hardware

1) “both are needed” 2) “In practice seamless connectivity to IP network”

price, in comparison to all-wired bus

“Competition is hard.” 1) “If too expensive, unlikely to be implemented.” 2)

“Comparable price to ‘cable version’ would be nice but the performance is the most important thing and it costs what it costs. That goes to reliability as well.”

“The advantage of wireless connection between machine and control room is obvious. But wireless bus in machine is dubious if power is still transmitted by wires”

Vema lift Oy, Kaarina (Kiitokori group)

- vema.fi
- working platforms on trucks, demanding conditions
 - o CAN
 - o wireless controlling of beam of the working platform

Appendix B: Vehicle computer manufacturers

ABtrack, Italy

- abtrack.it
- Vehicle telematic information systems, location based systems
 - o CAN, USB, RS-232, I/Os
 - o GPS/GPRS
- wireless machine to machine
 - o routing UMTS/HSDPA, HSUPA, HSPA+, EDGE, GSM/GPRS between vehicles

AC Electric Vehicles Ltd., Jokela (AC –Sähköautot Oy)

- acev.fi
- vehicle computers, data loggers
 - o CAN, ETHERNET, SAE J1850 PWM and VPW, ISO-9141, KWP-2000, I2C, Dallas 1-wire, VAN
 - o WLAN, Bluetooth, GSM, GPRS, DECT (cordless telephone @ 1880-1900 MHz)

Aplicom, Espoo (Nokia spinoff)

- aplicom.com
- vehicle tracking and telematics hardware
- advanced tracing and tracking
- telemetry
 - o CAN, OBD II, K-line
 - o WLAN, GSM/GPRS, TETRA (“walkie-talkie”)

Beckhoff Automation GmbH, Germany / Beckhoff Automation Oy, Hyvinkää

- beckhoff.com / beckhoff.fi
- I/O for all common fieldbus systems
 - o EtherCAT (Ethernet for Control Automation Technology)
 - o Ethernet
 - o Lightbus, fibre optics bus system has good immunity to EMI
 - o PROFIBUS is widely used as a fast bus for decentralised peripheral components
 - o PROFINET is the open Industrial Ethernet standard of the PNO (PROFIBUS users organisation). Internationally established IT standards such as TCP/IP are used for communication.
 - o Ethernet/IP is the Industrial Ethernet standard of the ODVA (Open DeviceNet Vendor Association). Ethernet/IP is based on Ethernet TCP/IP and UDP/IP.
 - o CANopen
 - o DeviceNet is a sensor/actuator bus system that originated in the USA, but which meanwhile is increasingly being used in Europe and Asia. DeviceNet is CAN based.
 - o Interbus is easy to configure, fast and reliable.
 - o SERCOS was originally developed as a fast fibre optic bus system for drives.
 - o ControlNet is an open, standardised fieldbus system. The protocol allows both cyclic and acyclic data to be exchanged over the bus without affecting each other.
 - o CC-Link (Control & Communication Link) is an open bus system for communication between the control and fieldbus level. It is predominately used in Asia.
 - o USB, can be used as a substitute for a fieldbus when distances are small.
 - o Modbus is an open, serial communications protocol based on the master/slave architecture. Since it is extremely easy to implement on all kinds of serial interfaces, it has gained wide acceptance.

- The “classic” serial interfaces, RS232 and RS485, continue in wide use.
- AS-Interface connects sensors and actuators with the higher control level via a simple and low-priced wiring method. AS-Interface is internationally standardised through EN 50295 and IEC 62026-2.
- IO-Link serves to connect sensors and actuators to the control level by means of an inexpensive point-to-point connection. As an open interface, IO-Link can be integrated in all common fieldbus systems.
- DALI, The “Digital Addressable Lighting Interface” is a building automation standard for the digital control of electronic ballasts. DALI is used as a subsystem, e.g. for controlling lighting, blinds or temperature, and can communicate directly with the building management system.
- EIB (European Installation Bus) is widely and mainly used in Europe as a bus system for cabling in buildings.
- LON (Local Operating Network) is a multi-network-capable communication system for distributed applications. It is predominately used for automation applications in commercial building

EPEC Oy, Seinäjoki

- epec.fi
- vehicle computers, control systems, harvester measuring systems, load optimizer
 - CAN, ISOBUS, ETHERNET, USB, RS-232/422/485, analogue and digital I/Os, PWM I/Os,
 - GPRS

Mitron, Forssa

- mitron.fi
- devices to access train passenger information system and all main buses within the train
 - CAN, digital I/Os, RS-485, Ethernet (Train Central Unit)

- Ethernet, PoE, RS-485/422, USB (Train PC)
- WLAN, 3G, GPRS

Motorola, USA

- motorola.com
- vehicle computers (e.g. VC6096)
 - SAE J1708 (2-wire, older), SAE J1939 (CAN), USB, Ethernet, RS-232, digital I/Os, analogue in
 - HSDPA 3.5G WWAN, WLAN, Bluetooth

Moxa

- moxa.com
- “total solutions for industrial devices networking”
 - RS-232/422/485, Ethernet, CAN, digital and analogue I/O lines, options for other connections
 - GSM/GPRS, WLAN
 - UMTS, HSDPA option

Nexcom, Taiwan

- nexcom.com
- industrial computers, in-vehicle telematics control
 - CAN, RS-232/485, USB, Ethernet
 - GSM/GPRS, WLAN, WCDMA, HSDPA, Bluetooth

Parker Vansco, Canada /Vansco Electronics Oy, Forssa

- vansco.ca / vansco.fi
- rugged electronic, electromechanical and electrohydraulic solutions

- forest harvesters (bought Automotive Electronics, Forest Systems and Bus Sign divisions of Mitron Oy of Finland in 2005)
- gateways, displays, monitors, terminals, instrument clusters
 - o SAE J1708 (2-wire, older)
 - o SAE J1939 (CAN)
 - o Power Line Carrier (PLC), data along electric power
 - o MUXBUS (Multiplex Interface Bus)
 - o GPS/GPRS, WLAN, CDMA

Sunit Oy, Kajaani

- sunit.fi
- in-vehicle computers
 - o CAN, digital I/Os, Ethernet, RS-232/485 (via PCI104)
 - o GSM/GPRS
 - o WLAN and Bluetooth etc. optional

Swarco, Austria

- swarco.com
- traffic management
- intersection control and adaptive control of traffic flows
- highway and tunnel guidance systems
- parking guidance
- traffic telematic software and communication solutions
- Oulun paikallisliikenteen reaaliaikaisen informaatio- ja liikennevaloetusjärjestelmä (GPS, wireless data transmission)
- variable message signs (VMS), LED technique
 - o RS-485/422, Profibus, Profinet, CAN, Ethernet, digital and analogue inputs
 - o WLAN, Bluetooth

Tamtron group / Tamtron Oy, Tampere

- tamtron.fi
- weighing equipment, vehicle PC and data handling
 - o CAN, digital I/O lines, analogue out, RS-232/485 (YES-Tracker)
 - o WLAN, Bluetooth, GSM/GPRS, point-to-point modems based on customer needs

WABCO Vehicle Control Systems, Belgium

- wabco-auto.com
- vehicle (sub)systems, diagnostics, driver assistance of heavy duty trucks and buses etc.
 - o CAN
 - o LIN (trailer telematics)