

		<b>Foundation Fieldbus</b>	<b>AS-Interface</b>	<b>Interbus</b>	<b>Modbus-1</b>	<b>CAN/Open</b>	<b>DeviceNet</b>	<b>Ethernet</b>
© 2006 R.A. Hulsebos.	<b>Profibus</b>	<b>Foundation Fieldbus</b>	<b>AS-Interface</b>	<b>Interbus</b>	<b>Modbus-1</b>	<b>CAN/Open</b>	<b>DeviceNet</b>	<b>Ethernet</b>
<b>General</b>								
Abbreviation	Process Field Bus	Foundation Fieldbus	Actuator Sensor Interface	-	Modicon Bus	-	-	-
Available since	Ca. 1990	Ca. 1996	Ca. 1995	Ca. 1988	Ca. 1979.	Ca. 1995.	Ca. 1996	Ca. 1975
Developer	Originally Siemens, later the Profibus Consortium (Germany)	Fieldbus Foundation (US).	AS-Interface Consortium (Germany)	Phoenix (Germany)	Modicon / Gould / Groupe Schneider (US)	CIA (CAN In Automation) User Group	Originally Allen-Bradley (US), later the Open DeviceNet Vendors Association (ODVA).	Xerox (US)
Number of members in main User Group								
National standards	DIN 19-245 (Germany)	ISA SP50 (US).	-	DIN 19-258 (Germany)	-	-	-	IEEE 802.3
European standards	EN 13321/1 (FMS), EN 50254/2, EN 50170/2	EN 50170.	EN 50295	EN 50254/1	-	EN 50325/4	-	-
International standards	IEC 61158 Type 3	IEC 61158 Type ??	IEC 62026/2, IEC 947	IEC 61158 Type 8	-	-	-	ISO 8802.3
Industry standards	SEMI E54.8 (DP)	-	-	-	-	-	-	-
Official website	<a href="http://www.profibus.com">www.profibus.com</a>	<a href="http://www.fieldbus.org">www.fieldbus.org</a>	<a href="http://www.as-interface.net">www.as-interface.net</a>	<a href="http://www.interbusclub.com">www.interbusclub.com</a>	<a href="http://www.modbus.org">www.modbus.org</a>	<a href="http://www.can-cia.de">www.can-cia.de</a>	<a href="http://www.odva.org">www.odva.org</a>	-
Non-official website	-	-	<a href="http://www.as-interface.com">www.as-interface.com</a>	-	-	<a href="http://www.canopen.us">www.canopen.us</a>	-	<a href="http://www.iaona-eu.com">www.iaona-eu.com</a>
Email list available?	Yes, at <a href="http://www.profibus.com">www.profibus.com</a> ; the old list is at <a href="http://www.profibus.cz/archive">www.profibus.cz/archive</a> (but no longer active).	-	Yes, see <a href="http://www.as-interface.com">www.as-interface.com</a>	None known.	Yes, see <a href="http://www.modbus.org">www.modbus.org</a>	Yes, see <a href="http://www.vector-informatik.com/canlist/">www.vector-informatik.com/canlist/</a>	-	There used to be an email list of the Industrial Ethernet Association, but this one is no longer active.
OSI layers covered	1, 2, 7	1,2,7	1, 2, 7	1, 2, 7	2, 7	1, 2, 7. A specification for layer 5 (session management) exists but is not often implemented.	1,2,7.	1, 2
Variants	FMS, PA, FDL, DP (with subversions DP/E, DP/V1 and DP/V2)	H1, HSE	V1.0, V2.0, V2.1, V2.11, V3.0	V1, V2, V3, V4, V4.6, Interbus/Loop	ASCII, RTU (Remote Terminal Unit)	V1, V2, V3, V4 plus minor variations on these.	-	10Base2 (coax), 10Base5 (coax), 10BaseT (twisted-pair), 100BaseTX (idem)
Most often used variant at this moment	DP/V1	H1, HSE	V2.11	V4	RTU	V4	-	10BaseT, 100BaseTX
Compatibility between these variants	FMS and DP and FDL are incompatible; but they can be connected to the same network without problems.	Compatible, to the extent that the protocol is identical, but the wiring different (can be connected via bridge).	Backwards compatible.	Backwards compatible.	Both variants have the same commandset but a different transmission-format; they can not be both on the same network.	-	-	Compatible when switches or hubs are used that handle the conversions.
Variants that are not used anymore or are seldomly used	FDL, FMS	-	V1.0	V1, V2, V3, Interbus/Loop	ASCII	V1, V2, V3.	-	10Base2, 10Base5
Intrinsically safe variant available?	Yes (PA).	Yes (H1).	-	-	-	No.	No.	-
Safety variant available?	Yes (ProfiSafe).	Under development.	Yes (Safety At Work).	Yes (Interbus Safety).	-	Yes (CAN/Open Safety).	Yes (CIP Safety).	-
Ethernet variant available?	Under development (ProfiNet); first serious usable version announced for end of 2005.	HSE (High-speed Ethernet).	No, this would make no sense.	No, this would make no sense.	Yes, Modbus/TCP.	No.	Yes (Ethernet/IP).	-
Profiles	ProfiDrive, ProfiNet, various others for DP and FMS.	-	Analogue I/O.	Drivecom, Encom, Mmicom, Robocom, Weldcom.	One (for semiconductor equipment).	I/O, measuring devices, closed loop controllers, PLCs, encoders, maritime devices, drives, passenger info systems, fluid power, inclinometers, medical devices, truck gateways, weaving machines, road construction, building door control, lift control, battery chargers, extruders, injectors, municipal vehicles ("CLEanOpen").	-	-

© 2006 R.A. Hulsebos.	Profibus	Foundation Fieldbus	AS-Interface	Interbus	Modbus-1	CAN/Open	DeviceNet	Ethernet
Other protocols that resemble it	MPI (Multi-Point Interface) from Siemens (like FDL).	-	-	-	The French "J-Bus" is not officially a Modbus-1 variant, but for 99% compatible.	CAL (CAN Application Layer), the predecessor of CAN/Open.	CAN/Open, SDS.	-
Specification of basic protocol free?	Only for members of the user's group; otherwise must be bought.	Only for members of the user's group; otherwise must be bought.	Only for members of the user's group; otherwise must be bought.	No.	Yes, can be downloaded from the website.	Only for members of the user's group. Others can get the previous version for free from the website.	Only for members of the user's group; otherwise must be bought.	Yes, can be downloaded from the IEEE website <a href="http://www.ieee.org">www.ieee.org</a>
Specification of profiles free?	No, must be bought from the user's group.	-	No, must be bought from the user's group.	Yes, can be downloaded from the website.	Yes, can be downloaded from the website.	Only for members of the user's group. Others can get the previous version for free from the website.	-	-
Stability of the system?	FMS is stable since about 10 years, but may be phased out. All new developments since about 8 years are for DP and PA. ProfiNet is a completely new development.	High.	High, but the trick employed to double the number of slaves can not be done again. The handling of analogue I/O has undergone a complete redesign.	High.	High.	High, although the CAN/Open specification is known to be unclear at some points.	-	High; the versions developed 20 years ago are still compatible.
Books about this system?	Yes; 1 book about FMS (German / English), but sold out. About a dozen books about DP (mostly German, some English).	Yes, mostly by ISA.	2.	8.	-	Three books specifically for CAN/Open, but many books about CAN also discuss this protocol.	Not known; but DeviceNet is usually discussed in books about CAN.	5; there are many other books, but these are usually written for the office-user of Ethernet.
Available as shareware or open source?	-	No.	-	-	Yes (various). Also not very difficult to implement yourself.	No, except for a partial implementation by <a href="http://www.esacademy.com/">www.esacademy.com/</a>	No.	-
Special hardware necessary?	In principle not, but in practice the special Profibus/DP controller chips are used. At lower bitrates any UART may work as well.	-	Requires AS-Interface chips both for master and slaves.	-	No.	No, not for the CAN/Open protocol itself, but for the lower OSI-layers a CAN-controller is necessary.	No, not for the Device protocol itself, but for the lower OSI-layers a CAN-controller is necessary.	Yes, any available Ethernet controller chip.
Most important competitor(s)	PA: Foundation Fieldbus. DP: Interbus, CAN.	Profibus/PA.	Interbus/Loop.	AS-Interface, Profibus/DP.	-	Profibus/DP, DeviceNet.	CAN/Open.	-
Major supporting company	Siemens (Germany)	-	-	Phoenix (Germany)	Schneider	-	Allen-Bradley (US).	-
Notes	-	-	-	-	-	CAN/Open is an extension of the older "CAL" (CAN Application Layer) whose specification was lacking, too formal and too difficult to understand for many users.	-	Ethernet itself is not a network, only a way of cabling. A higher-level protocol (ProfiNet, IDA, Ethernet/IP, Modbus/TCP, etc. etc.) is <b>always</b> needed.
<b>Usage</b>								
Applicable for sensor/actuator I/O?	No, too complex, and hardware too large.	No, too complex and hardware too large.	Yes, especially developed for this.	Yes, via Interbus/Loop.	No.	Yes.	Yes.	No, hardware too large.
Applicable for remote I/O?	Yes (DP only).	Yes.	Limited, can only have 4 digital I/O channels of 2 analogue channels per node.	Yes.	Yes.	Yes.	Yes.	Yes.
Applicable for communication between controllers, PC's, and/or intelligent equipment?	Yes (FMS for communication between controllers, PA for field instruments).	Yes (intended for process control devices such as transmitters, valves, flow metes, controllers, etc.).	No.	Limited.	Yes, but officially only for Modicon / Schneider controllers, although many other controller vendors also support Modbus.	Yes.	No.	Yes.
Application areas	Discrete industry (DP), process industry (PA)	Process industry.	Discrete industry, process industry partially (due to non-Exi).	Discrete industry.	Discrete industry, process industry.	Many (see list of profiles above).	-	Office automation; higher levels of industrial networks.

© 2006 R.A. Hulsebos.	<b>Profibus</b>	<b>Foundation Fieldbus</b>	<b>AS-Interface</b>	<b>Interbus</b>	<b>Modbus-1</b>	<b>CAN/Open</b>	<b>DeviceNet</b>	<b>Ethernet</b>
Availability of interface cards for PC's	Yes, several vendors.	Yes, several vendors.	Yes, several vendors.	Yes, several vendors.	Not needed when RS232 is used; for RS422/485 a converter can be used or a normal PC plug-in board.	Yes, several vendors.	Yes, several vendors.	Most modern PC's come with an integrated Ethernet on the motherboard.
Availability of protocol stack	Comes with the PC card or the PLC. For DP, a network configuration package is also needed.	Comes with the PC card.	Comes with the PC card or the PLC.	Yes, comes with the PC card.	In many cases the Windows or Linux support suffices.			Comes with Windows or Linux (virtually for free).
Number of nodes installed worldwide	14 million (source: Profibus User's Group, May 2005).		10 million (source: AS-Interface User's Group, May 2005).	8 million (source: Interbus User's Group, January 2005).	Unknown.			
<b>Cabling</b>								
Cable	2-wire.	2-wire.	2-wire (yellow AS-i cable), possibly power-supply via extra 2-wire cable (black or red).	4-wire (2 RX, 2 TX).	Commonly used are either RS232 or RS422/485, although this is not formally specified.	2-wire.	5-wire.	Coax (10Base2, 10Base5), 4-wire twisted pair (10BaseT, 100BaseTX).
Cable color	Purple (DP), blue (PA); although the color is of course not relevant for the functionality of the network.	Orange/blue (H1); although the color is of course not relevant for the functionality of the network. HSE uses Ethernet cables.	Yellow (network + power 30V), black (power 24V), red (power 220V).	Green; although the color is of course not relevant for the functionality of the network.	Not specified.	Not specified.	Gray.	Yellow (coax 10Base5), black (coax 10Base2), or usually grey for all other variants.
Redundant cabling possible?	Not yet (only specification for redundant slaves is now available).	H1 not possible; HSE uses standard Ethernet mechanisms.	No.	Not yet.	Depends on vendor.	No.	No.	Yes .
Fiber optic possible?	Yes (via repeaters).	Yes (via repeaters).	No.	Yes.	Yes, depends on vendor.	Yes, depends on vendor.	Yes (via repeaters).	Yes.
Power supply for nodes on the network	Via separate connection (FMS,DP). With PA via the network itself.	Via the network itself.	Via network itself (30V/8A), extra power (24V/8A) via black cable.	Via separate connection.	Not specified.	Via separate connection.	Yes.	Via separate connection.
Connector	9-pins sub-D connector (most common); other connectors possible.	Normal instrument wiring practice.	Via vampire taps (most common) or screw connector.	9-pins sub-D connector.	Not specified; often 9-pin sub-D is used, but the pinning is always different.	9-pins sub-D connector (most common); other connectors possible.	Various.	15-pins sub-D (10Base5), BNC (10Base2), RJ45 (10BaseT, 100BaseTX).
Topology	Bus (FMS, DP, PA), or chicken feet (PA).	Bus, chicken feet (H1). Star (HSE).	Tree, bus, star.	Bus, tree, star.	Bus.	Bus.	Bus.	Bus (10Base2, 10Base5), star (10BaseT, 100BaseTX).
Termination	3 resistors at both ends of the cable (FMS, DP). Combination of R and C (PA).	Combination of R and C, usually available in termination block (H1). HSE does not have to be terminated.	Not necessary.	Not necessary (integrated in equipment).	Not specified, depends on supplier (when using RS422/485).	Resistor of 120 Ohm at both ends of the cable.	Resistor of 120 Ohm at both ends of the cable.	1 resistor at both ends of cable (10Base2, 10Base5 only).
Vulnerability for incorrect termination	Nodes with terminators may not be switched off or be removed from the network.	Operation with incorrect termination is not defined, but network may remain functional (depending on network length and number of nodes).	None.	None.	Nodes with terminators may not be switched off or be removed from the network (not applicable for RS232).	Nodes with terminators may not be removed from the network (however they may be switched off). Too few or too many terminators can degrade network performance.	Nodes with terminators may not be removed from the network (however they may be switched off). Too few or too many terminators can degrade network performance.	None.
Signal transmission	According RS485 (FMS, DP) or IEC 61158/2 (PA).	IEC 61158/2.	AS-interface specific.	According RS485.	According RS232 or RS422/485.	According CAN datalink layer specified in ISO 11898.	According CAN datalink layer specified in ISO 11898.	Ethernet specific.
Maximum length (without using repeaters).	1200 m.	1900 m; depends on type of power system.	100 m.	Not applicable (every node is automatically a repeater).	According RS232 (15...60m), or RS422/485 (1200m).		500m.	500m (10Base5), 200m (10Base2), 100m between two nodes (10BaseT, 100BaseTX).
Speed (bit rate)	9.6 / 19.2 / 93.75 / 187.5 / 500 Kbit/s (FMS), DP like FMS but also supports 45.45 Kbits and 1.5 / 3 / 6 / 12 Mbit/s; PA only supports 31.25 Kbit/s.	31.25 Kbit/s (H1); 100 Mbit/s (HSE).	Always 167 Kbit/s.	500 Kbaud/s, or 2 Mbaud/s with the new version.	Not specified; usually not higher than 38,4 Kbit/s and most often only 19,2 or 9,6 Kbit/s (lower speeds are also possible).	10 / 20 / 50 / 125 / 250 / 500 / 800 Kbit/s and 1 Mbit/s.	125 / 250 / 500 Kbit/s.	10 Mbit/s (10Base2, 10Base5, 10BaseT) or 100 Mbit/s (100BaseTX).

© 2006 R.A. Hulsebos.	Profibus	Foundation Fieldbus	AS-Interface	Interbus	Modbus-1	CAN/Open	DeviceNet	Ethernet
Stubs possible?	Yes, with limitations (up to 1.5 Mbit/s only).	Up to 200m (called "spur" in FF terminology).	Yes (because of tree topology).	Yes.	Yes.	Yes.	Yes.	Yes (only 10Base5)
Repeaters possible?	Yes, maximum 3 according to standard, but more (up to 10..20) possible in practice (supplier-dependant!).	Up to 4 (H1).	Yes, maximum 2.	Not applicable (every node is automatically a repeater).	Yes, according to RS422/485 specification.	Yes, although the CAN timing requirements are very strict and repeaters are not very commonly found.	Yes.	Yes, but nowadays usually hubs or switches are used.
Maximum length (when using repeaters).	10 km (copper), more than 90 km (fiber optic).	9.5 km.	300m.	13 km (copper).	Not known.			Not applicable.
Speed configuration	Via local switches or software configuration; DP sometimes have an autobaud feature. Not needed for PA (only has 1 speed).	Not needed for H1 (only has 1 speed). HSE uses standard Ethernet mechanisms.	Not necessary.	Not necessary.	Via local switches or software configuration.	Via local switches or software configuration.	Via local switches or software configuration.	Not possible.
Usage of switches.	Switches don't exist.	Only for HSE.	Switches don't exist	Switches don't exist.	Switches don't exist.	Switched don't exist.	Switches don't exist.	As of 2006 switches are common in almost every Ethernet; hubs are seldomly seen anymore.
Usage of hubs (multiport repeaters).	Hubs don't exist.	Only for HSE.	Hubs don't exist.	Hubs don't exist.	Hubs don't exist.	Hubs don't exist.	Hubs don't exist.	Hubs are allowed; the maximum is limited by the higher level protocols and/or the hardware capabilities of the hubs and/or the wiring used.
TCP/IP traffic possible?	No.		No.	No.	No.	No.	No.	Yes.
<b>Nodes</b>								
Maximum number of nodes without using repeaters	32 (limitation of RS485).	H1: depends on power consumption of nodes and type of power system; typically 8..16.	31 (V2.0) or 62 (V2.1). Less when analogue I/O or safety I/O is used.	512.	2 (with RS232) or 32 (RS422/485).	64.	64.	Practically no limits.
Maximum number of nodes with use of repeaters.	126 (= maximum 125 slaves + 1 master).	H1: depends on power consumption of nodes and type of power system; typically 8..16.	31 (V2.0) or 62 (V2.1). Less when analogue I/O or safety I/O is used.	512.	2 (with RS232), 250 (RS422/485).	127.	64.	Practically no limits.
Network address configuration.	Via local switches, or sometimes via the network itself (DP).	Via the network itself.	Via network itself or via configuration tool. Limited automatic reconfiguration after swapping defective nodes by an identical node.	Not necessary.	Via local switches or software.	Via local switches or software configuration.	Via local switches or software configuration.	Not necessary.
Network address configured "out of the box".	None (FMS), 126 (DP/PA) in case no local switches are available.	A set of temporary addresses is reserved for devices joining the network (H1).	0 (zero).	Not necessary.	Not necessary.	None.	1.	Every Ethernet-node has a worldwide unique 48-bit address (MAC-address).
Communication relations between nodes.	Multi-master (FMS), master/slave (DP/PA), producer/consumer (DP/V2).	producer/consumer (also called publish/subscribe), client/server.	Master/slave	Master/slave.	Master/slave.		Master-slave, multi-master, producer-consumer.	Multi-master, but higher protocol layers can limit this.
Message destination.	Point-to-point, multicast and broadcast possible.	Point-to-point, multicast and broadcasts possible.	Point-to-point (between master and slaves).	Point-to-point.	Point-to-point, broadcast.	Point-to-point, broadcast.	Point-to-point, multicast, broadcast.	Point-to-point, multicast and broadcast possible.
Broadcast implementation.	Use network address 127.		Not possible.	Not possible.	Use network address 0. Note that this is very often not implemented in a slave.	Via special CAN identifiers.		Via MAC-address FF:FF:FF:FF:FF:FF
Network management.	Via token-ring between masters; otherwise master/slave.	Via one of the link-masters becoming the LAS (Link Active Scheduler).	Master/slave	Master/slave.	Master/slave.	Master/slave; but slaves may communicate amongst each other via special CAN identifiers.	Master/slave.	CSMA/CD for 10Base5 and 10Base2, and 10BaseT with hubs. Software may determine additional management strategies (such as token-bus, master/slave, etc.).

	<b>Profibus</b>	<b>Foundation Fieldbus</b>	<b>AS-Interface</b>	<b>Interbus</b>	<b>Modbus-1</b>	<b>CAN/Open</b>	<b>DeviceNet</b>	<b>Ethernet</b>
© 2006 R.A. Hulsebos.								
Maximum number of masters.	No limitation (in practice usually no more than 1).	No limitation (in practice usually 2, often 3..4).	1.	1.	1.	1 (but the network-management master can be a different node than the application master).		No limitation.
Routing possible?	No, although it has been prepared in the lower protocol layer (FDL).		No.	In a certain way; a network may be built as a (max.) 16 level hierarchy of rings.	No.	No.	No.	Depends on the higher-layer protocols being used.
<b>Messaging</b>								
Maximum data in one message	241 bytes (FMS), 244 bytes (DP,PA) but sometimes limited to 32 (dependent on chip used).	244 bytes,	4 bits for inputs; 4 bits for outputs (V2.0); as of V2.1 only 3 bits for outputs available.	8192 bits.	250 bytes (=125 registers or 2000 single bits).	8 bytes (in a so-called "Process Data Object").	8 bytes.	1500 bytes.
Minimum data in one message	0 bytes.	0 bytes.	4 bits.	4 bits.	0 bytes.	0 bytes.	0 bytes.	46 bytes.
Overhead per message	9 bytes (SD2), plus 3 bits per byte. Also short transmit pause between messages.		24 bits minus number of inputs (max. 4) and minus number of outputs (max. 4).	48 bits, plus 5 bits per byte.		47 bits, plus a variable number of stuff bits (average ca. 5) depending on the message contents.	47 bits, plus a variable number of stuff bits (average ca. 5) depending on the message contents.	38 bytes, plus minimal 46 bytes in the data field. For small amounts of data a minimum message is thus 672 bits long.
Number of messages needed for handling 'n' remote I/O modules	2*n (for inputs and for outputs).	2*n (for inputs and for outputs).	2*n (for inputs and for outputs).	1 (all inputs and all outputs are handled simultaneously).	4*n (for inputs and for outputs, which must be handled via two separate commands). Optionally 2*n, if the combined read/write command is used (often not supported).	Minimum 2*n (for inputs and for outputs). However it is possible to work event-driven, so with stable data less messages need to be sent.	Minimum 2*n (for inputs and for outputs). However it is possible to work event-driven, so with stable data less messages need to be sent.	2*n (for inputs and for outputs).
Fault detection	Balanced transmission per bit; parity bit per byte; 8 bits checksum per message; Hamming distance 4 on first and last byte of a message.		Manchester coding per bit; parity bit per message.	Balanced transmission; 16 bit CRC per message.	Paritybit per byte (optional); 8 bit checksum per message (ASCII) or 16 bit CRC (RTU).	Balanced transmission per bit; 15 bits CRC per message; automatic error counters with bus-off after exceeding limits.	Balanced transmission per bit; 15 bits CRC per message; automatic error counters with bus-off after exceeding limits.	32 bit CRC per message.
Number of retries after a fault is detected.	Configurable 1..8.		2.	3.	Not specified; it is vendor-specific and this usually means that application program must handle the retries by itself.	Indefinite (automatically handled by the CAN controller chip).	Configurable.	None (to be handled by higher protocol layers).
<b>Remote I/O</b>								
Cycle time calculation	Calculate number of bits transmission for inputs of slave, and also for the outputs. Add overhead: twice 9 bytes, and add master and slave pause which are bit rate dependent. Add 3 bits overhead per byte. Do this for all slaves, and sum the outcome. Divide by the bit rate. This gives a theoretically best cycle time.		Per slave it takes 0,15 msec. Multiply this with (amount of slaves +2).	Calculate size of the only message, which depends on the number of nodes and the I/O per node. Divide this by the bitrate.	Modbus has no standard for it, therefore it is impossible to calculate a cycle time in advance. Basically one can cycle I/O with separate commands for read and for write of inputs and outputs, or with one command for combined reading and writing. This can either be done in ASCII or RTU, giving 4 different methods to calculate a cycle time.	CAN/Open has no standard for this, therefore it is impossible to calculate a cycle time in advance. The best case cycle time is calculated by having 2 PDO's (for inputs and outputs) per device in every cycle. To this the master-overhead (vendor dependent) should be added.		Per remote I/O node this costs 672 bits per message. Multiply this by twice the number of slaves, and divide by 10 or 100 Mbit/s. This is the theoretical best cycle time (at 100% network load). In practice software delays cause much longer (slower) cycle times.

© 2006 R.A. Hulsebos.	Profibus	Foundation Fieldbus	AS-Interface	Interbus	Modbus-1	CAN/Open	DeviceNet	Ethernet
Analogue I/O possible	Yes.	Yes.	Yes. As of V2.1 this is standard, but about 8 times as slow as digital I/O. As of V2.0 and earlier analogue I/O had to be programmed in the application, and its speed thus became very application-dependent.	Yes.	Yes.	Yes.	Yes.	Yes.
Maximum I/O per node	244 bytes for inputs and 244 bytes for outputs in any combination analogue / digital.		4 bits digital inputs and 4 bits digital outputs (V2.0); as of V2.1 only 3 bits digital outputs. Maximum 2 analogue channels per slave.	16 bytes for inputs and 16 bytes for outputs in any combination analogue / digital.	250 bytes for inputs and 250 bytes for outputs in any combination analogue / digital.	8 Bytes data per event; multiple events per node are possible depending on the vendor.		1500 bytes for inputs and 1500 bytes for outputs in any combination analogue / digital.
Configuration	FMS is not standardized; the specification for using GSD files is hardly implemented. DP is configured via GSD files and a network-configurator. PA idem, and it also has EDD files.	Via Device Description (DD) files.	Via hand-held configurator or master. Master can automatically detect defect slaves and their replacement nodes, that do not have to be configured manually.	Via "CMD" software-package.	No standard known.	Each node has an "Object Dictionary", which is usually set by the vendor. The master is often configured via configuration files for each node, but this is not strictly necessary.	Via an "Electronic Data Sheet" (EDS).	No standard known.
Diagnostics at the network level	Which nodes are present and of what type (active or passive). Counters for transmission errors, etc.		Which nodes are present, and are they configured or not.	Several bus errors, and their physical location.	Not specified (vendor specific).	Which nodes are present ("node guarding").		None (to be handled by higher protocol layers).
Diagnostics at the node level	Part standard diagnostics bits (specified by DP); remainder is supplier-specific or profile-specific.		Presence; configured; in use; periphery fault (V2.1 and higher).	Periphery error.	A diagnostic command is specified, although very often it is not implemented,			None (handled by higher protocol layers).
Vulnerabilities	Nodes with terminators that are removed or switched off; short-circuit on the bus; dual use of network-addresses; incorrect termination.	Incorrect termination; improper grounding; short-circuit on the bus (H1).	Failure of power-supply; dual use of network-addresses (especially address 0); ground fault.	Ring broken.	Nodes with terminators that are removed or switched off; short-circuit on the bus; dual use of network-addresses.	Improper termination, short circuit of bus, duplicate addressing.	Improper termination, short circuit of bus, duplicate addressing.	Failure of hub/switch (10BaseT, 100BaseT); or failure of the power-supply of that equipment.
Can I/O nodes be removed from a running network?	Yes; this is detected.	Yes; this is detected.	Yes; this is detected.	Yes; after switching off the node.	Yes; this is detected if the master regularly communicate with that node (a timeout is the result).	Yes; this is detected (if switched on for that node).	Yes; this is detected (if switched on for that node).	Yes, but detection must be done in higher protocol layers.
Can I/O nodes be connected to a running system?	Yes. If node was configured earlier, it is activated again.	Yes; this is detected.	Yes. If node was configured earlier, it is activated again.	Yes. If node was configured earlier, it is activated again.	Yes.	Yes (but there are protocolstacks that depend on the application to handle this).	Yes, if the node has been configured earlier.	Is possible when supported by higher protocol layers.
What happens when a node is connected that is not configured?	Ignored.	Its presence is reported; but the node is not used until is is configured.	Ignored, after being reported to application.	Reported to application.	Ignored.		Ignored.	Depends on higher protocol layers.
Synchronous reading of inputs possible?	Yes; but only if supported by supplier (it is an option in DP). Not possible in FMS.		No.	Yes (standard).	-		Yes.	Is possible when supported by higher protocol layers.
Synchronous activation of outputs possible?	Yes; but only if supported by supplier (it is an option in DP). Not possible in FMS.		No.	Yes (standard).	No.		Yes.	Is possible when supported by higher protocol layers.