

Digital Bus Selection-It's not your typical Quick Pick at 7-11.

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OVERVIEW

With all the digital buses available on the marketplace it is not as easy to select the right one for your application, as it is to go into your local 7-11 and buy a Quick Pick lottery ticket. The International Electrotechnical Commission (IEC) under the IEC 61158 fieldbus has made this whole selection process for your control system more difficult with the classification of bus standards standard that includes 8 varieties. While you may find it easy to pick a lottery ticket the choice for your process is not so simple and definitely not as fast. To make matters worse the term Fieldbus brought to you by the ISA/SP-50 definition now spreads to any digital bus that can support a multidrop configuration. Another major point of confusion is found in the area of discrete buses that are found in both manufacturing and process plants. These discrete buses which are mostly on / off with some modulation capability have also grown in numbers and options to further make the selection process more difficult especially if they must co-exist in a controls system. In other words like the title of this paper say's its not as easy as picking the winning lotto ticket at 7-11 (or any other store).

Getting the selection process back on track will require a good working knowledge of your process, I/O mix, control system capability, engineering resources and naturally what field devices you plan to use. Each of these topics must be addressed independently then integrated into a solution that talks the same language, which ultimately narrows the bus selection.

APPLICATIONS

Applications, which are driven by plant needs and naturally derived from what industry they serve is the first criteria in the selection process. The process industry, which is primarily modulating control, has been the big supporter of Fieldbus (any variety). The biggest industries segments are Chemical, Refining, Power, Pulp & Paper and to a lesser extent Food and Pharmaceutical. These segments are driven to digital buses by the economics of reduced wiring costs, operational benefits and predictive maintenance. Pharmaceutical has the unique requirement of validation and historical data, which keeps them in compliance with regulatory agencies. The Food industry is somewhat hampered to invest in new technologies like Fieldbus due to their seasonal production which reduces the payback on investments. Manufacturing industries are primarily discrete since they are mostly assembly oriented.

Industry segments like Semi-Conductor, Computer & Electronics, Water Treatment, Automotive and Specialty Chemicals utilize a high degree of discrete signals. Industries like Pharmaceutical cross both modulating and discrete applications since they have a packaging component and just about all of the modulating industry segments have discrete applications in some form.

Industry Positioning

<i>Process Industry Segments</i>	<i>Discrete Industry Segments</i>
Mining	Aerospace
Refining	Automotive
Power	Computers & Electronics
Pharmaceutical	Pharmaceutical
Food	Semi-Conductor
Chemical	Specialty Chemical

Industry Applications

<i>Process Industry</i>	<i>Discrete Industry</i>
Boiler and Furnace Controls	Material handling & Packaging
Batching, Blending and Mixing	Printing and Painting
Dryer Controls	Can or bottle filling
Polymer cracking	Water Treatment
Filtering and Fermentation	Quality product sorting
Paper Machine Gauging	Energy monitoring and Security

DRIVING FACTORS

The driving factors among either modulating or discrete buses are very common themes. Cost reduction due to reduced wiring in new installations and some retrofits tops the list. Wire and conduit is the same in either business segment. Both require installation engineering (design time etc.) and conduit runs plus a contractor to install. The more wire the higher the cost and naturally with digital buses that support multi-drop devices wire runs are reduced drastically if devices are in reasonable proximity to one another and the risk of combining critical sensors / transmitters is acceptable on the same pair of wires. Next comes the benefit of diagnostics from the Sensor / Transmitter / Positioner in terms of finding out what the health of the device is and what is failing (electronics, sensor, mechanical linkage, responsiveness or connection to process). This allows Operations to make an informed decision as to how and if they continue to operate with the known error and by recoding the history of failure for each device they can predict maintenance intervals as opposed to being in the response mode. The diagnosis also helps Operations decipher if the problem is process or instrument related. Then in the case of device standards among vendors like Foundation Fieldbus it leads to Interoperability (mix-n-match) when it comes to replacements. This provides lots of options and reduces the dependency on one vendor. A few other benefits include multi-measurements, remote configuration and control actions at the device without depending on the host control system.

User Benefits Ranked by Industry

<i>Process Industries</i>	<i>Discrete Industries</i>
Reduced wiring and installation costs due to multi-drop	Reduced wiring and installation costs due to multi-drop
Interoperability (mix-n-match)	Fast throughput
Multi-Measurements	Flexibility and ease of expansion
Optional control in the field	Good diagnostics and good vendor support
Remote diagnostics	Simple to use and Openness

PROCESS BUSES

The digital buses that support modulating sensors seem to have the most options and the most contention among them. With the re-activation of ISA's SP-50 committee in 1984 to define a standard digital protocol, the evolution of the Fieldbus Foundation in 1994 by vendors, the movement of Profibus-PA support to the PTO (Profibus Trade Organization), the continuation of WorldFIP after death and the niche market for LonWorks plus the continued support of HART by almost every major vendor. There seems to be no clear winner or at least a default candidate. To complicate matters worse there is very strong support to move everything to Ethernet. The choice a user needs to make in this process market with primarily modulating transmitters is a tough one to place your bet on. With all the choices it is truly application dependant for the selection.

Competing Process Buses

<i>Protocol</i>	<i>Source</i>
F.I.P.	WorldFIP Association
Foundation Fieldbus	Fieldbus Foundation
HART	HFC (Hart Communication Foundation)
LonWorks	LonMark Interoperability Association
Profibus-PA	PTO (Profibus Trade Association)
SP-50	ISA

There are differences between each bus that are up for consideration. While they are all two wire and most conform to the basics when it comes to the Data Link and Application Layers as defined by the IEC (International Electrotechnical Commission) there are differences in their attributes that a user must review before selecting and these differences are not just relegated to the bus itself but to the control system that must support it. The control system is really the first to be selected since it is capital intense and must support an I/O structure that will read and write to the bus or buses selected for the process. Further the configuration of a "Smart" device on a digital bus needs software that is either on an independent platform like National Instruments NI-FBUS configurator or one integral to the control systems which has been supplied by the control system vendor typically in a Windows environment.

While HART maybe referred to behind closed doors as the "Poor Man's Fieldbus" it has grown up to take its place among the big guys due to its shear momentum. Worldwide HART is now supplied on

60% of the transmitters shipped by all suppliers and some only make their transmitters in HART. Users may only use it for configuration of “Smart” transmitters but some have gone further and strip the digital signal for the secondary measurement values that can be used by the control system while some use it to feed maintenance management software packages that look at predictive versus reactive actions based on historical information and sensor / positioner performance (asset maintenance). In some cases users have used rack-mounted splitters that take the HART signal off the analog, which goes to the control system I/O. Others have HART I/O modules built into the control system that send the analog signal to the controller and the HART signal to the maintenance database that is part of the control system architecture. In any case HART still has Heart and will continue to live on as a good alternative solution while the full digital buses gain a larger share of the installed base.

IEC 61784 Bus Standards

	Bus Name	Bus Source
Type 1	Foundation Fieldbus (H-1)	Fieldbus Foundation
Type 2	ControlNet	ControlNet International
Type 3	Profibus DP, PA and FMS	PTO
Type 4	P-Net	
Type 5	HSE (high speed Ethernet) H-2	Fieldbus Foundation
Type 6	SwiftNet	Designed for Boeing
Type 7	WorldFip	WorldFip Association
Type 8	Interbus-S	Interbus Club

The differences in the buses, which we can generically classify as Fieldbuses in the process industry are in the speed of throughput, control algorithms at the device level and in the higher layers of the protocol stack in the vendor specific software blocks that allow for advanced diagnostics. The use of control in the field is the biggest advantage that Foundation Fieldbus brings to the party. While it has not been implemented to any great degree on installed Foundation Fieldbus systems due to the fact that control can be executed within 95% of a loops required response time it is becoming a line item in most RFQ's. This is the one area that Profibus-PA and Foundation Fieldbus (H-1) differ most.

Process Bus Attributes

Bus	Speed	Distance	Protocol	Peer-Peer	# Devices	Control
FIP	2.5 Mbs	2000 M	Deterministic	Master/Slave	32	No
Foundation Fieldbus	31.25 Kbs	1900 M	Deterministic	Yes	32	Yes
HART	1.2 Kbs	3000 M	FSK	Master/Slave	15	Yes
LonWorks	1.25 Mbs	2000 M	CSMA/CD	Yes		No
Profibus-PA	12 Mbs	1200 M	Deterministic	Master/Slave	32	No
SP-50	31.25 Mbs	1900 M	Deterministic	Yes	32	Yes

ETHERNET

Coming on like a freight train are the digital buses for the plant floor based on Ethernet. While Ethernet has been used primarily as the basis for the control and information bus of choice with its many flavors of protocol the industry direction now is to move it to the plant floor. Ethernet is based on work by the University of Hawaii on the Aloha Protocol to solve radio communication problems in the islands later completed as a bus for computer to computer business applications by Xerox and commercialized for engineering and plant control in the DCS environment by DEC (Digital Equipment Corporation) and Intel. Remember, Ethernet is only the physical and data layers of the bus and needs a software protocol to move information. Today in addition to all the varieties of protocols in the business, enterprise and information technology areas there is a rapid emergence of flavors for factory floor devices. The most visible flavor comes from Foundation Fieldbus where in 1998 they selected it as the basis for the H-2 network called High Speed Ethernet (HSE). They mapped all the Layer 2 technologies from the H-1 standard into TCP/IP. This solution for a high-end, wide band bus is aimed at the process industries for modulation control. HSE can glue together H-1 segments and provide a good way to tie in those process analyzers that have so much information to move to the control system.

Ethernet based buses

<i>Name / Protocol</i>	<i>Description</i>	<i>Source</i>
EtherNet/IP	CIP (DeviceNet & ControlNet)	Rockwell Automation
Foundation Fieldbus (HSE)	High speed Ethernet (H2) /TCP	Fieldbus Foundation
Interbus on Ethernet		Interbus Club
Interface for Distributed Automation (IDA)	Based on HTTP and XML	IAONA and ODAA
Modbus/TCP	Modbus over TCP/IP	Group Schneider
ProfiNet	Profibus & DCOM over TCP/IP	PTO

Ethernet based buses also appear in another category but are not to be confused with plant floor applications. Commonly referred to as LAN's these are the buses that have grown up in the business, enterprise or process control areas. Naturally Ethernet is a big player since it was initially designed for this purpose and promoted extensively by DEC (Digital Equipment Corporation) in the early 80's with DecNet protocol. Later other suppliers found it to be a good basis for communication between control systems and remote I/O subsystems. The PLC manufacturers added it to handle the data between PLC's and workstations. Other contenders to Ethernet have evolved over the past 10 years to include another oldie but goodie, Modbus, which is still, considered a de facto industry standard. The table below lists some of the common buses in this higher-level communication category that are typically at a level above the plant floor applications.

LAN's & PLC buses

<i>Protocol</i>	<i>Source</i>
ConrolNet	Rockwell Automation
Profibus FMS	PTO
Data Highway	Rockwell Automation
Modbus	Group Schneider (Modicon)
Modbus Plus	Group Schneider (Modicon)

FDDI	
BACnet	HVAC industry standard

DISCRETE BUSES

The final group of digital buses are focused in the discrete manufacturing area and are typically on / off, simple switches or low-level sensors. They are easy to multi-drop but require high bandwidths due to the high-speed applications such as packaging, filling, assembly, machining, painting or sorting. Most of these buses were initiated by one of the PLC manufacturers who focus on this industry. The following buses represent some but not all of the many application specific buses found in the discrete manufacturing industry.

Competing Discrete Buses

<i>Protocol</i>	<i>Source</i>
AS-I bus	AS-Interface Association
DeviceNet	ODVA (Open DeviceNet Vendor Association)
Interbus-S	Interbus Club
Profibus DP	PTO (Profibus Trade Organization)
SERCOS	SERCOS Trade Association
Seriplex	STO (Seriplex Technology Organization)
SDS	Honeywell

SUMMARY & RECCOMENDATIONS

It's not easy to pick the right bus. Maybe not as easy as picking the lottery at your local 7-11 but certainly comes with a greater degree of risk if you care about your control system or more importantly your career. The first cut is a broad one in that the industry funnels your decision process into one camp or the other (process or discrete manufacturing) then the process gets interesting since a great deal of emphasis must be placed on the type of control system. Is it a PLC, DCS or Workstation based system? Is there a mix of modulating and discrete sensors (if so what is the ratio)? Can you group discrete or modulating devices together by process area or segments? What level of support does the plant have (skill level of maintenance and operations)? What buses are on the OEM equipment? How easy is it to configure the network? Are there many sources of sensors for the bus or are you relegated to a few select vendors? Can the control system support more than one bus protocol? Can you conduct remote diagnostics? Can you benefit from multiple measurements from a transmitter?

Some other issues to think about are who owns the "smart" field devices on a digital bus. Since we are not talking about simple analog devices anymore the complexity has gone up dramatically. Who takes responsibility? Are the devices now transferred to engineering since some may now become part of the control strategy if they have a PID loop incorporated or a fail safe action that can trigger a sequence of events upon failure. Maybe the grouping of transmitters on a bus segment needs to be reviewed in terms of the risk associated with that operation unit. In some cases engineering is doing the design and giving the configuration parameters to maintenance to implement. When it comes to bus diagnostics this can be conducted by communication savvy techs and operations usually lets engineering and maintenance divvy up the tasks. In any case each user needs to look at their personnel and decide how they will implement and support this new architecture.

The list goes on and is so applications dependent that there is no simple roadmap to follow until you clearly identify the needs and directions of the plant. Stick with major vendors especially in these early years of digital bus implementation. Stick with those buses that have a large following of sensor / transmitter suppliers in order to enjoy the benefits competition will bring in advances. A competitive supplier base will help stop any abrupt changes in the technology that would obsolete your investment before it meets the project payback timetable (let alone a useful life). Good luck and if all else fails save up for the next mega lottery and pool your resources with your friends then maybe just maybe you can avoid the bus decision process and live a good life.

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