CONTROL BUSES

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ATE System Design (Automated Test Eq)

- Common instrument considerations
  - Measurement functionality
  - Instrument performance
- Evaluate bus technologies of the instruments available
  - Meets performance needs
  - Suitable for application
- Various bus technologies are available
  - GPIB,LAN,USB , PCI,PXI ,And so on

Overview

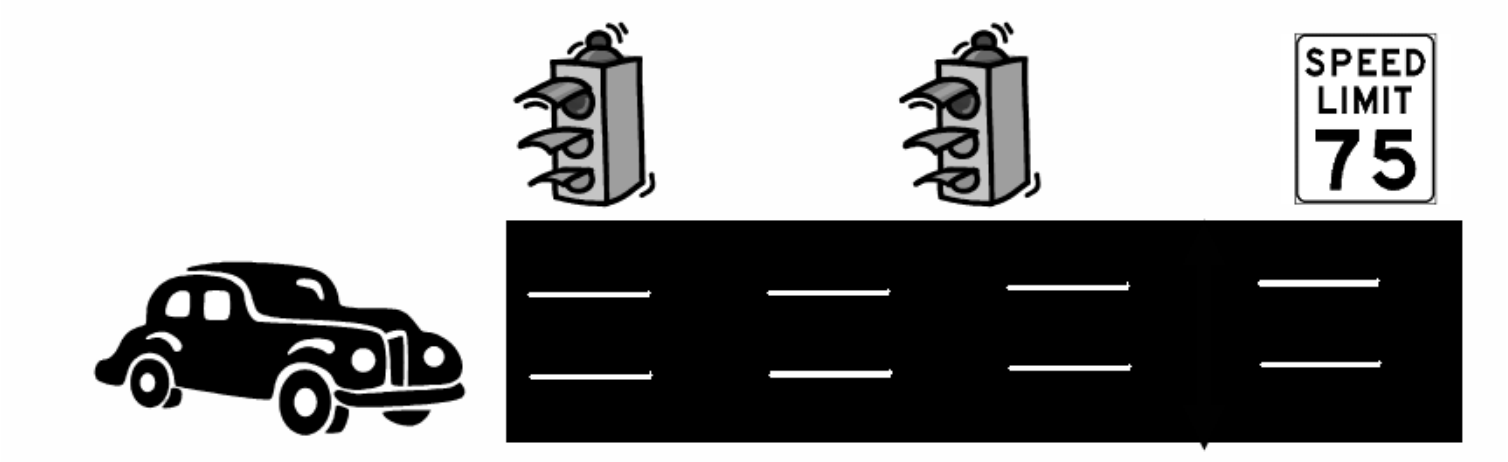
- In 1997 Hewlett-Packard (now Keysight) strongly claimed that IEEE 1394 (Firewire) was ideally situated to be the new leading bus technology in instrument control.
- HP advocated abandoning the then-leading technology, GPIB, in light of IEEE 1394 potential
- While other bus technologies have certainly proved more successful than IEEE 1394 in fulfilling a broad range of application needs, even GPIB, the most adopted instrument control standard in the past 40 years, cannot claim to be categorically superior to all other buses.

Bus Technology Considerations

- Key bus factors that affect instrument performance
  - Latency
  - Bandwidth
- Other considerations
  - Timing and synchronization
  - Distributed networks and remote monitoring (Some systems require either remote control of systems or distributed networks)
  - Standard software frameworks (does the bus specification implement a software framework?)

Latency and Bandwidth

- Latency measures the delay of transmission of data across a bus. The latency measures the delay of transmission of data, so you can think of it as corresponding to the number of stoplights in the road
- Bandwidth measures the rate at which data is sent across the bus (typically MBytes/s) (width of the road and speed of travel)



Impact on Application

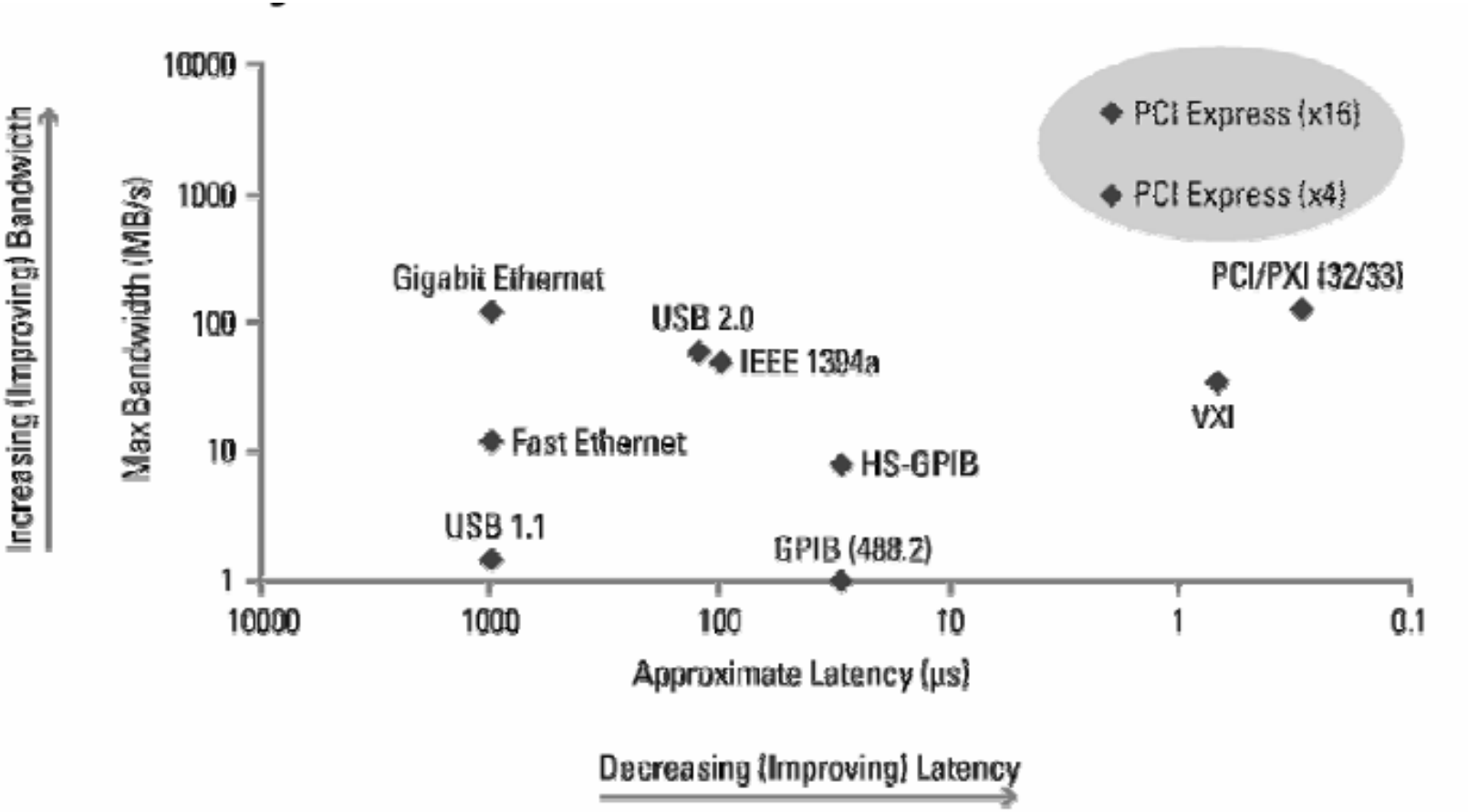
Latency

- Important for applications that include
- Digital multimeter (DMM) measurements
- Switching
- Instrument configuration
- Serial buses tend to have higher or worse latency

Bandwidth

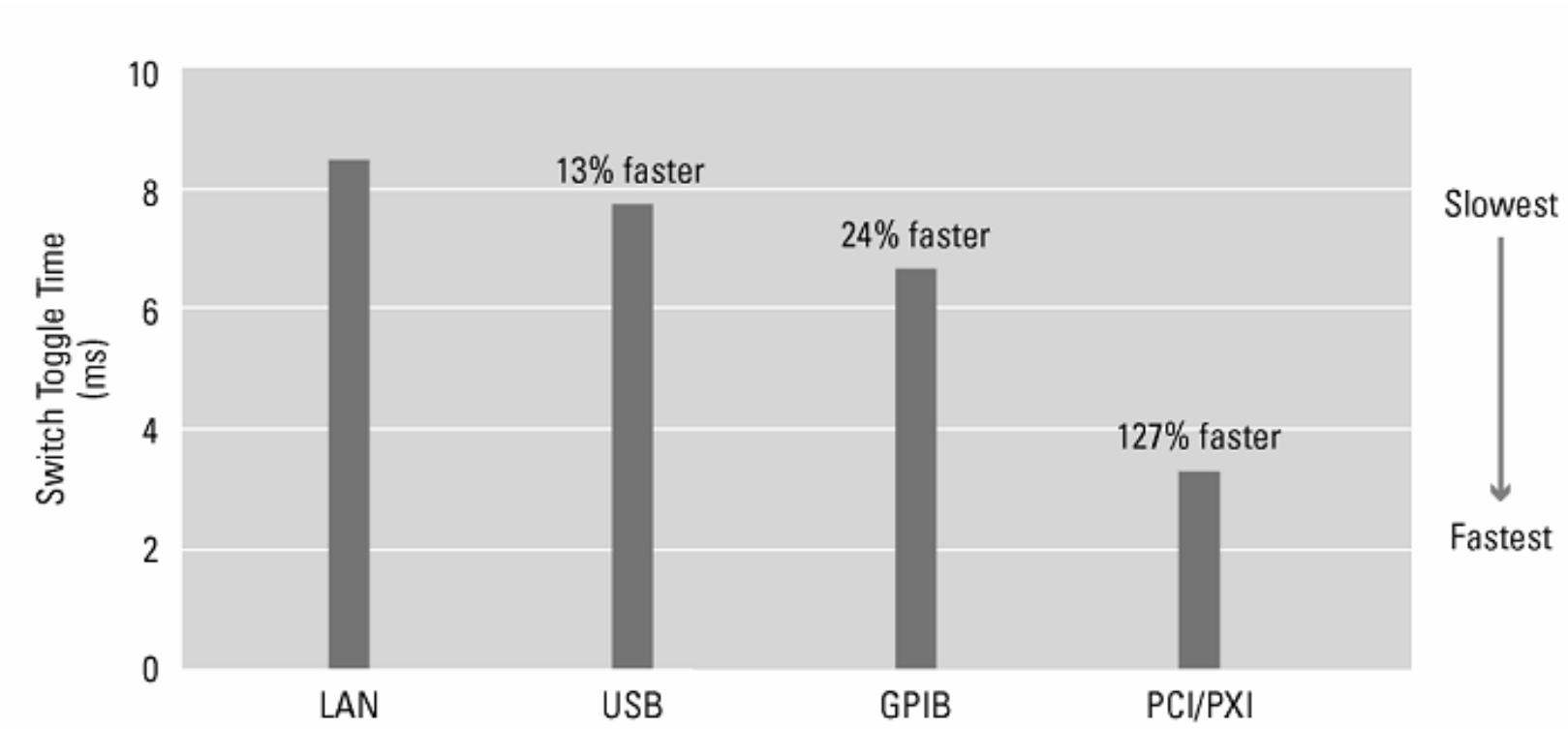
- Important for applications that send large sets of data
  or require data streaming
  - RF applications
  - Waveform acquisition or generation
- High-speed or high-channel
  systems often require 10 to
  100 MBytes/s or more

Industry Bus Performance



Single Command Performance

Latency in an application



Timing and Synchronization

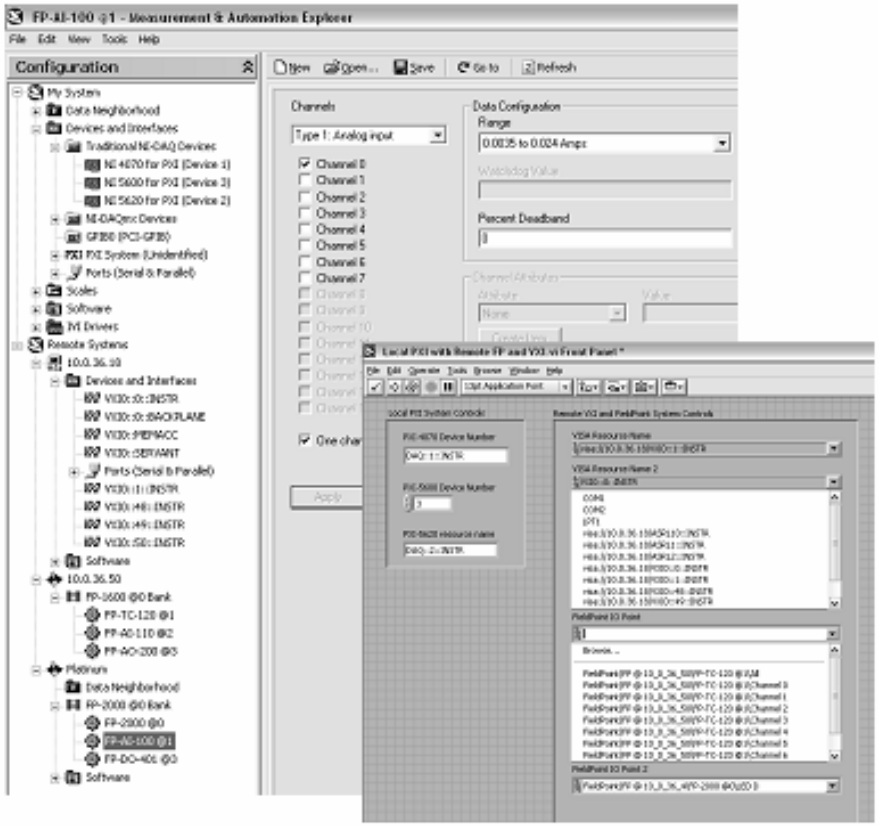
- Used for handling synchronous events.
  For example, Starting signal generator and digitizer at same time
- Used for performing asynchronous events.
  For example, Handshaking with switch and DMM
- Backplane buses provide most direct and accurate method of synchronization (PXI and VXI)
- IEEE 1588 protocol provides external synchronization (LAN)
- Input and output triggers available for GPIB, USB, and 1394

Distributed Networks or Remote Monitoring

Design Considerations

- Locality: Requirements to place certain measurement components close to other components. Timing and synchronization. (RF application)
- Distribution: Needs including physical requirements, remote locations, and connectivity. Distance support with and without repeaters. Programming connectivity protocols (software)

Software is Key



With proper software tools you can:

- Abstract system complexity
- Use instruments of various buses
- Integrate instruments into one system

Software Standard Frameworks

- Impacts development and integration of the system:
  - Ease system integration tasks
  - Driver software eases programming
    - VISA
    - Plug and Play drivers
- PXI and VXI specify a standard driver framework
- Virtual Instrumentation Software Architecture (VISA) available for PXI,VXI, LAN, GPIB, USB, and 1394

Bus Comparison

	GPIB	VXI	1394a	USB	TCP/IP Ethernet	Standard PCs	PXI
Latency (us)	◒	●	○	○	○	●	●
Bandwidth (Mbytes/s)	○	◒	○	○	◒	●	●
Timing and Synchronization	○	●	○	○	◒	○	●
Standard Software Frameworks	◒	●	◒	◒	◒	○	●
Measurement Availability	●	◒	○	○	○	◒	◒
High Channel Count	○	◒	○	○	◒	●	●
Data Streaming	◒	●	○	○	○	●	●
Distributed and Remote Systems	○	◒ / ●[1]	○	○	●	◒ / ●[1]	◒ / ●[1]

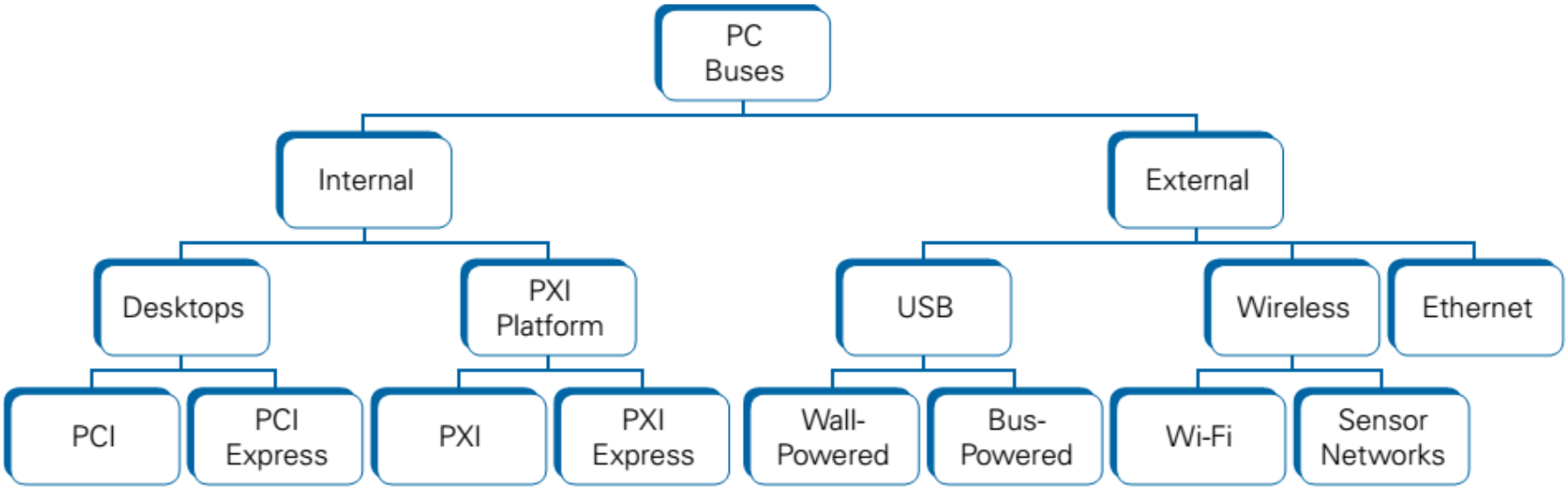
● Best
◒ Better
○ Good

[1] Achieved with Ethernet connection to controller

bus-selection guide based on application requirements

Bus	Waveform[1] Streaming	Single-Point I/O	Multidevice	Portability	Distributed Measurements
PCI	132 MB/s (shared)	Best	Better	Good	Good
PCI Express	250 MB/s (per lane)	Best	Better	Good	Good
PXI	132 MB/s (shared)	Best	Best	Better	Better
PXI Express	250 MB/s (per lane)	Best	Best	Better	Better
USB	60 MB/s	Better	Good	Best	Better
Ethernet	125 MB/s (shared)	Good	Good	Best	Best
Wireless	6.75 MB/s (per 802.11g channel)	Good	Good	Best	Best

You can choose from many buses to meet your DAQ requirements



PCI

- The Peripheral Component Interconnect (PCI) bus is one of the most commonly used internal computer buses today.
- With a shared bandwidth of 132 MB/s, PCI offers high-speed data streaming and deterministic data transfer for single-point control applications.
- There are many different DAQ hardware options for PCI, with multifunction I/O boards up to 10 MS/s and up to 18-bit resolution.

PCI Express

- PCI Express, an evolution of PCI, offers a new level of innovation in the PC industry.
- The single biggest benefi of PCI Express architecture is
- the dedicated bus bandwidth provided by independent data transfer lines.
- Unlike PCI, in which 132 MB/s of bandwidth is shared among all
- devices, PCI Express uses independent data lanes that are each
- capable of data transfer up to 250 MB/s
- 6 data lanes for a maximum throughput of 4 GB/s

USB

- The Universal Serial Bus (USB) was originally designed to connect peripheral devices, such as keyboards and mice, with PCs
- It is useful for many other applications, including measurement and automation.
- inexpensive and easy-to-use connection between DAQ devices and PCs.
- SB devices are inherently latent and nondeterministic. This means that single-point data transfers may not happen exactly when expected, and therefore USB is not recommend for closed-loop control applications, such as PID.

GPIB/IEEE 488 Bus

- The GPIB or General Purpose Interface Bus or IEEE 488 bus is still one of the more popular and versatile interface standards available today.
- GPIB is widely used for enabling electronics test equipment to be controlled remotely
- The standard has defined in 1978 by HP
- The GPIB or IEEE 488 bus is a very flexible system, allowing data to flow between any of the instruments on the bus, at a speed suitable for the slowest active instrument, max length 20m
- here must also be no more than 2 m between two adjacent instruments on the bus.

GPIB/**IEEE 488 Bus**

Within IEEE 488, the equipment on the bus falls into three categories, although items can fulfil more than one function:

Controller: As the name suggests, the controller is the entity that controls the operation of the bus. It is usually a computer and it signals that instruments are to perform the various functions. The GPIB controller also ensures that no conflicts occur on the bus. If two talkers tried to talk at the same time then data would become corrupted and the operation of the whole system would be seriously impaired. It is possible for multiple controllers to share the same bus; but only one can act as a controller at any particular time.

Listener: A listener is an entity connected to the bus that accepts instructions from the bus. An example of a listener is an item such as a printer that only accepts data from the bus

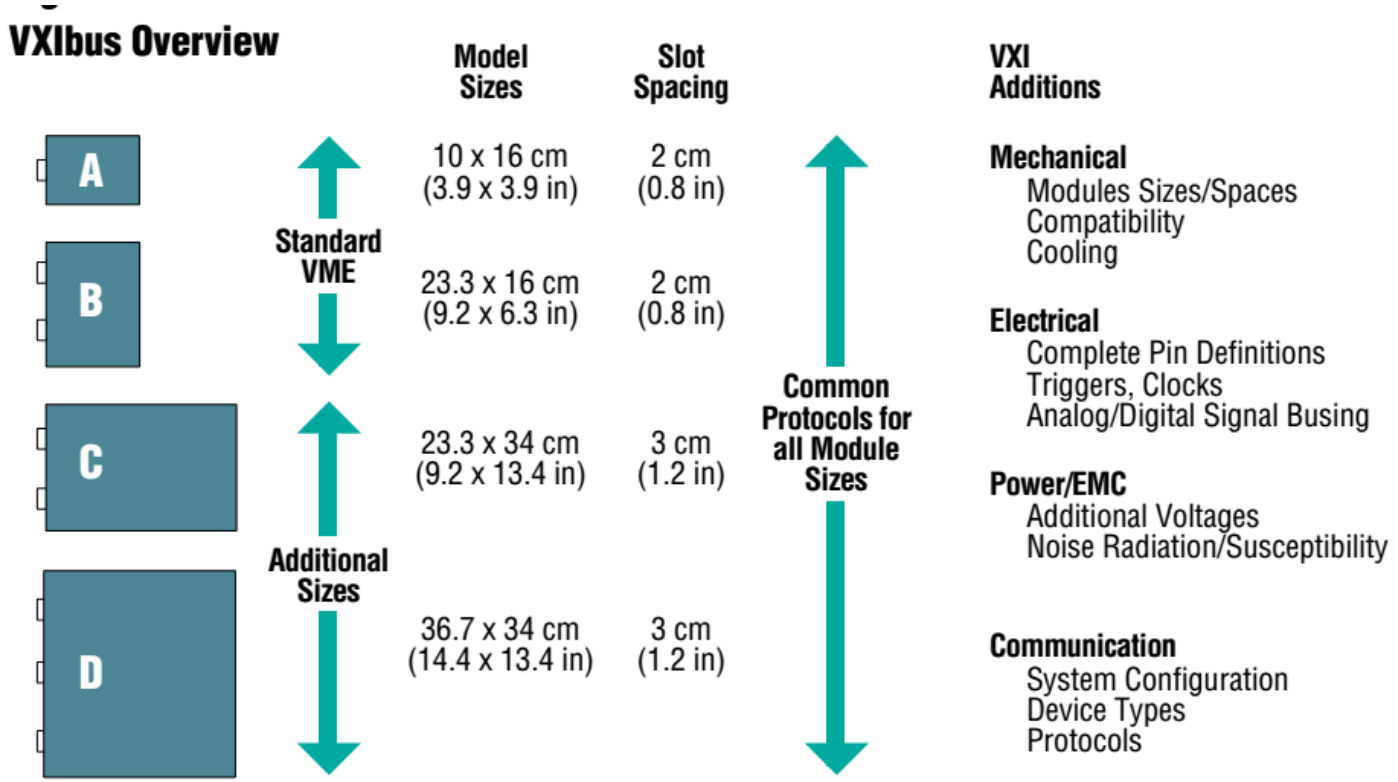
Talker: This is an entity on the bus that issues instructions / data onto the bus.

VXI

- VXIbus is an exciting, fast-growing platform for instrumentation systems.
- VXI standard was designed as an open specification to take advantage of the latest computer technologies to decrease test costs, increase throughput, and reduce development time
- Open, multivendor standards maximize flexibility and minimize obsolescence
- Smaller size and higher density reduce floor space, enhance mobility or portability, and give close proximity to device(s) under test or control
- More precise timing and synchronization improve measurement capability
- In essence, VXI combines the best technology from GPIB instruments, modular plug-in DAQ boards, and modern computers.

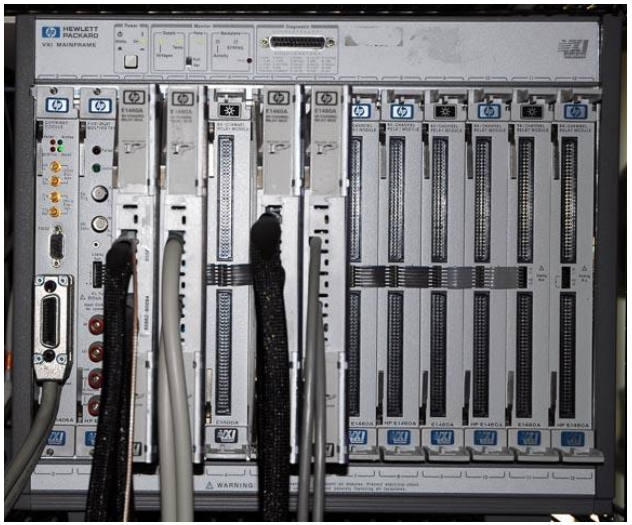
VXI

- VXI instruments have the ability to communicate at very high speeds
- Competitive pressures demand faster time to market, lower unit costs, and an increasing emphasis on quality



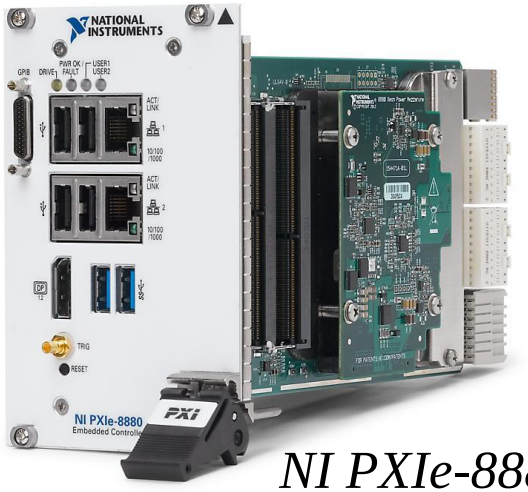
VXI

- Today, you can use VXI to build a variety of test systems, from portable testers for field use and remote data acquisition applications to high performance data acquisition and functional test systems.



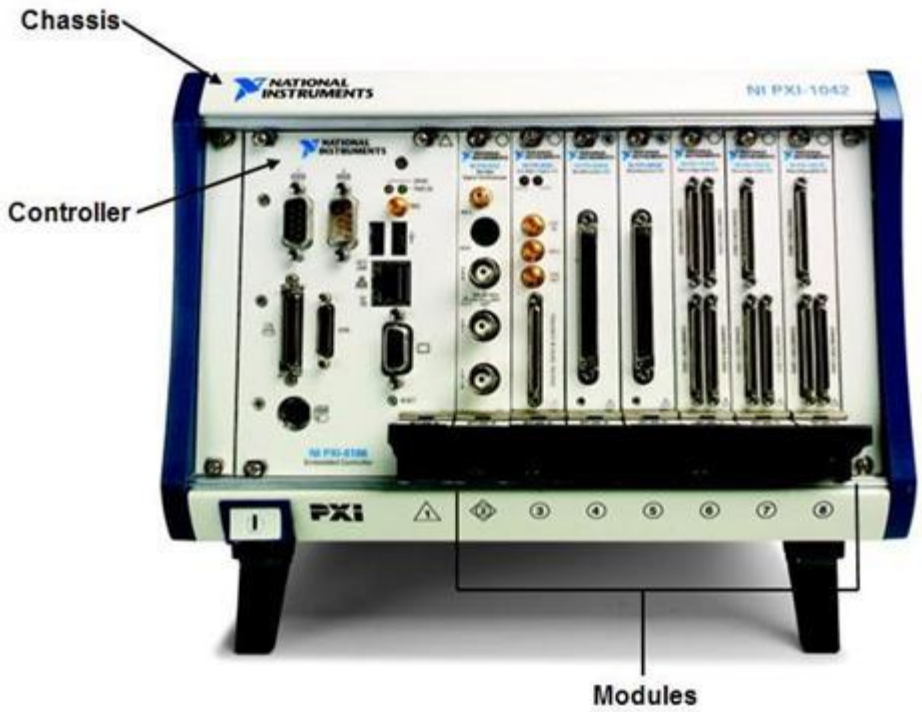
PXI Platform

- PCI eXtensions for Instrumentation (PXI) were developed to bridge the gap between desktop PC systems and high-end VXI and GPIB systems
- Open standard
- Rugged packing
- Modular architecture (hot swap, plug&play)
- integrated timing and triggering features



NI PXIe-8880 controller
XEON 8 Core, 24 GB/s

2.170.000 HUF



Ethernet

- Ethernet is the backbone of almost every corporate network in the world and, therefore, is widely available
- As a bus for DAQ, Ethernet is ideal for taking portable or distributed measurements at distances beyond the 5 m length of a USB cable (extend 100 m before needing a hub)
- Ethernet an ideal choice for distributing measurements to remote locations
- 100BASE-T (100 Mbit/s) Ethernet can accommodate multiple Ethernet DAQ devices running at full speed

Wireless

- Wireless technology extends the flxibility and portability of PC-based data acquisition to measurement applications where cables are inconvenient or impractical, such as wind farms or civil structures.
- wireless also has the highest latency of any other DAQ bus, so applications requiring high-speed control or determinism are not recommended
- The most popular is IEEE 802.11 (Wi-Fi)
- Connecting to a Wi-Fi “hotspot” is as familiar to most as plugging in a USB cable
- Secure

- B