PCaPAC 2002

Distributed Control Systems

Vance Carter

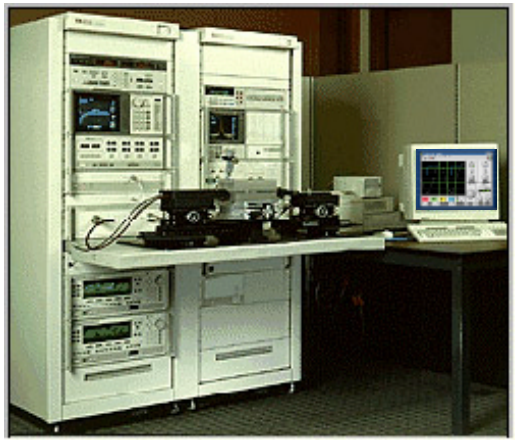
Academic Program Manager, Europe

ni.com

NATIONAL INSTRUMENTS

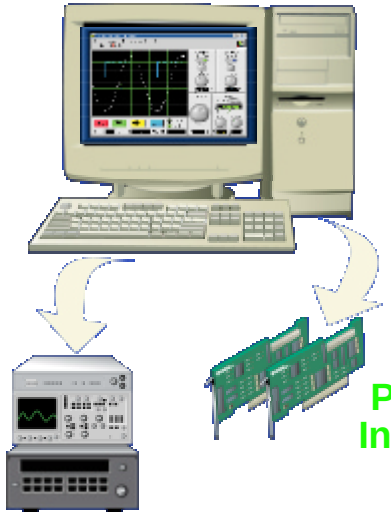
In the Beginning…

Control Traditional Instruments



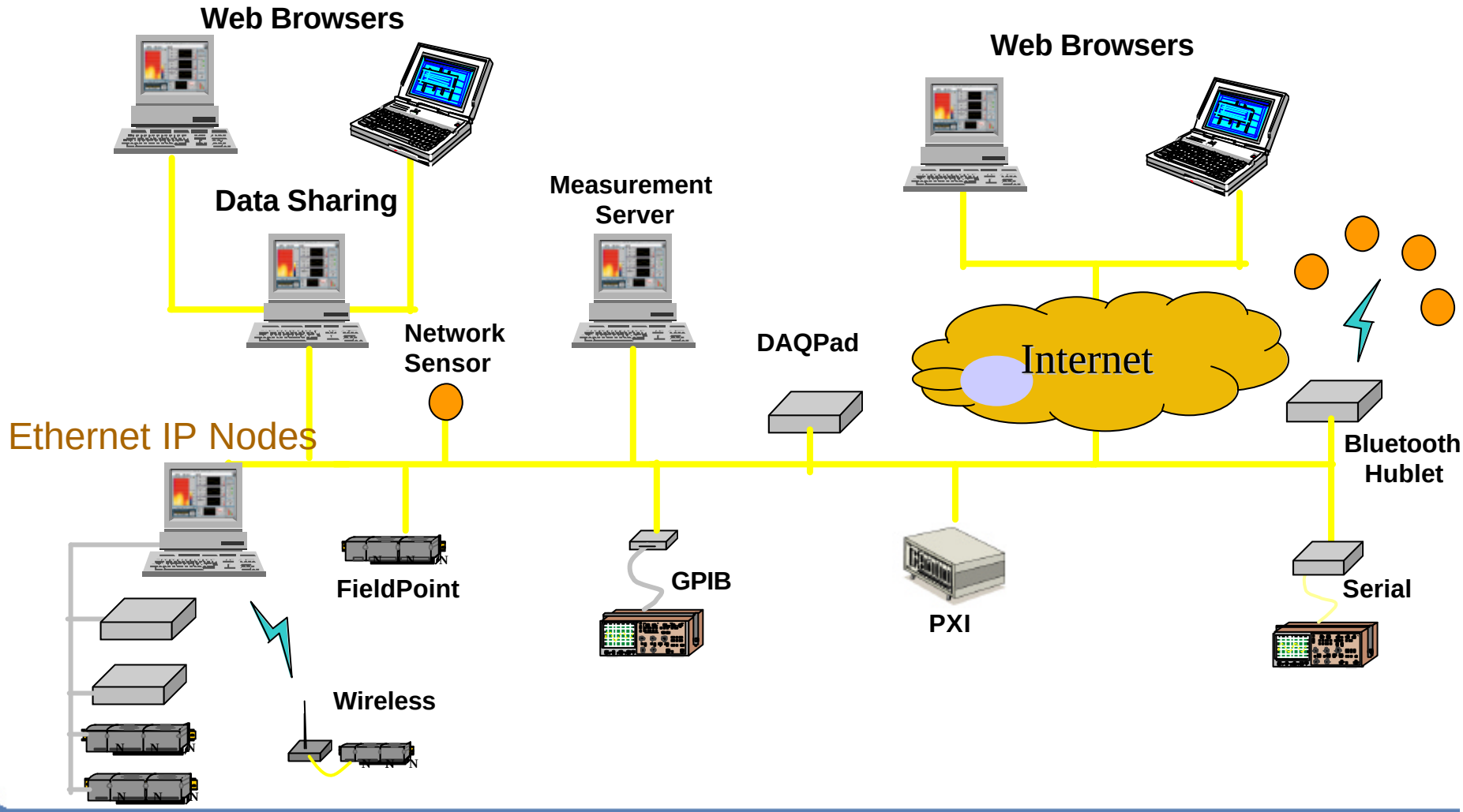
+

Simple PC-based Measurements

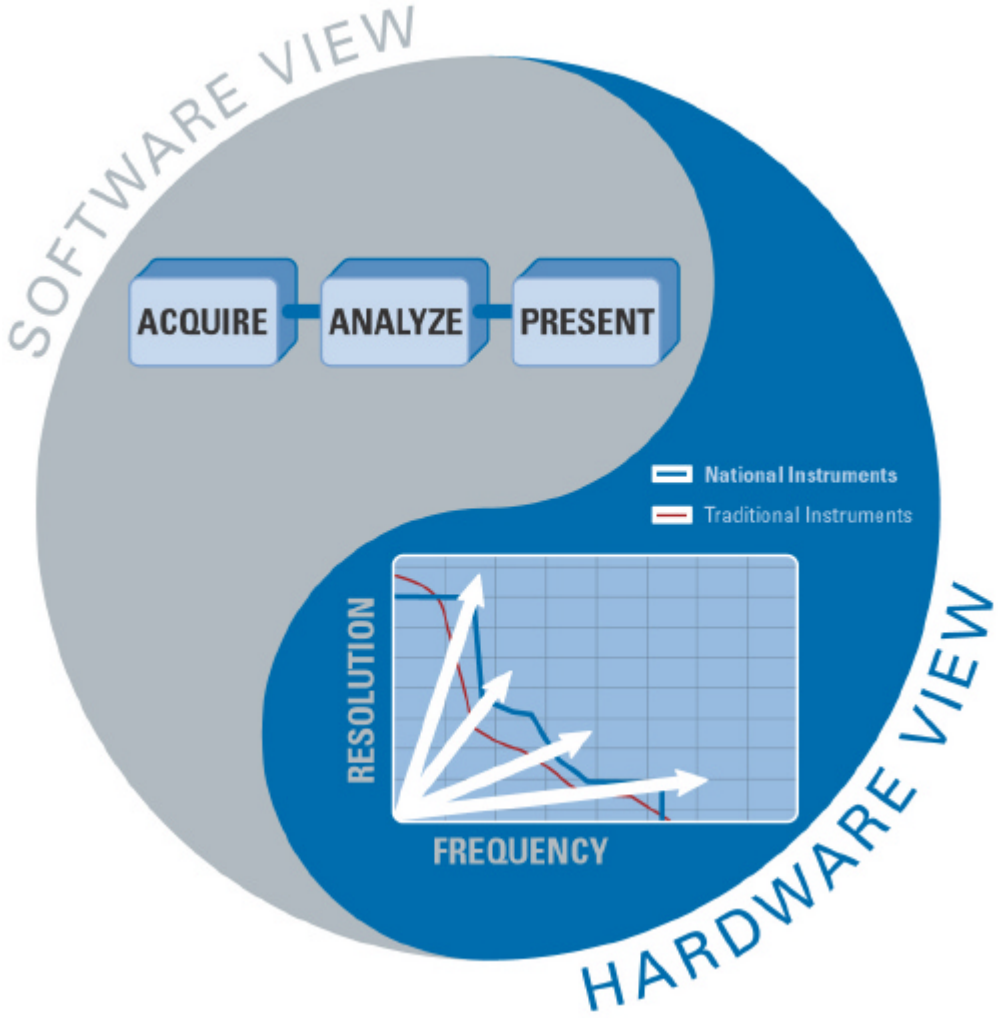


PC Plug-in Instruments

Networked Measurement and Automation



Virtual Instrumentation

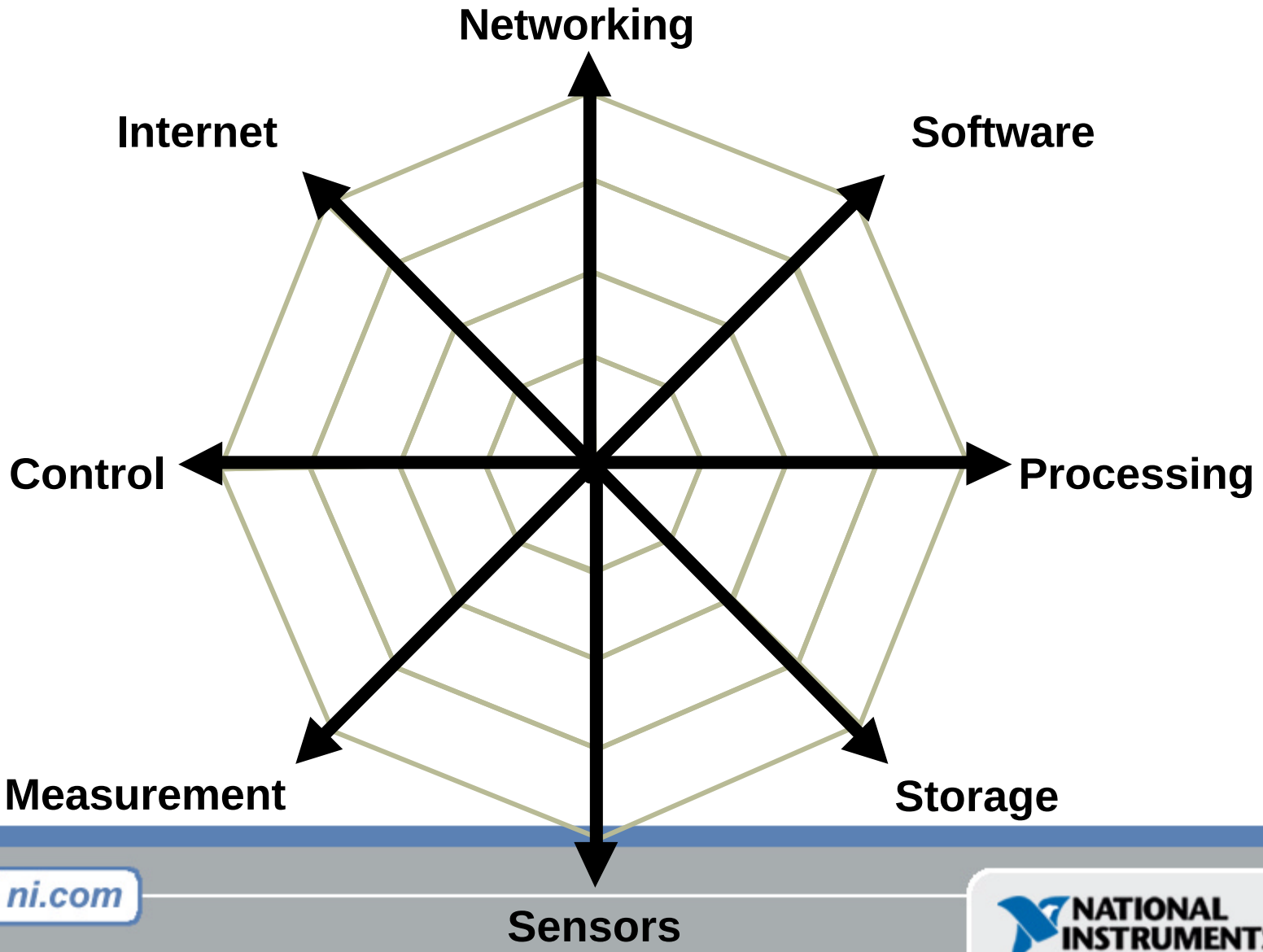


A Mandate for Virtual Instrumentation

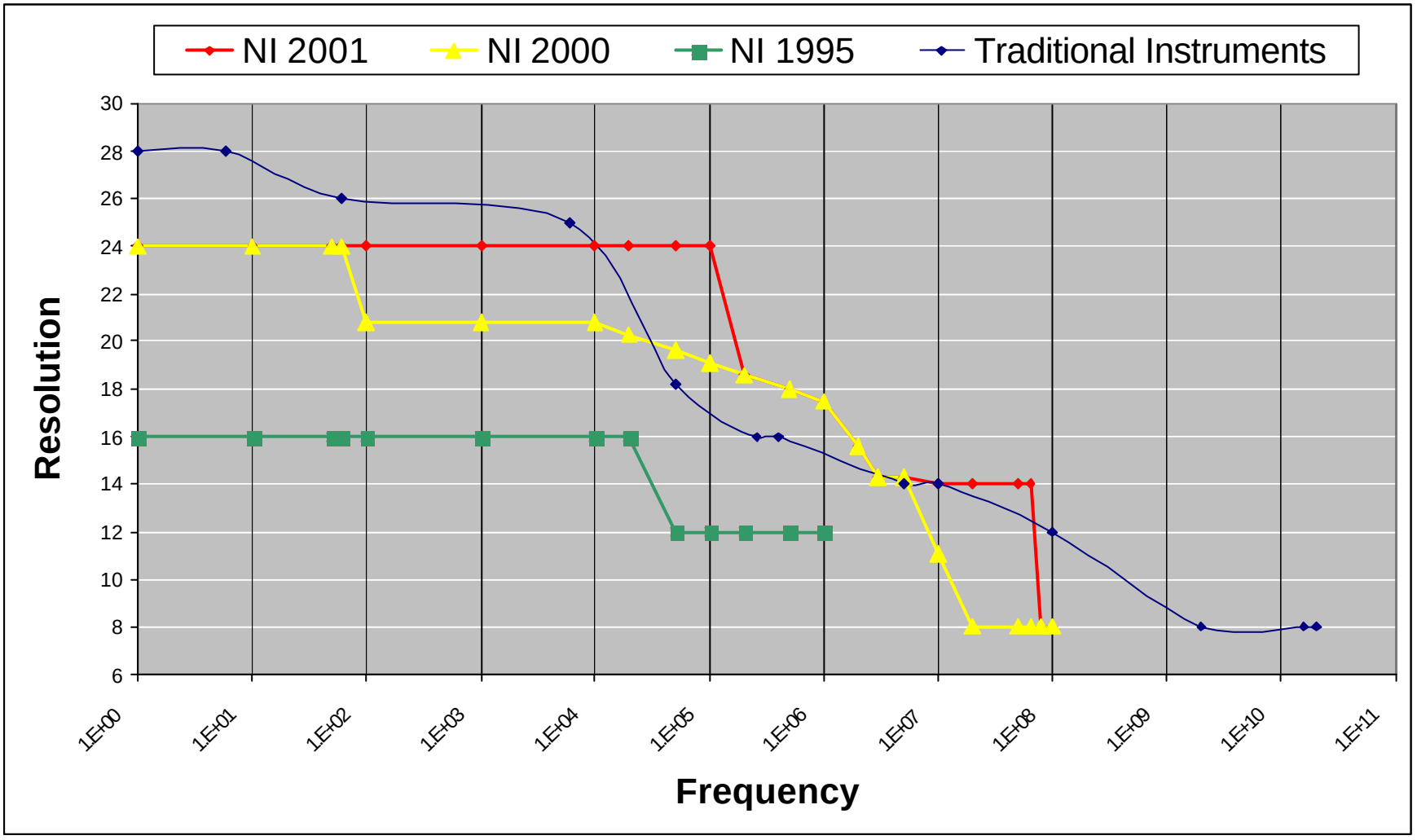
- *Integration is not a one time event*
- *The COTS marketplace drives continuous system upgrades*
- *Systems must be engineered to accommodate marketplace initiatives*

Source: Software Engineering Institute, Carnegie Mellon University

Vectors of Commercial Technology

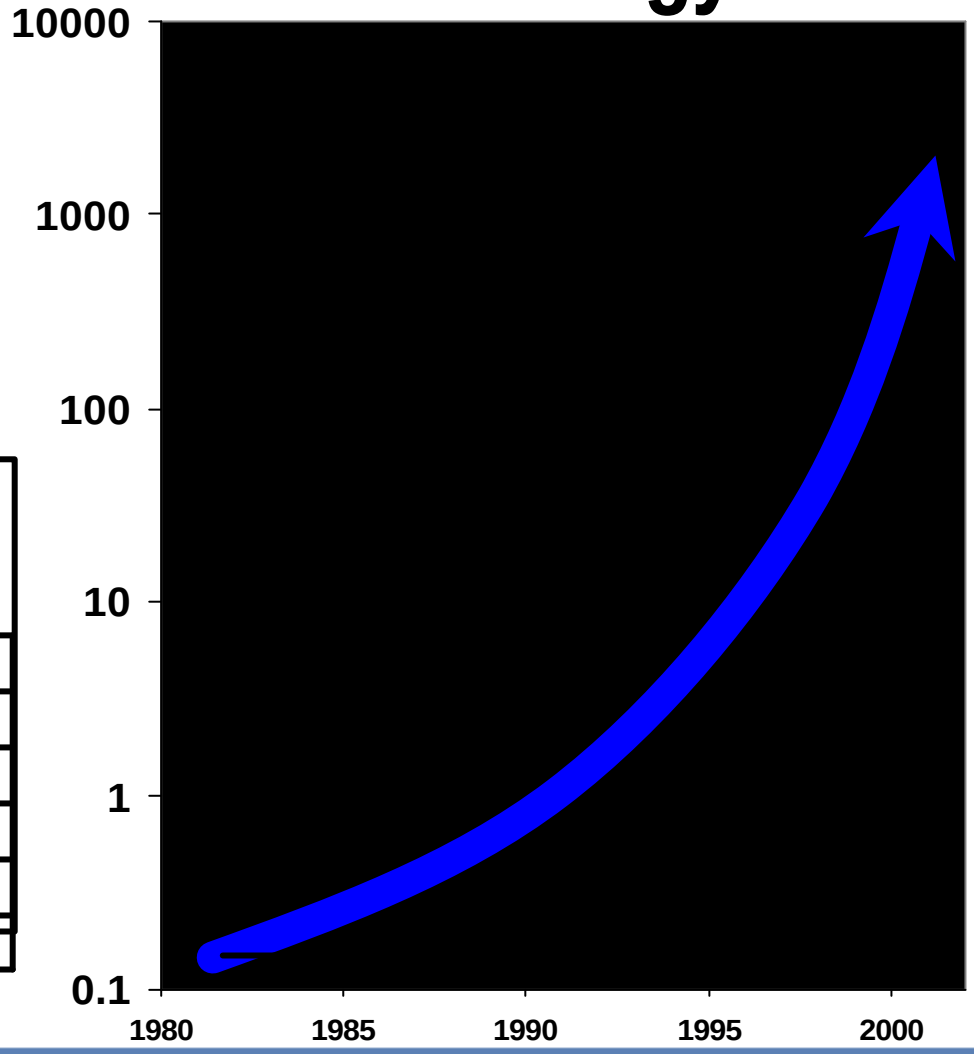


Virtual Instrumentation Hardware



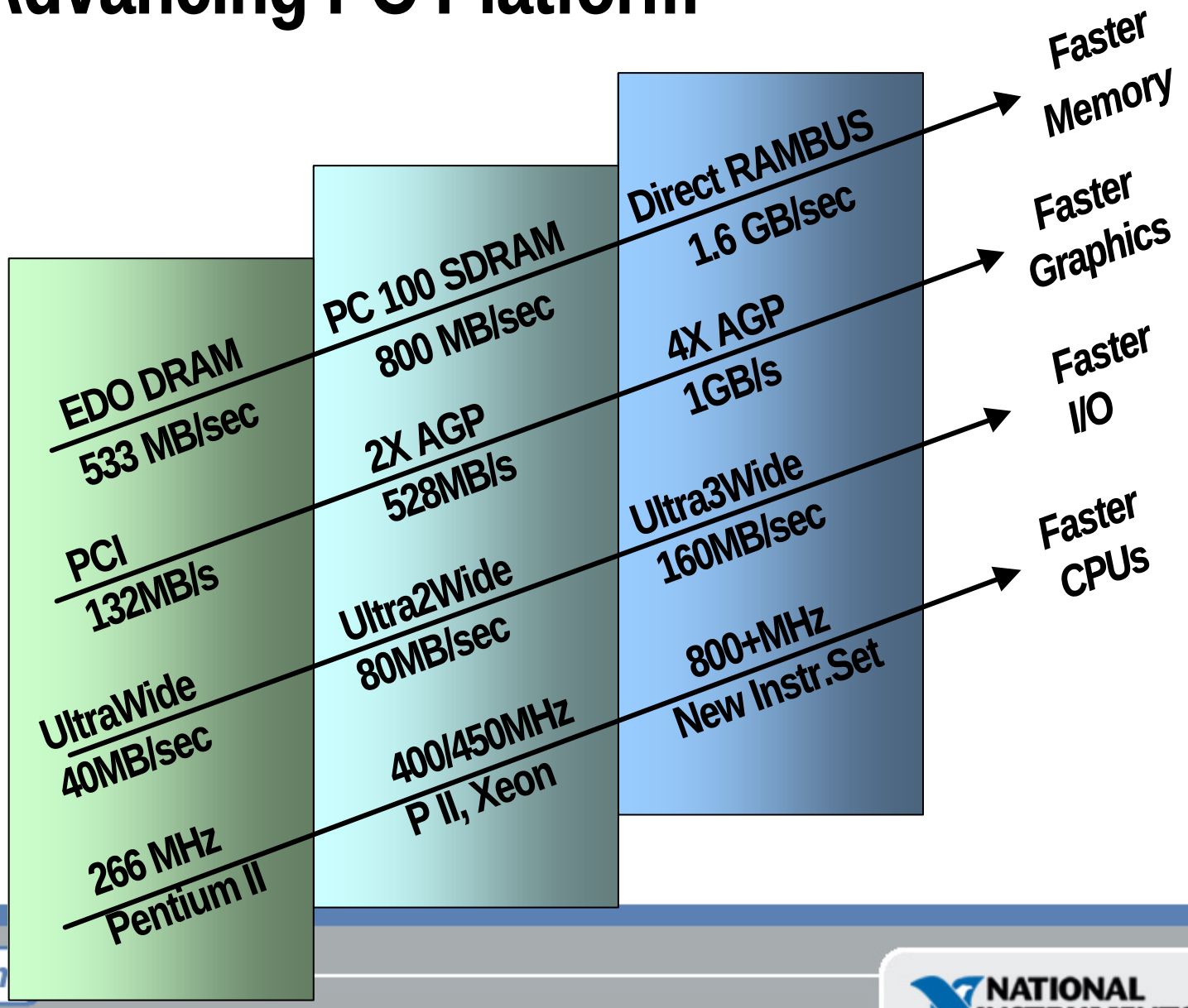
Evolution of PC Technology

1981
4.77 MHz
64 kB RAM
5.25” FD, 160 kB
Monochrome
$3000



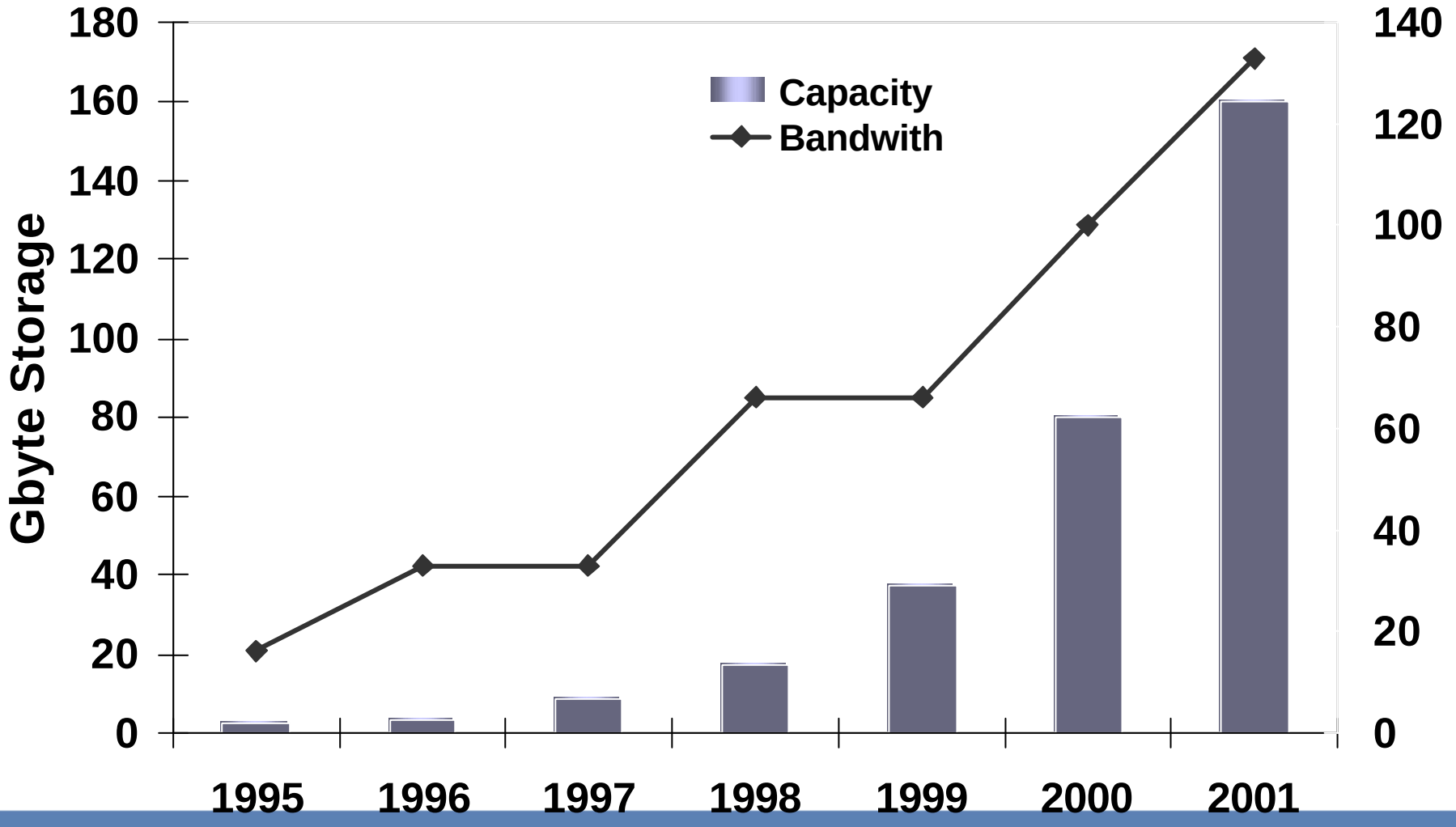
2002
2.2 GHz
512 MB RAM
80 GB HD
CD-ROM
100 MB Ethernet
Color VGA, 32 MB
$2100

The Advancing PC Platform

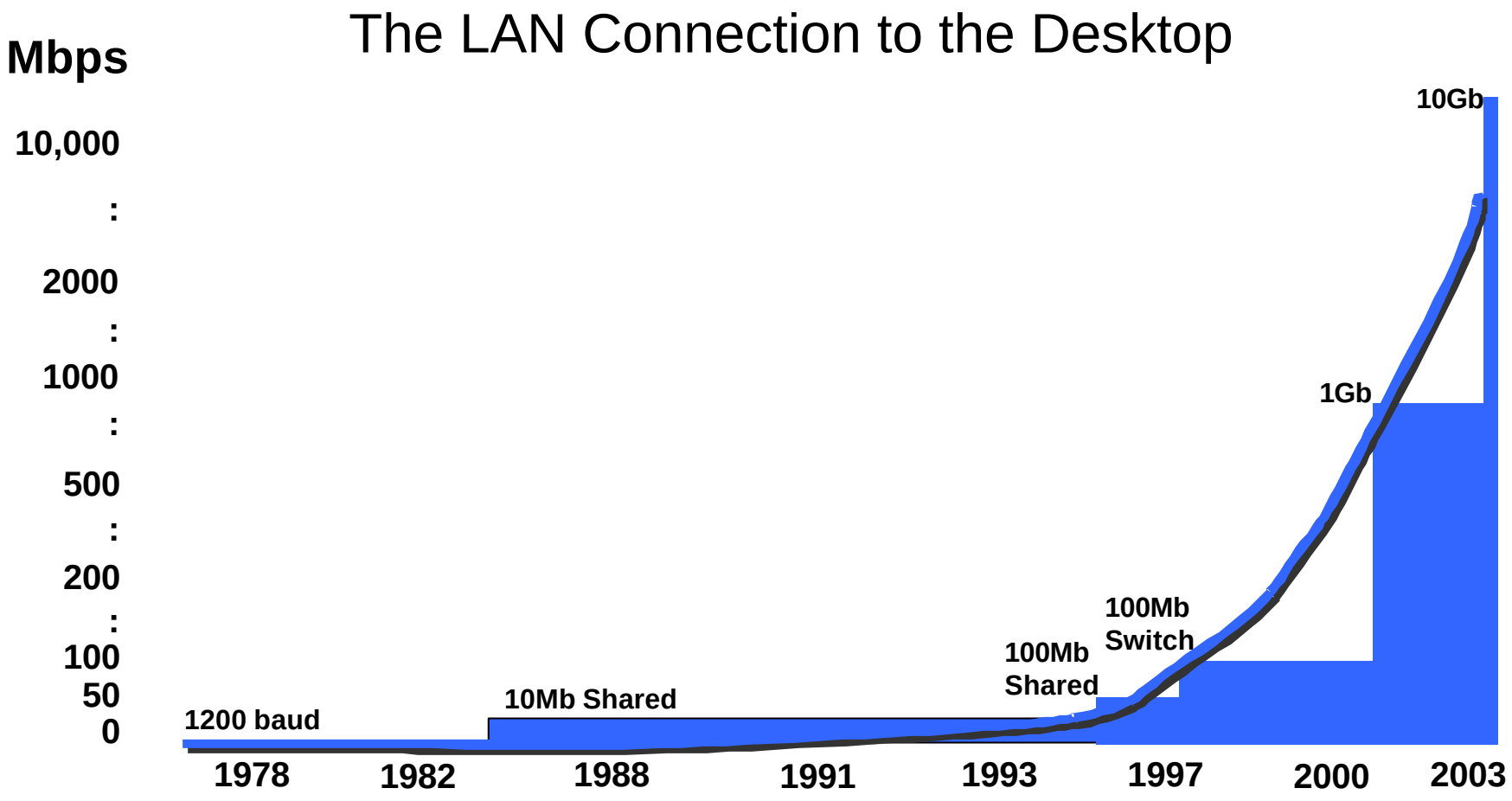


NATIONAL INSTRUMENTS

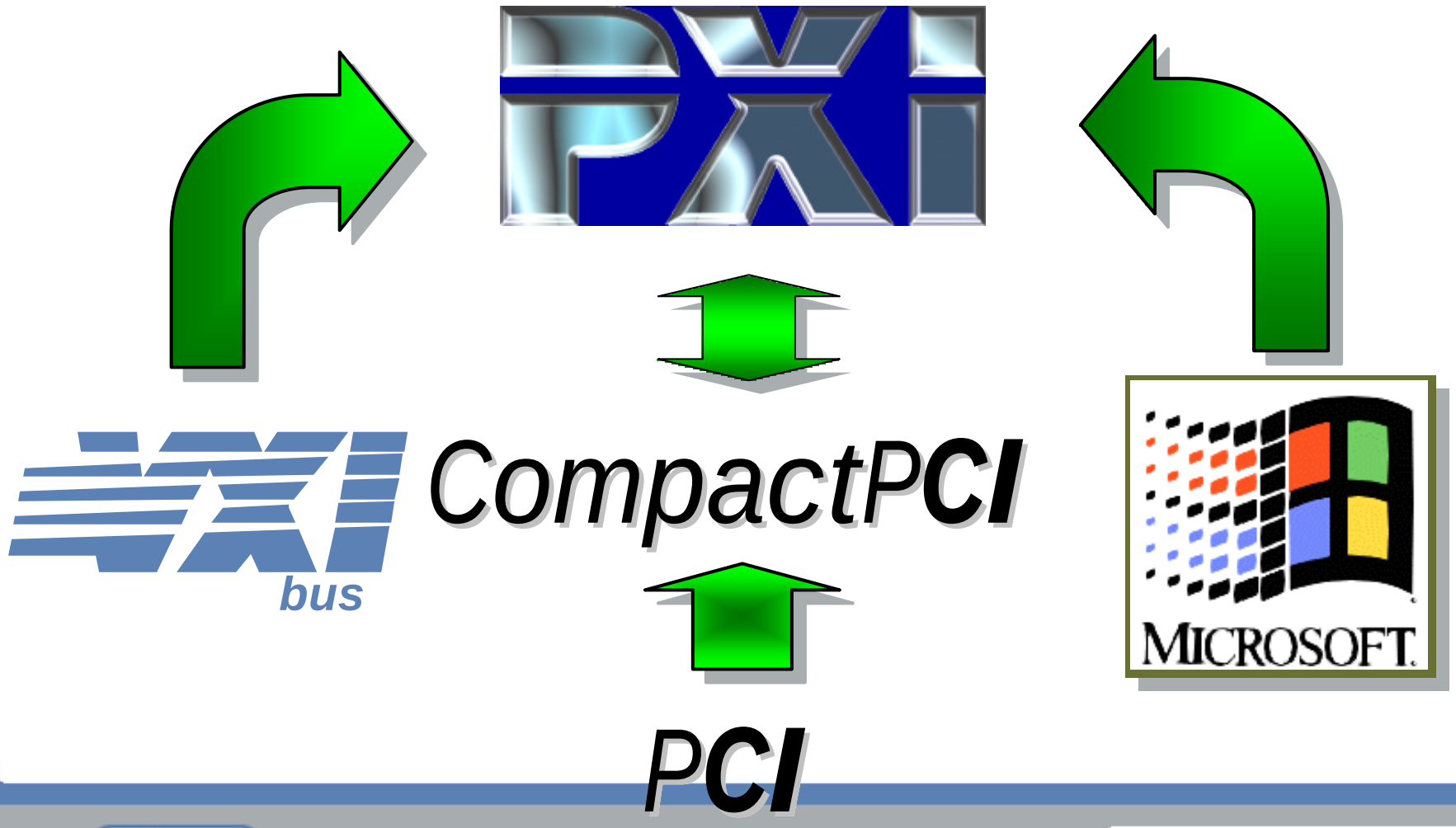
IDE/HDD Capacity Bandwidth Growth



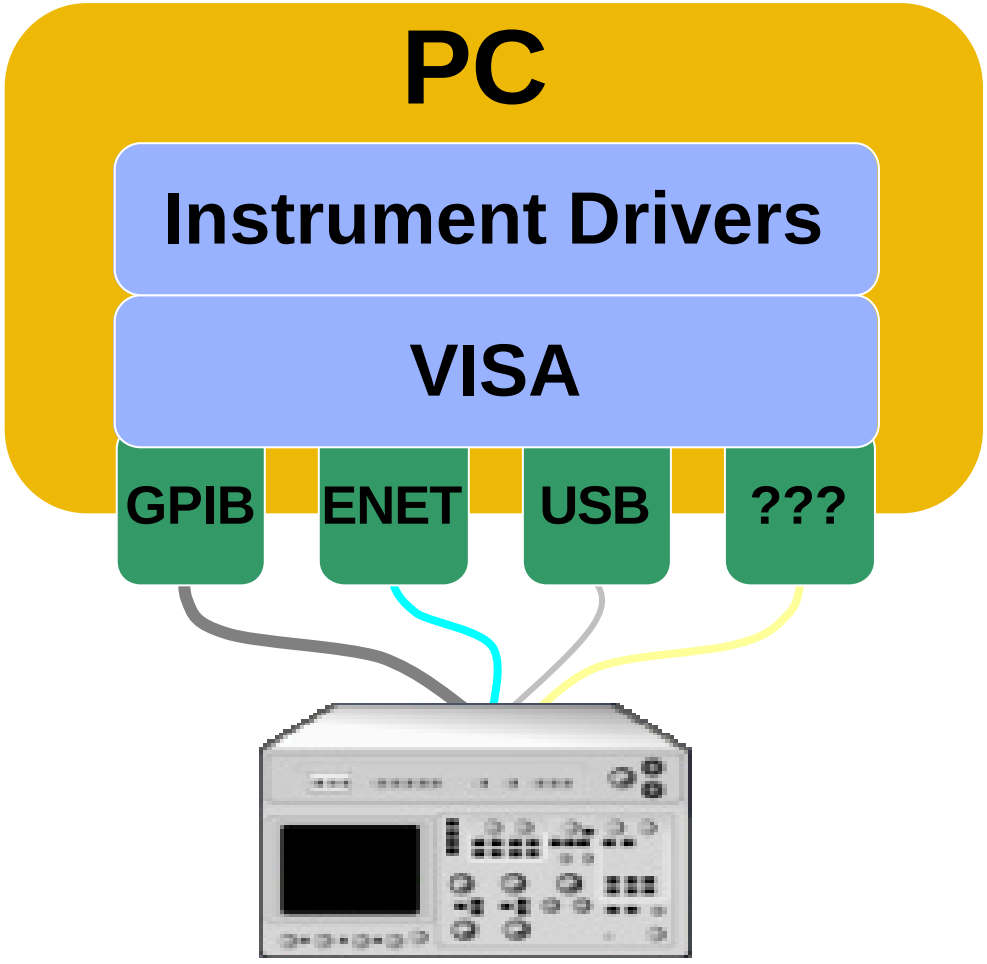
Evolution of Networking



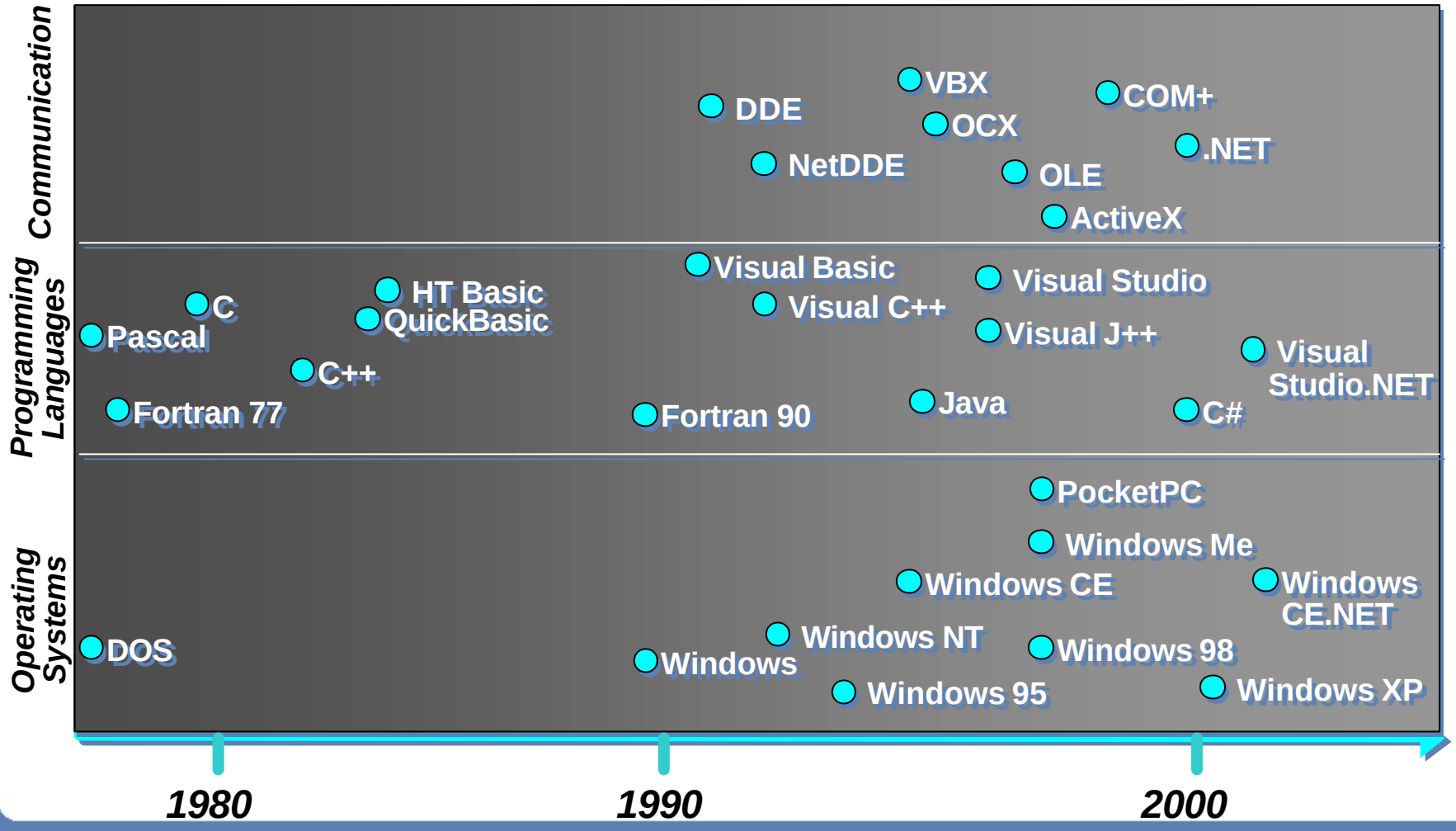
Leveraging Commercial Technologies



Instrument Control Update

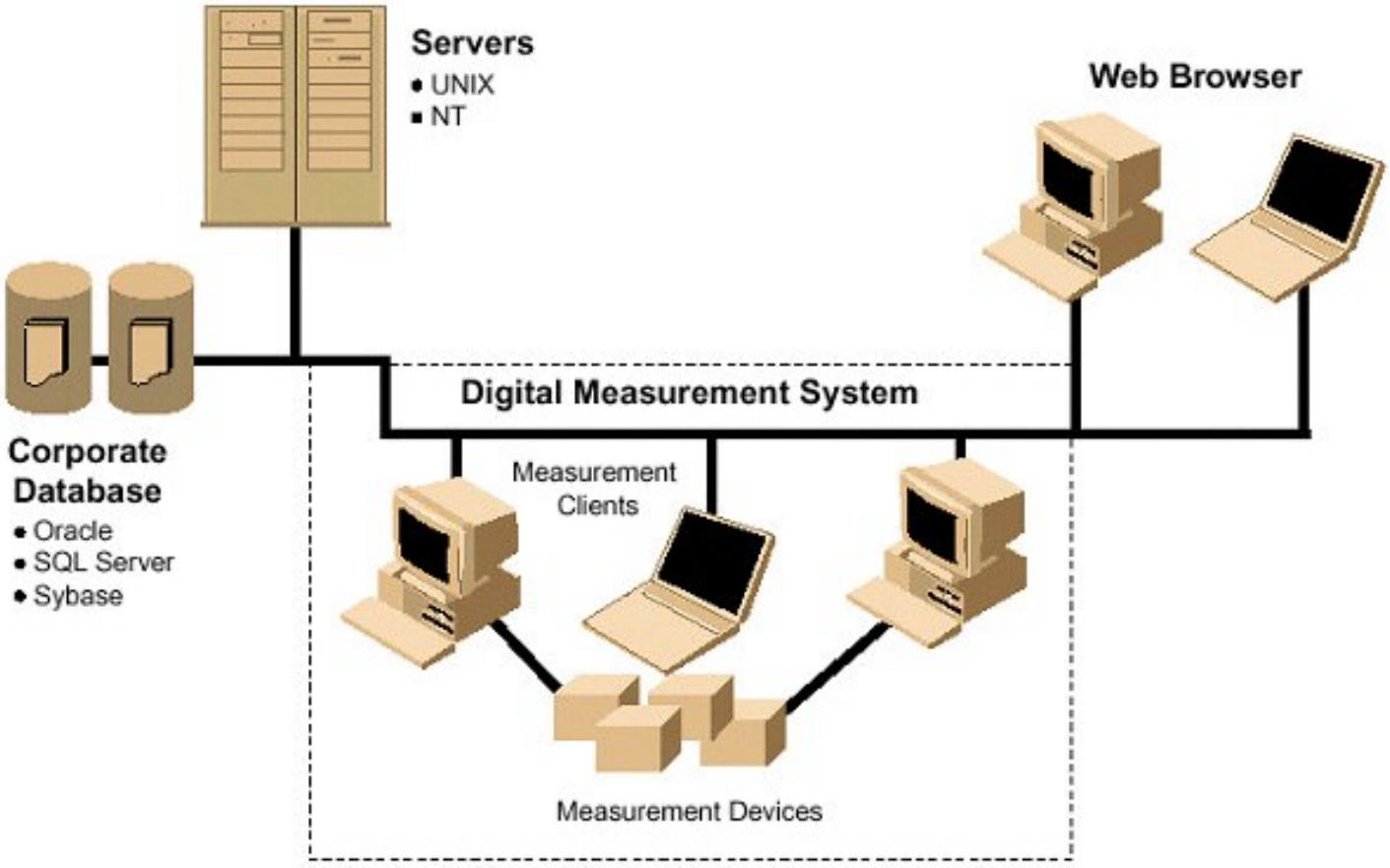


Evolution of Computing Technology



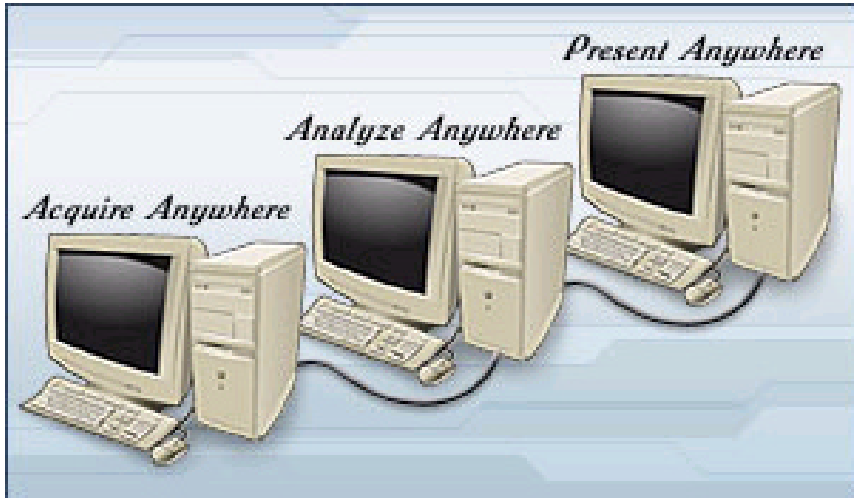
Components of Remote Labs

- Experimental Apparatus
- Measurement Hardware
- Visual Feedback
- Controlling Software
- Security/Administration

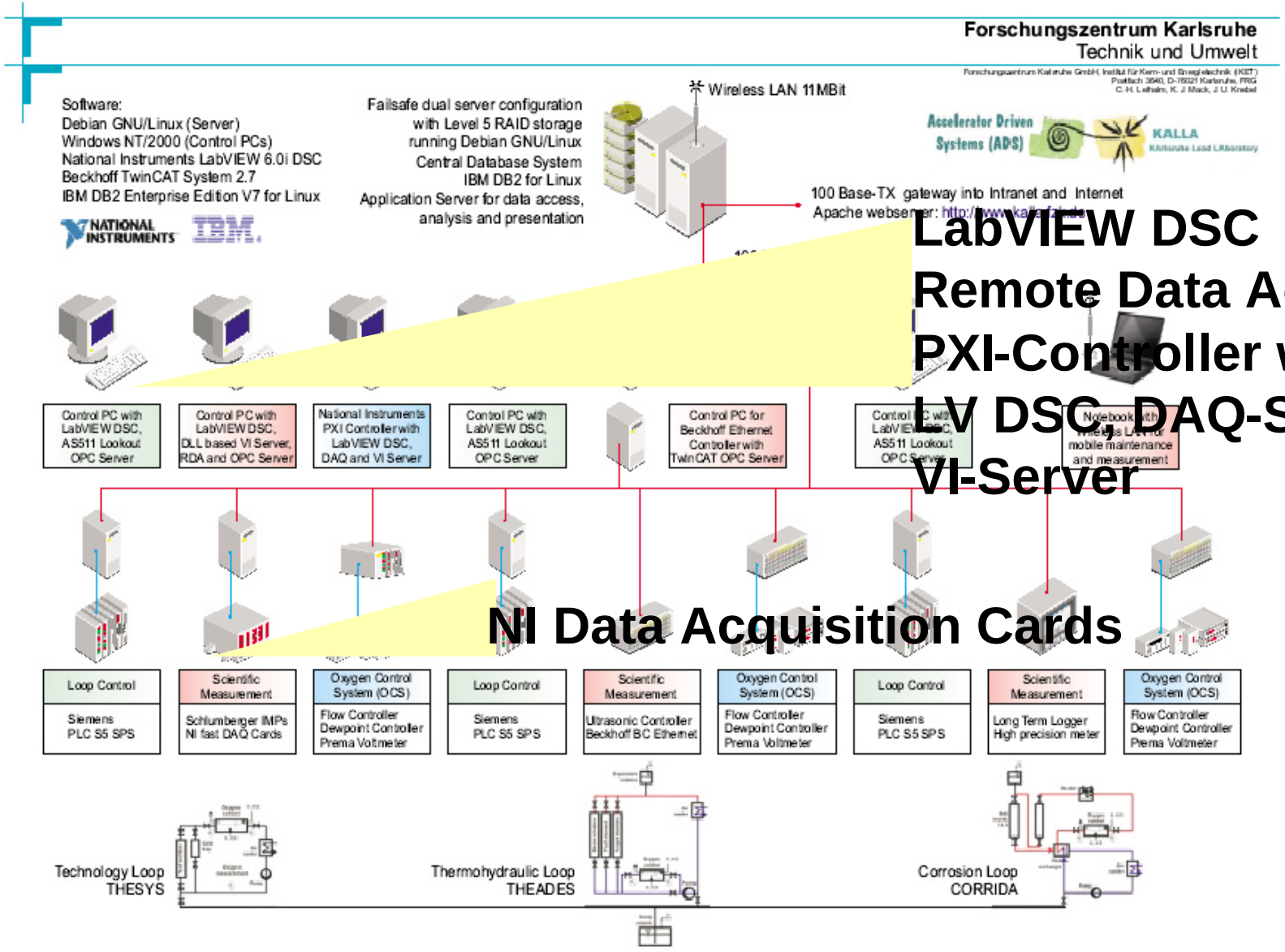

Servers
• UNIX
• NT
Web Browser
Corporate
Database
• Oracle
• SQL Server
• Sybase
Digital Measurement System
Measurement
Clients
Measurement Devices

Networked Measurement and Automation

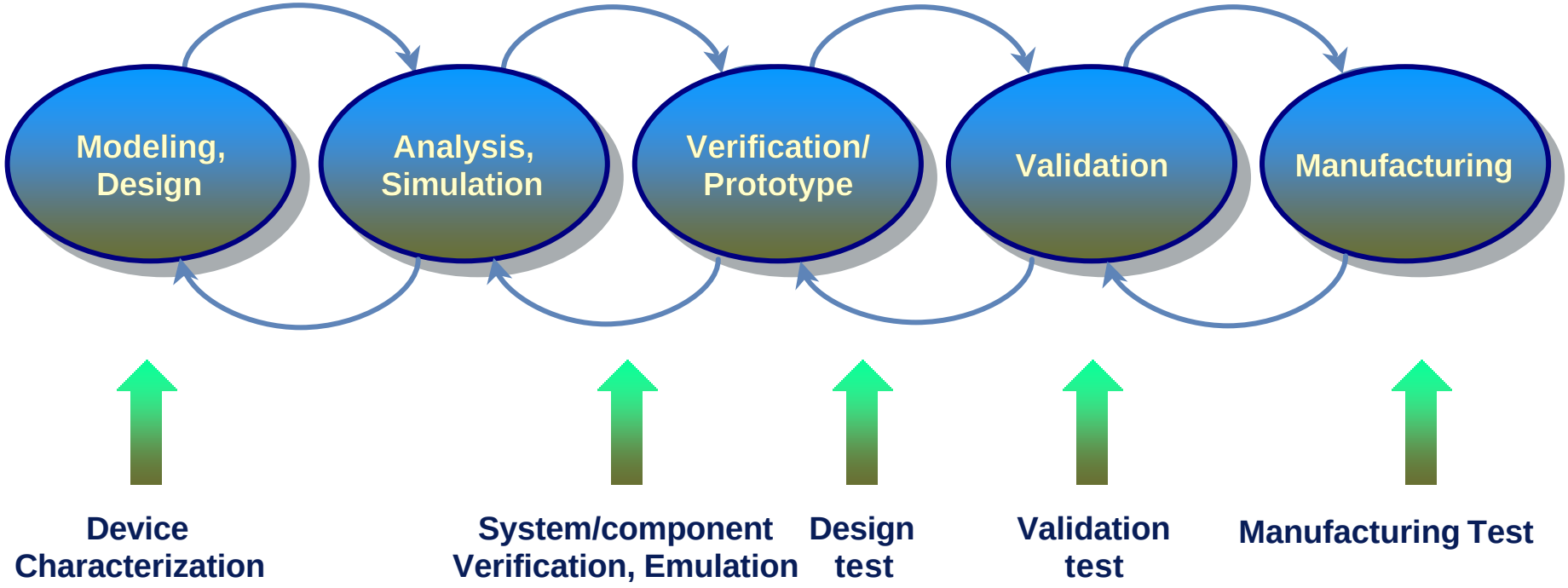
- Publishing results
- Sharing data
- Remote control
- Distributing execution



SCADA-System with Components from National Instruments



Measurements in the Flow



Publishing Results and Sharing Data

- Static Web report of test results
- Easy to access through standard Web browser
- Ideal for analyzing, monitoring, or storing data on other computers

- TestStand™ and LabVIEW provide HTML and XML report options
- DataSocket™ technology for easily sharing data

Remote Control

- Expands concept of sharing data
- Enables another computer to connect and remotely control an application
- Convenient for harsh environments or locations that are difficult to access

Windows XP Remote Desktop

UNIX Remote Login

Timbuktu

LabVIEW 6.1 Remote Panels

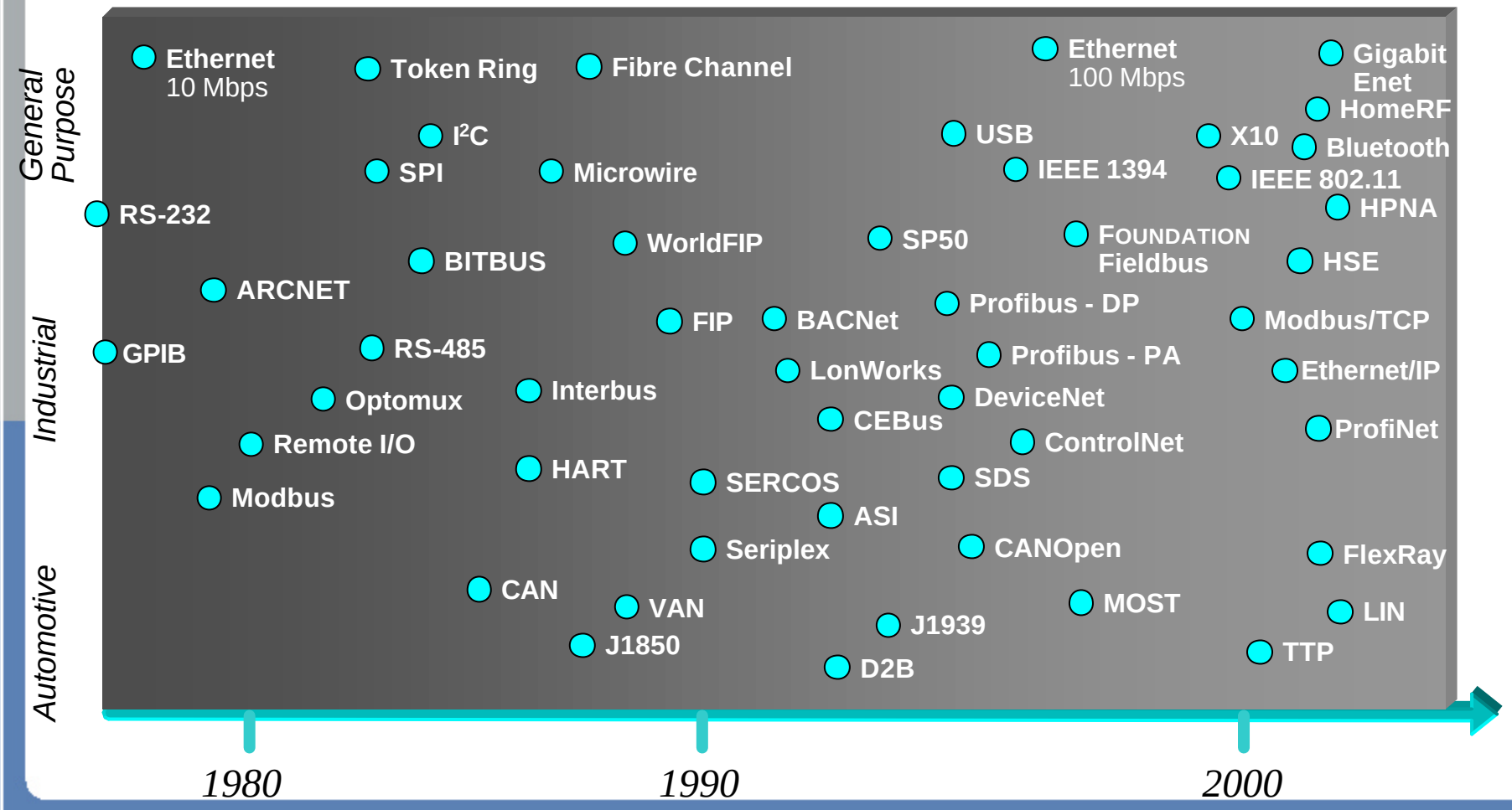
Networking and Collaboration Trends

- Networked systems and applications
  - Remote acquisition, sharing, and data publishing
  - Distributed code execution and application control
- Distributed development and support efforts
  - Sharing code among separated teams in different locations
  - Field engineers working at a customer site

But, wait . . .

What are the real issues in connecting instruments (or sensors) to computers?

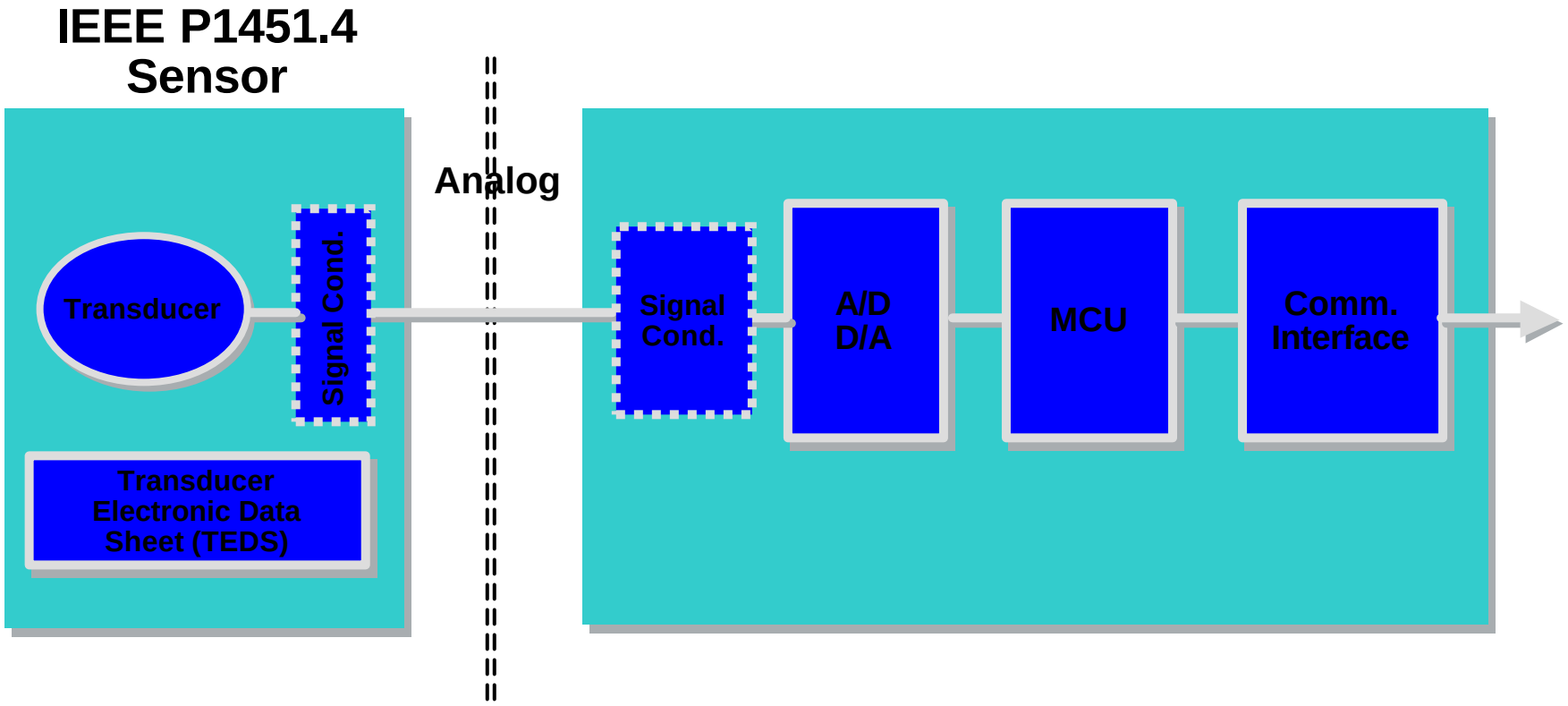
Proliferation of Network Technology



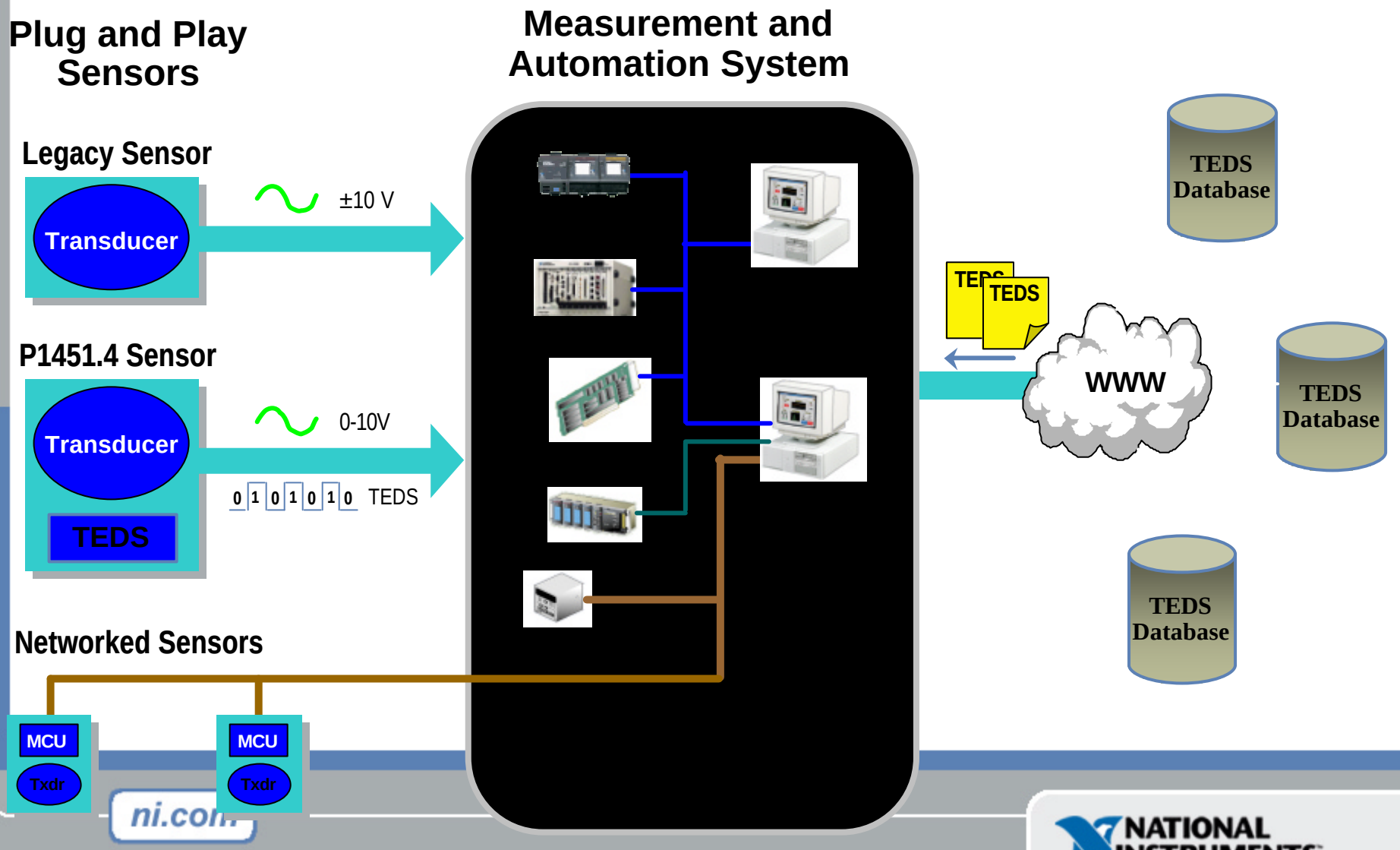
Users Perspective…

F-18 Aircraft Static Fatigue Test System
Boeing

Plug and Play Sensors



Next Generation Plug and Play Sensors



Using .NET in Measurement and Automation

Sensor

XML/SOAP

Sensor calibration web service

Data acquisition system

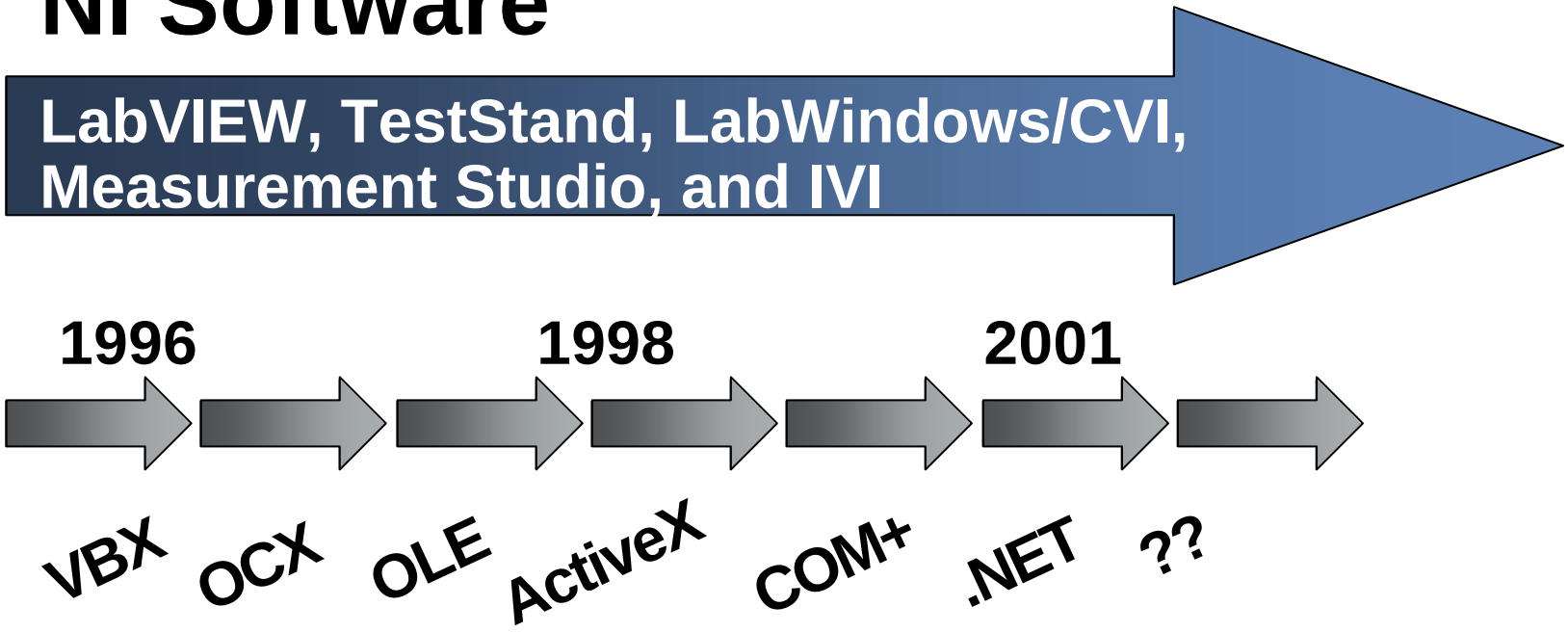
XML/SOAP

Remote web client

Enterprise Server or Database

Delivering Continuity and Productivity to the Microsoft Platform

NI Software



Toolsets
(Database Connectivity, Report Generation, PID Control, Wavelets, and more)

Real-time Module

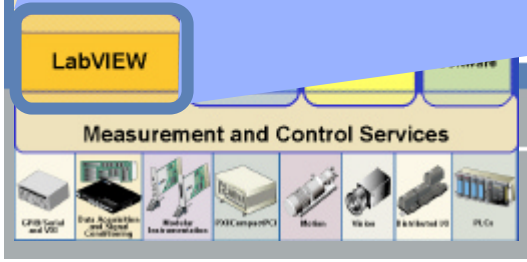
Datalogging and Supervisory Control Module

Vision Development Module

...

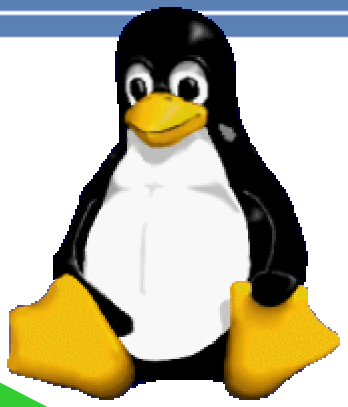
Development Systems

LabVIEW



NATIONAL INSTRUMENTS

Linux Usage in Virtual Instrumentation



Today

LabVIEW for Linux	Linux GPIB Driver	Linux E-DAQ Driver	Linux COMEDI Driver
1998	1998	1999	2001

Future Options

NI-DAQ	LabVIEW Cross Compiler	RT-Linux

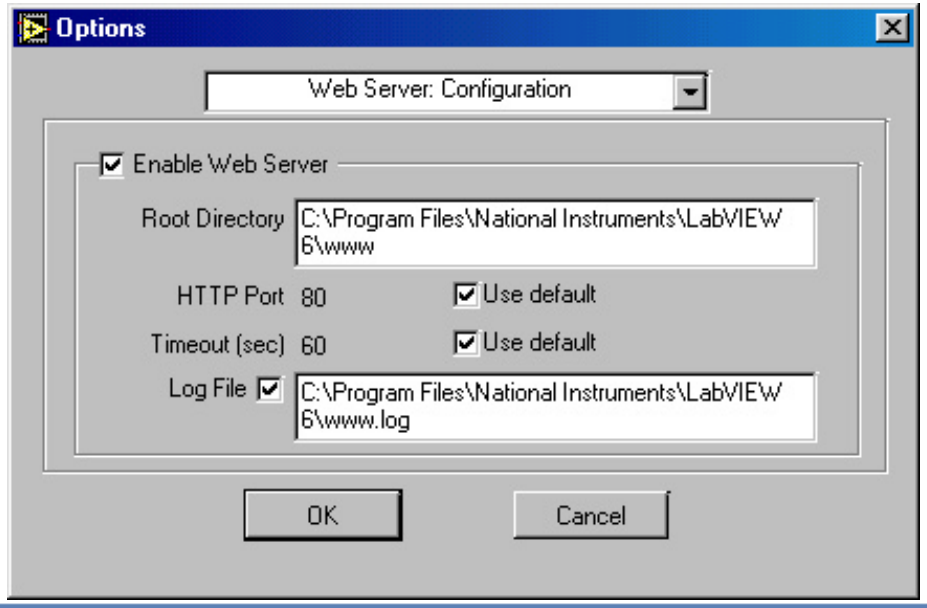
LabVIEW Tools for Remote Labs

- LabVIEW Web Server
- Internet Developers toolkit
- DataSocket (UDP Based)
- VI Server (TCP Based)
- NEW!! Remote Panels

LabVIEW Web Server

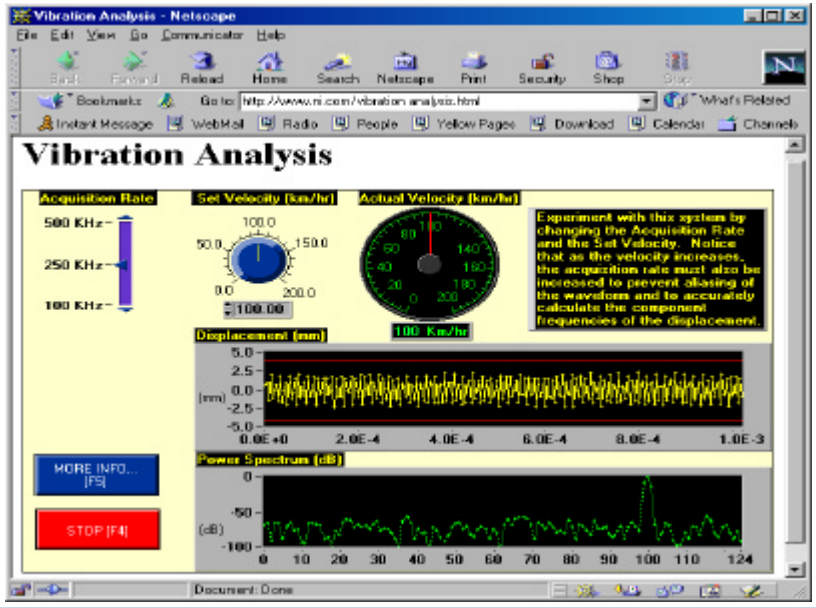
- LabVIEW has a built in Web server.
- LabVIEW Web server can be used for
  - Publishing static web pages (HTML files)
  - Publishing static and animated front panel images of VI

Tools»Options»Web Server: Configuration



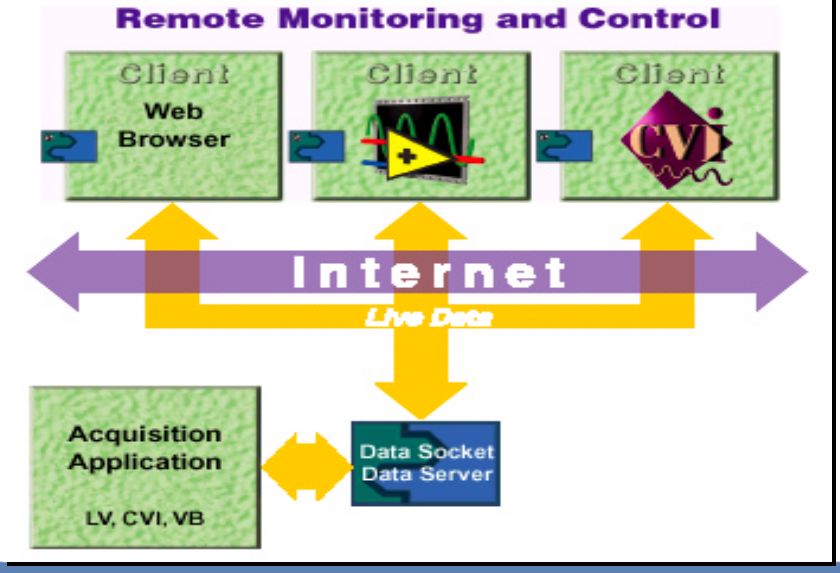
Internet Developers Toolkit

- View experiments across the internet
- E-mail or FTP experimental results
- CGI Scripting and interactive front panels
- Incorporate Web server access control/security



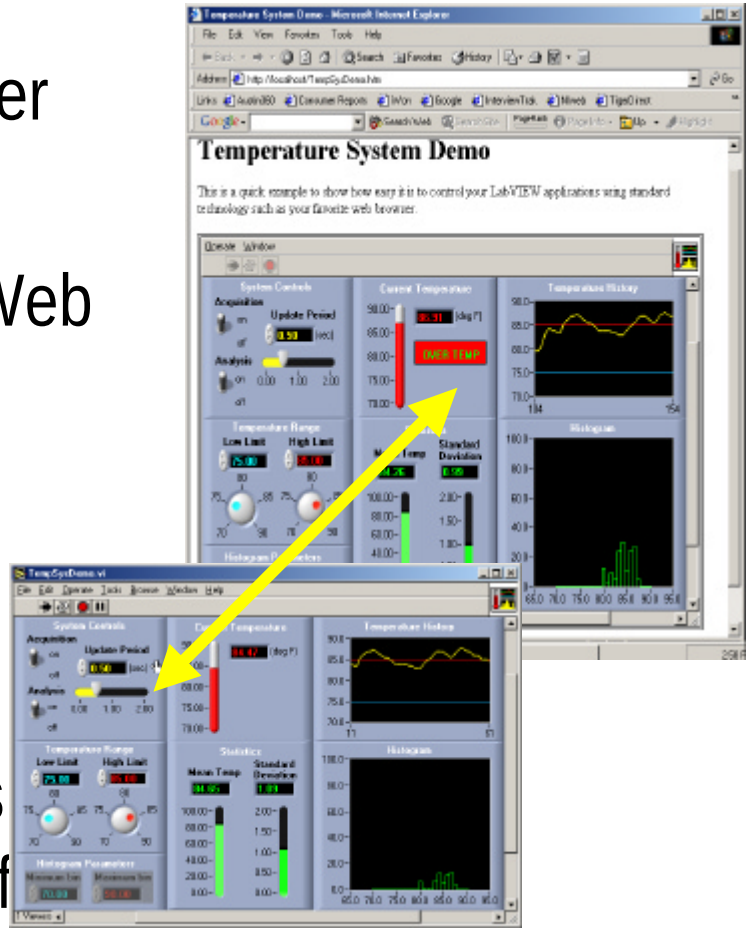
DataSocket

- DataSocket is a programming technology that's allows live data exchange between different applications on one computer or between computers via the network.
- It is protocol-independent, language-independent and OS-independent API.
- Consists of DataSocket API and the DataSocket Server.



LabVIEW 6.1 “Remote Panels”

- Publish the front panel of your user interface to a Web page
- LabVIEW automatically creates Web interface
- Control your application from anywhere on the Internet using a Web browser
- Enabled for all operating systems handled by LabVIEW.(Cross-Platf



Remote Desktop Versus Remote Panels

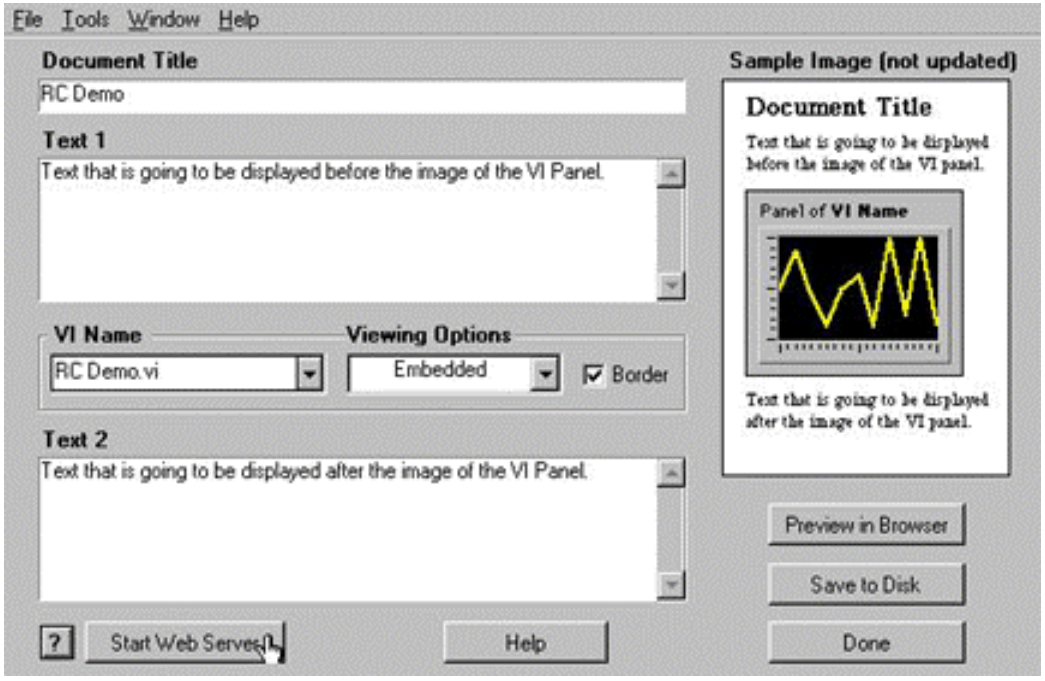
- **Windows Remote Desktop**
  - Access to entire desktop
  - One user at a time
    - Boots off current user
  - Requires user accounts
  - Requires XP or Windows Terminal Server Client
- Fix code, perform maintenance, irregular application monitoring

- **LabVIEW Remote Panels**
  - Access to specific LabVIEW applications
  - Cannot access other windows function
  - Remote access for up to 50 clients through Web browser
- Monitor and control applications from a wide variety of clients, while protecting access to the rest of the system

Remote Panels: Configuration

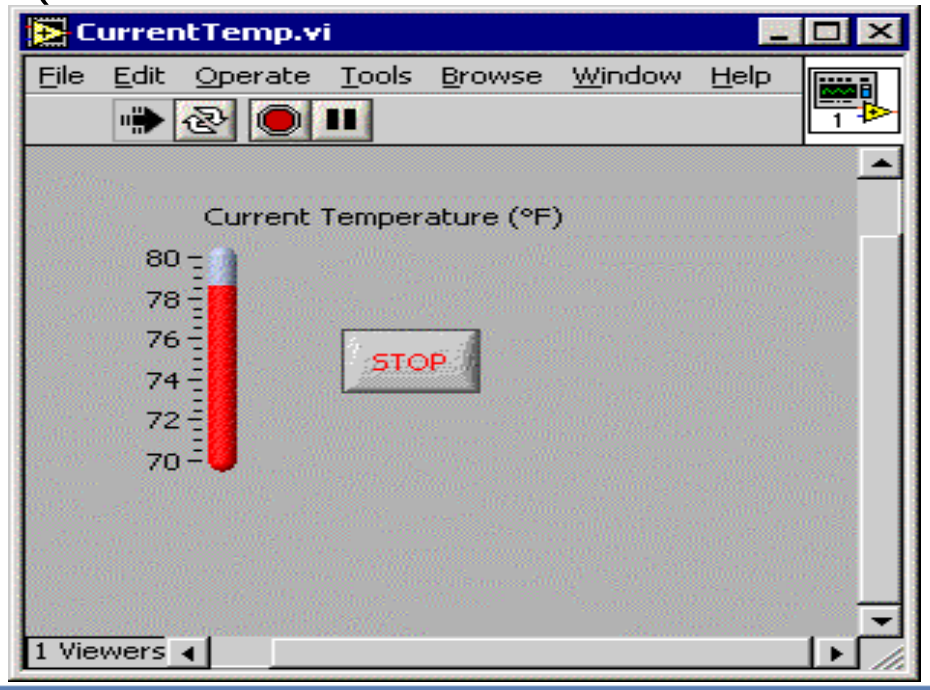
- With the VI to be remotely published loaded into memory, the web publishing tool in LabVIEW allows for easy configuration.

Tools»Web Publishing Tool



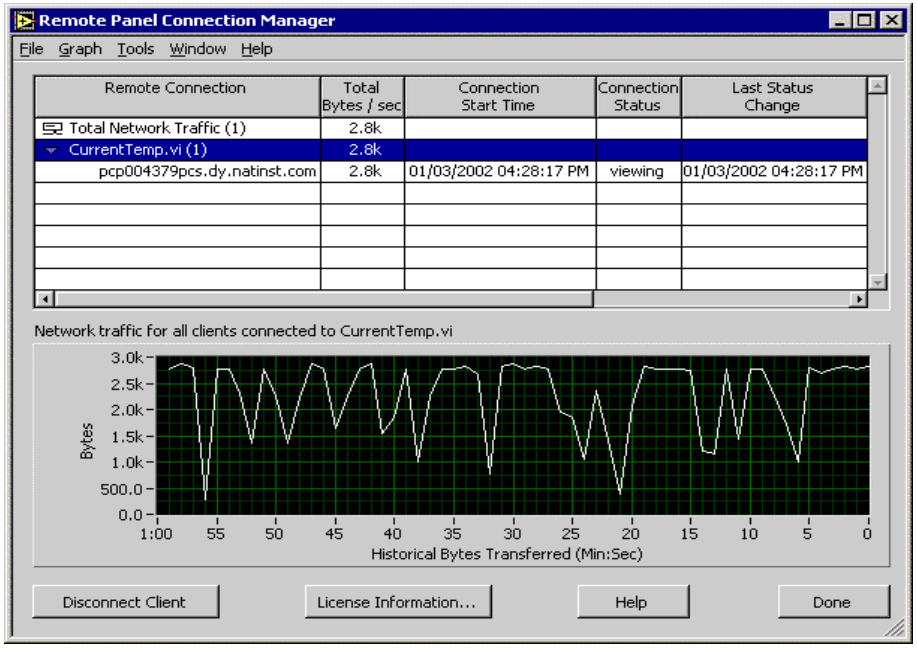
Remote Panels: Implementation

- Server is required to have application loaded into memory.
- LabVIEW Web Server must be active on the server.
- Clients are required to have the free LabVIEW runtime engine installed. (Available for download from www.ni.com)

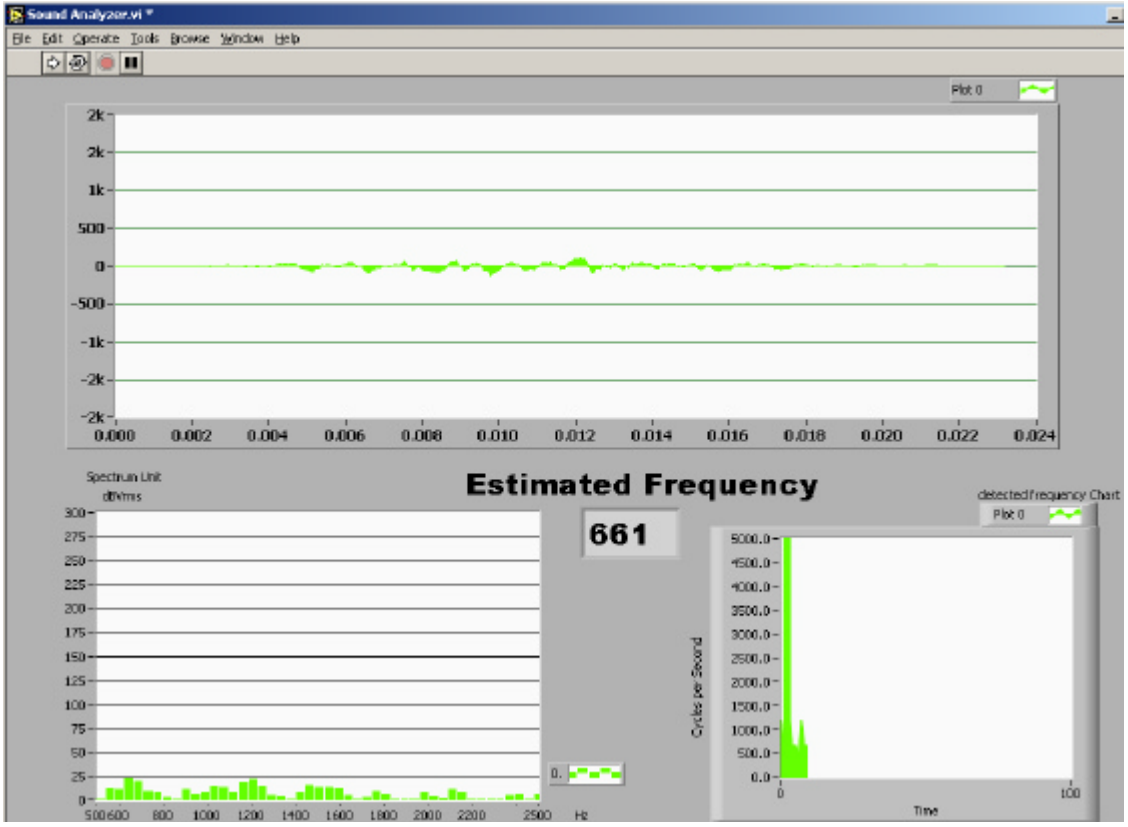


Remote Panels: Management

- Up to 50 clients may monitor the remote VI with a single client having control.
- The Remote Panel Connection Manager allows the administrator to manage client connections.
  - Network traffic
  - NI License manager



Remote Panels: Demonstration

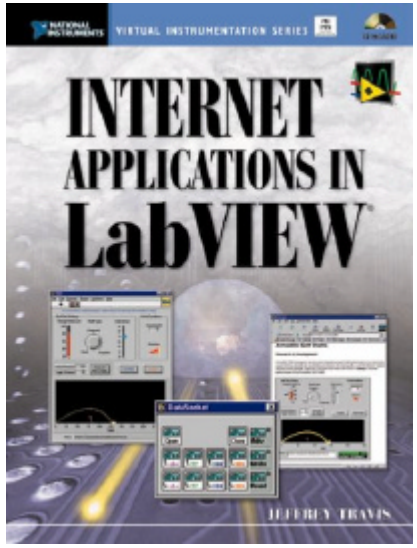


Remote Labs

- http://iawww2.epfl.ch/Lab/Preview.html
- http://iawww2.epfl.ch/Lab_IE.html
- www.Nano-World.org
- http://www.its.bth.se/distancelab/english/

Development Resources

- Internet Applications in LabVIEW
  - Prentice Hall; ISBN: 0130141445
  - Excellent technical reference!
- Distance Learning Guide
  - www.ni.com/academic/distance_learning.htm, free download
  - Collection of real user solutions
- Developing Remote Front Panel LabVIEW Applications
  - Application Note 183



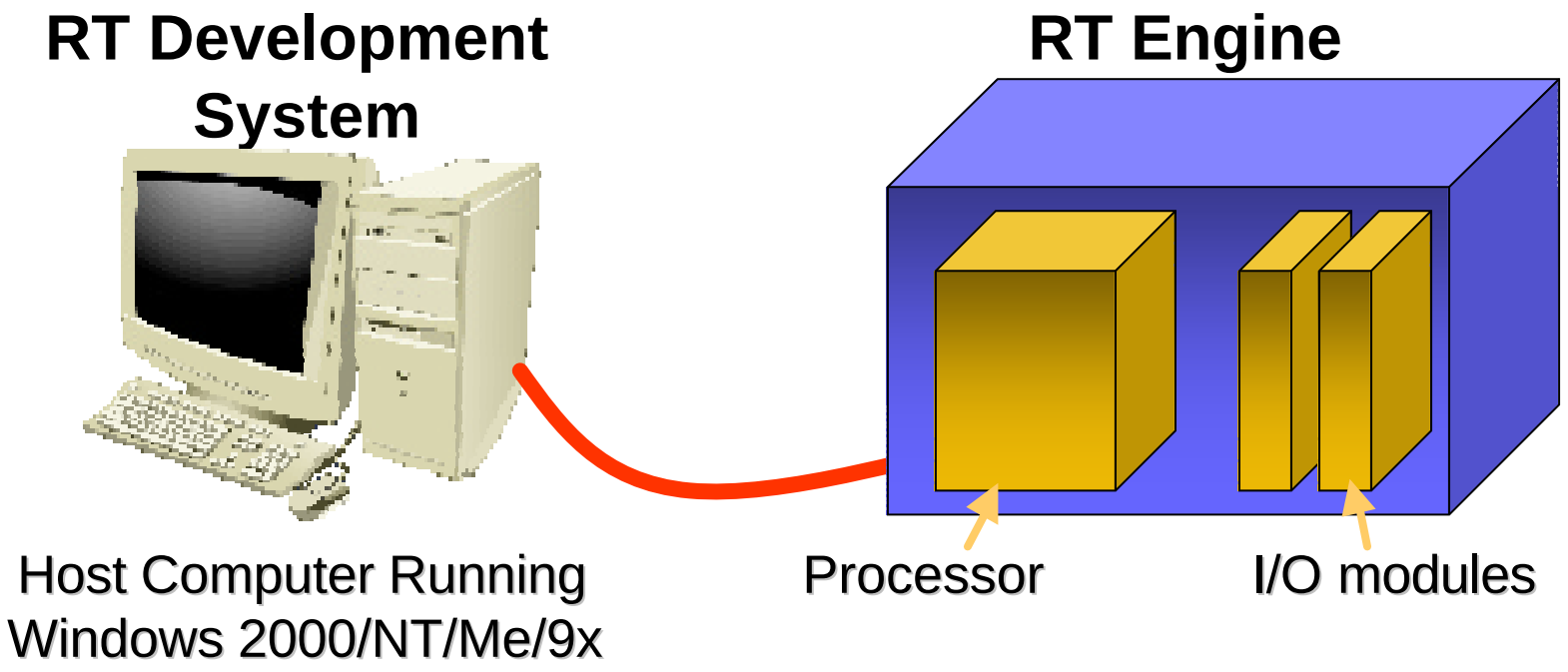
Distributed Execution

- Combines several of the previous concepts
- Shares acquisition, analysis, and presentation tasks among different computers
- Offers increased performance and flexibility
  - LabVIEW
  - FieldPoint
  - PXI
  - RT Series Hardware

LabVIEW RT Benefits

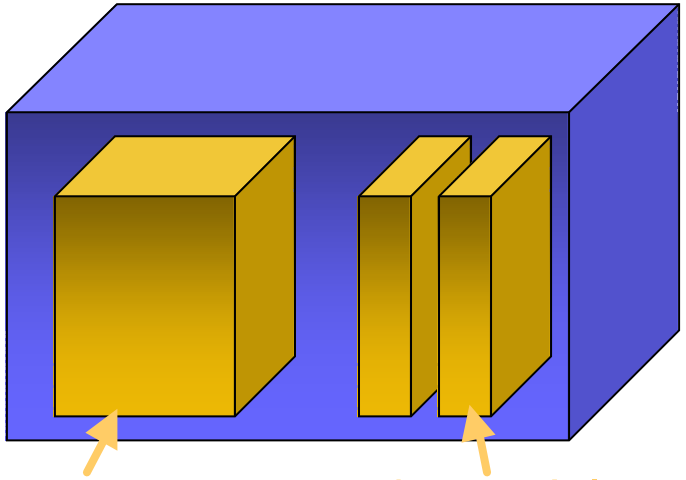
- Rapid development environment
- Tight software/hardware integration
- Scalable investment

LabVIEW Real-Time System Architecture



Develop **Download** **Execute**

Software Architecture



Processor

I/O modules

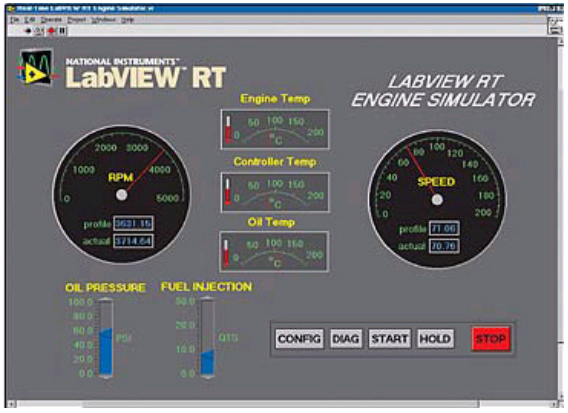
LabVIEW
+
RT Development System

RT Engine

User Interface
Debugging

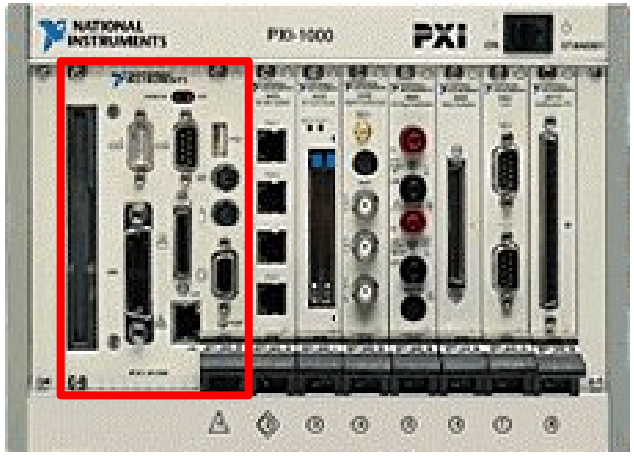
LabVIEW Real-Time

- Rapid graphical development of reliable, real-time control applications
- Complete flexibility and functionality
- Numerous add-on tools
- Seamless integration with RT Series hardware targets



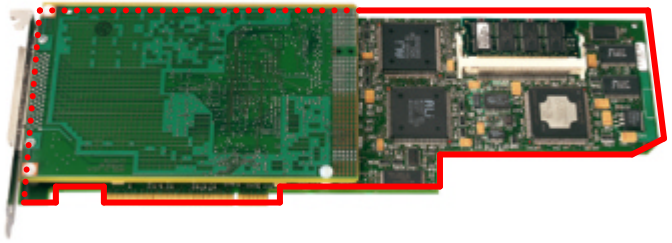
Real-Time Series Hardware

RT Series
PXI Controllers

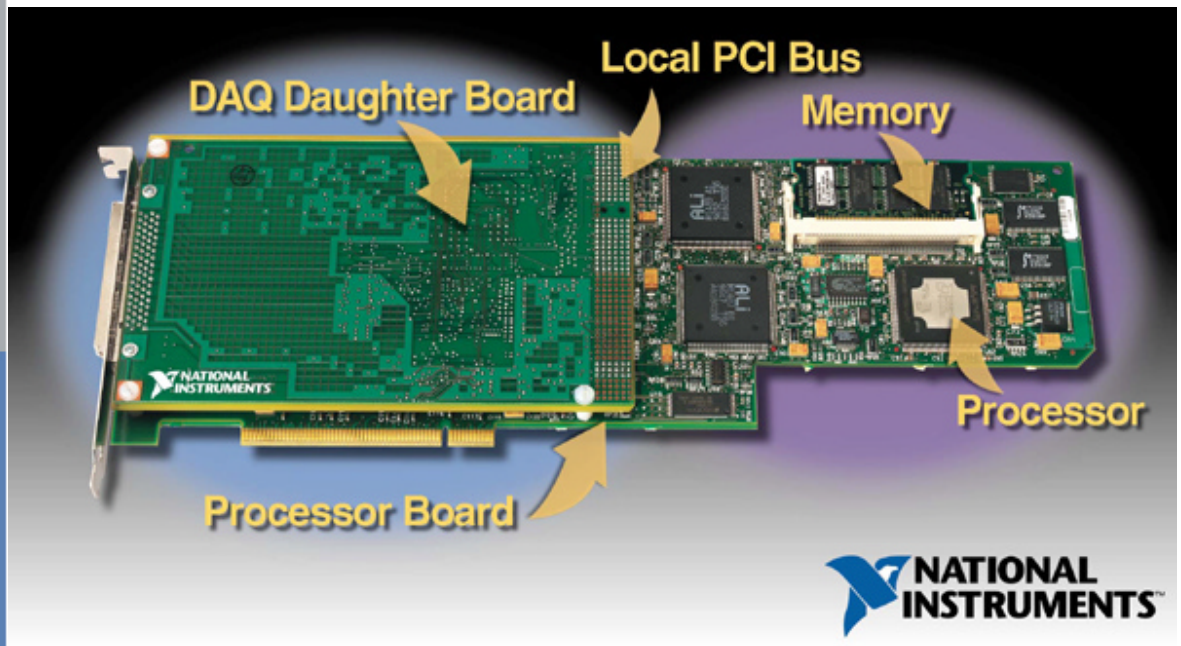


RT Series
FieldPoint

RT Series DAQ
(PCI/PXI-7030)



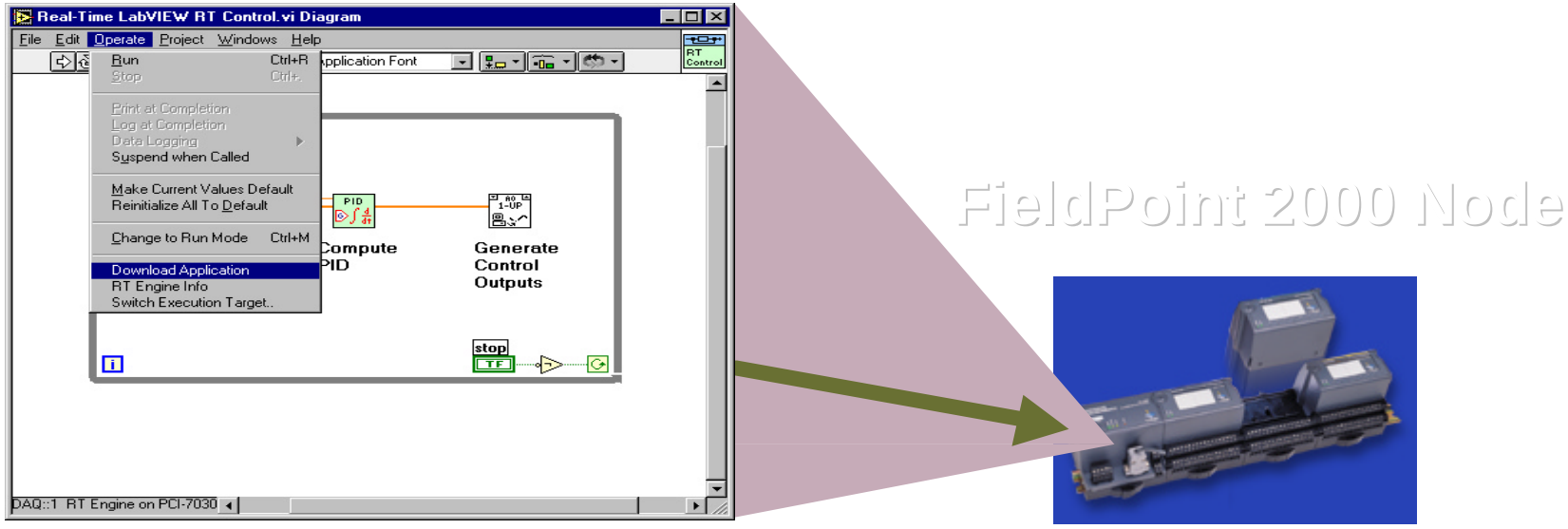
RT Series DAQ Board



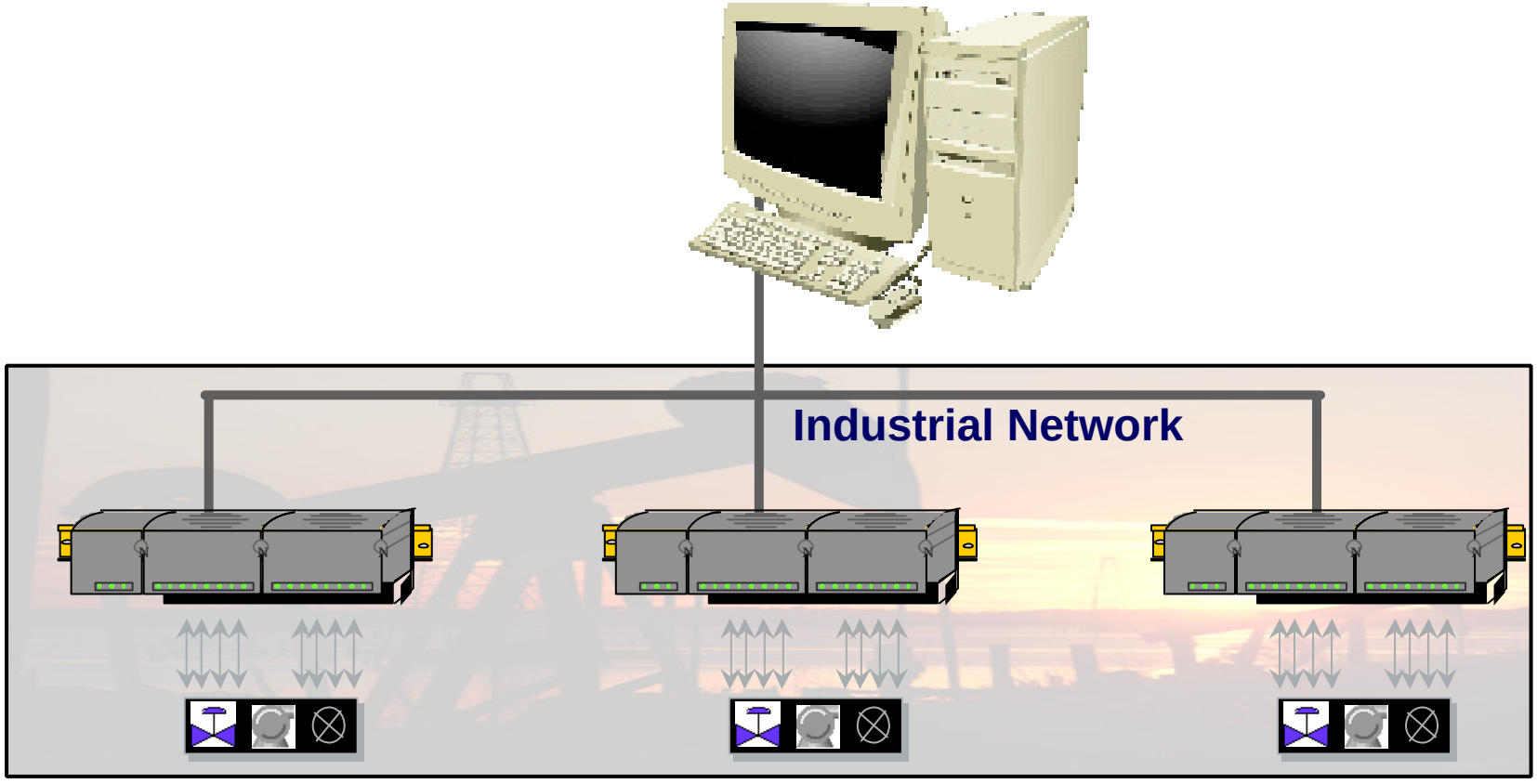
- Dedicated processor
- 8 MB DRAM for user programs
- PCI and PXI form factors

Distributed Real-Time Control

FieldPoint 2000 Family — LabVIEW running embedded on an Ethernet-based compact FieldPoint module



FieldPoint – Distributed I/O



Stand-Alone Operation

Watchdog timer

User-defined dip switches and LEDs

Connector for redundant power supply

Serial port

FieldPoint FP-2000

- Ethernet network controller for distributed I/O system
- Compact industrial module
- Reliable stand-alone operation
- Download LabVIEW Real-Time applications to FP-2000

The PXI Controllers

- 8156B for *Connectivity*
- 333 MHz processor, 256 MB RAM
- 2 serial, 1 parallel, 1 USB port
- 1.44 MB floppy drive
- 10BaseT Ethernet
- GPIB interface
- 6 GB hard drive, minimum

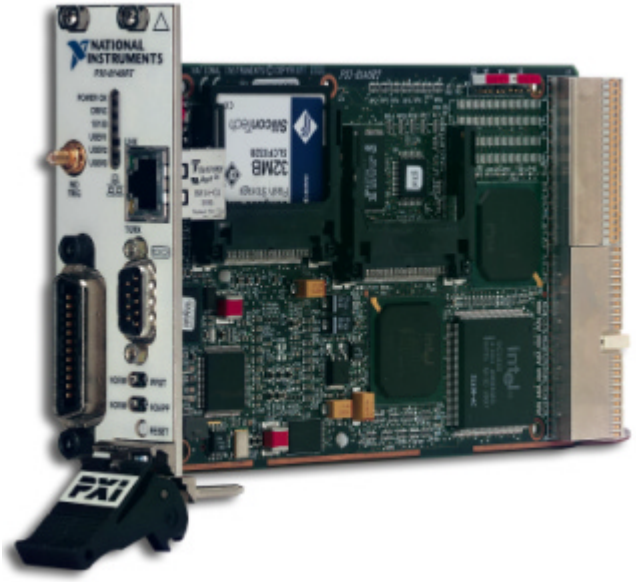
Preinstalled with real-time – or booted into real-time with a floppy disk

The PXI Controllers

- PXI 817x for *Speed*
- Up to 1.2 GHz CPU, 256 MB RAM
- 2 serial, 1 parallel, 1 USB port
- 1.44 MB floppy drive
- 10/100BaseTX Ethernet
- 6 GB hard drive, minimum

Preinstalled with real-time – or booted into real-time with a floppy disk

PXI 8140RT Series Controllers



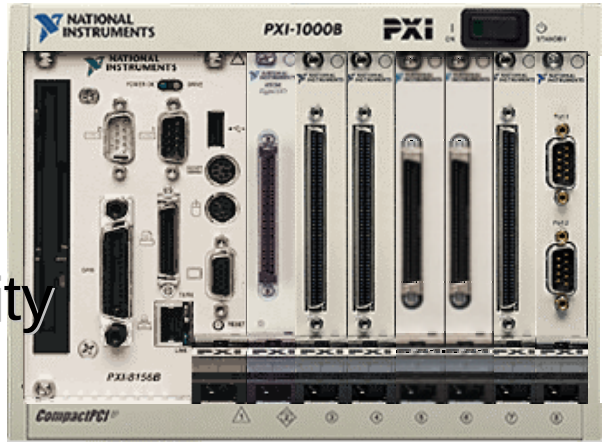
- 266 MHz CPU, 256 MB RAM

- 1 serial port
- 1 GPIB port (8146 RT only)
- 1 SMB watchdog (8146 RT only)
- Front Panel LED's
- 10/100BaseTX Ethernet
- CompactFlash Memory

- Reliable operation in rugged environments
- Built for networked embedded systems

PXI Modules and I/O Used with RT

- 4 to18 slot PXI chassis
- PXI NI-DAQ and Dynamic Signal Acquisition
  - Including signal conditioning
- NI-FlexMotion
- NI-CAN
- Serial and NI-VISA
- MXI-3 adds scalability
- NI-IMAQ adds vision capability

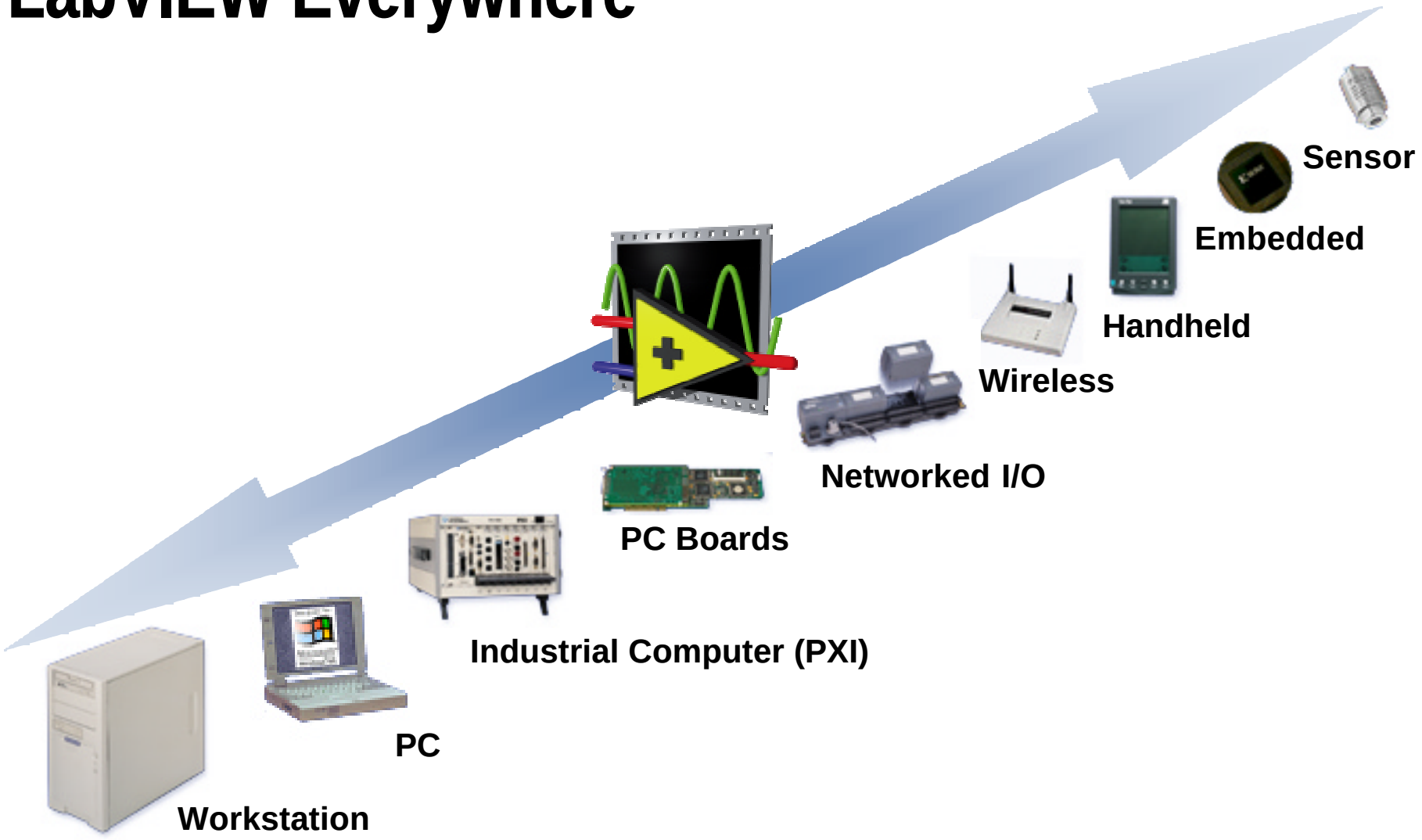


Configure your own system

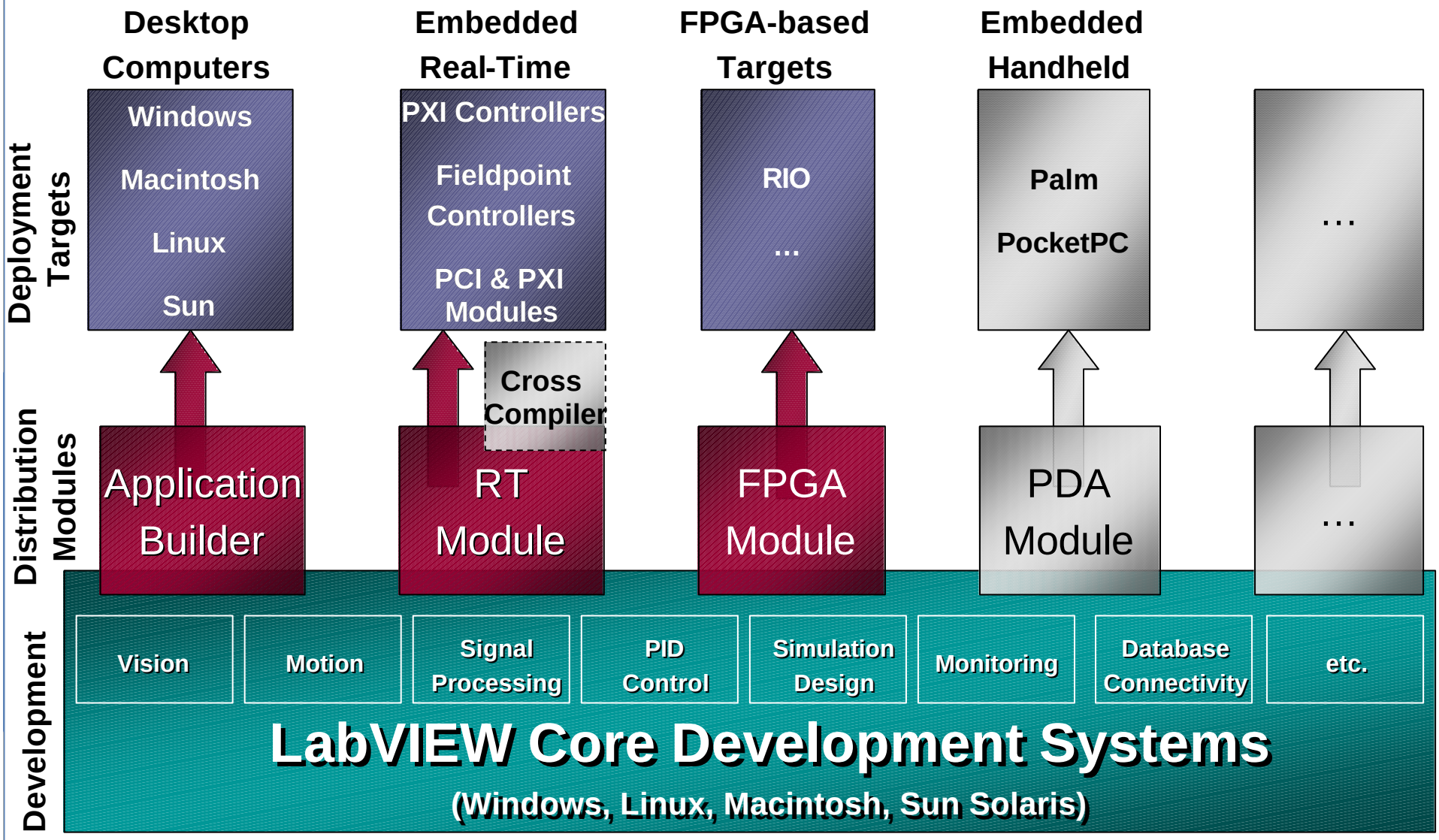
PID Loop Performance

- PXI-8170, 850 MHz
  - 1 PID 35,000 Hz
- PXI-8156B, 333 MHz
  - 1 PID 10,200 Hz
- PXI 8140RT, 266 MHz
  - 1 PID 6060 Hz
- PCI-7030/6040E, 133 MHz
  - 1 PID 2360 Hz
- FP-2000, 75 MHz
  - 1 PID 370 Hz

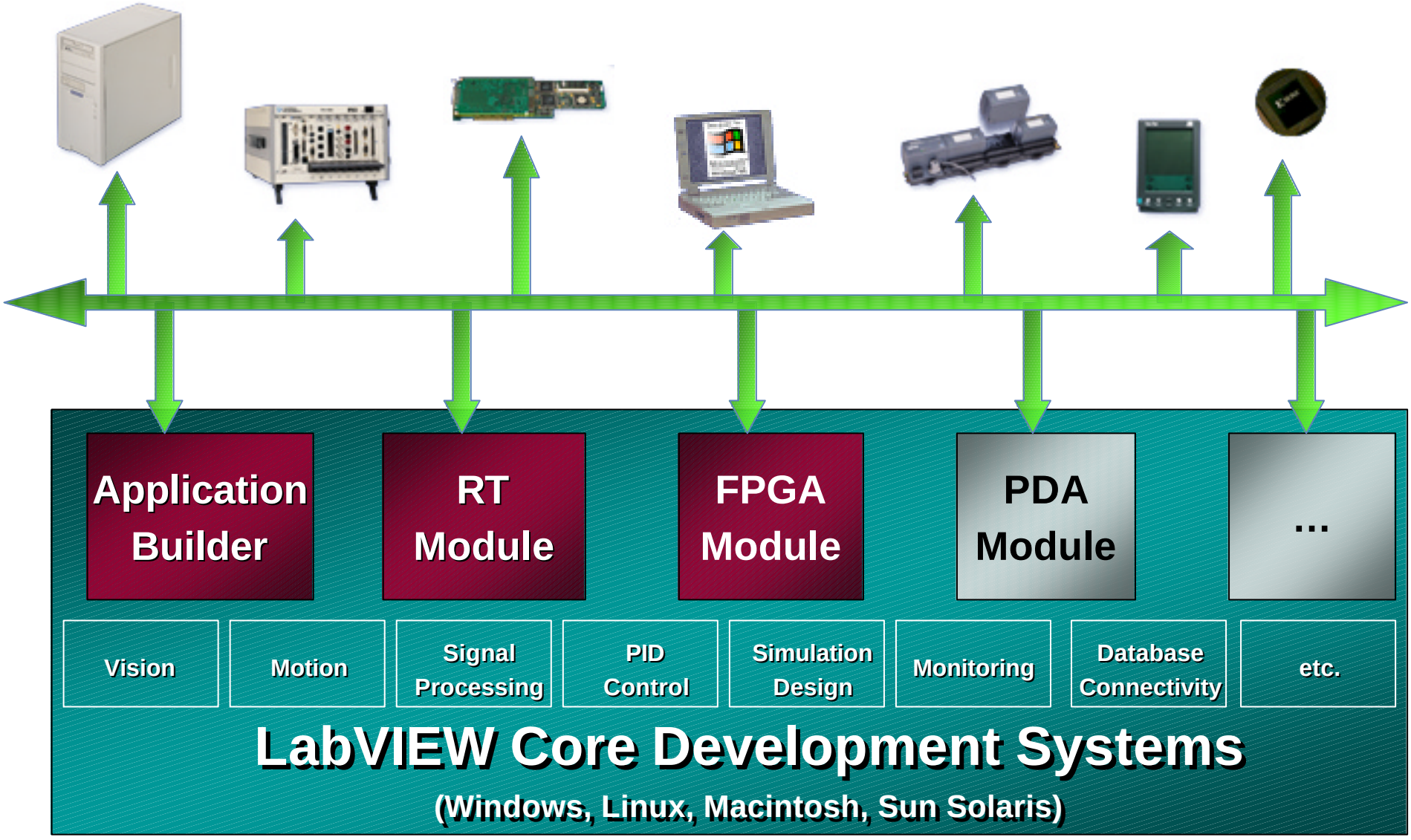
LabVIEW Everywhere



The LabVIEW Platform



Distributed LabVIEW



Recent Announcements

- New Start-Up Kit Delivers Lock-In Amplifier Functionality to NI LabVIEW
- LabVIEW Integration with Texas Instruments Code Composer Studio.
- 2.7 GHz RF Signal Analyzer Dramatically Improves RF Test Speed and Flexibility
- Mathematica Link for LabVIEW Integrates Design Models and Measurements
- National Instruments 6½-Digit DMM Shatters Traditional DMM Speed Barriers