CHAPTER **V**

Introduction to Virtual Instrumentation

1. *History of Instrumentation systems*
2. *Virtual Vs. Traditional Instruments*
3. *Architecture of Virtual Instruments*
4. *Introduction to LabVIEW*

History of Instrumentation systems

- An instrument is a device designed to collect data from an environment, or from a unit under test, and to display information to a user based on the collected data.
- The term instrument may also be defined as a physical software device that performs an analysis on data acquired from another instrument and then outputs the processed data to display or recording devices.
- Virtual instrumentation is an interdisciplinary field that merges sensing, hardware, and software technologies in order to create flexible and sophisticated instruments for control and monitoring applications.

History of Instrumentation systems

- The concept of virtual instrumentation was born in late 1970s, when microprocessor technology enabled a machine's function to be more easily changed by changing its software.
- The flexibility is possible as the capabilities of a virtual instrument depend very little on dedicated hardware – commonly, only application-specific signal conditioning module and the analog-to-digital converter used as interface to the external world.

History of Instrumentation systems

- Starting from first manual-controlled vendor-defined electrical instruments, the instrumentation field has made a great progress toward contemporary computer-controlled, user-defined, sophisticated measuring equipment.
- Instrumentation had the following phases:
  - Analog measurement devices
  - Data acquisition and processing devices
  - Digital processing based on general purpose computing platform
  - Distributed virtual instrumentation

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History of Instrumentation systems

- The first phase is represented by early “pure” analog measurement devices, such as oscilloscopes or EEG recording systems.
- They were completely closed dedicated systems, which included power suppliers, sensors, translators, and displays.
- They required manual settings, presenting results on various counters, gauges, CRT displays, or on the paper.

History of Instrumentation systems

- Further use of data was not part of the instrument package, and an operator had to physically copy data to a paper notebook or a data sheet.
- Performing complex or automated test procedures was rather complicated or impossible, as everything had to be set manually.

History of Instrumentation systems

- Second phase started in 1950s, as a result of demands from the industrial control field.
- Instruments incorporated rudiment control systems, with relays, rate detectors, and integrators.
- That led to creation of proportional–integral–derivative (PID) control systems, which allowed greater flexibility of test procedures and automation of some phases of measuring process.

History of Instrumentation systems

- Instruments started to digitalize measured signals, allowing digital processing of data, and introducing more complex control or analytical decisions.
- However, real-time digital processing requirements were too high for any but an onboard special purpose computer or digital signal processor (DSP).
- The instruments still were standalone vendor defined boxes.

History of Instrumentation systems

- In the third phase, measuring instruments became computer based.
- They began to include interfaces that enabled communication between the instrument and the computer.
- This relationship started with the general-purpose interface bus (GPIB) originated in 1960s by Hewlett-Packard (HP), then called HPIB, for purpose of instrument control by HP computers.
- Initially, computers were primarily used as off-line instruments.

History of Instrumentation systems

- They were further processing the data after first recording the measurements on disk or tape.
- As the speed and capabilities of general-purpose computers advanced exponentially general-purpose computers became fast enough for complex real-time measurements.
- New general-purpose computers from most manufactures incorporated all the hardware and much of the general software required by the instruments for their specific purposes.

History of Instrumentation systems

- The main advantages of standard personal computers are low price driven by the large market, availability, and standardization.
- Although computers' performance soon became high enough, computers were still not easy to use for experimentalists.
- Nearly all of the early instrument control programs were written in BASIC, because it had been the dominant language used with dedicated instrument controllers.

History of Instrumentation systems

- It required engineers to become programmers before becoming instrument users, so it was hard for them to exploit potential that computerized instrumentation could bring.
- An important milestone in the history of virtual instrumentation happened in 1986, when National Instruments introduced LabVIEW 1.0 on a PC platform.
- LabVIEW introduced graphical user interfaces and visual programming into computerized instrumentation, joining simplicity of a user interface operation with increased capabilities of computers.

History of Instrumentation systems

- Today, the PC is the platform on which most measurements are made, and the graphical user interface has made measurements user-friendlier.
- As a result, virtual instrumentation made possible decrease in price of an instrument. As the virtual instrument depends very little on dedicated hardware, a customer could now use his own computer, while an instrument manufactures could supply only what the user could not get in the general market.

History of Instrumentation systems

- The fourth phase became feasible with the development of local and global networks of general purpose computers.
- Since most instruments were already computerized, advances in telecommunications and network technologies made possible physical distribution of virtual instrument components into telemedical systems to provide medical information and services at a distance.
- Possible infrastructure for distributed virtual instrumentation includes the Internet, private networks, and cellular networks.

Virtual Instruments Versus Traditional Instruments

- Stand-alone traditional instruments such as oscilloscopes and waveform generators are very powerful, expensive, and designed to perform one or more specific tasks defined by the vendor.
- However, the user generally cannot extend or customize them.
- The knobs and buttons on the instrument, the built-in circuitry, and the functions available to the user, are all specific to the nature of the instrument.

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Virtual Instruments Versus Traditional Instruments

- Virtual instruments, by virtue of being PC-based, inherently take advantage of the benefits from the latest technology incorporated into off-the-shelf PCs.
- These advances in technology and performance, which are quickly closing the gap between standalone instruments and PCs, include powerful processors and operating systems and technologies.
- In addition to incorporating powerful features, these platforms also offer easy access to powerful tools such as the Internet.

Virtual Instruments Versus Traditional Instruments

Table 1.1. Traditional versus virtual instruments

Traditional instruments	Virtual instruments
Vendor-defined	User-defined
Function-specific, stand-alone with limited connectivity	Application-oriented system with connectivity to networks, peripherals, and applications
Hardware is the key	Software is the key
Expensive	Low-cost, reusable
Closed, fixed functionality	Open, flexible functionality leveraging off familiar computer technology
Slow turn on technology (5–10 year life cycle)	Fast turn on technology (1–2 year life cycle)
Minimal economics of scale	Maximum economics of scale
High development and maintenance costs	Software minimizes development and maintenance costs

Architecture of Virtual Instrumentation

- A virtual instrument is composed of the following blocks:

– Sensor module

– Sensor interface

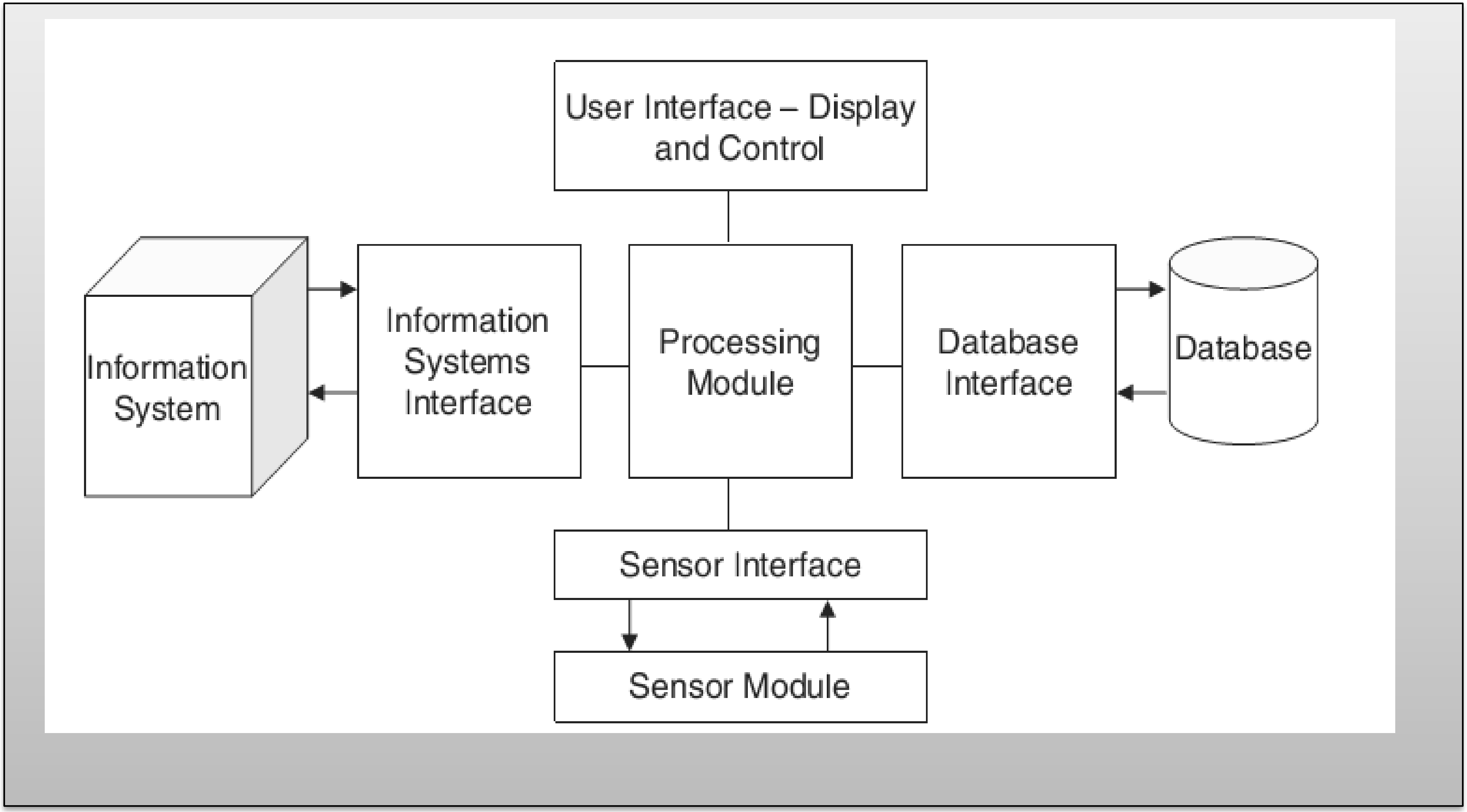
– Information systems interface

– Processing module

– Database interface

– User interface

Virtual Instruments Versus Traditional Instruments



Architecture of Virtual Instrumentation

- Sensor Module
- The sensor module performs signal conditioning and transforms it into a digital form for further manipulation.
- The sensor module interfaces a virtual instrument to the external, mostly analog world transforming measured signals into computer readable form.
- A sensor module principally consists of three main parts:

– The sensor

– The signal conditioning part

– The A/D converter

Architecture of Virtual Instrumentation

- Sensor Interface
- There are many interfaces used for communication between sensors modules and the computer.
- According to the type of connection, sensor interfaces can be classified as.

–Wired Interfaces

–Wireless Interfaces

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Architecture of Virtual Instrumentation

- Wired Interfaces are usually standard parallel interfaces, such as GPIB, Small Computer Systems Interface (SCSI), system buses (PCI eXtension for Instrumentation PXI or VME Extensions for Instrumentation (VXI), or serial buses (RS232 or USB interfaces).
- Wireless Interfaces are increasingly used because of convenience. Typical interfaces include 802.11 family of standards, Bluetooth, or GPRS/GSM interface.

Architecture of Virtual Instrumentation

- Processing Module
- Broadly speaking, processing function used in virtual instrumentation may be classified as analytic processing and artificial intelligence techniques.

–Analytic processing. Analytic functions define clear functional relations among input parameters. Such as spectral analysis, filtering, windowing, transforms, peak detection, or curve fitting. Most of those functions can nowadays be performed in real-time.

Architecture of Virtual Instrumentation

–Artificial intelligence techniques. Could be used to enhance and improve the efficiency, the capability, and the features of instrumentation.

- Artificial intelligence technologies, such as neural networks, fuzzy logic and expert systems, are applied in various applications
- Using artificial intelligence it is even possible to add medical intelligence to ordinary user interface devices. For example, several artificial intelligence techniques, such as pattern recognition and machine learning, were used in a software-based visual-field testing system

Architecture of Virtual Instrumentation

- Database Interface
- The eXtensible Markup Language (XML) may be used to solve interoperability problem by providing universal syntax.
- The XML is a standard for describing document structure and content. It organizes data using markup tags, creating self-describing documents, as tags describe the information it contains.
- Contemporary database management systems such SQL Server and Oracle support XML import and export of data.

Architecture of Virtual Instrumentation

- Many virtual instruments use DataBase Management Systems (DBMSs).
- They provide efficient management of data and standardized insertion, update, deletion, and selection.
- Most of these DBMSs provided Structured Query Language (SQL) interface, enabling transparent execution of the same programs over database from different vendors.
- Virtual instruments use these DMBSs using some of programming interfaces, such as ODBC, JDBC, ADO, and DAO.

Architecture of Virtual Instrumentation

- Information System Interface
- Virtual instruments are increasingly integrated with other medical information systems, such as hospital information systems.
- They can be used to create executive dashboards, supporting decision support, real time alerts, and predictive warnings.
- Some virtual interfaces toolkits provide mechanisms for customized components, such as ActiveX objects, that allow communication with other information system, hiding details of the communication from virtual interface code.

Architecture of Virtual Instrumentation

- Presentation and Control
- Since computer's user interfaces are much easier shaped and changed than conventional instrument's user interfaces, it is possible to employ more presentation effects and to customize the interface for each user.
- According to presentation and interaction capabilities, we can classify interfaces used in virtual instrumentation as:
  - Terminal user interfaces
  - Graphical user interfaces
  - Multimodal user interfaces and
  - Virtual and augmented reality interfaces