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## ***Integrating Computer and Technology Systems Networks in Industrial Technology Programs***

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# Integrating Computer and Technology Systems Networks in Industrial Technology Programs

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## Introduction

The next generation of networking systems will be powered by microscopic microchips. The chips will be invisible to the naked eyes, will have very low power ratings and will have astronomical speeds. These chips will constitute yet another technology revolution created by technology advancement of microprocessors. Such development will create more sophisticated and wide varieties of Electronic Control Units (ECU) and Intelligent Electronic Devices (IED) that will be used in both Computer Systems Network (CSN) and Technology Systems Network (TSN). These predictions gleaned by the author from annual state of business addresses given to employees by CEO's at Mettler Toledo (1994), CompuServe (1996) and Liebert Corporation (1998) can not be overemphasized. Judging from the past, it is only a matter of time before this seemingly emerging technology fiction will turn into technology facts. And the fact that these technology imaginations are not impractical dictates that industrial technology faculty explore different dimensions of networking systems in preparation for the challenges ahead.

## Networking Systems

Networking is the process of interconnecting computers and/or technology systems by means of electronic connection boxes and cabling or wireless systems to achieve electronic information transfer or control for various purposes. The process is carried out with the connectivity of discrete physical and wireless electronic

devices, components, and systems with mostly built in customized intelligence. The computers or equipment used in networking systems normally have micro-processor(s) or micro-controller(s) and a number of other active electronic control units such as ECU's or IED's. In many cases, the devices have specialized microchips designed to perform various functions and make systems compatible to each other. Modern networking systems use microprocessor based Direct Digital Control (DDC) sampling methods governed by layered protocols.

## Computer systems network

Computer Systems Network (CSN) involves interconnection of two or more computers for the purposes of sharing equipment such as printers, sharing files or information such as web pages or sites and passing messages such as emails. Applications include Local Area Network (LAN) and Wide Area Network (WAN) to which World Wide Web belongs. Inter networking of computers popularly known as internet is a big part of CSN. CSN is the area generally known as Information Technology (IT). Some industrial technology faculties have developed information technology based electronic networking courses.

## Technology systems network

Technology Systems Network (TSN) involves interconnection of computers and complex technical equipment or their sub-systems by means of cabling or wireless systems. Generally, the purposes of TSN focus on effective management, operation, monitoring

and control of simple and complex technical systems or sub-systems. The complexity of technical equipment is determined by the microprocessor or controllers used. These microprocessors or controllers may be found in portable gadgets such as those used in Private Area Network (PAN) or smart controllers such as those used in distributed processing. TSN is an area that involves some kinds of automatic control or automation and, therefore, should be of much interest to industrial technology educators.

Technology equipment used in networking are either in-band or out-band. In-band equipment is one equipped with or has provision for an adapter card or integrator that conforms to underlying protocol for the network system. Computer programs (software) can be used to change, alter or modify equipment functions by changing some instructions in the program without rewiring the equipment (Hardware). Out-band equipment does not have any interfacing device in the network but can be wired directly and controlled by the network system. Operation of some out-band equipment can be controlled by computer programs but must be rewired to change equipment function. This is often the case with an Heating Ventilation and Air Conditioning (HVAC) zoning system that is remotely controlled by a network of controller systems.

### Hybrid systems

In-depth integration of CSN and TSN results in hybrid systems. Hybrid applications provide much needed technology advantage to many complex activities and reduces human input in the operation, control and management of complex technology equipment. The increasing use of Programmable Logic Controllers (PLC's) and other automatic control machines in industrial networking systems make hybrid systems attractive to industrial technology laboratories.

### Network Layers and Configurations

CSN and TSN compare interestingly with each other in many aspects

including their system configurations. These configurations are important information in integrating networking systems in industrial technology laboratories. In essence, the industrial technology content areas in relation to network configurations should include network communication protocol layers, software, hardware, and media as they apply to both CSN and TSN. Each of these areas are briefly discussed below.

### Network communications protocol layers

The seven layers used as reference model are developed by the International Standards Organization and is often compared to TCP/IP four Layers. Another important layer is developed for LAN by the Institute of Electrical and Electronic Engineers (IEEE). For the purpose of this article, the relationships among these layers including the author's conjectured positions of CSN and TSN are shown in the table below. The table can also be used to illustrate other important relationships. For example, Manufacturing Automation Protocol (MAP) that uses token passing bus will be identified in a column under TSN while token passing ring used by IBM will be identified in a column under CSN

### Network programs (software)

In CSN, there is a proliferation of software for many different network applications. The available software for CSN is familiar to users of computer

network systems. Software for TSN is numerous and is available for various configurations, data acquisitions and analysis for technology management purposes. Most TSN software requires modular and DDC applications to control multiple applications and locations of hardware for improved productivity and quality management.

### Hardware configurations

The hardware for CSN are the main-frame, mini computers and personal computers or micro computers and peripherals. Interconnection of the above make up a computer systems network. Typical CSN topologies are Star, Token Ring, Bus, and Tree. The hardware for TSN are two or more physical complex technical equipment and sub-systems interconnected together. Examples of a typical TSN hardware are CPU, equipment, memory, controllers, indicators, programmers, recorders, peripherals, sensors, actuators, etc. Typical TSN topologies are Star Bus, Token bus, Serial bus, and Tree bus. With these configurations hardware products are interconnected as part of a Local Area Network (LAN) as shown below. The hardware for hybrid systems use combinations of CSN and TSN hardware as also shown below. The purpose of the computers and peripherals used determines if the application is a TSN or a hybrid system.

Examples of some Software and Hardware used for Honeywell's Plant

**Table of Comparison of Network Layers**  
(Note: Abbreviations used are explained on pages 7 and 8).

ISO-OSI	CSN	TCP/IP	TSN	IEEE
Application Presentation Session		Application		
Transport Network		TCP/UDP IP		
Data Link		Network		LLC MAC
Physical				Physical

Wide Local Area Network (PWLAN) are shown below.

**Communications media**

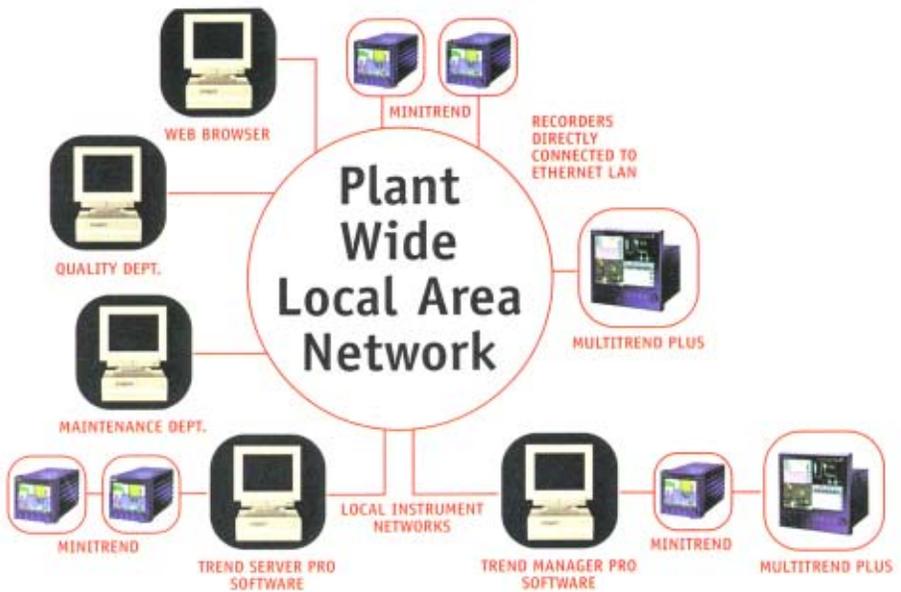
CSN and TSN use common media systems often attached to the various available adapter cards. Among the communications media are wires, cables and optical fibers. Wireless systems are also used for both CSN and TSN. The IEEE layers provide a good insight into the physical characteristics of hardware layers including software logical link or interface and media access. Media access deals with the two cable sharing methods known as Token Passing and CSMA/CD used in network systems.

**Establishing Network Courses and Projects**

Electronic networking has drawn the interest of almost all high-tech companies in North America. Therefore, integrating computer and technology systems networks will afford industrial technology educators the opportunity to establish needed relationships with business and industry and show the effectiveness of our flexible programs. It will help to create visibility and differentiate the capability of our graduates from other related disciplines such as engineering and management.

As previously stated, some industrial technology programs have incorporated electronic networking courses primarily focused on information technology. Such inclusion, without doubt, is an effort in the right direction. However, exclusion of TSN may inadvertently threaten the philosophy and mission of Industrial Technology. In fact, all Industrial Technology programs should design electronic networking courses to include TSN. This will enable Industrial Technology to embrace new technologies and maintain the identity professed in its philosophy and mission which purport to educate technical competent graduates who will manage complex technical systems. Since CSN (computers) and TSN (technical equipment other than computers) differ considerably in the opportunities they provide for industrial technology

*Fig 1. Honeywell's PWLAN that uses Ethernet TCP/IP Modbus protocol to allow various departments to access real-time data acquisition for improved technology management.*



*(Courtesy of Honeywell Automation and Control Solutions, Honeywell International, Inc.).*

graduates, we may as well integrate both in our programs.

**Technical and technology management content**

The developments in networking technology are favorable to industrial technology. This is true for both its technical and technology management content areas. The first three IEEE hardware layers involve electronic communication hardware and media which are natural technical content areas of Industrial Technology. A basic networking course for Industrial Technology students should not only incorporate networking configurations based on layered protocol standards but should also include concepts such as distributed processing and Direct Digital Control (DDC).

Industrial Technology has already successfully integrated many manufacturing and industrial automation courses into its programs. Among well developed programs that would easily be articulated with TSN are manufac-

turing automation areas which include Numerically Controlled Systems, Programmable Controller Systems, Robotics Systems, Material Handling Systems and Flexible Manufacturing Systems.

Other automation areas that would easily integrate in the Technology Systems Network or hybrid systems include Computers, PLC's, Home automation, Utility automation (power & telephone systems), HVAC systems, Facilities, and Uninterruptible Power Supply (UPS). Each of these areas not only provides opportunity for course content but also for class and research projects for students and faculty.

**Technology Management Applications**

Technology management is a new frontier which is presently being championed by Industrial Technology and few other related disciplines such as business and engineering. Our unique approach and leadership in technology management should not

only be strengthened but should also be expanded with every opportunity such as is presently being provided by networking systems.

Computer and Technology Systems Networks are useful in fostering technology management. Among the technology management applications are Computer Integrated Manufacturing (CIM), Energy Management Systems (EMS), Building Management Systems (BMS), Facilities Management Systems (FMS), Flexible Manufacturing Systems (FMS) and Plant Wide Local Area Network (PWLAN). These are concepts that naturally belong to core Industrial Technology programs. While CSN provides great opportunity for network management in Information Technology, TSN provides equally unique opportunity in industry-based network management. Thus, with CSN and TSN courses, Industrial Technology will produce the best networking administrators in business, industry, government and educational institutions.

### **Industrial Technology Class Projects**

Within Information Technology, software and hardware devices for CSN projects abound. However, in order for graduates of industrial technology to meet expectations of industries in networking tasks, it is important to supplement traditional laboratories with “design and build it yourself projects”. Such projects would simulate and emulate CSN, TSN and hybrid systems with simple, meaningful and familiar equipment such as an HVAC equipment.

Heating, ventilation and air conditioning (HVAC) systems especially use typical control loops that can be controlled, monitored and managed with computer workstations and window software. Many HVAC equipment, such as those used in EMS, BMS, FMS and PWLAN have net-

working capabilities to provide in-depth networking knowledge and skills for students. Further, a review of the technical content areas of university level HVAC programs or courses will show that TSN and HVAC systems use generic control systems. Thus, HVAC has great potential and versatility for networking class projects. Information on the type of devices suitable for class projects can be obtained from Johnson Control’s Metasys Facilitator website at [www.johnsoncontrols.com](http://www.johnsoncontrols.com) and Honeywell’s Automation and Control Solutions website at [www.honeywell.com/sensing](http://www.honeywell.com/sensing).

### **Summary**

Industrial technology educators are known to transform with time relative to technology development. With current and predicted future technology developments, Industrial technology will continue to serve as the agent for useful applications, effective management and thorough understanding of existing and emerging technologies. Networking is one of the areas that will be revolutionized by the predicted microscopic microchip and currently require our attention and input. The challenges that are occurring in the areas of computer and technology systems networks cannot be over emphasized. Doubtlessly, they pose numerous new challenges to the discipline that we must respond by expanding, updating and including network courses in all Industrial technology programs. By integrating Computer and Technology Systems Networks in industrial technology programs we would have appropriately positioned ourselves for the challenges ahead.

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### **Glossary of abbreviations**

ISO-OSI stand for International Standards Organization and Open Systems Interconnection. ISO teamed up with Consultative Committee on International Telephony and Telegraphy (CCITT) to develop OSI as the seven layer reference for data communication standards.

LLC: Logical Link Control Layer. This IEEE (Institute of Electrical and Electronic Engineers) layer is a software interface to lower adapter cards or hardware.

MAC: Media Access Control Layer. This IEEE layer defines hardware that arbitrates access to a shared cable.

MAP: Manufacturing Automation Protocol. This is one of the standard protocols used extensively in manufacturing. It uses token passing bus equivalent to IEEE 802.4 and ISO 8802/4 standards. This MAP differs from Novell’s MAP command

TCP/IP: Transmission Control Protocol and Internet Protocol. IP is the basic packaging mechanism while TCP is connection oriented and, therefore, adds reliability to the data. Generally, protocol suites show how data is packaged for transmission and the type of action that would be taken in the event data is lost

TCP/UDP: Transmission Control Protocol and User Datagram Protocol. UDP is connectionless.

TSN: Technology Systems Network. This is used to identify networks other than Information Technology.