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Progress of Smart Sensor and Smart Sensor Networks

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ABSTRACT
The fast advancement of industrial applications presents additional difficulties for conventional sensors that just provide unprocessed signals. Due to the benefits, they may provide to the system, smart sensors and smart sensor networks are becoming more and more popular in industrial settings. Sensor data will eventually be employed for control purposes, one way or another. Smart sensors and smart sensor networks will give a certain amount of information and knowledge in addition to raw signals and data, which may greatly increase the overall performance and decrease dependability of the control system. A short overview of smart sensors, smart sensor networks, and their advancements is provided in this study. A few noted problems are also emphasized. The authors think that to overcome such challenges and advance the development of smart sensors and smart sensor networks, researchers and developers from academic and industrial communities should and should collaborate by drawing people's attention to these concerns.
Keywords: Smart Sensor, Smart Sensor Network, Inference, Fieldbus, Standard.

I. INTRODUCTION

The sensor industry is very competitive and is predicted to reach $43 billion by 2008 [I]. The largest consumers of sensors are industries. The rapid advancement of IT technology has led to a significant transformation in industrial applications. For instance, more data is required to regulate the quality of the manufacturing process, lower the requirement for pointless maintenance, and enhance system functionality overall. Easy-to-use, increased connection, increased capacity for self-diagnosis, and other features are becoming more important to program users. Accurate and dependable sensor signals are essential to the system, but other value-added improvements, including lower setup and maintenance costs and increased system dependability, can also assist users succeed in more competitive markets. The market is always looking for appliances, systems, and gadgets that are easier to use, have more features, and are more capable. Enhanced built-in intelligence is a useful option for sensors, which are employed in these systems and devices to recognize control states or to offer information on the parameters being monitored [2].

A smart sensor is being developed to deal with all those issues. In the middle of the 1980s, the phrase "smart sensor" was first used in the sensor industry [3]. The development of this kind of "smart" sensing has been facilitated by three key developments: the decline in the cost of sensors, embedded microcontrollers, microprocessors, and analog-to-digital and digital-to-analog converters (ADCs and DACs); the spread of networking and diagnostic software; and the emergence of interface standards that streamline sensor networking. For more effective and adaptable operations, industry, the government, the military, and enterprises are turning to smart sensors and digital communications [4]. The advantages of "smart" sensors over conventional analogue sensors in terms of connection and ease of setup are shown in Fig. 1. Smart sensors and sensor integration have become more realistic due to technological advancements and market demand; in fact, they are a leading trend in industrial applications that is still growing.

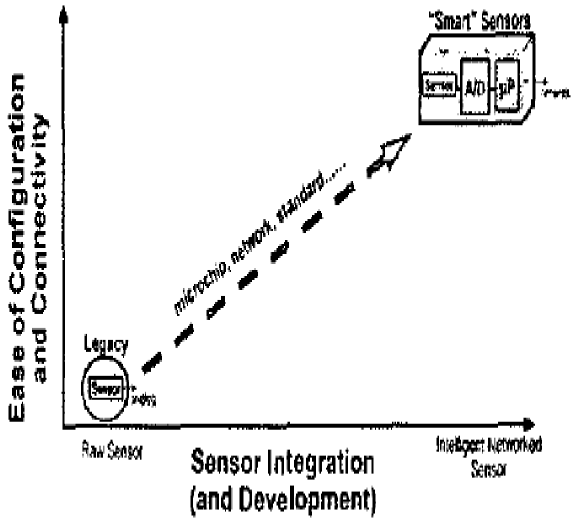

Figure No. 1: Smart Sensor Technology Evolutions

The most fundamental feature of smart sensors is their non-analog communication capacity. A smart sensor's communication interface is thus crucial. The following are the primary, though not exclusive, reasons why sensors and networks should be interfaced:

- Cost-saving measures include fewer wires, quicker startup times, and easier servicing, operation, and maintenance. The benefit is obvious: no more big, bulky cable bundles and the mess they cause.
- Robust remote monitoring: Remote monitoring may help with preventative maintenance and better asset management. Additionally, enterprise data may be incorporated to increase supervisory and administrative insights.
- Modularity: Software is used to connect modules together. It's far simpler to disassemble a big system, load it onto a truck, and put it back together someplace.
- Flexibility: The capacity to quickly modify sensors and sensor systems allows for the transmission of data to remote or challenging-to-reach areas and/or adaptation to various applications.
- Increased network capacity, remote and/or self-diagnosis, remote calibration, sensor parameter adjustment, and other functions may be added to smart sensors with this feature. More precise measurement and effective coding at greater data rates are also possible.

This article introduces smart sensors, smart sensor networks, and their advancements. The detected hues are indicated. The structure of the paper is as follows. Section II addresses smart sensors. The state and problems of the smart sensor networks of today were covered in Sections 111 and IV. Section V contains the conclusion.

II. SMART SENSOR

What further characteristics must a general dumb sensor have in order to qualify as smart? The term "smart sensor" has not yet been defined in a way that all parties can agree upon, and no formal definition has been issued by anybody that sets standards. Some people refer to devices with digital communication as "smart sensors," while others use the term to describe single-chip sensing systems. Some devices that don't execute actuation and control or that have calibrated output are excluded from this category [6]. A sensor "that provides functions beyond those necessary for generating a correct representation of a sensed or controlled quantity" is classified as a smart sensor by IEEE. This feature usually makes it easier to integrate the transducer into applications in a networked setting [7]. This criterion might serve as a basis for determining what a smart sensor's minimal content should be.

The combination of information processing, communication, and sensing technology—also referred to as the sensor, if you don't want to get confused—gives smart sensors their additional functions beyond just detecting raw data. The next paragraphs address two approaches to investigating the design and functionality of smart sensors, in that order.

From an architectural standpoint, the hasic architectural features seen in Fig. 2 [8] are included in most definitions of a smart sensor. There are seven main components to this architecture:

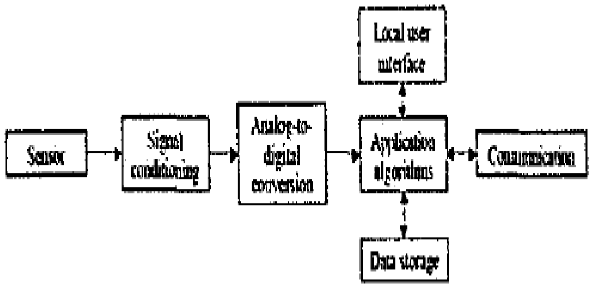

Figure No. 2: The Basic Architectural Elements of a Smart Sensor

- ***Sensor:*** An apparatus that transforms energy across different domains. The apparatus might be an actuator or a sensor.
- Circuitry that readies an electrical signal for conversion to the digital realm is known as signal conditioning. (Note that some sensors are inherently digital, such as basic presence detectors, limit switches, counters, etc.). To name a few, signal conditioning might include amplification, bandwidth limitation using anti-aliasing filters, conversion of one kind of electrical signal to another (such as current- or frequency-to-voltage), and more.
- An apparatus that transforms an analog input signal into a digital code that indicates the analog signal's magnitude is known as an analog-to-digital converter. In general, it is best to carry out this conversion as near to the measurement location as feasible.
- Applications include converting data to user-specified units, signal processing, data analysis and reduction, monitoring for alarm conditions, logging timestamped records to memory, executing local control loops, and other appropriately carried out close to the point of measurement. Application algorithms are software or hardware at the application level. Smart sensors get their "smartness" from these algorithms.
- ***Data storage:*** Digital data storage for user display choices, calibration data, time-stamped recorded data, sensor identification and configuration information, and anything else that is important to save in the sensor. The possibility exists that all or most of the sensor's documentation, such as setup instructions, user manuals, manufacturing and user histories, and memory and communication bandwidth may be kept in the device, so they won't be lost.
- ***User interface:*** A uniform way of presenting updated data to the user in their native language and terminology, together with the physical components unique to that program.
- ***Communication:*** An interface that connects to a communication channel to enable remote setup, calibration, diagnostics, data collection, and status monitoring of the sensor, among other functions. Communications may contain orders like "updating operation should be provided to support proper outputs and changing set points," etc. for smart actuators or systems with a combination of sensors and actuators.

From the standpoint of functionality, more capabilities are required. As technology advances, a multitude of benefits are available to convert a dumb sensor into a smart one. wise people are in the positive the authors' qualities list highlights the capabilities of smart sensors and highlights the significance and/or development of the smart sensors industry, drawing on our analysis. Here are a few advantages, to name a few:

- Twilight-time digital currency: This is, by far, the most important characteristic, as shown by almost all 191. Other crucial duties can only be accomplished when communication is provided. Remote calibration and setup is one of the main features. Scalable, re-configurable, re-arrangeable, calibrable, and downloadable with process loop variables are all requirements for smart sensors. Simple signal forms (such RS-232 or RS-485) or even more complex standard buses like HART, Profibus, or FF (Fieldbus Foundation) may be used to build this kind of communication. In some situations, a smart sensor can communicate in both directions in the factory; however, while it is in use, it only transmits data back for dependability purposes.
- Self-identification: The smart sensor must be aware of its identity and operational principles. It should share this knowledge with other components over a network. This is achieved by giving users the option to use a tiny amount of nonvolatile memory to include important sensor data and its performance in a defined format. In a setting with several vendors for sensor components, this functionality facilitates the automation of processes

related to diagnostics, setup, and identification. Furthermore, plug-and-play functionality will be possible if sensors are able to identify themselves and their capabilities to a system.

- Se/f-diagnosis: One of the fantastic things about smart sensors is that, in the event of a suspected issue, it may not be necessary to send a maintenance personnel out into a driving downpour in the middle of the night to examine an instrument on top of a distillation tower. Alternatively, an appropriate HMI display may always do a remote diagnostic by just calling it from the cozy control room. The smart sensor's self-diagnosis feature allows it to tell you if it's broken or if anything is about to go wrong. This kind of diagnostic includes the meter body, wiring, electronics, loop power supply, and sensing device. [9]
- More powerfir1 duta processing: More and more modern sensors are being equipped with low-cost, tiny microprocessors. Strong measurement and computation capabilities might provide sensors sophisticated algorithms—such as auto-calibration, self-correction, compensation, and other functions—to convert raw data into information and eventually knowledge. Furthermore, it is necessary to offer triggering, status, control, and matching data operation to enable the sensors' correct outputs, altering set points, and other functionalities.

Sensor manufacturers are under pressure to use new technologies in the competitive market of today to provide affordable smart sensors that can fulfill the ongoing demand for a wide range of sensor applications. One area of ongoing research and application for smart sensors is networking and system integration. Considering this, the networked smart sensor and sensor tildbus technologies will be covered in the next sections. The North American Smart Sensors Market Study by Frost & Sullivan states that sales in 1998 were $259.5 million, growing at a rate of 4.0%. By 2001, revenues were predicted to reach $287.9 million, as shown in Fig. 3, at a compound growth rate of 3.8% [IO].

This percentage was also present in 1998. HART was developed by many companies during the last ten years. Protocol A. Sensor Network Using Fieldbus Technology Currently, there are several, generally incompatible fieldbus technologies being developed and marketed for smart sensor networking. Technological advancements in the fields of computers, communications, and sensing have fueled the growth of sensor networks. These networks' expansion has quickened in response to the need for enterprise-wide information sharing and the use of sensors in a greater variety of applications.

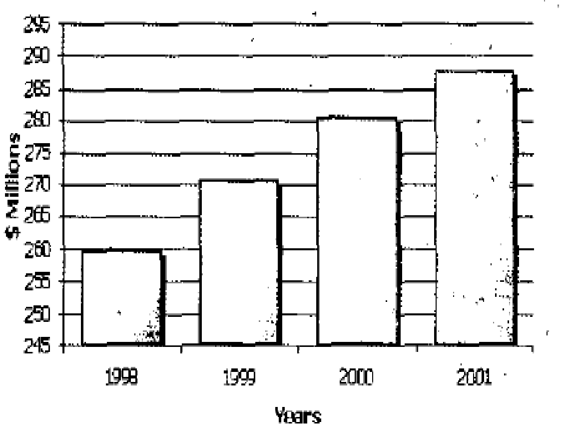

Figure No. 3: Total Smart Sensor Market in North America.

Many application industries are already beginning to integrate smart sensors into their systems. Smart sensors are becoming the go-to tools for a variety of sectors, including industrial control, automotive, and consumer electronics. As previously said, engineers and plant managers find these sensors to be very appealing due to their high degree of dependability and self-diagnosis. The percentage of sales for some of the most promising end-user groups in the North American smart sensor industry is shown in Table I. As of 2000, the process control sector had 22.2% of the global smart sensor market, making it the biggest end-user group.

Three distinct generations have emerged when these technologies are integrated into sensor networks, as seen in Fig. 4 [12]. We talk about the development below.
compatible electronics. These gadgets provide a strong link between the digital and analog worlds. In a nutshell, the most widely used communication protocol for smart process instrumentation now is the HART protocol. Future growth in the smart sensor market is anticipated to be aided by the end-user industries' fast expansion, which includes the automotive, electrical, HVAC, and process control sectors.

Year	P.C. (%)	P.G. (%)	T&M (%)	HVAC (%)	Elect. (%)	Auto (%)
1997	22.6	19.7	15.5	8.3	5.6	4.3
1998	22.2	19.4	15.3	8.4	5.9	4.1
1999	21.8	19.5	15.1	8.5	6.2	4.2
2000	22.2	19.5	15.1	8.6	5.5	4.4

Key:

P.C. = Process Control

P.G. = Power Generation

T&M = Test & Measurement

HVAC = Heating, Ventilating and Air Conditioning

Elect. = Electronics

Auto = Automotive

Table No. 1: Revenuer by End user in North America, 1997-2000

III. SMART SENSOR NETWORK

As early proponents have said, smart sensor devices may not be the answer to problems (more on this in the section that follows). Other technologies, including smart sensor interfaces, can provide crucial resources to improve the efficiency of industrial processes and the integration of manufacturing activities with the rest of the company [I I]. Smart sensor networks are quickly taking the lead, especially in industrial settings where many outdated and, as some could say, "dumb" sensors are common. In this case, industry seeks to take advantage of the operational cost and efficiency advantages that come from networking its sensors to increase system intelligence on a bigger scale.

3.1: Networked Sensor Based on Fieldbus Technology

Currently, there are several, generally incompatible fieldbus technologies being developed and marketed for smart sensor networking. Technological advancements in the fields of computers, communications, and sensing have fueled the growth of sensor networks. These networks' expansion has quickened in response to the need for enterprise-wide information sharing and the use of sensors in a greater variety of applications. Three distinct generations have emerged when these technologies are integrated into sensor networks, as seen in Fig. 4 [12]. We talk about the development below.

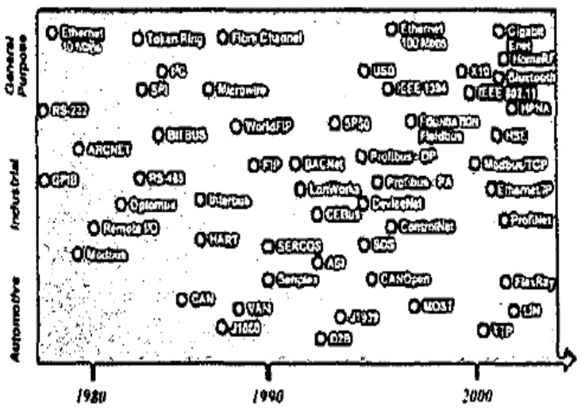

Figure No. 4: Chronology of key sensor networks

- Going straight to the source: Sensor network technology was initially developed as point-to-point. Sensors and actuators can receive and transmit sensing and control information thanks to interface standards like current loops and the I-5V signal. The analog signal from the sensors and/or actuators offers a single measurement dimension.
- From network to direct link: The advancement of microprocessor technology, which made it possible to combine computational power with unprocessed sensors, led to the creation of the second generation of sensor networking technology.

The node's increased intelligence highlighted the fact that communication was starting to get congested. The emergence of digital standards like RS-232, RS-422, and RS-485 prompted the development of several straightforward sensor networking systems. Even now, many of them—like Modbus—are still in frequent usage.

- From basic nehvork to intricate system: The advancement of Manufacturing Automation Protocol (MAP) technology led to the creation of the third and current generation of sensor networking technology. The goal of MAP is to lower the cost of combining several networking systems into a system that spans the whole plan. The Manufacturing Messaging Specification (MMS) was created, therefore.

In keeping with network advancements, there are over 60 distinct sensor network protocols designed for a wide range of sectors, each offering a different level of functionality and performance to meet specific needs. Popular sensor buses or networks that are now in use were listed by the authors:

- A group of sensor providers in Germany created the "Actuator Sensor Interface," or ASI. a low-cost, bit-level system that can operate up to 100 meters away from binary devices in a master-slave configuration and manage four hits per message. It is primarily intended for use in process control and industrial automation environments.
- Rosemount Inc. is pushing a network called HART, or "Highway Addressable Remote Transducer," which offers 1200 bps of two-way digital communication across conventional 4mA–20mA loops. It is ideal for continuous and hatch control applications as it uses a continuous analog signal as the main process signal. HART is a simple yet efficient option for a lot of users who have outdated control systems and find it difficult to justify comprehensive retrofits or migrations to more recent all-digital technology. It remains well-liked in the market for sensor networks.
- FF, or "Foundation Fieldbus," was created by combining WorldFlP and Profibus supporters' specifications to test and showcase fieldbus components in preparation for the future creation of a single, global fieldbus standard. However, even though FF technology has been around for around five years, there are now just 250,000 FF-enabled instruments in circulation. FF's technology still must show enough promise to win over more users.
- Siemens provided significant assistance for the German development of Profbus, often known as "Process Field Bus." German DIN Standard 19245 is what it is. There are four components to it. Parts 1 and 2 address general automation applications and are intended as Profibus-FMS. A quicker system for industrial automation applications is Profibus-DP, which is part of Part 3. The fourth part, Profibus-PA, is ready for use in process control applications.
- Control Area Network, or CAN Bus, was created in Germany in the early 1980s by Robert Bosch GmhH in collaboration with Intel and Philips for use in automotive in-vehicle networking. It supports twisted pair, fiber, coax, and radio frequency (RF) media and has a selectable baud rate of up to 1 Mbps. I S 0 Standard 1 1898, or CAN, has been certified for use in passenger vehicle applications. The SAE authorized CAN-based systems as Standard 11939 for trucks and big vehicles and Standard J 1850 for American passenger automobiles.
- DeviceNet: An Allen-Bradley application protocol that was created on top of CAN. It is mostly utilized in industrial control systems and uses object-oriented software. Using a 4-wire shielded cable (signal and power pairs), it can handle up to 64 nodes per network segment at up to 5OOKbps at LOOM or 125Khps at 500111 speeds. There is now an Open DeviceNet Vendors Association (ODVA).
- Industrial Ethernet: In the twenty-first century, the term "Industrial Ethernet" has come to represent innovative industrial networking. TCPfiP is being used by several industrial fieldbus providers to encapsulate current protocols. Now, there are four main competitors: Foundation Fieldbus High-speed Ethernet, EtherNeaP (the ControlNet and DeviceNet objects on TCPiIP), ProfiNet (Profibus on Ethernet), and ModbusfKP (the Modbus protocol on TCPIIP).

The instrumentation protocols have become industry standards for establishing connections between Ethemet and sensors, as well as discrete and analog I/O and smart devices. According to an ARC Advisory Group assessment, in the next two to three years, there will be an 84% rise in the usage of Ethemet in these applications. The survey also found that between 2000 and 2002, there was a 54% increase in the usage of Ethernet in manufacturing floor IiO. Ethernet will inevitably make its way to the factory floor even though there are still some issues that need to be resolved before it can become a practical, widely used, and plant-floor fieldbus. This is because Ethemet provides far more bandwidth than proprietary I/O networks like DeviceNet and Profibus, as well as greater communication connectivity between manufacturing operations and front offices, which have been using Ethemet for many years [14].

IV. EFFORT TO STANDARDIZE THE FIELDBUS

An international standard should be followed by a smart sensor interface. Real-time communication standards have long been desired, but manufacturers' resistance to supporting a single, widely accepted standard has hindered attempts to reach an agreement since they fear losing some of their competitive advantages. Additionally, providers wish to make minor changes to their proprietary standards to portray them as "open". This simply leads to several standards that are not "inter-operable" with one another and have unique properties. Committee discussions on the industrial automation network standard have lasted for a very long period. A few of the current suggestions have been merged and made more uniform.

- The Fieldbus Foundation (FF) was established in 1994 by the merger of two sizable competing fieldbus organizations, the Interoperable Systems Project (backed by Fisher-Rosemount, Siemens, Yokogawa, and others) and the WorldFIP (backed by Honeywell, Bailey, and others). In collaboration with the Instrumentation Society of America (ISA) and the International Electrotechnical Commission (IEC), the FF aims to create a single, interoperable fieldbus standard.
- The IEC61158 standard was developed by the IEC. Its foundation is made up of eight current fieldbus solutions. After several disputes, the IEC fieldbus draft standard was not approved in the final approval vote. The main drawback of the IEC61158 is that it is not really an "open" standard, since it maintains eight distinct solutions.
- Committees from the IEC and the ISA, which created the SP50 standard, collaborated to enable the creation of an integrated standard. The 4-20 mA standard was first established in the 1970s by the same committee, ISA SP50.

But so far, their attempts to harmonize various fielbus practices have not produced the desired results. End consumers are still confused; they are either forced to utilize one of the several, passably decent proprietary "open" networks or wait for the standard that never materializes.

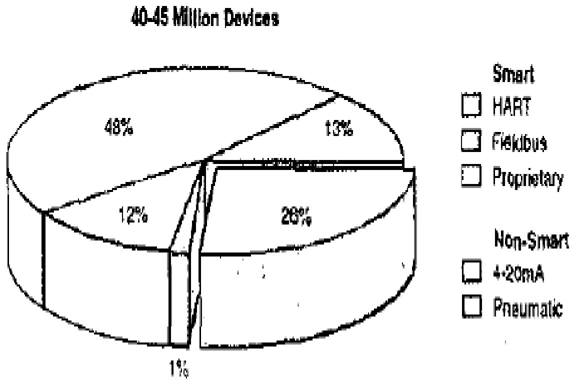

Figure No. 5: Worldwide inslalled base sensor distribution

This indicates that smart sensor technology is still in its infancy and lists the barriers to the growth of the smart sensors industry in North America from 2001 to 2007.

The fragmented structure of the fieldbus industry and transducer manufacturers' refusal or incapacity to support all already in use networks are two contributing factors. There are several fieldbus or sensor network implementations available, each having advantages and disadvantages unique to a particular application class. For sensor manufacturers and integrators, connecting sensors to all these control networks presents a significant difficulty due to the absence of an established standard interface for smart sensor networking. For manufacturers and system integrators, supporting the vast array of communications protocols is an important and expensive undertaking.

Furthermore, since specialist components are included in the creation of smart sensors, their present cost is double that of standard analog sensors. Even with the additional advantages of smart sensors, end customers won't be willing to employ them until costs fall. Many manufacturers lack the infrastructure necessary to switch to more digital technology right once, and their products also often don't work with the wiring and process control systems already in place in their plants. Manufacturers need to create the right items in accordance with market drivers to grow their client base and get a larger market share.

Industry efforts lately have been concentrated on defining, implementing, and standardizing communication protocols for smart sensors. Interoperability across a broad spectrum of applications is the aim. a practical and humble method of bringing people together. The IEEE 1451 Committee is driving the adoption of interface standards, which is where these divergent viewpoints come from [15]. The Committee works to reorganize the disorganized field of smart sensing. It is necessary to monitor the development of this standard.

V. CONCLUSION

In industrial applications, smart sensor and matt sensor networks are starting to gain traction. The fast advancement of information technology combined with the ongoing reduction in the cost of electronics hardware will eventually remove obstacles related to technology and implementation. Advances in sensor intelligence and communication will assist users and applications alike in several ways, including overall system dependability, auto re-range, remote diagnostics, and more. Researchers and developers from academia and business may and should collaborate to address present problems and further this kind of development.

REFERENCE

[1]. Amos, Kenna. "Sensor Market Goes Global," Intech -The international Journal for Measurement and Control, pp 40-43, June 1999

[2]. Thurston Brook, Steven Chen and Kang Lee. IEEE14SI smart wireless machinery monitoring and control for naval vessels. Thineenth international Ship Control System Symposium in Orlando, Florida. 2003

[3]. Randy Frank. Undentanding Sman sensors (second edition). Anech House, Boston. London. 2000

[4]. Roger Allan, Industry-Aligning Standards Boos1 Sensor Networking, Electronic Design, ED Online ID#3041, March 3,2003

[5]. 1EEE1451 committee. IEEE Standard 1451.2-1997, Standard for a Smart Transducer Interface for Sensors and Actuators ~ Transducer to Microprocessor Communicarion Protocols and Transducer Electronic Data Sheet (TEDS)", Institute af Electrical and Electronics Engineen, Inc., Piscaraway, New Jeney 08855, September 26,1997

[6]. Roben N. Johnson and Stan P.Wood . Proposed Enhancement to the IEEE1451.2 Standard for Smart Transducers. Srnsan magazine, Sep. 2001

[7]. Danicla L. Carrillo. Microcontrollen Enhancing the Intelligence Superiority of Digital Sensors. https: iiwwfmt.cod, 2002

[8]. James Wiezrr. Connectivity: smart sensors or sman interfaces. ISA 2001 emerging technologies conference, Sept 10-13. 2001

[9]. Jay Warrior, Smart Sensor Nehvorkr of the Future, Sensors Magzine. March I997

[10]. Roben Johnson. Building Plug-and-Play Networked Sman Transducers. Sensor's magazine, Oct. 1997

[11]. Perry Sink. A comprehensive guide to industrial nctnork (punlJ. Sensor's magazine, June. 2001

[12]. Kang Lee, UML Model for the IEEE 1451.1 Standard, Instrumentation and Measurement Technology Conference, May 20-22.2003

[13]. KangB. Lee (1999J.Asynopsisofthe lEEEPI45I-standardsforsman transducer communication. National Institute of Standards and Technology

[14]. NI, Plug and Play Sensor Forum, Sept.25,2002

[15]. Mark Clarkon. Sman sensors. Senson magazine, May. I999