UNIT 5

Syllabus

Concept of sustainability and united nations sustainable development goals (SDGs)

Application of sensor networks in smart agriculture: Introduction, Smart agriculture, objectives, role of wireless sensors in smart agriculture, classification of WSN, sensor market, application of WSN in smart agriculture, Challenges (chapter 1: section 1.1, 1.2, 1.3 and 1.4)

Energy sustainability in buildings (section 6.1 and 6.2 to 6.4), WSN-BASED PERSONAL LIGHTING MANAGEMENT (section 7.6)

Sensor networks in health care Chapter 10 (10.1 to 10.2)

Sustainability

The term ***sustainable development*** aims toward allowing human progress and the development of society to meet human needs, both in present times and for generations to come, while at the same time ensuring the sustainability of the environment and of natural resources.

OR

Meeting the needs of the present without diminishing the ability of future generations to meet their needs. Sustainability also means that human practices **do not result in the permanent damage** (minimize the damage), alteration or depletion of the environment, ecosystems, species or natural resources.

https://youtu.be/0XTBYMfZyrM

The Sustainable Development Goals (17)

1. No Poverty
2. Zero Hunger
3. Good Health & Well being
4. Quality Education
5. Gender Equality
6. Clean water and Sanitization
7. Affordable and Clean Technology
8. Decent work and economic growth
9. Industry Innovation and Infrastructure
10. Reduced Inequalities
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13. Climate action
14. Life below water
15. Life on Land
16. Peace, Justice and Strong Institutions
17. Partnership for the Goals

What is SAMRT AGRICULTURE?

INTRODUCTION: The world population is likely to **double by 2050**; it is estimated that by 2050, the current world population is likely to grow from 6.7 to 9 billion, with most of the increase occurring in sub-Saharan Africa and South Asia. It is projected that feeding the world in 2050 will require a 70% increase in total agricultural production

Neither the area under cultivation nor the availability of water is likely to double to meet the challenge. There are other challenges too, such as reduction in the number of farms and in the number of agriculture workforce. Climate change is expected to further worsen the existing situation. Therefore, in order for humanity to survive, agriculture has to become smart—one way is by **integrating Wireless Sensor Networks (WSNs) in different types of traditional agriculture** and that too at different levels. In this chapter, we will discuss different types of sensors, their market and different types of WSNs with their application in smart

Wireless Sensor nodes (WSN) are **small electronic sub-systems capable of sensing many types of information from their surroundings**, including temperature, light, humidity, radiation, the presence or nature of biological organisms, geological features, seismic vibrations, specific types of computer data, and more.

Sensor nodes are usually very small and are capable of **gathering, processing, and communicating information to other nodes** and to the outside world. Based on the information-handling capabilities and compact size of the sensor nodes, **sensor networks are often referred to as *smart dust*** as they may have the capabilities of adaptation, self-awareness, and self-organization.

What is WSN ?

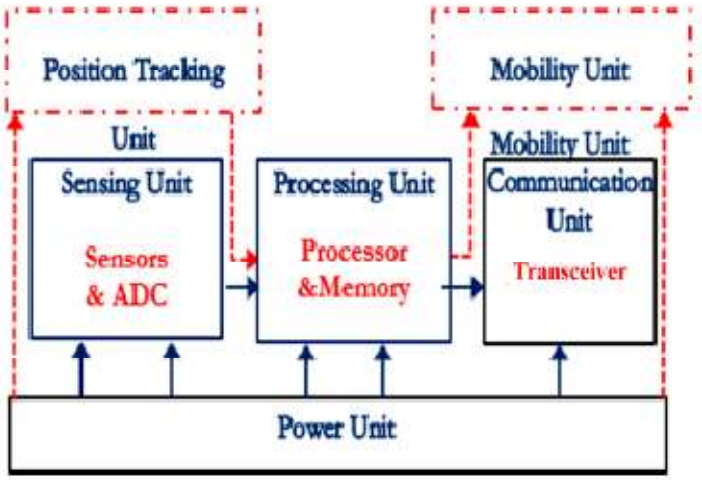


Figure 1. The typical architecture of a sensor node used in Wireless Sensor Networks (WSNs).

WSN also called Mote: **Electronic device** which consists of a processor along with a storage unit, a transceiver module, a single sensor or multiple sensors, along with an analog-to-digital converter (ADC), and a power source, which normally is a battery. It may optionally include a positioning unit and/or a mobilization unit.

The objectives of smart agriculture are as follows

1. Using a combination of sensors such as temperature, light, and humidity, so as to spot the risk of frost, possible plant diseases and establish watering requirements based on soil dampness.
2. Manage cultivation of crop and to monitor the exact conditions in which the plants are growing from the comfort of your own home.
3. Control conditions in green houses, nurseries, and closely monitor performance of sensitive crops, such as vines or tropical fruit, where the smallest amount of change in climate can affect the final outcome.
4. Determine the best conditions for each crop, by comparing the data obtained during the best harvests.

Why smart Agriculture ???

1. Labor shortage (In numbers and also in skill)
2. Climate change: Because of climate change , long term changes in the patterns of temperature and precipitations are expected. These changes are likely to shift production seasons, patterns of pests, and diseases. These changes will subsequently alter the set of practicable crops affecting production, prices, incomes, and eventually, livelihoods and lives.
3. Between now and 2050, **agriculture has to convert much less territory**, **increase yields on existing farms** and prairies and use water and other resources more effectively. **Fertilizers and pesticides have to be used in a way so as to minimize pollution.**

Farming has traditionally been a labor-intensive human activity, which involves tending plants and animals on an almost discrete basis. However, after the industrial revolution, modern agriculture became mechanized and automated. This has resulted in large farms per farmer and the subsequent disappearance of small farms. For example, in the United Kingdom, 200,000 farms vanished between 1966 and 1995, and 17,000 farmers and farmworkers abandoned farming in 2003.

Furthermore, the global demographic shift in farm labor and reduced employment of young workers has created an aging farming population and an imminent labour shortage.

Agricultural production is also threatened by climate change. Climate change is expected to reduce yields to even lower levels and make it even more erratic. Because of climate change, long-term changes in the patterns of temperature and precipitation are expected. These changes are likely to shift production seasons, patterns of pests, and diseases. These changes will subsequently alter the set of practicable crops affecting production, prices, incomes, and eventually, livelihoods and lives.

Advantages of WSN

- low power consumption,
- cost-effectiveness,
- easy installation, and
- small footprint.

Wireless sensors can be deployed **almost anyplace** (including underwater and underground) and that too at a far lower cost as compared to a wired system. Developments in wireless technology and embedded systems, the cost of hardware used in WSN has not only reduced, but has also become widely available. These devices also comply with industry standards such as the IEEE 802.15.4 for radio communication hardware and the emerging ZigBee

All this has to be done while adjusting to the shifting weather patterns and a more erratic climate. Clearly this strengthening of agriculture has to be sustainable.

Therefore, **agriculture has to become smart** in order to cope with these challenges, for example, by sensor-based greenhouse cultivation, precision agriculture

1.1.3 Why WSN ??

Wireless Sensor Networks (WSNs) are among the 10 emerging technologies that will change the world. WSNs are being used in varied and important applications such as military, agriculture, healthcare, and industrial process monitoring.

WSN is an intelligent private network consisting of a large number of sensor nodes having explicit functions. Wireless transmission allows the placement of sensors at far-flung, dangerous, and tough environments

Why SENSORS/Role of WSN in smart agriculture ??

One of the major challenges of agriculture is field data collection and consequent action. Significant time and effort is involved in data collection from a large field or plantation.

For example, to analyze soil, along with the environment temperature, humidity and other field parameters also need to be recorded. Depending on the nature of crop, field trips could be required every day, or in some cases, several times per day in order to collect samples or perform site monitoring. This is not only time consuming, but also requires trained manpower, resulting in a corresponding increase in expenses. Sensors are therefore a solution of choice for agriculture data collection and

Types of Sensor Networks/Classification of WSN

From the Analysis of different WSN around the world, FIVE Types of WSN are in use

1 ESN-Environmental Sensor Networks : Used in Static Harsh environments

Environmental sensor networks (ESNs) are the forerunners of WSNs. Usually, environmental sensor networks have been exclusively deployed for data collection and monitoring. Environmental sensor networks are often static, non-dense, large scale, and are deployed in harsh and unsupervised settings. ESNs are subject to harsh environmental elements that cause swift device and sensor failure. *A recent example of ESN is monitoring of dangerous gases in manure storage facilities*

2. BSN Body sensor networks (BSN): Human body (Body area network)

Body Sensor Networks (BSNs) usually consist of very few wireless sensor nodes attached to a living body unified with one or more powerful personal device.(e.g., smart phone).

A recent example of BSNs is body temperature monitoring of farm workers to prevent thermal exhaustion

3. Structure Sensor Network (SSN): Industrial Locations

Structure sensor networks (SSNs) consist of medium to large number of wireless nodes usually installed in specific sites such as industrial locations or attached to structures (e.g., bridges) or buildings (e.g., office) or infrastructure (e.g., rails). As compared to **ESNs, which are almost always deployed outdoors**, SSNs may be installed both indoors and outdoors and can combine several environments simultaneously, including restricting access to buildings.

4. Transport and Logistics Sensor Network (TSN): Transport vehicles

Recently numerous efforts have been focused toward wireless communication and networking between transportation vehicles such as cars, trucks, and trains. This has resulted in the development of a number of communication standards for vehicle to vehicle communication

A recent example of TSN is food tagging by FoodLogiQ (www.foodlogiq.com) whereby the produce is tagged and tracked from growers to the retail outlet

5. Participatory Sensor Networks (Machine 2 Machine) : In its most basic form, M2M (Machine to Machine) involves devices that communicate independently, that is, without human intervention. Under M2M everyday objects are locatable, addressable, recognizable, readable, and **controllable through the Internet** (Ward 2012). In fact, M2M is now synonymous with the ***Internet of things*** (Anonymous 2010).

Ex: Animals [zebraNet] Zebras are tagged with M2M zebra net for monitoring their activities

Comparison of WSN sensor types

TABLE 1.1

Comparison between Different Sensor Network Types

	Covered Area			Lifetime		Mobility		Density	
	Large	Medium	Small	Long	Short	Mobile	Static	Low	High
1. ESN	✓			✓			✓	✓	
2. BSN			✓		✓	✓		✓	
3. SSN	✓	✓	✓	✓			✓		✓
4. TSN	✓	✓			✓	✓	✓		✓

1.4 Applications of sensor networks in smart agriculture

Established Applications

- Precession Farming and Green house

Upcoming applications

- Cattle-net
- Food quality monitoring/tagging
- Agriculture worker safety

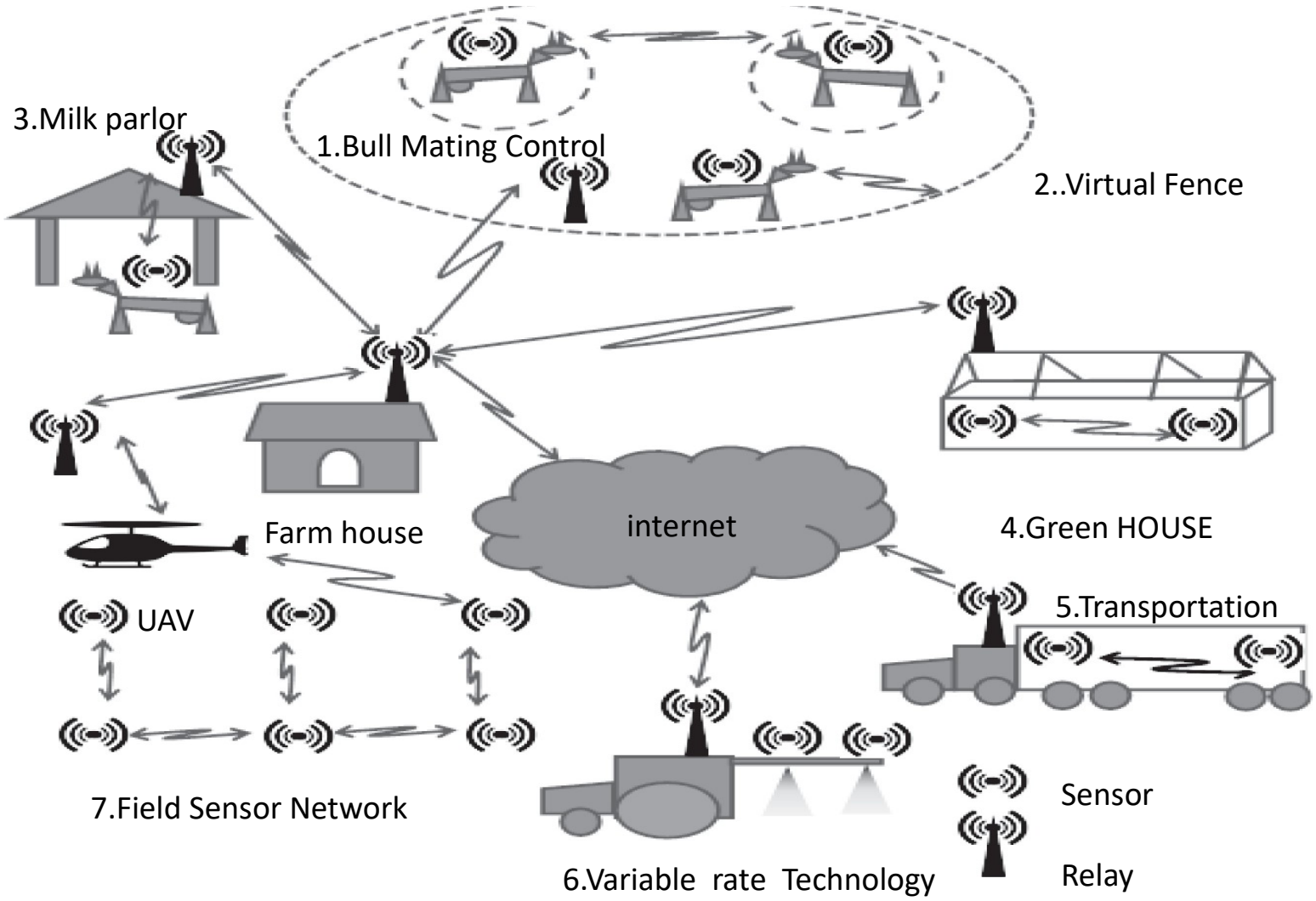


Figure 1.6 shows **a smart farm** with multiple nested levels of WSN consisting of the **relay nodes and the sensor nodes**

Relay nodes are used to expand the WSN coverage throughout the smart farm.

The first level consists of the *wireless cloud* that connects broadband Internet to the farm along with connectivity with far-flung TSN.

The second level of network is the **farm-wide WSN with both monitoring and actuation nodes.**

The third level of nested network is a **WSN at the field level** where it is used to monitor the field parameters.

The fourth nested level is the PSN (participatory sensor network) or M2M between the cattle being reared on the farm/ranch.

The fifth level is the hovering UAV (Unmanned Aerial Vehicle), which is a mobile wireless node;

UAV is used to collect data from the sensors while it passes over them and subsequently transmits it to the farmhouse.

The sixth and possibly the last level is the agriculture worker net without a relay node.

Sensor Market

The global environmental sensor and monitoring market was grown exponentially over the last decade (Anonymous 2013), and in 2010, it was valued at US$11.1 billion. This market is expected to reach US$15.3 billion in 2016, that is, a compound annual growth rate of 6.5% between 2011 and 2016. The market for the terrestrial category is expected to increase at a 5.3% compound annual growth rate to reach US$3.7 billion in 2016.

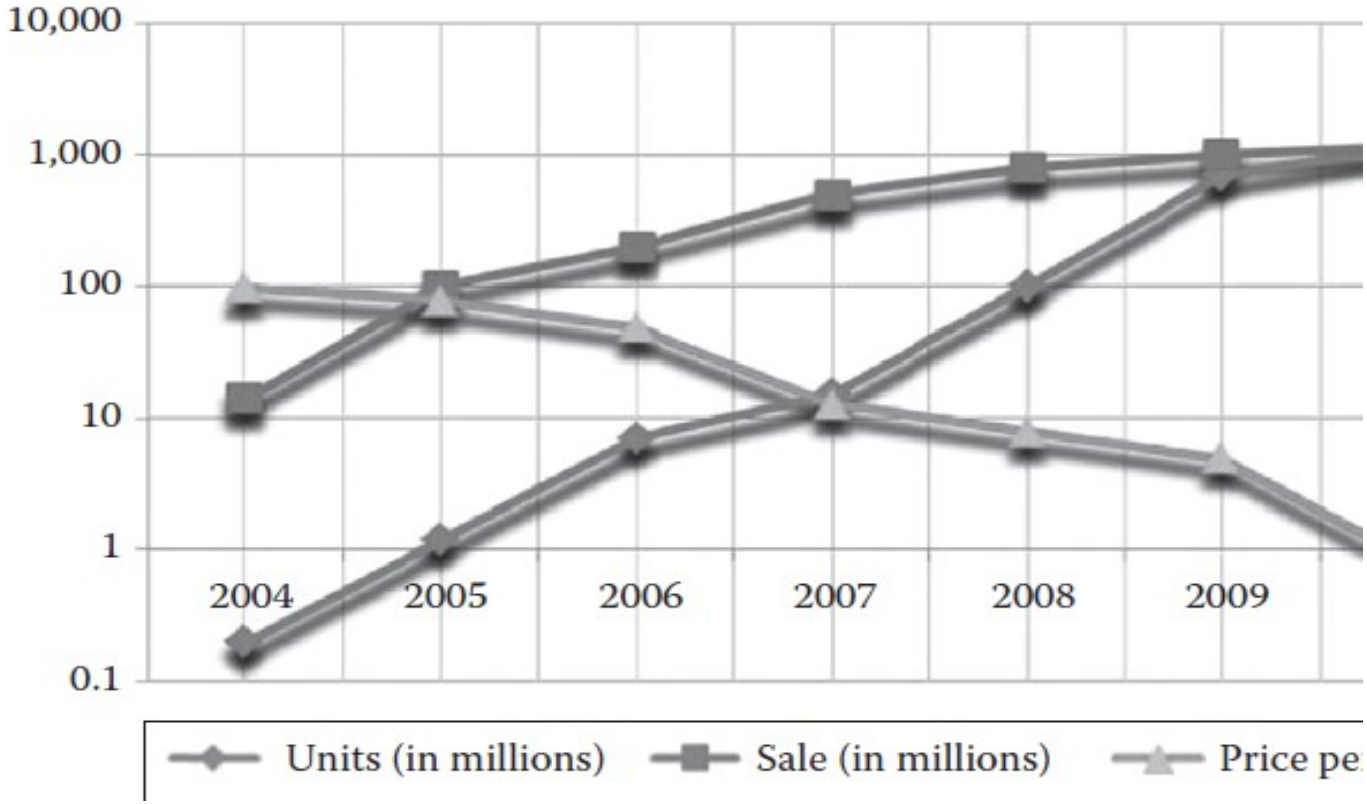


Figure 1.5 shows the adoption of WSNs. As the cost of producing WSNs is dropping, their sales are on the rise. This industry trend is expected to continue as the new technology matures and sensor applications grow.

ENERGY

6.1 INTRODUCTION

The issue of energy efficiency is now a days raising the interest of researchers and developers all over the world, due to the ever increasing awareness about the economic and environmental costs of a misuse of available resources. The attention devoted to the development of models for sustainable global energy consumption stimulates the adoption of suitable policies for cutting unnecessary energy consumption; however, in order to effectively enforce such policies, it is necessary to properly characterize energy consumptions so as to identify the main causes of wastes. Specialized studies show that a relevant fraction of worldwide energy consumption is tightly related to indoor systems for residential, commercial, public, and industrial premises.

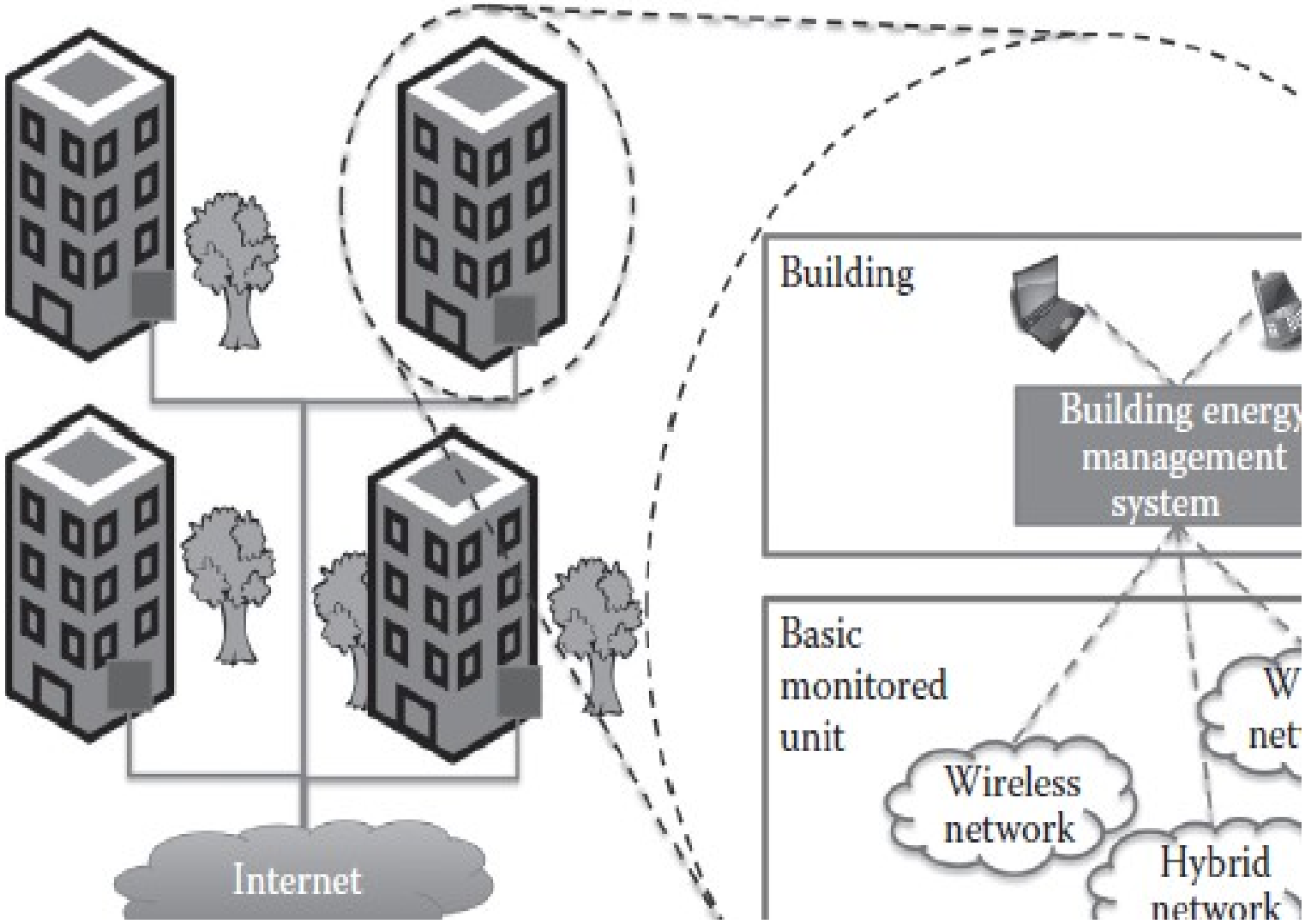
Building energy management System (BEMS)

Assumption that the environment is permeated (filled) by a large set of sensory and actuator devices and remotely controllable according to some defined policy, in order to bring the environmental conditions closer to the user's desires while also taking into account some globally defined constraints.

Such networks (WSN) do not only passively monitor the environment, but represent the tool by means of which the system interacts with the surrounding world and modifies the environment according to the observed data in order to meet high-level goals (e.g., energy efficiency).

BEMS will chiefly focus on the sensory infrastructure for the specific purpose of energy consumption monitoring in buildings, without neglecting its potential use in the context of an overall, complex system.

BEMS has specialized technologies used for the construction of efficient buildings but also the overall information and communication technology (ICT) control architecture. **A tight correlation exists among the chosen technology, the architectural paradigm, and the energy-saving policies.** Indeed, the choice over the available technologies and the architectural paradigm represents a constraint over the viable energy saving policies; on the other hand, the complexity of such policies is dictated by the corresponding complexity of the sensory and actuator infrastructure for energy monitoring system.


Building
Building energy management system
Basic monitored unit
Wireless network
Hybrid network
Internet

6.2 TOWARDS ECO-SUSTAINABILITY IN BUILDINGS

Four approaches for optimizing the energy/reducing the energy consumption in buildings

- user's awareness about energy consumptions,
- reduction of standby consumptions,
- scheduling of flexible tasks, and
- adaptive control of electrical equipment.

User feedback on Energy consumption

The simplest approach to **energy efficiency consists in providing appropriate feedbacks about energy consumptions to users so** as to increase their awareness and encourage eco-friendly behaviors. User awareness has been leveraged in many commercial and **prototype systems** such as Google PowerMeter, Microsoft Hohm, Berkeley Energy Dashboard, AlertMe, and Cambridge Sensor Kit (CSK) for energy. Providing simple feedbacks can valuably **influence the user's behavior**

However, to reduce costs, these systems typically provide only **aggregate measures** of energy consumption. Hence, they do not allow to identify the **specific device** or behavior causing the highest energy waste.

Reduction of standby consumptions

It has been estimated that most consumer electronics such as printers, setup-boxes, TVs consume more energy in stand by mode than in active mode, as they remain in stand by for longer duration/times, The standby mode can be detected by monitoring the energy consumption of the specific device. This requires a metering infrastructure, which, of course, should have a very low energy consumption by itself. Once the standby mode has been detected, the device can be switched off.

The widespread adoption of smart technology in many electrical appliances enables the **scheduling of their activity plans** for energy optimization. In case of constraints on the energy peak demand, or in the presence **of time-dependent fares**, ad hoc strategies can be implemented for determining the optimal scheduling of energy-hungry tasks that do not require user interaction (ex. Washing machine). The user can specify the exact time (or time period) when a certain task is to be executed by a specific appliance (e.g., dishwasher). Such a policy makes sense only when energy fares vary over time, but their variations are known a priori. identification of the most convenient time intervals is left to the user.

However, it is foreseeable that energy providers will be able to supply information about the current contractual offer, scheduled shortages, and low-fare hours, so that the overall system can autonomously plan for an optimal scheduling of flexible tasks

A final approach is based on the consideration that both in residential and commercial buildings, a significant fraction of energy is wasted due to electrical appliances that are left unnecessarily on (e.g., when no user is present). Hence, the most effective approach to energy savings consists in **enforcing a more intelligent utilization of such appliances** so as to avoid energy wastes.

Heating, ventilation, and air conditioning (HVAC) account for the major fraction of energy consumption both in residential and commercial buildings. Thus, adaptive control on such systems is essential for effective energy management in buildings.

Closed-loop control scheme of personal lighting

Here, Xk denotes the set point of sensor k, and N_{ADC} is the measured lumen value. They are fed into a proportional integral derivative controller (PID controller) whose output u_k is used by the decision making algorithm. The other parameters of the decision making algorithm are the timer, T, that is used to check the time of day condition, while the output of the pyroelectric infrared (PIR) sensor is a binary value, which is 1 if the space is occupied. The output of the decision making algorithm controls the light intensity

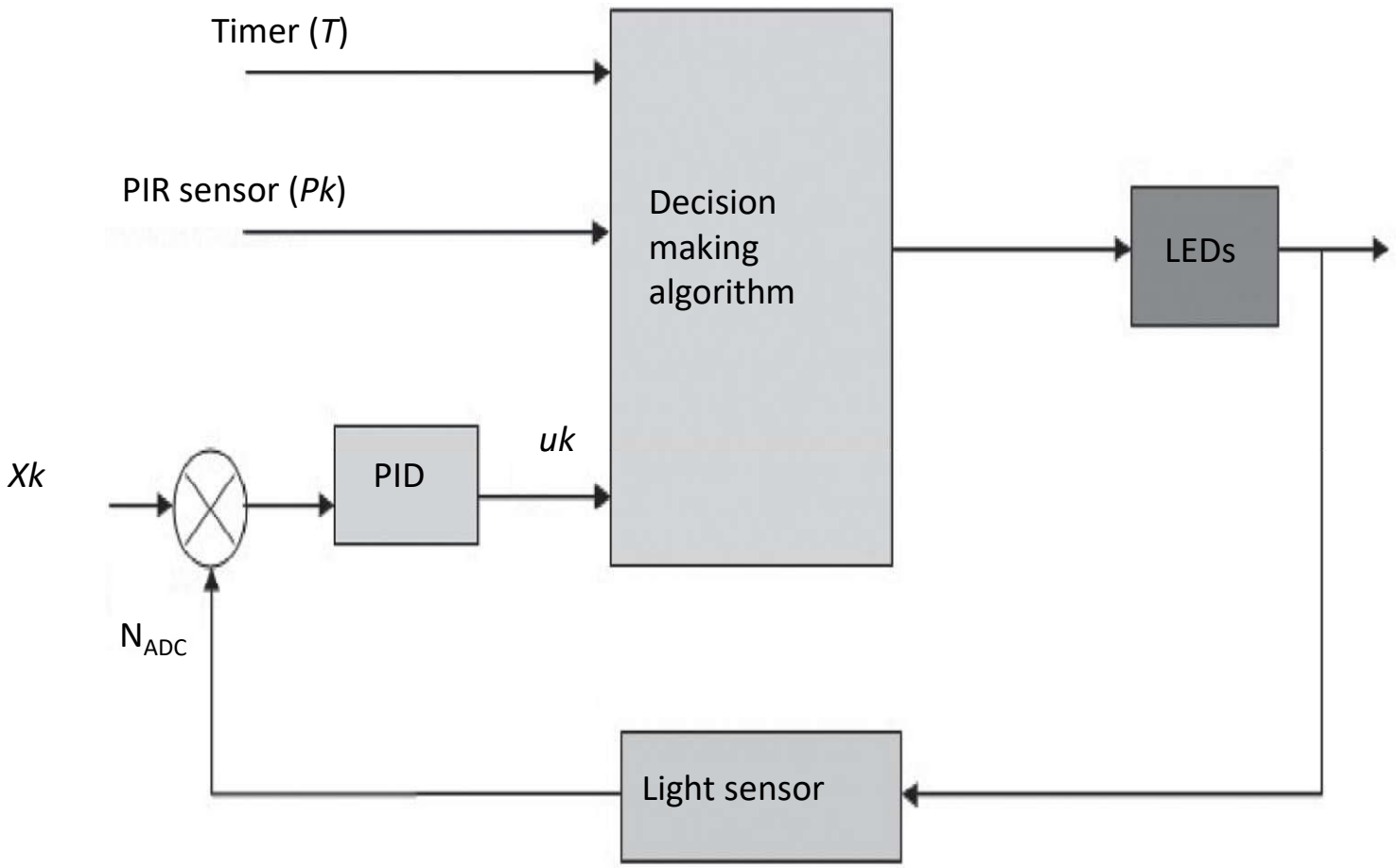


Fig 7.10 Closed-loop control scheme of personal lighting

Health care

INTRODUCTION

A wireless sensor network is composed of sensors that are used to monitor a particular environment. The capabilities of such a network have advanced such that sensor networks can be used in healthcare systems. There has been much progress toward the integration of specialized medical technology with pervasive, wireless networks . The use of sensors can enhance the care provided by a healthcare individual to a patient

Continuous healthcare monitoring can become extremely **expensive** for a patient with chronic illness, and the use of sensors would alleviate the physical and financial burden of having a **permanent caregiver**. This would also give the patient a sense of independence, especially with elderly patients, while still having family and caregivers to monitor them and be alerted to any urgent situations. Wireless networks are the optimal method of providing continuous pervasive monitoring of not only the patient but also of the environment. This offers a variety of **applications for the use of these networks** in healthcare.

Applications

They can be used in

- Disaster-response scenarios to allow for efficient tracking of patients and **emergency response** personnel
- For **continuous monitoring** of patients in assisted living facilities
- For other mechanisms that require **wearable sensors** and provide efficient delivery of patient data.

EMERGENCY RESPONSE APPLICATIONS

During emergency response situations, it is important that the responders have a timely and accurate assessment of the health of the patients. Wireless sensor networks can be used to coordinate different teams of rescue personnel and also multiple organizations to create a cohesive and an efficient response effort. These networks usually comprise wearable sensors that can be placed on patients for continuous monitoring , a way of keeping track of response personnel and the patients, and a means of data collection and storage.

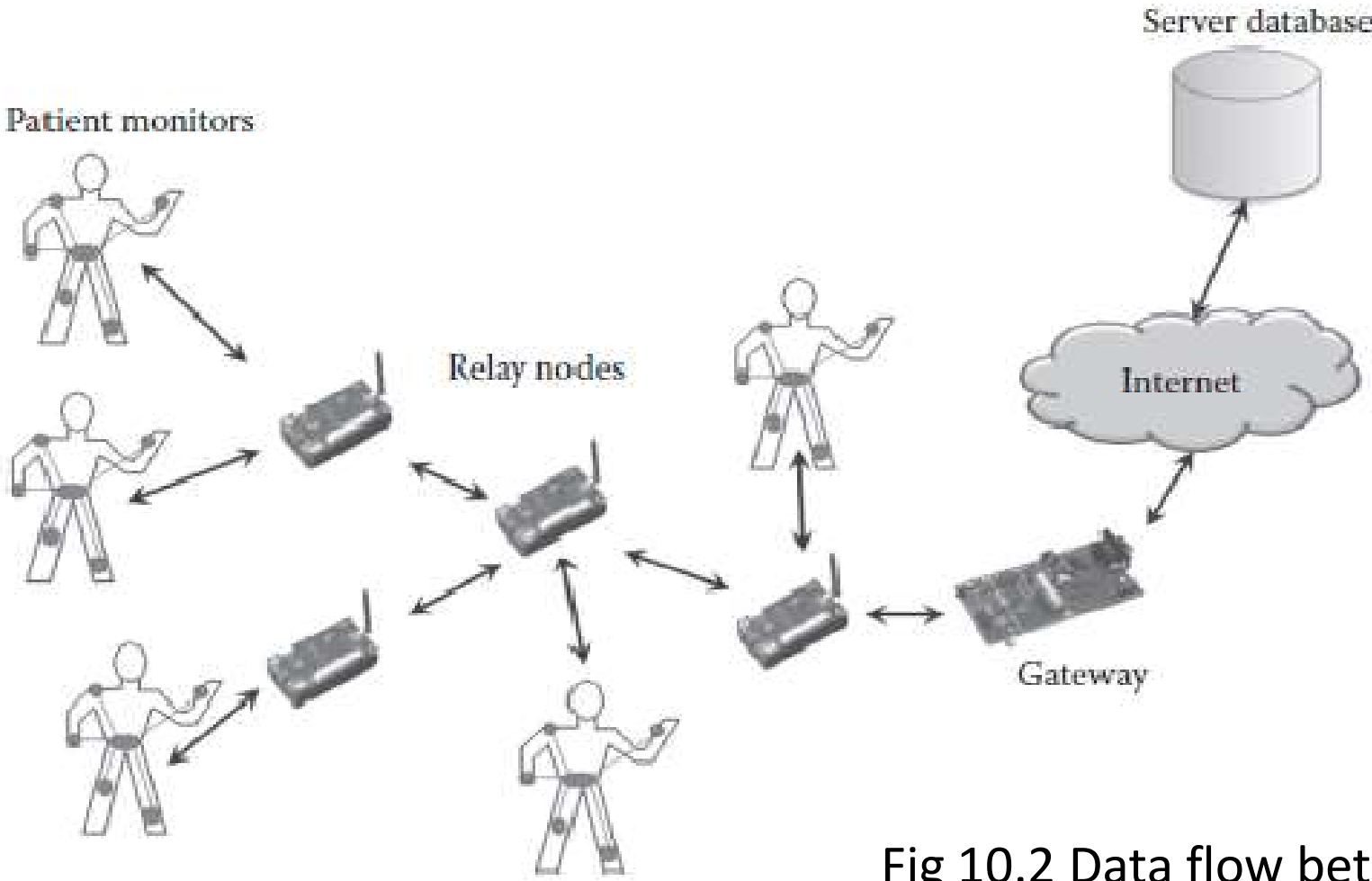


Fig 10.2 Data flow between patient and medical services.

Medical emergency detection in sensor networks (MEDiSN), was proposed for purpose of the medical **emergency detection using** sensor networks . It is also designed for **monitoring patients in hospitals** and disasters. MEDiSN consists of patient monitors that are custom built, wearable motes that will collect and secure the data, relay points that will create a multihop wireless backbone for transmission of the data and a gateway, as shown in Figure 10.2. it uses a wireless mesh infrastructure of relay points that transmit the data from the patient monitors. This increases the scalability of the mechanism so that it can be used in situations with a large number of injured people

MEDiSN **secures patient data by performing end-to-end encryption and authentication of the data** from the patient monitor. Only authenticated clients can access and control the sensor network at back-end server

Since there will be a large volume of data collected, any compression algorithm is used to **condense the data** as much as possible. Delta Compression algorithm will have a very high compression ratio, while providing relatively low implementation complexity.

healthcare gateway serves as an interface between the patient's home and the caregiver's medical system, which processes all the sensing data and transmits them to the remote medical care system

Question Bank

AGRICULTURE

1. What is sustainability and List any eight sustainable development goals (4+1)
2. Discuss and identify the challenges to be addressed while employing the WSN for smart agriculture (5)
3. What are the objectives of SMART agriculture ? (5)
4. What is a WSN explain with a block diagram (5) [section 1.2.1]
5. Discuss different types of WSNs with reference to smart agriculture applications. (10)[section 1.3]
6. Compare various types of WSN (8)[Table 1.1 page 13]
7. Illustrate application of WSN at various levels in SMART agriculture with a diagram (10) [section 1.4]
8. Identify and explain the challenges in use of WSN in SMART agriculture (8) [section 1.5]

ENERGY

1. Describe concept of Building Energy Management System in energy saving (4)
2. Explain various approaches for reducing the energy optimization in residential and commercial buildings (8)
3. Explain closed loop control of a personal lighting system (6)

HEALTH CARE

1. Explain features of MEDiSN (8) OR Explain how data flow can happen remotely between a patient and medical service (8)
2. Explain the role of WSN in Health care . Mention few applications (5)