Wireless Sensor Networks: Nurturinggreen Evolution

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Abstract- Sensor networks are wireless networks of small, low-cost sensors, which collect and propagate environmental data. They offer numerous applications and, at the same time, offer several challenges due to their peculiarities, the stringent energy constraints, which sensing nodes are typically subjected. Wireless sensor networks enable monitoring and controlling of physical environments from remote locations with better precision. They have diverse applications such as environmental monitoring, military applications like battle field surveillance and enemy tracking and gathering sensing information in inhospitable locations. Sensors and sensor networks have an important impact in meeting environmental challenges. In this paper, we will have an overview of sensor technology and some selected fields of application that have high potential to reduce greenhouse gas emissions

Index Terms -Sensor, sensor network, smart grid, smart building, smart logistic.

1. INTRODUCTION

1.1Recent technological improvements have made the deployment of small, low-power, inexpensive distributed device, which is capable of local processing and wireless communication, a reality. Such networks are called as sensor networks. A sensor network can be described as a collection of sensor nodes which co-ordinate to perform some specific action. We can think of it as a large number of small sensing self-powered nodes which gather information and communicate in a wireless manner, with the goal of handing their processed data to a base station. The combination of three key elements sensing, processing and communication gives rise to numerous applications. Sensor networks provide several opportunities, but at the same time offer formidable challenges such as the fact that energy is a scarce and usually non-renewable resource.

1.2 Environmental degradation and global warming are the major global challenges facing us. These challenges include improving the efficient use of energy as well as climate change. Internet and the ICTs play an important role in both, as they consume energy and are a source of pollution and have the potential to provide important solutions to it. Some sensor networks such as smart grids and smart power systems in the energy sector can have major impacts on improving energy distribution and optimizing energy usage. Smart transportation systems are a powerful way of organizing traffic more efficiently and reducing CO2 emissions[1]. In this paper, we will study some technological fundamentals of sensor technology and sensor networks and then followed by an overview of different fields of applications.

2. MAJOR HEADINGS SENSORS, ACTUATORS AND SENSOR NETWORKS – A TECHNOLOGYOVERVIEW

Sensors can be considered as 'the interface between the physical world and the world of electrical devices such as computers'. There are different type of sensors such as electronic sensors, biosensors and chemical sensor. Actuators function in a different way, they convert the electrical signal into a physical phenomenon (e.g. displays for quantities measures by sensors (e.g. speedometers, temperature reading for thermostats). Sensor networks form adistributed feedback loop that has the potential for efficiently controlling geographically distributed processes at a scale thatwas previously unthinkable. Table 1 provides examples of the main sensors type and their outputs.

TABLE I
EXAMPLE OF SENSOR TYPES AND THEIR OUTPUT

Physical property	Sensor	Output
Temperature	Thermocouple	Voltage
	Silicon	Voltage/Current
	Resistance temperature detector (RTD)	Resistance
	Thermistor	Resistance
Force/Pressure	Strain Gauge	Resistance
	Piezoelectric	Voltage
Acceleration	Accelerometer	Capacitance
Flow	Transducer	Voltage
	Transmitter	Voltage/Current
Position	Linear Variable Differential Transformers (LVDT)	AC Voltage
Light Intensity	Photodiode	Current

Wireless sensor and actuator networks or WSANs are network of computer controlled sensors and actuators that sense and potentially control their environment. Communication is done via wireless links "enabling interaction between people or computers and the surrounding environment" (Verdoneet al., 2008). The data collected by the different nodes is sent to a sink which either uses the data locally, through actuators,

or which "is connected to other networks (e.g. the Internet) through a gateway (Verdoneet al., 2008). Figure 1 illustrates a typical WSAN.

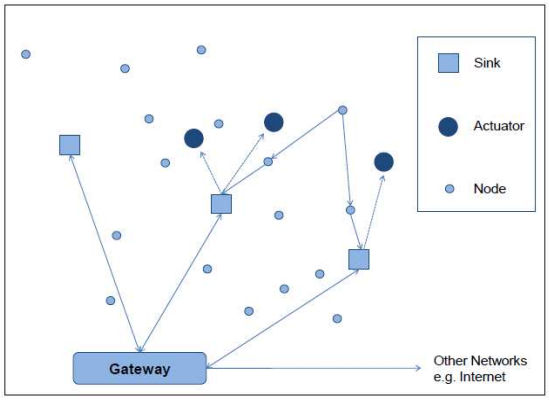

Fig 1: Typical Wireless Sensor and Actuator Network

A Sensor node consists of five main parts: one or more sensors measure physical data of the parameter to be monitored and produce a response to a change in physical condition like pressure or temperature. The central unit is in the form of a microcontroller that perform tasks, processes data and controls the functionality of other components in the sensor node[2]. A transceiver communicates with the environment and a memory is used to store data temporarily during processing. The battery is used to supply all parts of the network with energy. From an energy perspective, the most appropriate kinds of memory are the on-chip memory of a microcontroller and Flash memory. Flash memories are used because to their cost and storage capacity[3].A wireless sensor node is a popular solution when it is difficult or impossible to run a main supply to the sensor nodes. However, since the wireless sensor nodes is often placed in a hard-to-reach location, changing the battery regularly may be costly and inconvenient.

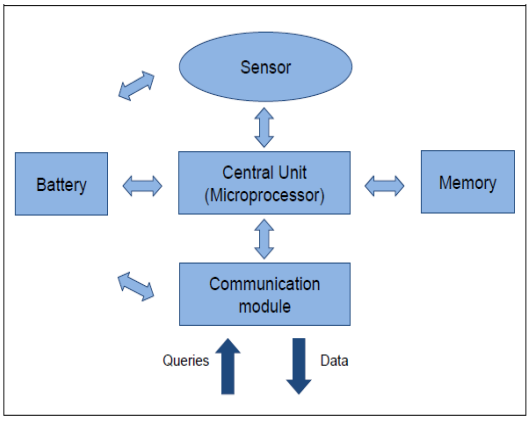

Fig 2: Architecture of a Sensor Node

3. SOME APPLICATIONS AND THEIR ENVIRONMENTAL IMPACT

3.1. *SMART GRIDS AND ENERGY CONTROL SYSTEMS*

Coal power plants are responsible for 'nearly 45% of electricity production worldwide', and electricity generation are responsible for a significant share of CO2 emissions (Atkinson, Castro, 2008). To decrease emissions from the energy supply side, different clean technologies can be used to produce electricity or energy can be distributed in a more efficient way[4]. In both cases, sensor networks contribute to better and more efficient processes.

The smart grid is an innovation that has the capacity to revolutionize the transmission, distribution and conservation of energy[5]. It uses digital technology to improve transparency and to increase reliability as well as efficiency. ICTs and especially sensor and sensor network play as important role in turning traditional grids into smart grids.

From a solution perspective, the smart grid is characterized by:

- Provides more efficient energy routing and thus an optimized energy usage
- Reduction of the need to excess capacity and increased power quality.
- Provides better monitoring and control of energy and grid components.
- Improved data and thus an improved outage management
- Bi-Directional flow of electricity and real-time information allowing for the incorporation of green energy sources, demand-side management, real-time market transactions.
- Highly automated, responsive and self-healing energy network with seamless interfaces between all parts of the grid.

3.2. *NEW AND ADVANCED GRID COMPONENTS*

New and advanced grid components allow for more efficient energy supply, availability of power and better reliability. Its components include advanced conductors and superconductors, new materials, improved electric storage components, advanced power electronics as well as distributed energy generation. Superconductors are used in various devices along the grid such as cables, storage devices, motors and transformers[6][7]. The rise of new high-temperature superconductors allows large amounts of power to be transmitted over long distances at a lower power loss rate. Various new kinds of batteries have greater storage capacity and can be employed to support voltage and transient stability. Distributed energy is generated close to the customer to be served

which improves reliability, can reduce greenhouse gas emissions and at the same time expand efficient energy delivery. Furthermore, most of these alternative energy generation technologies such as solar panels and wind power stations are renewable energy sources. These technologies, e.g. solar panels, small hydro-electric and small hydro-thermals can be operated by consumers, and small provider.

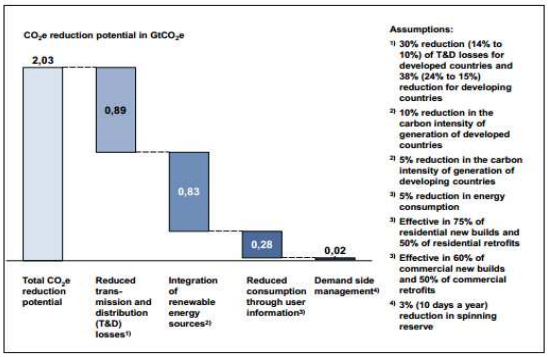

Fig 3: Positive environmental impact of Smart Grid according to GeSI(2008)

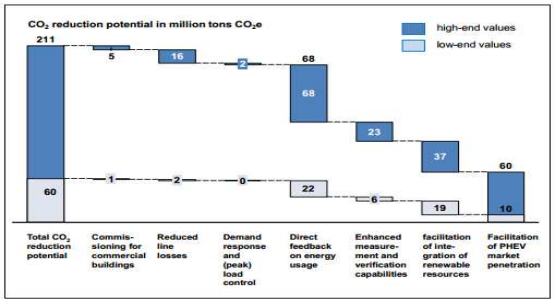

Fig 4: Positive environmental impact of Smart Grid according to EPRI(2008)

3.3. *SMART BUILDING*

This is a field closely linked to Smart Grids. These buildings use various energy-enhancing technologies. One of the important technologies is Information and Communication Technology (ICT). ICTs are used in: i) building up management systems which monitor heating, lighting and ventilation, ii) software packages which automatically switch off electronic devices such as computers and monitors when offices are empty (SMART, 2020) and iii) security and access systems[8].Smart buildings are the largest contributor to global carbon emissions, accounting for about 40 percent of the world's total carbon footprint. After salaries, smart buildings are one of the biggest operational expenses for organizations. Energy plays an important role in this[9].

Sensors and sensor networks are used to multiple smart building applications:

- Heating, ventilation, and air conditioning systems (HVAC)
- Lightning
- Shading
- Air quality and window control
- Systems switching off devices
- Metering
- Standard household applications (e.g. televisions, washing machines)

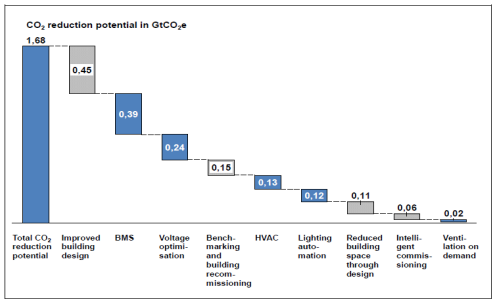

Fig 5: Positive environmental impact of Smart Building acoording to GeSI(2008)

3.4. *SMART LOGISTICS*

Smart product and services are evolving from new technologies in a technology driven approach. Their function is based upon proximate environment and relations including assets, spare parts, tools related to smart products. Sensors and sensor networks play an important role in the increase of transport efficiency.[10] For example, sensor network technology pays to better tracking of goods and vehicles which might be resulting into lower level of inventories and thus energy savings from less inventory infrastructure as well as a reduced need for transportation.

In case of environmental impact of smart transportation, the GeSI study estimates the potential of 1.52 GtCO2e worldwide in the field of smart transport[11][12]. Levers that can include a positive impact of sensors and sensor networks are marked in blue solid shading in Figure 6, other levers have diagonal lines.

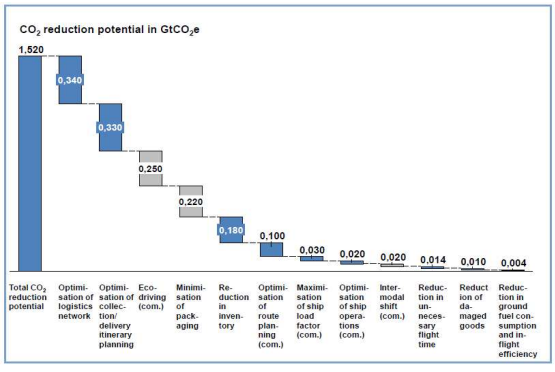

Fig 6: Positive environmental impact of Smart Logistics acoording to GeSI(2008)

3.5. *CONCLUSION*

This paper gives an overview of sensor network and various technologies and their impact on environment. It discusses fields of application which have potential to handle environmental challenges. A review of different studies considering the environmental impact of ICTs and especially sensor and sensor networks reveals that these technologies can contribute significantly to more efficient use of resources and an important reduction of greenhouse gas emissions. Many applications in promising fields are still at an early stage of development. Joint R&D programmes and implementation projects can endorse the use of sensor technology and contribute to industry-wide solutions and the development of open standards. With the progress on sensor network technique, sensor network research and increasing multi-disciplinary cooperation, we can expect that real-world sensor network application will come to life in the near future.

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