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Research Paper

INTERNET OF THINGS AND SMARTDUST: THE FUTURE OF WIRELESS NETWORK SENSORS

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Abstract

This Paper reviews the key elements of the emergent technology of "Smart Dust" and outlines the research challenges they present to the mobile networking and systems community, which must provide coherent connectivity to large numbers of mobile network nodes co-located within a small volume. This has enabled very compact, autonomous and mobile nodes, each containing one or more sensors, computation and communication capabilities, and a power supply. Large-scale networks of wireless sensors are becoming increasingly tractable. Advances in hardware technology and engineering design have led to dramatic reductions in size, power consumption and cost for digital circuitry, wireless communications and Micro Electro Mechanical Systems (MEMS). The missing ingredient is the networking and applications layers needed to harness this revolutionary capability into a complete system. The main aim of this study was to explore the application of Internet of Things and smart dust in Academic Institution.

Keywords: Internet of Things, Smartdust, sensors, smart dust, MEMS, micro-electromechanical, small robot, small sensor, nanotechnology, sensor networks.

1.0 Introduction

The Internet of things is a system of interrelated, internetworking smart devices or physical devices which are connected to the internet and are embedded with electronics, software, sensors and actuators that enable these objects to collect and exchange data. An IoT device can be a computing device, mechanical or digital machine, an object, animal or human that is provided with a unique identifier and has the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. For example, thing, in the Internet of Things, can be a human with an implant to monitor heart, any animal with a transponder chip to track its location and more parameters in real-time, a vehicle with sensors that alerts the driver when tire pressure is low or any other natural or man-made artificial object that can be assigned an identifiable address i.e. IP address and has been devised with the ability to transfer data over a network.

The term “smart dust” originally referred to miniature wireless semiconductor devices made using fabrication techniques derived from the microelectronics industry. These devices incorporate sensing, computing and communications in a centimetre-sized package. This article discusses the construction of much smaller silicon-based systems, using the tools of nanotechnology. The synthesis of millimetre- to micron-sized functional photonic crystals made from porous silicon is described. It is shown how the various optical, chemical, and mechanical properties can be harnessed to perform sensing, signal processing, communication and motive functions.

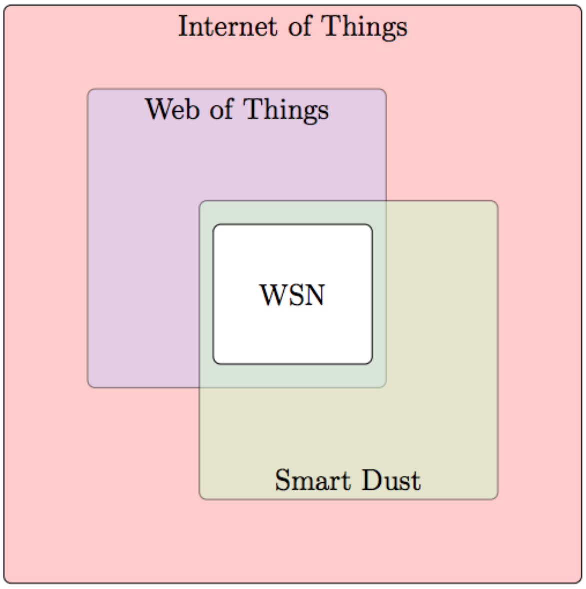


Figure 1.1: The relationship between IoT, WoT, WSN and Smart Dust.

The smartdust concept was introduced by Kristofer S. J. Pister (University of California) in 2001 , though the same ideas existed in science fiction before then . Stanislav Lem had introduced that kind of possibility in his book The Invincible, 1964. Imagine a cloud of sensors, each the size of a grain of sand, blown in the air and gather different kind of data on the sky to weather stations. Or picture tiny robotic chips drifting through a human artery to locate, and erase, a hidden blood clot.

2.0 Literature Review

The buzz going around IoT may seem to be a recent technology but it's not quite the case. The first ever Internet of Thing (IoT) implementation was in the form a network of smart devices. The Carnegie Mellon University has the credit of having implemented the first internet-connected appliance - a modified Coke machine that reports its inventory and could tell whether newly loaded drinks were cold. This was done so that one would not have to go all the way to the machine to find out that there were no drinks or they were not cold enough

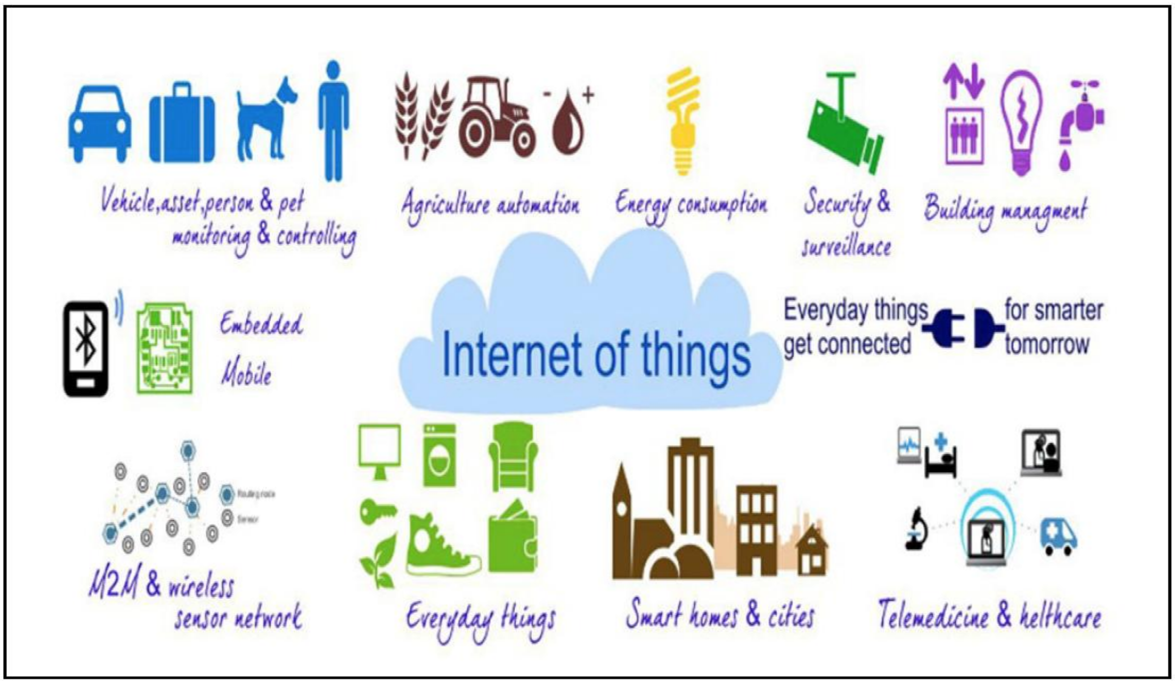
A recent review discusses various techniques to take smartdust in sensor networks beyond millimetre dimensions to the micrometre level and the aim can be molecule-size electronic devices. Some attribute the concepts behind smart dust to a project at PARC called Smart Matter. Smartdust devices will be based on sub-voltage and deep-sub-voltage nanoelectronics and include the micro power sources with all solid state impulse supercapacitors (nanoionic supercapacitors). The progress in this science area is just born and the first-generation smart dust products are hitting the market like monitor building controls, pipelines, factory equipment and drug-making processes with tiny sensors but the real Nano technological solutions have to wait some time.

In 1985, Peter T. Lewis in his speech at a U.S. Federal Communications Commission (FCC) conference coined the term "Internet of Things"(IoT). He said "The Internet of Things, or IoT, is the integration of people, processes and technology with connectable devices and sensors to enable remote monitoring, status, manipulation and evaluation of trends of such devices."

According to Vermesan and Friess (2013:2), the Internet of Things is developing and has yet to mature, but when it does, it will increase the potential for cloud computing, future Internet, big data, robotics and semantic technologies. The Internet has become the foundation of connectivity leading to key concepts such as The Internet of Everything (IoE) or the Internet of Things (IoT). According to Kaushik (2016: Internet), IoT connects machines to machines, using the Internet, which connects human to human, ultimately resulting in the Internet of everything (IoE), which is the networked connections of everything such as people, data, objects and processes. The internet of things is founded on the reality that all entities are constantly connected or continuously on.

Kaushik (2016: Internet), explains that because there are key differences between IoE and IoT, these terms should not be used interchangeably. The word "things" refers to objects, for example a smartwatch or a smartphone. However, the Internet does not only include objects; services including websites such as Google, Facebook and Dropbox do not exist in physical spaces. The Internet allows for data streams across multiple connected computers. The Internet of Everything requires several technologies including 3G, 4G, WiFi, LTE, VoIP, Bluetooth and heterogeneous networks. The interconnected relationship of these technologies leads to an efficient web of interaction on WAN and LAN connections.

According to Rose, Eldridge and Chaplin (2015:4), organisations have made a range of projections on the impact of IoT on the Internet. For example, Cisco projects 24 billion networked devices by 2020, and McKinsey Global believes that the financial impact of IoT could be $3.9 to $11.1 trillion by 2025.

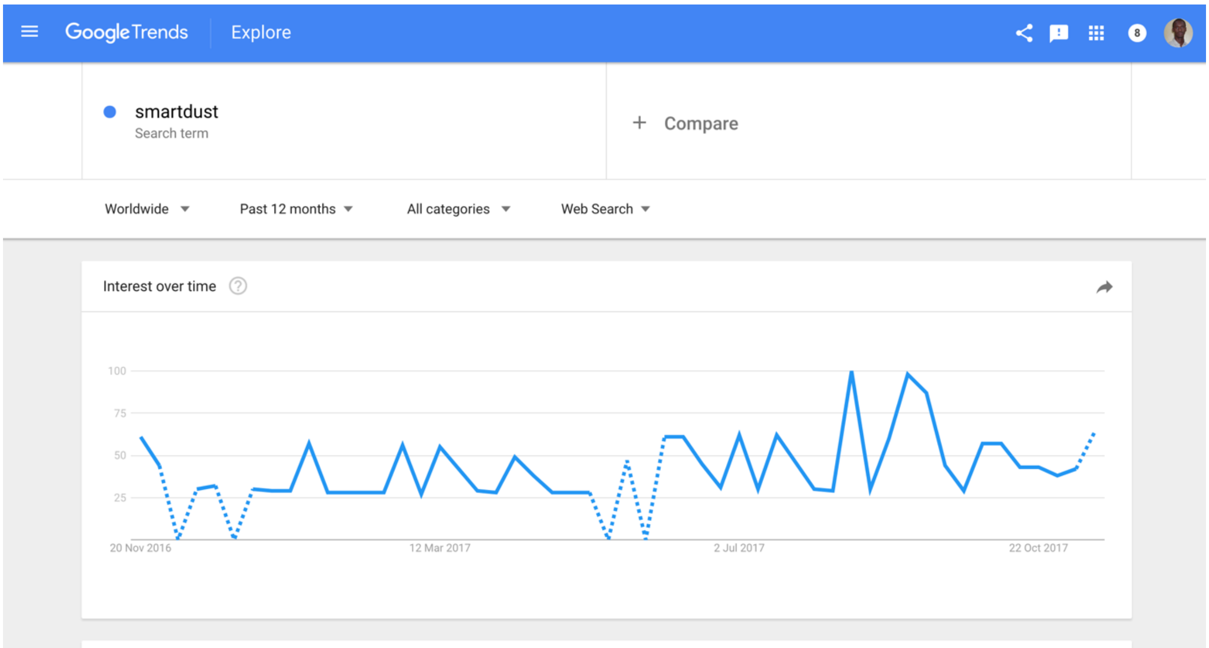


Source: Omnibridge, 2015: Internet
Figure 2.2 paints a picture of the influence IoT has on connecting a multitude of things.

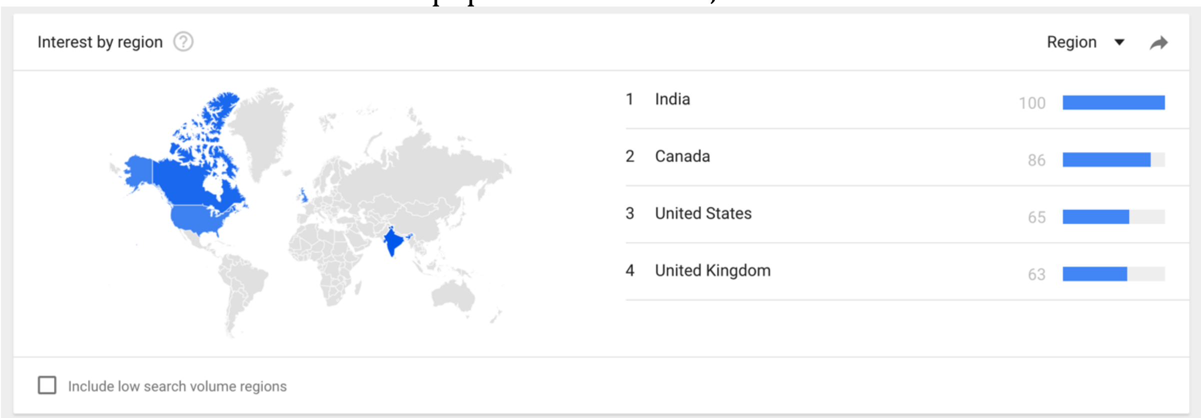
3.0 Research Design and Methodology

As research design is vital to success of empirical research, it is crucial that attention is given to selecting a design that will appropriate answer the research. This research study was use Google Trends, Google Trends is a novel, freely accessible tool that allows users to interact with Internet search data, which may provide deep insights into population behaviour and IoT and Smartdust-related phenomena. However, there is limited knowledge about its potential uses and limitations. We therefore systematically reviewed Internet of Things and Smartdust literature using Google Trends to classify articles by topic and study aim; evaluate the methodology and validation of the tool; and address limitations for its use in research.

First, we used Google Trends to see how the online searches for the word “smartdust” have grown in the last ten years. This data analyzing method creates a clear graph that shows how often a particular search term is entered. We confirmed that “smartdust” was a trend, particularly in August this year and September this year. Google Trends also gives the possibility to compare two search terms. We compared “smartdust” and “internet of things” and obtained results.



Finally, Google Trends creates a map that told how popular are search terms in different countries. smartdust was more popular in The India, Canada and United States.



3.1 IoT APPLICATION AREAS

IoT has become a part and parcel of every aspect of day to day life. Its applications extend from smart connected homes manufacturing, wearables to healthcare. Apart from bringing comforts to our lives, IoT enhances the control by simplifying the routine work and personal tasks. This hype in IoT has forced companies to take the initiative of coming up with sophisticated hardware, software and support the developers to develop and deploy applications that can connect anything within scope of IoT. Following is a list of Top ten IoT applications as per IoT Analytics

3.1.1 Smart home – Some of the services offered in a smart home would be Home monitoring, Access control , Lighting control, Fire detection - Leak detection, Temperature monitoring, Energy efficiency and HVAC control, Automated meter reading, Family care.

3.1.2 Wearable Devices - Wearable devices are now at the heart of almost every discussion related to the Internet of Things (IoT). Health & fitness oriented wearable devices that offer biometric measurements such as heart rate, perspiration levels, and even complex measurements like oxygen levels in the bloodstream have becoming available.

3.1.3 Smart City - Smart city covers a wide variety of applications including from traffic management, water distribution, waste management, urban security and environmental monitoring. Its popularity is driven by the fact that many Smart City solutions promise to alleviate real pains of people living in cities these days. IoT solutions in the area of Smart City offer solution to traffic congestion problems, reduction of noise and pollution and help make cities safer.

3.1.4 Smart grids - Smart grids is a special one. A futuristic smart grid promises to use information about the availability from electricity suppliers and consumption from consumers in an automated fashion to improve the efficiency, reliability, and economics of electricity.

3.1.5 Industrial internet - The industrial internet is also one of the special applications of Internet of Things. While many market researches such as Gartner or Cisco underscore the industrial internet as the IoT concept with the highest potential, its popularity currently has not reach the masses like smart home or wearables has reached.

3.1.6 Connected car - The connected car is slowly becoming a reality. Google, Microsoft, and Apple have all announced connected car platforms and regularly announce testing of new features.

3.1.7 Smart Health Care - Connected health is an area with vast potential for the Internet of Things applications not just for companies also for the well-being of people in general.

3.1.8 Smart retail - Proximity-based advertising is a subset of retailing that has taken off and is doing pretty well.

3.1.9 Smart supply chain - Supply chains are been getting smarter year by year. Solutions for tracking goods during transportation are applications of IoT.

3.1.10 Smart Agriculture - Smart farming is an often ignored for the internet of Things because it does not really fit into the well-established categories such as health, production or logistics. The Internet of Things could revolutionize the way farming is done by closely monitoring soil nutrient levels and giving real time suggestions based on heuristics of crop data.

3.2 SMART DUST APPLICATION AREAS

If we survey the literature for different ways that people have thought of to use smart dust, we find a huge assortment of ideas. Here's a collection of applications where smart dust can be used.

3.2.1 In Bridges

We can embed smart dust in bridges when we pour the concrete. The smart dust could have a sensor on it that can detect the salt concentration within the concrete. Then once a month we could drive a truck over the bridge that sends a powerful magnetic field into the bridge. The magnetic field would allow the smart dust, which are buried within the concrete of the bridge, to power on and transmit the salt concentration. Salt (perhaps from deicing or ocean spray) weakens concrete and corrodes the steel rebar that strengthens the concrete. Salt sensors would let bridge maintenance personnel gauge how much damage salt is doing. Other possible sensors embedded into the concrete of a bridge might detect vibration, stress, temperature swings, cracking, etc., all of which would help maintenance personnel spot problems long before they become critical.

3.2.2 In Machines

We could connect sensors to a smart dust that can monitor the condition of machinery - temperature, number of revolutions, oil level, etc. and log it in the smart dust's memory. Then, when a truck drives by, the smart dust's could transmit all the logged data. This would allow detailed maintenance records to be kept on machinery (for example, in an oil field), without maintenance personnel having to go measure all of those parameters themselves.

3.2.3 In Water Meters

You could attach smart dust to the water meters or power meters in a neighborhood. The smart dust would log power and water consumption for a customer. When a truck drives by, the smart dust get a signal from the truck and they send their data. This would allow a person to read all the meters in a neighborhood very easily, simply by driving down the street.

3.2.4 In Power Meters

A building manager could attach smart dusts to every electrical wire throughout an office building. These smart dusts would have induction sensors to detect power consumption on that individual wire and let the building manager see power consumption down to the individual outlet. If power consumption in the building seems high, the building manager can track it to an individual tenant. Although this would be possible to do with wires, with smart dusts it would be far less expensive

3.2.5 For Tracking Climate

A farmer, vineyard owner, or ecologist could equip smart dusts with sensors that detect temperature, humidity, etc., making each smart dust a mini weather station. Scattered throughout a field, vineyard or forest, these smart dusts would allow the tracking of micro-climates.

3.2.6 To Monitor Traffic

Smart dusts placed every 100 feet on a highway and equipped with sensors to detect traffic flow could help police recognize where an accident has stopped traffic. Because no wires are needed, the cost of installation would be relatively low.

3.2.7 For Biological Studies

A biologist could equip an endangered animal with a collar containing a smart dust that senses position, temperature, etc. As the animal moves around, the smart dust collects and stores data from the sensors. In the animal's environment, the biologists could place zones or strips with data collection smart dusts. When the animal wanders into one of these zones, the smart dust in the collar would dump its data to the ad hoc network in the zone, which would then transmit it to the biologist.

3.2.8. For Exploration of Planets

A recent survey about the application of smart dust says that smart dust can be used to explore planets .Tiny smart dusts that can be borne on the wind like dust particles could be carried in space probes to explore other planets. The devices would consist of a computer chip covered by a plastic sheath that can change shape when a voltage is applied, enabling it to be steered. Details were presented at the National Astronomy Meeting in Preston. Smart dust could be packed into the nose cones of planetary probes and then released into the atmospheres of planets, where they would be carried on the wind. For a planet like Mars, smart dust particles would each have to be the size of a grain of sand. By applying a voltage to alter the shape of the polymer sheath surrounding the chip, dust particle could be steered towards a target, even in high winds. Wireless networking would allow these particles to form swarms. Dr Barker and his team in University of Glassgow has carried out mathematical simulations and have found that a swarm of 50 dust particles can organise themselves into a star formation, even in turbulent wind. The ability to fly in formation would allow the processing of data to be spread, or "distributed" between all the chips, and a collective signal to be beamed back to a "mothership".

3.2.9 In Hospitals
Another typical application scenario is scattering a hundred of these sensors around a building or around a hospital to monitor temperature or humidity, track patient movements, or inform of disasters, such as earthquakes.

3.2.10 In Military
In the military, they can perform as a remote sensor chip to track enemy movements, detect poisonous gas or radioactivity. All of these ideas are good; some allow sensors to move into places where they have not been before (such as embedded in concrete) and others reduce the time needed to read sensors individually.

3.3 Future of Sensors
Sensors measure and record everything from temperature, light and motion to biohazards and physical indicators from the body.

Sensor technology in 2020:

3.3.1 The 'Unobservable' sensing:
It breaks new ground in sensing biohazards, smells, material stresses, pathogens, levels of corrosion and chemicals in materials

3.3.2 Micro-sensor implants:
In patients track the healing process of internal injuries, enables health care professionals to take remedial action based on continual data from the system.

3.3.3 Biodegradable sensors:
This monitors soil moisture and nutrient content for optimum crop production.

3.3.4 Self-powered sensors:
This powered sensors use the heat difference between the patient's body and surrounding air which find applications in medical care.

3.3.5 Self-healing sensors:
It repair themselves in the event of disaster or other structural disruptions

3.3.6 Live cell-based sensing:
An amalgamation of sensor technology and living cells, allow scientist to understand the biological effect of medicines, environment and biohazards.

3.3.7 Sensor swarms:
These coordinate their activities, deciding what to measure and where through a self-learning system directing their movements and data collection

3.3.8 Smart dust:

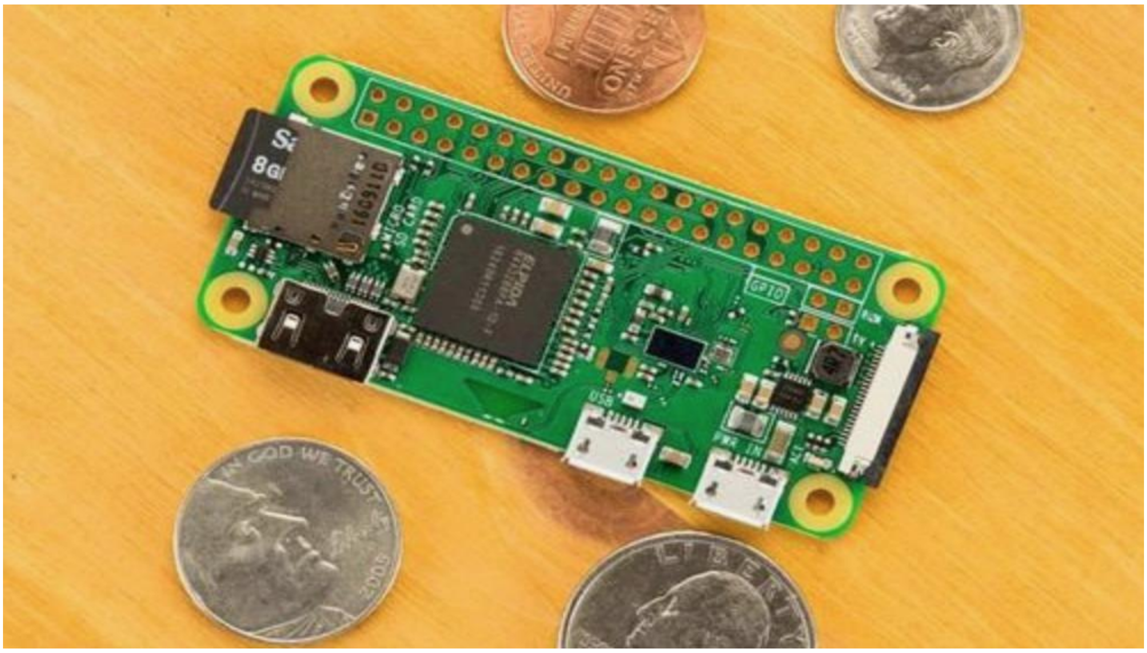
These microscopic sensors powered by vibrations, monitor situations ranging from battlefield activities, structural strength of buildings and clogged arteries.

4.0 Implementation and Result Discussion

It is clear that the world need smart dust kind of solution. There is lot of benefits of this kind of technology is obvious. The sensors are small enough to be put anywhere and work wirelessly, sharing data and can make some computing to gathered data. This tiny equipment can help people keep up better healthy by monitoring human body different kind of function or solve ecological environmental disaster problem by fixing it with the millions of smart micro machine. To use this technology benefit the scientist must solve some major problem like how to make it small, give them a safe energy source and very small and effective antenna is one big problem which wait today to solve. The technology can also use in harmful solution like military solutions and the future is that case also open, because we don't know how intelligent we are to use this amazing new breaking through technology. We have now to take the first, hard step to concrete the vision. The next decade show us is this hard work worthless or do it give us opportunity that open a new door in the world what we cannot imagine.

Design of the Proposed System

From our research on Internet of Things and Smartdust, you will find some Educational Institute deploy their system, but their system is still working half-way manual, most of the system developed the cannot work automated, or using machine to machine communication, example in some Institute many students use RFID Smart ID Card, but their ID card is not fully automated, they are doing attendance manual, and other school activities, we will build the automated system using Raspberry PI, smallest computer in the world, and connect the pi to the Internet, and develop real-time database system using Google Firebase and GunJS Real-time database for online access.



Raspberry Pi zero smallest computer, as our hardware part of the system

5.0. Conclusion

Internet of things (IoT) is an emerging field which has improved the quality of human life. The functionalities provided by IoT save time, energy and cost of processing by providing accurate real-time data enabling timely decision making. This paper presents an overview of the Internet of Things (IoT) concept, its benefits, driving factors; challenges faced by IoT and finally highlighted the security concern with respect to Indian context. The Indian Cyber Security currently lacks the infrastructure to mount defensive and offensive operations against cyber-attacks. It is currently engaged in tackling localized cyber-crime on a case-by-case basis. With the ever increasing number of entities getting connected to the internet and the rise in cybercrimes, maintaining the security of the devices, data and users of IoT becomes of paramount importance.
Dust is usually a nuisance. But "smart dust" could revolutionize how we monitor and understand the world around us. Smart dust is an ongoing research project whose main objective is to design a cubic micrometer-scale sensing nodes capable of bidirectional communication. The applications of miniature distributed sensor networks are numerous. Smart dust has four major components: power, computation, sensors, and communication. With these four components, a number of smart dust systems can be designed and modified depending on the applications.

Smart dust is a completely new paradigm for distributed sensing and it is opening up a fascinating new way to look at computers. If the smart dust networks successfully emerge, the line between reality and fiction would be blurred. Lets hope that the brainchild of Kristofer S .J. Pister i.e, “Smart Dust”, will make the entire world one huge ubiquitous and happy network.

Continuous dialogue between the industry and the ICT education is needed to develop a different kind of smart dust solution. To reach that we need lot of new resource for study nano size technique. Nano technology is one of them. That technique is typically very expensive, there is not so much practical knowledge about technical solution and that is the point where company can give their helping hand.. The most important action in the educational side is to bring the students near practical problems and working in the companies and adopt the theoretical and technical way to think and create a new way to use technology benefits.

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