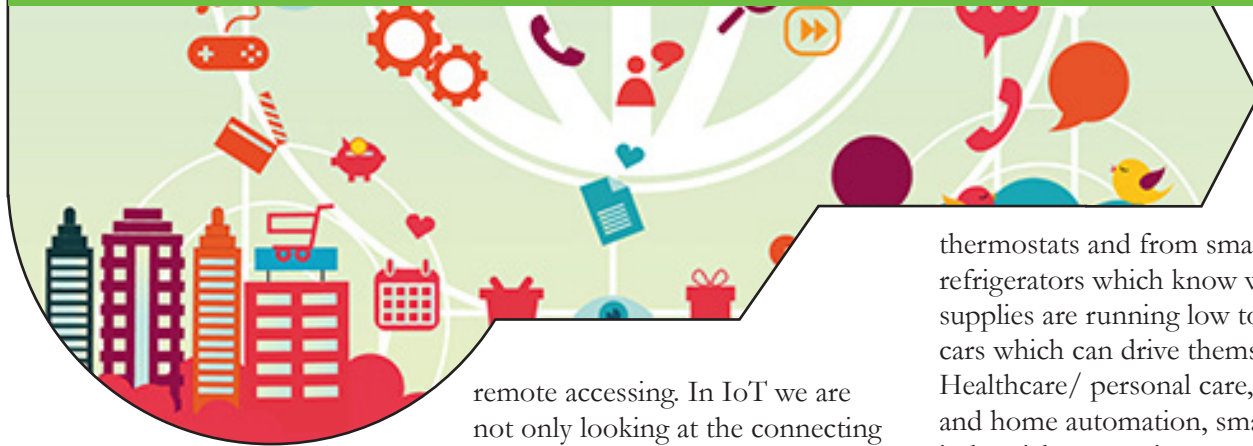


Devices for Enabling IoT Applications

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Introduction

IoT refers to the networking of physical objects through the use of sensors, actuators, and other devices that can collect or transmit information about the objects. The term networking generally refers to connecting computers and other IT peripherals. Networking enables resource sharing and

remote accessing. In IoT we are not only looking at the connecting computers about also everything around us even not limiting to physical things. IoT enable us to create a self-aware environment, very much like a Central Nervous System for the Planet Earth.

IoT technologies can be applied in almost everywhere to make the environments in which we live, work and play, smart, from smart light bulbs to net connected

thermostats and from smart refrigerators which know when the supplies are running low to smart cars which can drive themselves. Healthcare/ personal care, building and home automation, smart cities, industrial automation, automotive are some of the major sectors that IoT is being applied. Figure 1 illustrates the primary application domains of IoT and possible applications within each. This article focuses on major application areas of IoT, some emerging deployments, examples of services they can offer, and devices that are emerging to enable such applications.



Fig. 1 : IoT Domains of Application

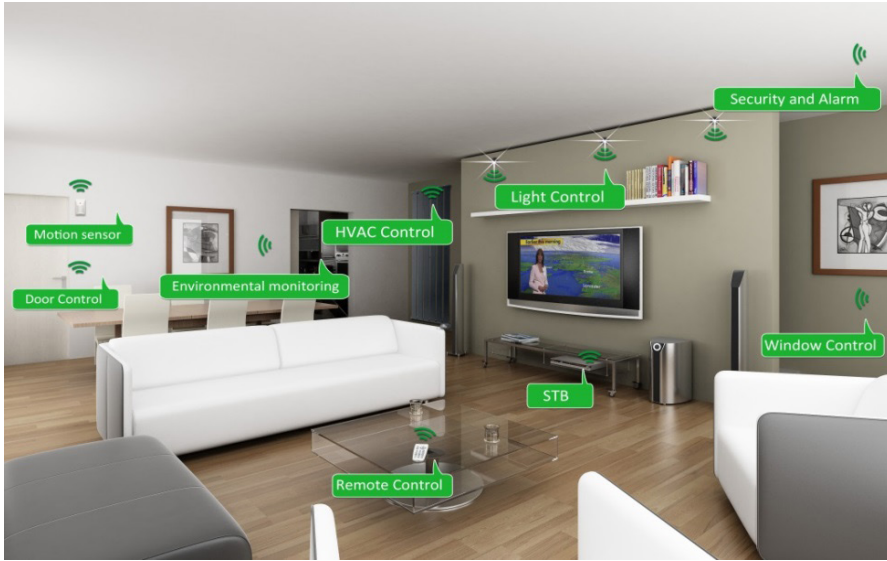


Fig. 2 : SMART home



Fig. 5 : AmbiClimate: Smart add -on for your air conditioner

Devices That Enable Smart Homes

Imagine you are coming home from a long day’s work. The moment you enter through your front door, the lights immediately turn on a shade past dim – just the way you like it. Your home AC has started at the time you left your office and now as you enter your home you are feeling the cooling air refreshing your body. By the time you remove your shoes, watch etc, and your clothes, your phone will beep, it’s your bath room; the hot water bath has been prepared - just the way you want.

You have spent a couple more minutes in the bathroom than usual, and your favorite TV



Fig. 6: Footbot : Indoor air quality monitor

show has begun. The television has turned on and detecting your absence, has automatically started recording the program. You start to walk to the living room, but a beep from the kitchen stops you and persuades you to go there instead. It is your refrigerator, reminding you that there are some snacks readily available. You open the fridge and grab a snack. But a beep again from your wrist band interrupts you. It seems you have exceeded your calorie goal for the day, so better to go for a fruit juice. You pour out a glass of juice and something to eat. You see that a display on the outside of the fridge informs you that milk and eggs are over. You tap a button on the display and your refrigerator dials the local store on your mobile



Fig. 3 : Nest Thermostat



Fig. 4 : Philips Hue Bridge : Homekit ready



Fig. 7 : Vivint

phone, for you to place an order. You place your order and make your way back to the TV and settle down to watching your program. A little while later you see a second notification that informs you that you’ve forgotten to activate your security system, but that it has been done for you. You silently marvel at how simple life has become as you sit back to enjoy the TV show. Speaking about this kind of a domestic bliss may once have been purely within the realm of science fiction, but with the introduction of IoT to homes/ building this is set to become a reality in the not-too-distant future. Figure 2 shows a smart home environment with numerous IoT devices to support services of the kind described above. Figures 3 to 10 show



Fig. 8 : Philips Hue : Dimmer switch

some IoT-enabled devices that are already available in the marketplace. The benefits of the smart home are not limited to convenience, it has a great potential in making our homes greener and cheaper. Home automation systems offer us time saving: the time we can spent with our loved ones rather than attending to routine chores. Water and energy-monitoring tools, and programs to optimize energy consumption could help us lower our water and energy usage, which could in turn, lower our bills and reduce our carbon footprint.

Energy Management and IoT



Fig. 9 : Maid : Smart Microwave oven

go hand-in-hand. In today's building eco systems, a major portion of the power is used for lighting, heating and cooling . A well connected network of smart devices which have the capability of monitoring, reporting and controlling the light, cooling and heating fixtures can not only cut down the energy consumption, but also optimize the user experience of the inhabitants by effectively using the resources.

Wearables for Health, Fitness and Safety

Longer life is a global triumph



Fig. 10 : Pantelliget : Smart frying pan

as well as a global challenge. Worldwide, the number of persons over 60 years of age is growing faster than any other age group. The number in this age group was estimated to be 688 million in 2006, and is projected to grow to almost two billion by 2050. Automation and centralized control have significant benefits for family caregivers. By integrating home healthcare equipment such as monitoring and diagnostic tools, smart homes could simplify the caregiving process for hundreds of millions of adults worldwide who care for their elderly persons Furthermore, smart homes could



Fig. 11 : Withings Activité : Activity tracker



Fig. 12 : Fitbit Flex : Activity tracker



Fig. 13 : Olive bracelet :Stress management tool



Fig. 14 : MisFit : Activity tracker



Fig. 15 : FILIP : Wearable phone and locator for kids

assist independent living of the elderly and provide peace of mind to their relatives through continuous remote monitoring. Non Communicable Diseases (NCDs) are posing a great threat to human health. The busy life style with reduced peace of mind and increased consumption of fast foods have been identified as main causes for the growth of NCDs worldwide. Even though most of us know these facts, we are reluctant to change the way we live. A gentle reminder or just the impression of someone monitoring you can create the prtdusyion that one needs to change his habits towards a healthier lifestyle. Wearable technology empowered by the IoT has created a range of applications which enable us to monitor our bodies as never before. The parameters under observation can be simple as the number of steps that you take or as complex as your blood glucose level. Activity tracking devices have evolved from mere wrist bands to fashionable jewelry with elegant designs and sophisticated

technologies to harness every movement of the body. With the use of miniaturized components such as accelerometers, gyroscopes and altimeters, these trackers have become an add-on to the daily attire for measuring the activeness of a person. The development in communication technologies such as Bluetooth Low Energy



Fig. 16 : iBabyMonitor : Digital video monitor

(BLE) has paved a pathway for these devices to engage in energy efficient communications. The advances in cell chemistry has created more compact, long lasting and lightweight batteries for wearables. Figures 11 to 14 illustrate some commercially available wearable health and fitness devices.

Like the elderly, the child population is another segment of society who needs continuous supervision from their parents. With the advancements in IoT



Fig. 17 : Mimo : Baby sleep monitor

technologies, every parent who owns a smartphone has the ability to monitor their children around the clock. A web connected camera streaming instant information on how well your baby is at home can provide peace of mind for a busy mom at work. Connected sleep monitors, temperature, humidity sensing devices can alarm the parents with the early sense of



Fig. 18 : Scully: Connected Moto cycle helmet

signs. Wearable devices specially designed for young children can be pinned to a shoe, bag or worn as a watch to enable patents to monitor their movements outside the home.

Wearables equipped with outdoor localization techniques and hazarders environment detection



Fig. 19 : Athos : Smart appeals



Fig. 20 : FieldWiz: performance measuring system for outdoor team sports



Fig. 21 : FitBark : Activity monitor for Dogs



Fig. 22 : E-Trakka : Equine Fitness Monitor

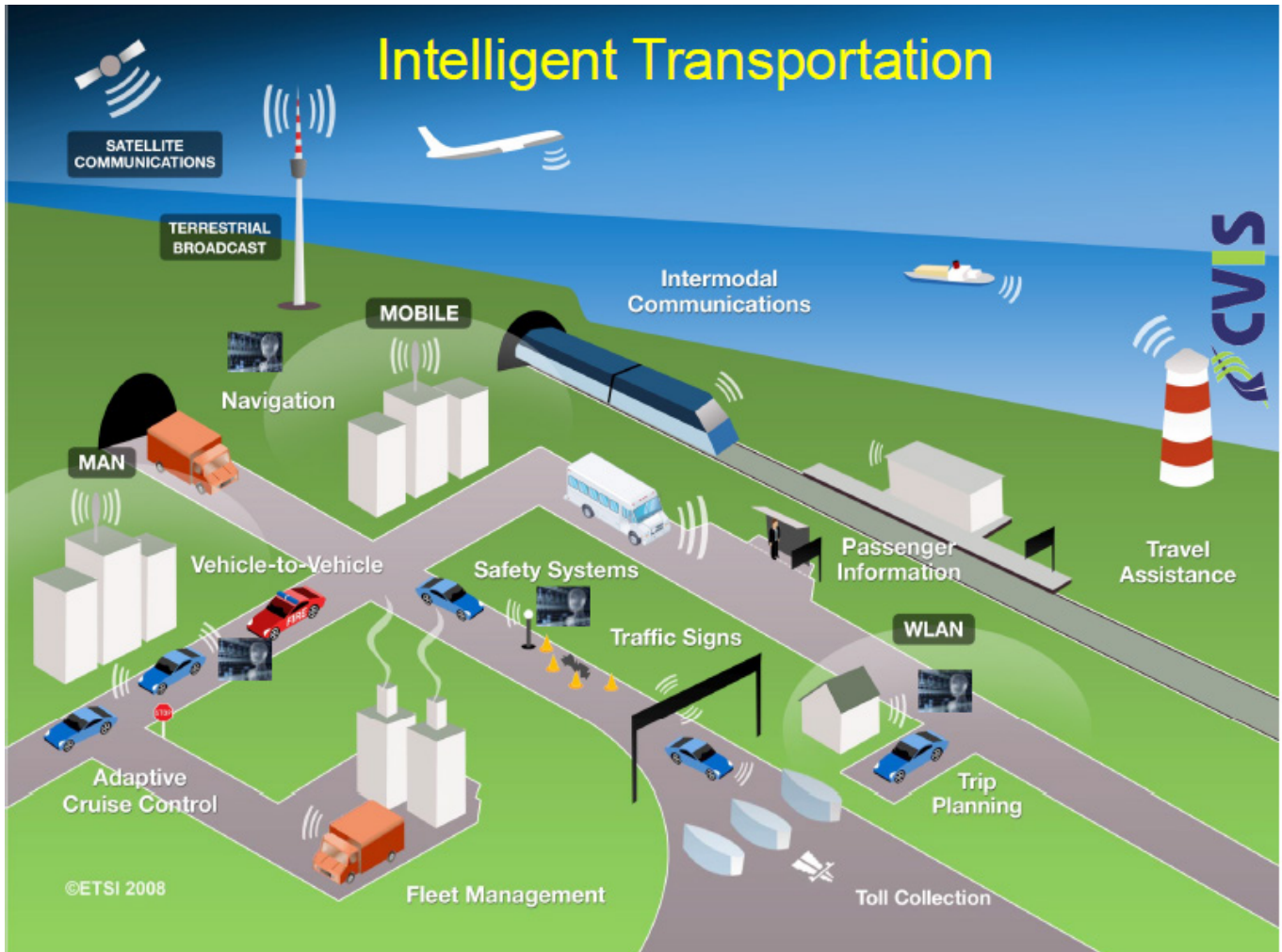


Fig. 23 : Smart Transportation system

capabilities (e.g, impact detection) combined with WiFi or cellular communications technologies can be used in applications that communicate a message that your child has had a fall at school, or that the school van’s driving characteristics are unsafe, or automatically alarming early responders in case of road accidents. Figures 15 and 16 show IoT devices for infants, and Figures 17 and 18 for young children.

Miniaturization of sensors and communication hardware and advances in conductive fabric technologies have opened a new pathway to integrate electronics

into the clothes that you wear. Revolutionary smart wear products have created a new era in analysis of muscle activity and heart rate in real time in everyday life. Algorithms turn this data into guidance on movement and posture which are designed to provide detailed feedback to athletes, perfecting a tennis serve or golf swing, or physiotherapy patients recovering from injuries.

Some examples of smart wear, where the devices are integrated into clothes are shown in Figures 19 and 20. Wearables are not limited to humans. Figures 21 and

22 show wearables for dogs and horses respectively. Such devices keep track of your pet, monitor its level of activity and wellbeing, or can perform more complex analysis on animals used in sports.

Devices and Applications for Smart Transportation

Vehicles, highways and transportation are also fast becoming part of the Internet of Things, in emerging Intelligent Transportation Systems (ITS). Components of ITS include vehicle-to-vehicle and vehicle to roadside communications. Figure 23 shows an ITS scenario. On-board devices include navigation

Devices for Enabling IoT Applications

devices enabled by GPS receivers, inertial components, a variety of sensors to facilitate on-board diagnostics (OBD), proximity sensors etc. Roadside devices include traffic sensors, cameras, digital signage etc.

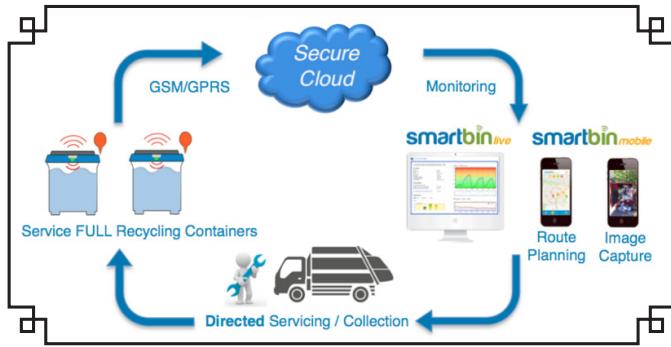
IoT technologies have spread to all sectors of transportation. This transformation creates many new and exciting opportunities to help save lives with improved safety on our roads, rails, waterways, airways, and public transit systems. Better asset and vehicle use, increased ridership and market share with faster travel times, and on-time delivery of people and goods are

all possible today. Electric vehicles which are gaining a popular share in the market completely depend on smart devices and connectivity to provide better performance and added functionality to their owners. Smart sensors have also contributed to increasing the safety in mass transit systems such as railways. GPS enabled collision avoidance systems monitor trains in the local network and informs conductors if a train is approaching on the same track, helping the railways become even safer. Looking for a safe parking space in busy urban centers is frustrating, intensifies congestion on the roads, and increases pollution

from circling cars. Sensors fixed in parking spaces can determine the availability of the parking space and transmit that information to a centralized system which can distribute the information directly to drivers, helping to guide them more quickly to an available spot, or to cities, which can use the data to adjust pricing based on demand. Of all the forms of transportation, driving remains the most dangerous. Governments around the world are exploring ways to leverage IoT to make the roads safer by connecting the vehicle and the driver with the surrounding environment. The US Department of Transportation is testing



Fig. 24 : Smart cities



the uses of vehicle-to-vehicle communication, enabling cars to sense and respond to possible risks on the road. Cities are also connecting to drivers within their cars: Walnut Creek in California has implemented a system that connects with drivers' smartphones, pushing alerts when the light changes from red to green to discourage distraction while driving.

Smart Cities, Applications and Enabling Devices

The number of urban residents is growing by nearly 60 million every year. In addition, more than 60 percent of the world's population will be living in cities by 2050. As a result, people occupying just 2 percent of the world's land will consume about three-quarters of its resources. Moreover, more than 100 cities of 1 million people will be built in the next 10 years. Today's cities face a variety of challenges, including job creation, economic growth, environmental sustainability, and social resilience. Given these trends, understanding where we are in the evolution of the Internet is critical to future city-planning processes. Smart City scenarios are shown in Figure 24. Chicago's Array of Things and Dublin's CityWatch are models for the deployment of citywide sensor networks. Partnering with research institutions and corporations,

the urban sensor network can be analyzed in expert analysis tools to identify patterns in microclimates, and make predictions about vehicle and pedestrian congestion. Moreover the data is used to give a self awareness to the general public about the impact they are making on the environment.

Many cities face severe problems with water, irrespective of the amount of rain they get. Irrigation planning using IoT is not limited to plan and manage irrigation, but also covers areas like flooding and wastewater management during storms.

Although waste management is traditionally a hands-on service, IoT companies are developing two-way communication tools to reduce labour and increase the efficiency of waste management systems. Sensor-enabled trash receptacles measure waste levels in public bins and compact trash to reduce overflow. The bins share the data with local authorities, allowing them to enhance efficiency by planning collection routes when and where pickup is needed.

The smart grid is one of the most well-developed and widely recognized IoT systems. Smart metering is the prime component of a smart grid, which enables self-awareness among the consumer. The information collected on buildings' energy usage is fed back

these cities are installing sensors on lampposts to monitor environmental conditions including temperature, noise, and air quality. The data collected through

to a central management system, in order to efficiently allocate resources.

Concluding Comments

As IoT technologies expand, the world around us becomes smarter. However the prime question is, "is it smart enough?" In architecting these solutions, power consumption, connectivity, data security, ergonomics are some of the challenges that the designer must face. Connecting each and every object around us poses new threats to one's privacy, and doubts have arisen about organizations spying on their employees through connected devices. Technology is the only way of providing solutions to the problems created by technology itself. Today, technology is developing at a rapid pace, and there is much hope for addressing these challenges successfully. With smart and forward-looking leadership, IoT has the potential to create a revolution in the way we live. By embracing the potential of IoT, policy makers going hand in hand with technology creators can improve service delivery, increase sustainability, and make the world safer and a more livable place for all living beings.



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