Pervasive (sensor) computing, a new disruptive paradigm shift.

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Introduction

Pervasive computing (also called ubiquitous computing or ubicomp[1]) is the growing trend towards embedding microprocessors in everyday objects and activities so they can communicate information [2]. The words pervasive and ubiquitous mean "existing everywhere." The Internet of Things (IoT) is a related term. It refers to uniquely identifiable objects (things) and their virtual representations in an Internet-like structure: completely connected and constantly available. Someone using pervasive computing engages many computational devices and systems simultaneously, and is often not aware that they are doing so. In that way the model is considered an advancement of the desktop paradigm: machines that fit the human environment instead of forcing humans to enter theirs [3]. A simple example is the piano stairs [4], where the stair next to an escalator is changed in a real piano, showing a huge increase in individual taking the stairs. It shows how the experience and behaviour of people can be influenced in a voluntary challenging way.

With embedding microprocessor techniques we can create smart products that sense the environment and communicate unobtrusively. It goes beyond the realm of pc's. It is the idea that almost any device, from clothing to tools to appliances to cars to homes to the human body to your coffee mug, can be imbedded with chips to connect the device to an infinite network of other devices.

Pervasive computing encompasses a wide range of research topics, including (with the earlier mentioned ubicomp and IoT) distributed computing, mobile computing, human-computer interaction, context-aware computing and artificial intelligence.

History

Mark Weiser introduced the phrase "ubiquitous computing" around 1988 [5]. The idea built on Mark's earlier research on human-computer interaction. Mark hoped to create a world in which people interacted with and used computers without thinking about them.

Pervasive computing can be seen as the third wave of computing technologies to emerge since computers first appeared [6]. The first wave is the mainframe computing era, where one computer is shared by many people via workstations. The second wave is the pc era where one computer is used by one person, requiring a conscious interaction and the user is largely bound to the desktop. The third wave is the pervasive computing era: one person uses many computers. Millions of computers embedded in the environment, allowing technology to recede into the background.

The research of pervasive technology evolved from the early 1990s.The first applications where often using Radio-frequency identification (RFID). RFID is the use of wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to an object. RFID matured in the 1990s in

applications for automatic identification and tracking. Recently RFID are replaced by intelligent embedded microprocessors with sensors.

Technique
Pervasive computing relies on the convergence of three areas: mobile computing, embedded computing and sensors [6]. We are all aware of the widespread use of mobile computing with Smartphone's and tablets. It is changing the way we live and work, as profoundly as the introduction of the automobile did almost a century ago. Embedded computing provides computing and communication services all the time and everywhere. It is the core part of pervasive computing and is the combination of hardware and software components that autonomously respond to the needs of its occupants. Sensors can be used for real-time identifying, locating, tracking, monitoring, etc.

The recent acceleration is caused by progressively smaller and more powerful computing devices. Sensors and microboards are available for only a few euro [7]. Microboards, like Arduino [8] and Phidgets [9], are often developed in the open source environment and supported by strong communities. They can be programmed with a pc and sensors can easily be connected. A great spectrum of sensors are available to measure light, sound, tilt, pressure, CO2, motion, heat, etc. [10]. Youtube gives over 30000 hits for Arduino applications.

Applications and opportunities
IBM's Smarter Planet team has created a 5 minute video explaining the emerging trend of Internet of Thing [11]. Internet of Things is about, as the video explains, the coming future when there are more "things" on the Internet (sensors especially) than there are people. The result of that will be "a kind of global data field" the video says. "If we can actually begin to see the patterns in the data, then we have a much better chance of getting our arms around this. That's where societies become more efficient, that's where more innovation is sparked."

David Barnes spoke on the Web 2.0 Summit 2011 about IBMs future plans into developing smart cities and a smarter planet [13]. It's a more literal notion of "big data," one that involves sensors everywhere to measure the living, breathing planet. IBM wants to build a Web of sensors producing massive amounts of big data for governments, health care providers, first responders and businesses. It wants to measure the weather, the sewers, the vehicles, the buildings and the people.

By smarter, IBM means the world is becoming instrumented, interconnected and intelligent [15]. Data is being captured today as never before. It reveals everything from large and systematic patterns to the location, temperature, security and conditions of every item. IBM wants to infuse that intelligence into the systems and processes that make the world work, into things no one would recognize as computers: cars, roadways, powergrids, clothes, even natural systems such as agriculture and waterways.

the Danish Alexandra Institute has just released a comic book called "Inspiring the Internet of Things," which explains the benefits of networking everyday objects through 15 illustrated scenarios. The PDF version is available for free download [12]. A few exciting scenarios are:

- A smart urban waste management that will allow a more efficient waste collection and, in addition, incentives can be brought forward to encourage citizens to produce less waste and recycle more.
- Applications to improve the quality of life for the elderly. For a person that is diagnosed Alzheimer's disease, for example, a monitoring solution with sensors can be installed so the doctor or family can monitor him remotely and receive a message in case of a problem. The patient retains his private and social life which is very important for coping with his condition and happiness.
- Applications for emergency response. Sensors in a car and on the passengers, for example, detect a serious collision and send a signal to the emergency services with geo-location information and condition of the passengers.
- Applications for intelligent shopping with augmented reality. By pointing your mobile phone on products you get additional information overlaying the camera view such as origin, ingredients and suitability for your allergies.
- Applications for home automation that will tell you what you did for how long, where and when. With this behaviour information, the information from all electric systems in your house and environmental data like weather conditions, it can control access, energy, heating according to your profile ad price. In this way it adjusts the house energy consumption to the real needs of the family, and helps you to save money.

Future
Pervasive computing (IoT or smart objects) is in the top of many recent trend reports. Surf [15] recently combined four trend reports from Gartner, UK, USA en New Zealand and ranked it on the tenth position.

The EU has chosen pervasive computing as one of her target research areas [2] in the Internet of Things Initiative. They recognize it as one of the most important areas of a Future Internet with high potential to positively impact European economy and society.

IoT developments show that we will have 16 billion connected devices by the year 2020, which will average out to six devices per person on earth and to many more per person in digital societies [17]. Devices like smart phones and machine to machine or thing to thing communication will be the main drivers for further IoT development. The first direct consequence of the IoT is the generation of huge quantities of data, where every physical or virtual object may have a digital twin in the cloud, which could be generating regular updates. The IoT contribution is in the increased value of information created by the number of interconnections among things and the transformation of the processed information into knowledge for the benefit of mankind and society. The Internet of Things market is connected to enabling technologies such as nanoelectronics, communications, sensors, smart phones, embedded systems, cloud computing and software technologies that will create new products, new services, new interfaces by creating smart environments and smart spaces with applications ranging from smart transport, cities, buildings, energy, grid, to smart health and life.

Bronnen
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