Tracking People's Movements by RFID Implants

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Abstract:

Assume it is 2050. There is no place and time which cannot be tracked. There is nothing that anybody can hide. Everything has an identity number in a central database in United States and it is connected to internet. It is obvious that one is sitting on a chair, the chair is in a room and the room is located on the thirtieth floor of a skyscraper in Manhattan. Spatial relationship of objects can be measured. It is real time city where anything can be tracked.

Rolex Company wants to measure the density of its watches which has been bought by customers in Brooklyn. They want to be more specific and find the percentage of Asian people who have their watches on their hand at this moment in Brooklyn. They narrow down their scope and apply apartment price to this measurement. Now Rolex can make decision about its new employee who is going to be employed in that area. According to previous researches the new staff must be a female and be aware of Chinese culture. She has to be a little conservative because Rolex has found the majority of its customers in that area are rich Chinese people who are so conservative.

This science fiction story will be feasible if the identity of everything can be scanned at any time. That identity can be a code which comes with goods and people from the first day of their lives. Newborn babies will not be brought out of hospitals without identity code. New goods and products will not be accepted by sellers. Nowadays it is happening. Babies have identity code and goods have bar code. The question is how these codes can be alive and be used in a real time city.

In this article the nature of these controversial codes will be discussed and some examples of their application in transportation planning and urban planning will be mentioned.

Introduction:

What is RFID? The acronym means Radio-Frequency Identification. They are small devices which consist of a chip and antenna. The RFID chip is like traditional bar code on an object in a shopping mall which provides unique information for that object. There are some differences between RFID chips and bar codes. Barcodes have to be scanned by a linear scanner but RFID chips do not need to be positioned in front of the scanner. As an example you can have a bag full of stuff which has RFID chip and you can scan the bag quickly and all the stuff will be scanned(Landt 2005).

Each RFID chip has a unique identification number and this identification number can be linked with other information in external databases. For example medical history, personal identification numbers, contact information and any other information. When a RFID tag passes through a scanner, its ID can be stored and linked to the other existing information (Foster, Jaeger, 2007).

RFID tags can contain more data than identification numbers. For example, they can include information about the host object. If RFID tags combined with sensors, they are able to save some information about the environment where they are in. For instance, temperature and humidity can be sensed and stored in the tag (Rotter, Daskala, Compano, 2008).

RFID human implant is a rice-grain size RFID chip which can be implanted in body(Arellano 2008). They can be tracked and data can be stored in these implants too. They are always with people and they can be used as an identification card in airports, hospitals and any other places which require identification information.

There are different issues about RFID and human right. Some scholars believe the concept of RFID implant is a kind of violation of people's freedom (Reynolds, 2004). In this paper we will focus on the positive effects of RFID technology in society.

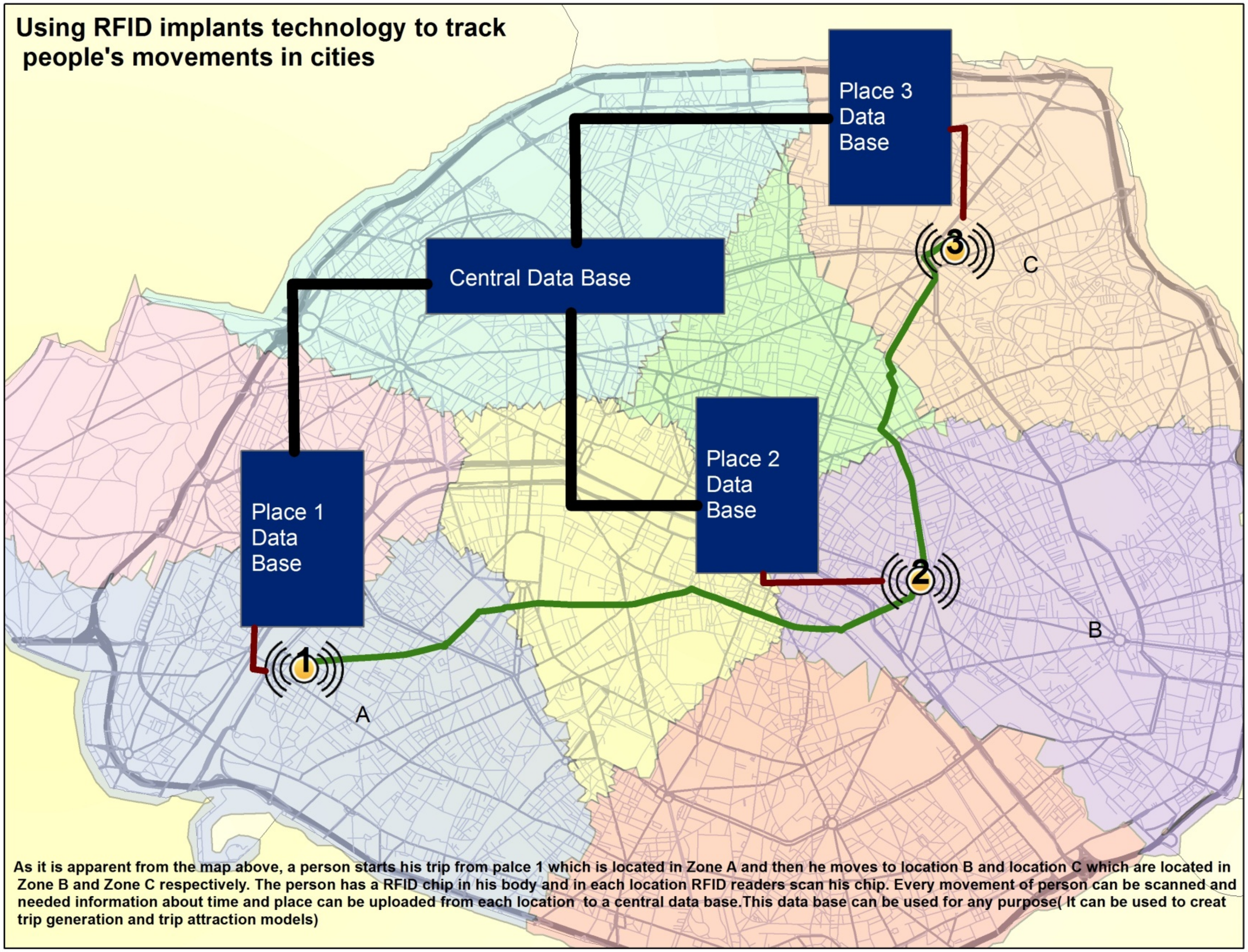

Figure 1 Tracking people's movemnets in cities

RFID tag number	Zone	Enterance time	Exit time	Credit info	Bill amount
370214471	A	8:25 AM	8:56 AM	…	…
370215324	A	12:36 PM	14:43 PM	…	…
037…	…	…	…		

Place 1 data base (ex: local store, commercial zone)

RFID tag number	Zone	Enterance time	Exit time	health background	Allergic to
370214471	B	12:51 PM	13:39:00 PI	…	…
38033584	B	16:12	16:47	…	…
037…	…	…	…		

Place 2 data base (ex: Hospital)

RFID tag number	Zone	Enterance time	Exit time	Apartment number	rent balance
370214471	C	16:27 PM	-	…	…
-	-	-	-	…	…
-	…	…	…		

Place 3 data base (residential area)

	Zone A		Zone B		Zone C	
	Enterance	Exit	Enterance	Exit	Enterance	Exit
370214471	8:25 AM	8:56 AM	12:51 PM	13:39 PM	16:27 PM	-
370215324	12:36 PM	14:43 PM	-	-	-	-
38033584	-	-	16:12 PM	16:47 PM	-	-

Central data base

History of different applications of RFID:

In 1948 of the earliest articles about RFID systems were published (Roberts, 2006). During the Second World War this technology were used for the first time. The Germans, Japanese, Americans and British all used radar during the war but they could not determine which plane belonged to the enemy and which was their own (Mark Roberti, n.d.).

On the basis of the Watson-Watt secret researches, the British developed a transmitter which they put under each plane. When the transmitter received signals from their own radar, it began broadcasting a radio wave back. In this way the British could find which plane is for enemy and which is belonged to alley. Nowadays RFID system works based on this concept. When RFID tags receive a signal, they send a signal back (Mark Roberti, n.d.).

From that time onward, different scientists all over the world tried to develop RFID systems. In 1950 to 1960 RFID tags were used in stores. They called it anti-theft systems and stores used it to know whether an item had been paid or not. This technology is being used nowadays in stores too. Each tag has 1 bit data. It is either on or off. If someone pays for it, the tag will be off. If the person does not pay for it, it will be on and readers in front of the door will detect them and sound an alarm (Mark Roberti, n.d.).

In 1970s, there was a lot of research and development in the field of RFID and first animal tags were used. In 1980s, different countries used RFID tags for pay tolls and drivers could pay the toll without stop. In 1990 a great deal of researches were done to reduce the size of RFID chips. In early 1990s IBM developed an ultra-high frequency (UHF) RFID system. The read range of this system was up to 20 feet under good conditions. IBM did a pilot project in

Walmart but they did not finish the project due to financial problem. In the mid-1990, Intermec, a bar code systems provider bought the patents from IBM. RFID systems offered by Intermec were used in warehouse tracking and farming. The technology was expensive at that time (Mark Roberti, n.d.).

In 1999, two professors, David Brock and Sanjay Sarma, worked on RFID systems in the Auto-ID Center at the Massachusetts Institute of Technology. They wanted to develop a low cost RFID system. Their initial idea was put RFID tags on all products. It gave ability to manufacturers to track product through the supply chain. A serial number in the tags could be linked to a database through the internet (Mark Roberti, n.d.).

Between 1999 and 2003 the Auto-ID center gained the support of big companies. It opened a research lab in different countries such as Australia, the United Kingdom, Switzerland, Japan and China. Two air interface protocols, EPC [1]numbering scheme, and a network architecture for looking up data associated on an RFID tag on the Internet were developed by Auto-ID center (Mark Roberti, n.d.).

Some of the biggest companies in the world announce that they will use RFID chips in their products widely. On the other hand, Department of Defense has said they plan to use EPC[2] to track goods in supply chain (Mark Roberti, n.d.).

1 Electronic Product Code:
A serial, created by the Auto-ID Center, which will complement barcodes. The EPC has digits to identify the manufacturer, product category and the individual item.
2 Electronic Product Code

Main Components of RFID:

Each RFID system consists of three main components:

- an RFID device (tag)
- a tag reader with an antenna and transceiver
- a host system or connection to an enterprise system (Roberts, 2006)

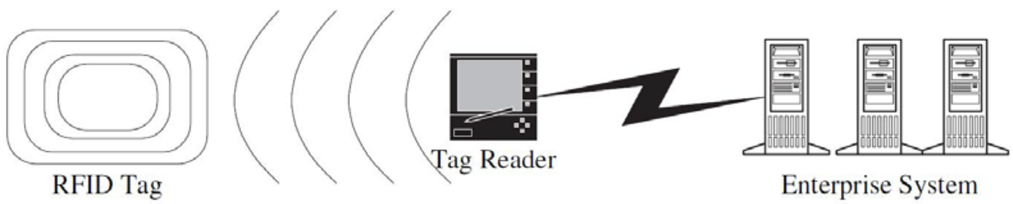

Figure 2 Three main components of a RFID system (Roberts, 2006)

There are different kinds of tags. Tags are chosen according to their application. Three different categories of tags are: Passive tags, Semi Passive tags and Active tags. Passive tags do not have a battery in them and they use the power generated by reader. When a passive tag is placed in the scanner or reader it will become active (Smith, 2008). Passive tags are generally read only. These tags are lighter, cheaper and smaller than other kinds of tags and they have a longer life. They need higher power reader and their read range is short (Roberts, 2006). Passive RFID tags could have different read range according to the frequency of waves and reader. These tags can be activated in frequencies between 30 KHz and 2.5 GHz. Low frequencies have shorter reading range and high frequencies have longer reading range. Higher frequency systems usually are used in automated toll collections (Smith, 2008).

In semi –passive tags battery powers the chip but the device communicate by power gained from reader (Roberts, 2006). The device can beep, blink or perform other operations using battery. The semi-passive tags are faster than passive tags but they are not faster than active tags (Smith, 2008).

Active tags have an internal battery in them and they are read/write capable. The read range of active tags differs from very close range to 100 m (Smith, 2008). Active tags have larger memory and they can store more data than passive tags. These tags are more expensive than two other kinds of tags. The battery shortens the life of the tag and they usually work for 10 years (Roberts, 2006). For the cases which manufacturers and clients need a longer read range, active tag is the best choice for instance in container tracking systems(Mizuno, Shimizu, 2007).

Read rang vary according to different factors. These factors influence the read range: frequency of the radio waves, the size of the tag antenna, the power output of the reader, whether a tag has a battery or gather energy from a reader. As mentioned before battery-powered tags have a read range of 100 meters. These kinds of tags are used for toll collection. UFH[3] tags which are used in supply chains and on the pallets have a read range between 20 to 30 feet in ideal condition (A Summary of RFID Standards, n.d.).

The cost of the RFID systems is one of the important issues which has to be considered. The most popular tags are Article Surveillance (EAS, class 0[4]) which cost between 1 and 6 US cents each. These EAS tags contain 1-bit or no information and they determine presence or

[3] Ultra-high frequency

4 Class 1: a simple, passive, read-only backscatter tag with one-time, field-programmable non-volatile memory

absence. Passive tags (class 1[5]) with data storage cost between 5 and 10 US cents each. For large and value items, Class 2-4[6] are being used and they cost up to US$100 each (Roberts, 2006). The cost of the reader differs according to features. Most UHF7 readers cost between $500 to $2000. Low frequency readers cost less than 100$ and high frequency readers cost $200 to $300 (A Summary of RFID Standards, n.d.).

Presently other technologies are being used to reduce the costs of RFID systems specially RFID tags. There are some companies that seek to replace metal tags with organic material. This method allows cheap mass-production of tags. One of the projects to replace the tags material is MaDriX. This project is supported by German Federal Ministry of Education and Research (Zudor, Keme´ny, Blommestein,Monostori, Meulen, 2010).

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5 Class 2: a passive backscatter tag with up to 65 KB of read-write memory.
6 Class 3: a semi-passive backscatter tag, with up to 65 KB read-write memory; essentially, a Class 2 tag with a built-in battery to support increased read range.
Class 4: an active tag that uses a built-in battery to run the microchip's circuitry and to power a transmitter that broadcasts a signal to a reader.
Class 5: an active RFID tag that can communicate with other Class 5 tags and/or other devices (RFID Journal, n.d.)
[7] The read range for UHF readers is 1m to 15m

RFID applications:

The technology of RFID systems have been developing since World War Two. Anti-theft systems, toll collection systems, tagged pallets in supply chain are only some examples to show how the RFID concept is being widespread. RFID can be used in every place where we need information about an object or person. This information can be about the object, person, the environment where they are in or the time when they are in a place. Here some examples of application of RFID are provided.

Yo-Ping Huang, Shan-Shan Wang, Frode Eika Sandnes discuss how RFID system can provide a more interactive experience in museum? When a visitor with a PDA (with a RFID) reader approaches a tagged object in museum, the information about the object will be shown in his or her PDA (Huang, S Wang, Sandnes, 2011). If a person has a personal RFID with language background, information could be shown in his or her language.

The US military and United Kingdom armed forces have used RFID systems for years to control their warehouses and supply chain (Radio frequency identification ready to deliver, 2005). UK's Tesco supermarket chain has used RFID systems to control distribution of their products to 98 branches all over the country (Tesco Begins RFID Rollout, 2004). Walmart and US Department of Defense use RFID tags to organize their products (RFID Gazette, 2004).

RFID implants:

RFID implant is a rice-grain size RFID chip which can be put in the human body. In 2004, a first RFID implant was approved by U.S Food and Drug Administration. The name of this implant is VerChip. They include a 16 digit identification number and they can be scanned from a distance up to 10-15 cm. The ID number is long enough to be given to everybody in the world. Other information related to the owner is not stored in the chip. When an implanted person goes through a scanner, this unique ID can be linked to the data base and other data related to the person will be extracted from data base. VeriMed, the commercial application is designed to identify patient in the healthcare system. In a healthcare center the patients with implants can be scanned and an authorized doctor will have access to the health background of the patient. This kind of implant is a passive tag and has a short read range (Rotter, Daskala, Compano, 2008).

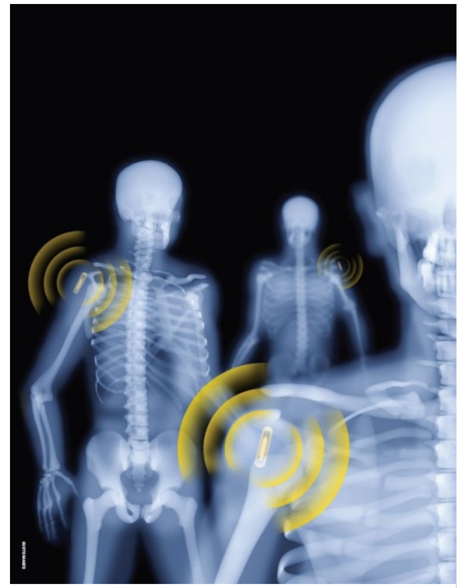

Figure 3 3RFID Implants (Foster, Jaeger, 2007)

Veri Chips now is being used in Mexican hospitals and over one thousand patients are using these implants. They tell each person's blood type, known allergies, prior treatments and any other possible information about the person's health background. The idea is to reduce errors by doctors (Smith, 2008)

Richard Seeling, Vice president of VerChip Corporation estimates 45 million people will use these implants. He believes cancer patients, people with pacemakers, people suffering from loss of consciousness, diabetes, Alzheimer's disease will use these implants (Foster, Jaeger, 2007).

There are some other applications of RFID implants. When an implanted person approaches the door it will be opened if the person is authorized. Readers can be put in cars and when the owner of the car sits in the car, it will be started (Foster, Jaeger, 2007). There are thousands of examples of application of RFID implants but there are some security issues which have to be solved. Martin Reynolds discuses how RFID implants can be scanned without permission and readers can be hidden. Gartner [8]believes these RFID implants will not be used widespread until secure devices become available (Reynolds, 2004)

[8] Gartner, Inc. (NYSE: IT) is the world's leading information technology research and advisory company

Figure 4 Components of a RFID Implant (Foster, Jaeger, 2007)

RFID implant and urban planning:

If we assume a day will come when everyone has an implanted RFID chip in his or her body and everywhere has a RFID scanner, we will have spatially distributed people with unique ID which can be scanned everywhere and anytime. Why do we have to assume this nightmare will happen? This question does not have a simple answer. You have to think who are the most influential people in the world? People who assume RFID implants are nightmare; owners of big companies wanting control thousands of workers with RFID implants, directors of insurance companies with millions of clients[9], politicians who strive for power or leaders of the society who seek for security[10]?

If Google and IBM announce their personnel have to be implanted and implanted personnel are eligible for some incentives, If insurance companies announce implanted clients have to pay less than others, If airports say implanted passengers can pass easily through gates without security check, if schools do not take responsibility of students without RFID implants, if U.S Homeland Security does not allow international students without RFID implant come to the United States and thousands of other if, then people who assume RFID is a nightmare have two choice: living in a desert or being implanted.

Now it is more feasible to have spatially distributed people with unique ID in near future. In this hypothetical society everything has a unique ID. Everything and everyone could

[9] RFID could have an important influence in insurance systems. When doctors have access to health background of the patients, the number of errors in healthcare systems will be reduced.

[10] If everyone has an RFID implant and everywhere equipped with reader, criminals can be tracked easily. For example if computers only start up after RFID scanning, it will be more feasible to track hackers.

be connected to internet. There could be thousands of proposals for this utopia (or dystopia).Does this network of people, objects and places have any application in urban planning?

There are different theories and methods in urban planning which focus on the relationship between people and place. Kevin Lynch in his book "Image of the City" talks about the Image of the city in people's mind. He discusses landmarks and their visual quality. He believes land marks have to be different from their surrounding and they have to be in nodes in cities. These qualities make them more attractive and people can recognize them better (Lynch, 1960). On the basis of Lynch theory there must be a visual relationship between people and environment. Why do we not have a relationship between land use and people's interests? Why do people not have a map of their favorite places in their minds? To build this new image of the city we need to digitize people's background and interests. RFID implant is the key to solve this mystery. As mentioned before RFID implant can be linked to a central database and this data base can include any data. For example it includes your search history in Google [11]or history of restaurants where you have been this week[12]. Now you are passing through a street and one shop on the other side of the street has the book you searched yesterday in Google[13]. Bookstore can scan your RFID[14] or Mobile phone. So the bookstore finds your favorite book according to your search history. It sends a message to your cell phone to inform you it has your

[11] If we assume every object has a reader, every computer will have a RFID reader too. So what we searched can be stored in a data base linked to our ID.
[12] If we assume every place has a RFID reader so every restaurant where you have been, have scanned your RFID and it is obvious what you have eaten there because you were connected to the data base of the restaurant.
[13] The book has a RFID chip in it and the shop has a reader so the book is connected to the data base of the shop.
[14] RFID implants have short read range but they can connect to your mobile phone (equipped with RFID reader) and then you can be connected to internet and your data base (Rotter, Daskala, Compano, 2008).

favorite book. The shop can show the picture of the book which you searches yesterday in an advertisement screen in front of it.

In the case of restaurants: yesterday you have been in Pizza Hut and in your food history there are some fatty foods. When you are passing a fitness club, a message will be sent to your cell phone and shows that you need some exercise today. These are only two examples to show how RFID implant can be used to integrate our personality and background with built environment.

RFID implants have this potential to be used in transportation studies. According to figure 1 In forecasting travel demand, we usually split the city to different zones and then we calculate how many travels have been accrued from zone A to Zone B and then we forecast travel demand. For example Zone A is a commercial zone and Zone B is a residential zone. Questionnaire is the traditional way to find the trend of people's travel. In our assumed city with implanted residents where, when, who and speed and any other useful information for transportation planning could be found. For example it is apparent that you left your home at 4:00 pm and then you went to Walmart at 4:30[15]. This information can be surveyed for millions of people not only a limited number of people in a sample. Transportation planning on the basis of this information will be more accurate.

In this paper a short history of RFID and main components of RFID systems were mentioned. These two issues were discussed to show how a concept can be developed and

[15] Your home has RFID reader and Walmart has RFID reader too. Your home is in residential zone and walmart is in commercial zone. They are connected to GIS land use data bases. All these data bases are connected to a central server.

what limitations we are facing. Costs and read range of RFID chips were discussed because without mentioning them the new idea for cities is only a simple dream. It is obvious which two proposed ideas are only initial ideas on the basis on a hypothetical society. It is a little disappointing when we think these ideas are fiction but every new thing comes from a dream. Also if we take a look at the history of RFID, cell phones or internet, the hypothetical society will be feasible.

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