11

Tony: Helping People Find Lost "Things" using the "Internet of Things" Technologies

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Abstract

Human beings exert a sense of ownership over the "things" in their lives. They own books, tennis rackets, cell phones, and handbags just to name a few. They transport these "things" from home to the office and, then, to recreational areas. And, in the process, they often loose these "things". Pupils misplace school books. Adults misplace eye glasses. Often these items are found by other people but these other people have no idea who owns these "things" or how to return the "things" to the original owners. Tony helps solve this problem. Tony is a JEE application running under Mobicents on a Beachcomber platform. It allows users to register various "things". The users are sent a QR (Quick Response) code label to affix to the registered "thing." If the "thing" is lost and later recovered, the finder need only take a photo of the QR Code and the original owner is notified that his "thing" has been recovered. Depending on the facilities of the item taking the photograph of the QR Code (for example, it might be a smart phone), then GPS coordinates can also be sent to the original owner indicating where the lost "thing" can be found.

Introduction To "Internet of Things"

As more and more "things" become electronically labeled, the cost of communication decreases and the embedded processing power in "things" increase, the "Internet of Things" grows. More and more "things" can be tracked and, possibly, controlled via the Internet. In the fight against crime, many cars have tracking devices and remote immobilisers. In the fight to preserve the environment, geysers (or hot water heaters) often have remote temperature controls so electrical power utilities can turn down the temperature when demand for electricity is at a peak. In the search for better health, recently, a 61-year old woman had a pace maker embedded into her body which supported a wireless connection to enable her medical practitioner to monitor how her heart is doing [Caruso, 2009].

"Things" communicate with the Internet using a wide variety of protocols. Some "things" communicate using radio frequency identification (RFID) tags or other wireless mechanisms. Some "things" are labeled with visible codes such as bar codes or QR Codes to enable linkage with the Internet. Some "things" are labeled with microscopic codes which are too small for the human eye to see such as microdot technology that can be sprayed onto cars to enable police to track pieces of stolen cars which have been broken down and sold as spares [Stevens, 1983 and Venter, 2010].

Once "things" are connected to the Internet, an opportunity exists to create intelligent value add services and application on the Internet which enhance our private and economic environments.

Research Question and Objective

People often lose possessions or "things". These possessions or "things" are often found by other people but the finders have no mechanism to determine who owns the object which they have found. The research question, therefore, was:

Can Internet of Things technologies be used to reunite people with things they have lost?

The research objective was:

Develop a mechanism where people who find objects can easily notify the original owners that their objects have been found.

The research object could be broken into sub-objectives:

1. Develop a mechanism where owners could register their "things"
2. Develop a mechanism where "things" could be labeled
3. Develop a mechanism where people who find "things" can easily inform the original owners
4. Unite these facilities in a unified architecture

Design and Creation Research Methodology

A Design and Creation Research Methodology as defined by Oates [Oates, 2006] was used for this project. The Design and Creation Research Methodology is an iterative methodology containing five steps:

1. Awareness – the recognition and statement of a problem
2. Suggestions – tentative ideas about how this problem could be solved
3. Development – implementation of those ideas
4. Evaluation – assessment of the development item
5. Conclusion – consolidation of the results

In terms of this methodology, these steps were:

1. Awareness – awareness of the problem that people loose "things" and need to be reunited with those "things"

2. Suggestions - "Internet of Things" technologies could be used to assist in reuniting people with their lost "things"
3. Development – Tony was developed using the Beachcomber platform which provided bearer agnostic communication between "things" and their owners
4. Evaluation – Tony was evaluated through the means of a number of small pilots
5. Conclusion – The results were consolidated

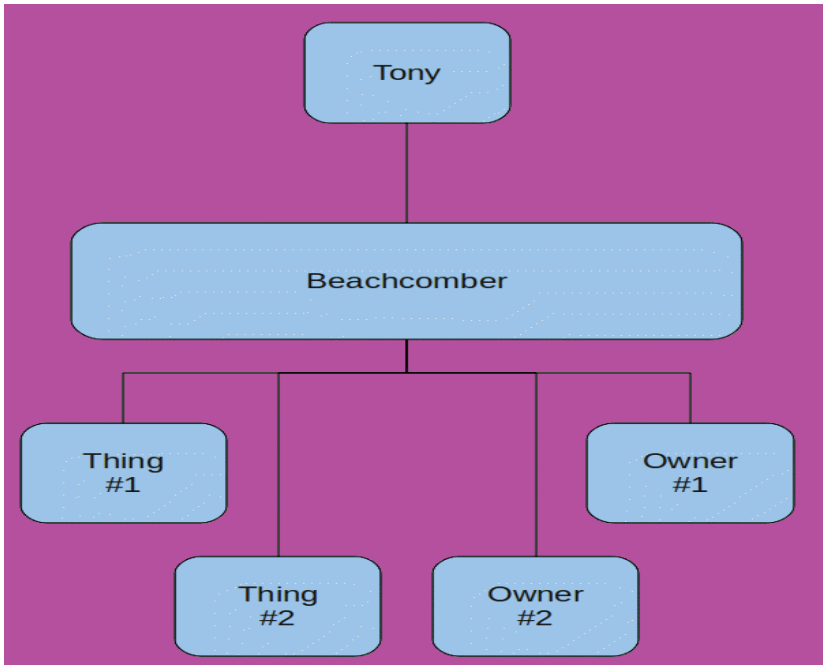
It is important to note that this methodology is iterative and numerous smaller cycles of these five steps occurred.

Tony

Tony is an innovative application of "Internet of Things" technologies to assist people in keeping track of their "things". It is a business service hosted on the Beachcomber platform. Beachcomber provides bearer agnostic communication between "things" and people thereby linking the "Internet of Things" with the "Internet of People" [Butgereit and Coetzee, 2011]. At the time of writing, Beachcomber provides for communication via XMPP (Extensible Messaging and Presence Protocol), POP3 (Post Office Protocol version 3) email, MXit, HTTP (Hypertext Transfer Protocol) servlet and client, Twitter, and JMS (Java Messaging Service). These different protocols are implemented as resource adaptors and more may be added in future.

Communication with the "things" and the owner of the "things" is maintained through Beachcomber. Beachcomber then communicates with Tony using a bearer agnostic message type. Illustration 1 provides a visual representation of this configuration showing how all "things" and owners communicate with Beachcomber and how Beachcomber maintains the communication with the Tony application.

Illustration 1: Overview of Beachcomber and Tony



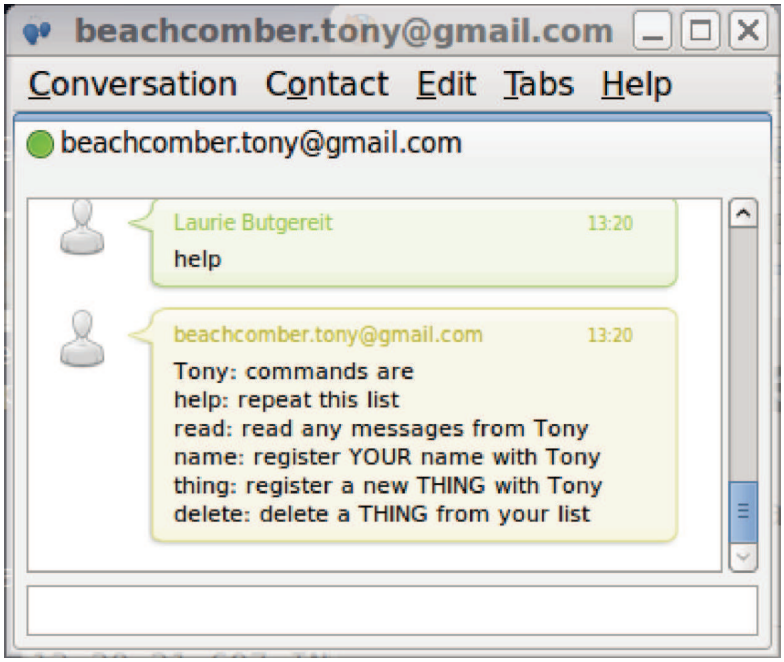
This type of implementation means that the developers of Tony do not need to know the intricate protocols of RFID tagging, or commercial bar codes, or QR Codes. That type of information is handled directly by Beachcomber. All Tony developers need to concern themselves with is the business logic of tracking and recovering "things". In addition, the Tony developers do not need to understand the intricacies of communicating with the owners using various chat protocols. That is also handled by Beachcomber. Again, Tony developers only need concern themselves with the logic of labeling, tracking and recovering "things".

In addition, although this application currently uses QR Codes to facilitate communication between people and "things", this could easily be changed to a wireless mechanism and the developers of Tony would not have to make major changes. Beachcomber provides a bearer agnostic mechanism for communication between things and business services.

Owner Interface to Tony

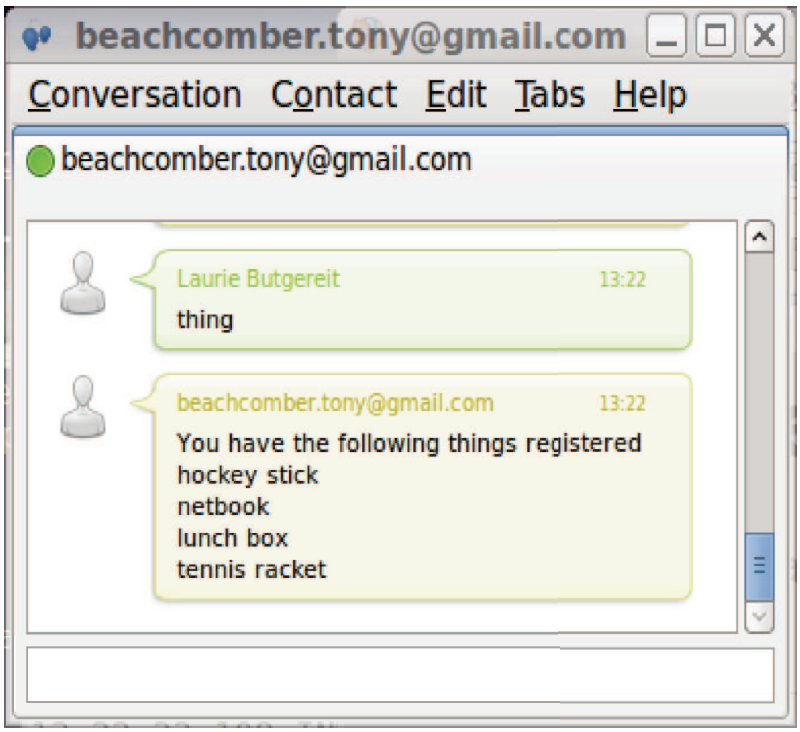
The owner of a "thing" could interface with Beachcomber through any XMPP or Jabber chat client. Beachcomber would forward the messages received via XMPP to Tony. This allowed easy access to Tony by owners through either desk top Internet based workstations or chat clients on mobile devices such as cell phones. Illustration 2 shows a list of commands available with Tony.

Illustration 2: Owner commands in Tony



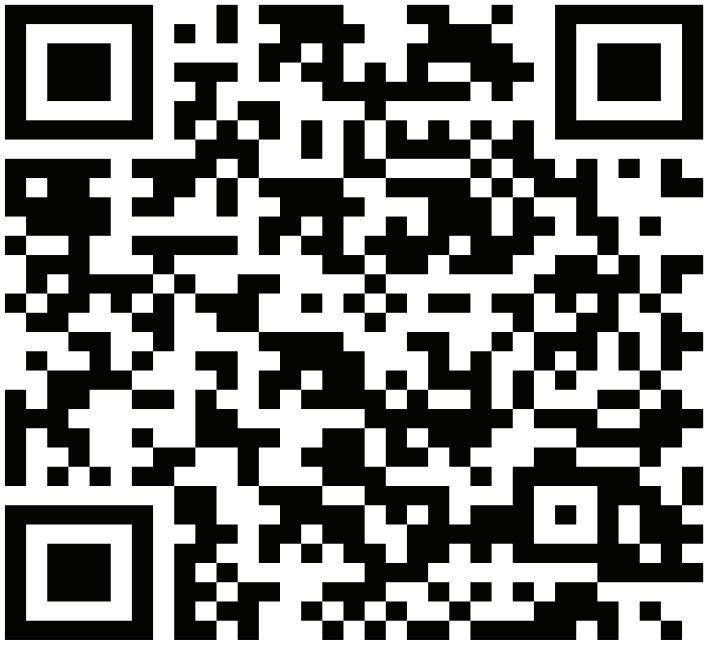
Any number of "things" can be registered with Tony as can be seen in Illustration 3

llustration 3: Example of Tony Thing list



When Tony registers an item, a QR Code is generated as seen in Illustration 4 and sent back to the user. The Tony user must affix this QR Code to the "thing" which must be tracked.

Illustration 4: QR Code generated by Tony



QR Codes are 2-dimensional visual codes which can be attached to physical objects in order to retrieve object-related information and functionality. QR Codes can be printed on paper (and possibily laminated to protect against the weather) or displayed on electronic screens. Additional information about the object is encoded in the visual code. Often the visual code contains a URL which provides even more information about the object [Rohs and Gfeller, 2004].

In the case of Tony, the QR Code had a URL back to the Beachcomber server with a parameter which told the server which "thing" had been found.

Finder Interface to Tony

The person who finds the lost thing must merely take a photo of the QR Code with his or her cell phone (assuming the cell phone is configured to recognise these QR Codes). Many high-end cell phones come with QR Code recognition software already installed. If such software is not factory-installed on the cell phone, a number of free and open source QR Code recognisers are available for both Symbian and Android cell phones. By having this software loaded on a cell phone, the cell phone becomes a sensor to identify lost "things".

Enhancing cell phones with this software provides promise for interesting applications. People usually keep their cell phones nearby, in their pockets or in their

handbags. Modern cell phones can provide continual wireless communication and usually have cameras on board. The ability to detect objects which are identified by a QR Code within the cell phone owner's vicinity strengthens the role cell phones can play in various scenarios such as education, gaming, m-commerce, in addition to "Internet of Things" applications [Rohs and Gfeller, 2004].

ZXing (pronounced "zebra crossing") is one example of an open source QR Code processor which does both encoding and decoding of various 1-dimensional and 2-dimensional bar codes include QR Code.

As part of the Tony research project, additions were done to the open source ZXing application. If ZXing detected that the cell phone also had an on-board GPS (Global Positioning System), ZXing queried the GPS to find the longitude and latitude of the cell phone owner. This information was added to the URL which was encoded in the QR Code and sent to the Tony server.

The original URL encoded with information about the found "thing" along with the GPS coordinates where returned to the Beachcomber server. If the GPS coordinates were available (and this was not supported by all phones), Tony would also create a KML file such as:

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml/2.2">
<Placemark>
<name>Tony Placemark</name>
<description>Your hockey stick has been found at this location</description>
<Point>
<coordinates>
28.278984,-25.756823
</coordinates>
</Point>
</Placemark>
</kml>
```

In addition, Google provides a geocoding platform which is free for less than 2500 queries per day. If the following URL is accessed:

```
http://maps.googleapis.com/maps/api/geocode/xml?latlng=-25.756823,28.278984&sensor=false
```

Google returns an XML file which contains a wealth of information about the physical location. Extracts from this XML include:

```
<formatted_address>
    Scientia 627-Jr, Pretoria, South Africa
</formatted_address>
<formatted_address>
    Pretoria 0081, South Africa
</formatted_address>
<long_name>Faerie Glen</long_name>
```

In view of the fact that this conference is being held in Kampala, Uganda, it is interesting to note that this geocoding information is also available for many African cities:

```
http://maps.googleapis.com/maps/api/geocode/xml?latlng=0.339984,32.558725&sensor=false
```

Google returns an XML file which includes the information

```
<formatted_address>Nanfubambi Rd, Kampala, Uganda</formatted_address>
```

Communication Between Thing Owner and Finder

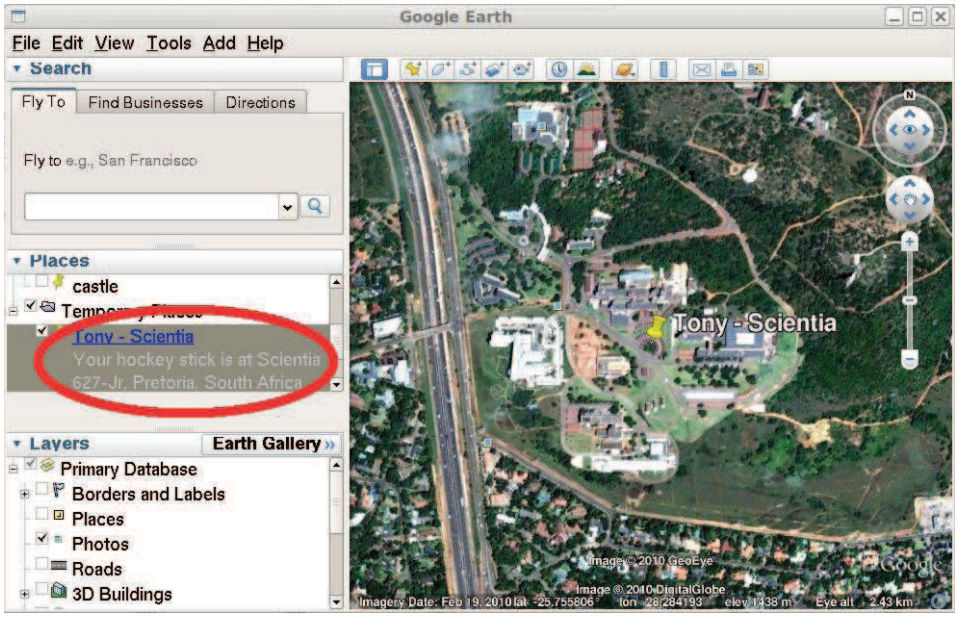
Communication between the owner of the "thing" and the finder of the "thing" was mediated by Tony. For research purposes, a number of cycles of the Design and Creation Research Methodology was traversed giving additional functionality to Tony.

1. The initial implementation of Tony merely sent a message to the owner of the "thing" stating that the "thing" had been found. This message was sent back to the owner of "thing" via the same channel with which the "thing" was registered. This could be XMPP or POP3 Email for example.
2. In the second implementation, Tony allowed the finder of the "thing" to voluntarily send his telephone number to the owner of the "thing" so that the two people could communicate about the "thing". This was for research purposes only. The

researchers are well aware of the dangers of putting strangers in touch with each other using social media.

3. In a third implementation of Tony, the GPS co-ordinates captured by the modified ZXing application were displayed on Google Earth as can be seen in Illustration 5
4. In the fourth implementation of Tony, various Google geocoding platforms were queried with the coordinates to find more information about the physical location of the "thing" that was found as can be seen in the red highlighted portion of Illustration 5

Illustration 5: Sample Google Earth shot



Evaluation

Tony (along with the Beachcomber platform) was the first project undertaken by the Internet of Things Engineering Group. As such it was primarily a learning experience for the project members enabling them to familiarise themselves with various Internet of Things technologies such as geocoding, QR codes, etc.

However a number of small pilots were conducted. The evaluation includes the following:

1. There are numerous cell phone applications to decode the QR Codes on the cell phone itself. Some applications work better than others. ZXing (as mentioned previously) often crashed with Java null pointer exceptions. A QR Code decoder which is 100% stable needs to be identified.
2. By modifying an existing open source software package to access the cell phone internal GPS, Tony basically required that people finding the "things" labeled

with a QR code needed to have the modified software already installed on their phone. Although this is acceptable in a research project, it is not feasible in real life implementation. The web server application which receives the decoded information from the QR codes needs to return instructions to the phone to automatically bring up the GPS. A way to do this in a phone agnostic manner needs to be investigated. One possible low-tech solution would be to print instructions at the bottom of the QR code when the thing is first tagged.

3. In order to cater for the situation where finders of "things" who do not have cell phones which can decode QR Codes but do have cell phones with cameras, a mechanism which allows the finders to take photos of the QR Codes and then MMS them to a specified number needs to be implemented.
4. The QR Codes often had to be quite large. This project used a 1000x1000 bit matrix for the QR Code and printed it on A4 paper. This resulted in a QR Code which was quite large for small "things".

Overall, however, Tony worked as designed.

The four sub-objectives of the project were satisfied thereby satisfying the primary research objective. The answer to the research question is affirmative. Internet of Things technologies can be used to reunite people with their lost "things".

Conclusion

The Internet of Things is the phenomenon of more and more "things" getting connected to the Internet – as opposed to people getting connected to the Internet. There are a number of protocols or methods which are currently used for "things" connecting to the Internet. These include wireless, RFID, wired connections, and QR Codes.

This paper describes a project where "things" were labeled with QR Codes. If the "things" were then lost, the finder could merely photograph the QR Code with his or her cell phone. The finder and the original owner of the "thing" would then be put in contact with each other. In addition, if the cell phone of the finder included GPS facilities, when possible, the original owner of the "thing" was also given coordinates and geocoding information about the current location of the "thing".

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