ZIBAT

4th Semester Exam Project

Android & IOT

Teacher: Anders Børjesson

Made by: Mathias Drost Henriksen

5/27/2016

Image from: http://www.canon.dk/Images/Android-logo_tcm81-1232684.png

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Introduction

In an ever evolving world, the need for data is ever rising. But not just data on one device, data shared in real-time across several devices. For this need the rise of interconnectivity has evolved and allows almost any device to share its data with any external source built to receive it. This project is based on the need for interconnectivity and what options are provided by one of the most used devices in modern age, the mobile phone.

Questions

What options does android provide for connecting external sources to it and how viable are these options?

How have other companies done a similar task and with what technology have they done it?

What is the best (fastest, least problematic, etc.) method of connecting an android device to an external source like a raspberry pi and why?

Schedule

Initial time schedule:

Research - 10 days total split in sections
Testing - 7 days (more or less depending on success)
Report - 6 days total split in sections

Estimated distribution:

Research - 3 days
Report - 2 days
Research - 2 days
Testing - 3 days
Report - 2 days
Research - 3 days
Testing - 2 days
Research - 2 days
Testing - 2 days
Report - 2 days

Methods

For this project the two most used methods will be research based on already achieved solutions made by the android community and building my own solution with experimental code and setup. For this I will be using a Raspberry Pi 3 which offers Bluetooth and internet support natively with the ability for external modification if needed.

Relevant connection types

After doing some research, the three most prominent types of connection are: Bluetooth, Internet connection and NFC. The possibilities for infrared connections exist but are highly experimental and are based on extreme conditions on which the camera of the phone have to be modified to detect the signals or by using the front infrared receiver on a select few phones which is also not a decent solution as it has fairly low range and the one solution found did not provide any code to demonstrate what was done to achieve reading capabilities. The usage of standard SMS messages could be done but this provides no guarantee of data transfer, very slow transfer speed and requires special physical setup to be able to send the messages. This makes SMS semi-useless in a data transfer scenario which is why I have chosen not to include it.

Bluetooth

Pros:

Bluetooth provides fairly decent range and offers guarantee of data transfer as it is based on sockets and can use the TCP protocol (a modified version of the TCP protocol but with the same principal including the guarantee of transfer) and even when using TCP the Bluetooth connection offers almost instant data transfer, but Bluetooth can also use the UDP protocol for even faster data transfer but with the possibility of data loss. Bluetooth is also not interrupted by walls and such which give it an advantage in some environments.

Cons:

Bluetooth's range is both a good and a bad thing. The range can vary from 10 to 100 meters depending on hardware which makes it useless for long distance transfer as it simply does not work when trying to send to longer ranges. The sender also needs to know one piece of information about the receiver: their "friendly name" which is a name that the user of the receiving device can designate to any desired name which the sender can then use to scan all possible receivers and ask for their name and then compare to the known name until a match is found, and once a match is found the following steps involves basic TCP connection setup.

Internet

Pros:

Data transfer over the internet is fast and provides many methods of doing the transfer such as direct transfer using TCP or UDP socket connections, but can also be done with a server as a "middle man" or many other ways which offers the possibility for data to be altered based on desired output.

Cons:

For data to be transferred the sender needs to know where the receiver is located which requires some beforehand knowledge.

NFC

NFC works a bit different than the 2 previous methods. NFC requires an "activator" and a data holder. In most cases this involves a NFC chip imbedded in a solid case of plastic to allow data transfer and help prevent loss of chips and prevents damage to the chips. The chip is "dead" for the most part as it has no way to power itself and therefore have no option to transmit the data constantly. This is where the activator is needed. An activator is any device capable of generating a radio frequency wave field. In modern days many devices has this capability such as phones. When the activator generates the field, the chip gets powered on due to the power of the field that the chip absorbs which allows it to transmit the data it is holding. The activator can then read the transmitted data and then handle the data. When the activator terminates the field the chip no longer receives power and returns to its "dead" state.

Pros:

NFC has almost instant data transfer.

Cons:

The range of NFC is extremely low as it in most scenarios has a range of a few centimetres but in extreme conditions can transmit up to 20 centimetres (this range is only obtained with high-end equipment and in a near perfect environment). NFC is highly insecure as anyone within range can read the data that a chip is holding. Each chip can only hold between 96 and 4096 bytes of data.

My choice for testing

After evaluating all the different connection methods that android phones allow I chose to run tests on Bluetooth as I have previously made applications for both internet and NFC data transfer and because Bluetooth at this stage of research seemed like the best solution.

Physical tests and setup

My setup consists of a Samsung Galaxy S6 smartphone and a Raspberry Pi 3 model B.

For the raspberry I downloaded 3 libraries in order to make the Bluetooth transfer work: PyBluez, Bluetooth and libbluetooth-dev. The code used on the raspberry is a simple while loop that allows the user to type in text and then sends that text using a Bluetooth socket.

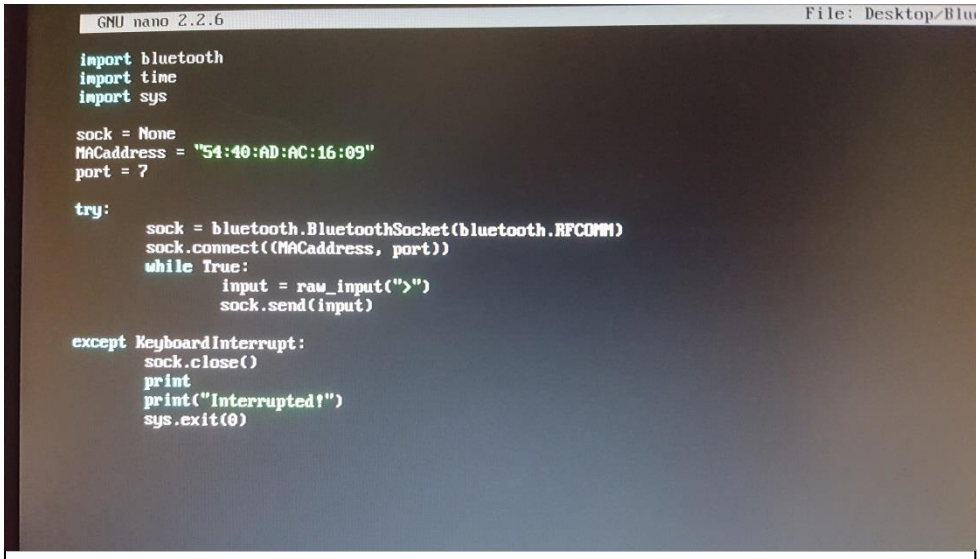

Image is taken from the raspberry pi 3 that I used for testing. The picture is of the code that the raspberry pi runs to transmit data to my phone.
The code is specialized for my devices as seen from the MACaddress variable which is the MAC address of my phone and has to be manually changed to test with another device like another phone.

For android I used the basic method of making a TCP welcoming-socket to grab the initial connection and then passes that connection to a while loop that infinitely attempts to read incoming data from the connection and when data comes it updates a text field in the UI. The application code is by no means well-made and it runs a while loop on the main thread which is very wrong, but the importance of this project is not the code but rather the fact that a connection could be made.

Viability

After doing research and listing some of the pros and cons of each of the more prominent connection types and performing my own tests, it stands clear that NFC is only viable in very specific scenarios like a login or payment system as it does not offer any long range transfer and only does limited data. Internet and Bluetooth are both very viable as they offer fast transport over a between fair and infinite range.

What technology have others used

In the commercial world devices need to be cheap and efficient meaning that every company is trying to find the best method to achieve the best output for the least input. For the majority this highly depends on the purpose of the device but the phasing of old methods into new ones gives a good indication of what is the preferred method of technology use. Looking at the 3 methods from earlier: NFC, Bluetooth and internet, Bluetooth is the least used in modern time and have been phased out and replaced by either NFC or internet. For example: file sharing between phones used to be done by Bluetooth but have now been replaces by NFC for very local sharing like copying info from an old phone (one that have NFC capability) to a new phone can be done instantly by simply holding the phones close together as phones with NFC capability can emulate NFC chips or by internet for global sharing (Some applications still offer support for Bluetooth transfer). Many companies have also shifted from a log in terminal for workers on which they would type a user name and password into a custom made program on a stationary pc in order to confirm that they were present at work, to a NFC bases system in which the worker would simply hold his work ID card in front of a reader when he/she enters the work place. This system also allows companies a more secure work place as they can use the workers ID card to allow them to open doors using the same card in which they previously would need to carry keys for each door they were allowed in or by other methods.

For the most part, Bluetooth was a more used solution 10 years ago but have been almost completely phased out and is only used in select few scenarios like fitness equipment, as the user often has a phone within range of the fitness equipment when using it.

NFC is a still rising solution as many companies seek to improve its use. Banks and shops are also interested in the development of NFC as it allows the customer almost instant payment by just holding the NFC chip near the reader in the shop which also could allow the shop to track each customer's purchases and help the shop improve the wares that the shop provides to be more user specific. This use is still experimental as it holds high security risks currently.

The internet connection method is in high demand as almost any device can access the internet in modern days. Companies can monitor external work places without traveling to the place and it allows many services more direct control and monitoring of their deployments. For example: a hot water provider can install a monitor in each house that can monitor the heat levels and usage of water in each house and then transmit that data back to the workers at the provider which can then regulate the transfer of water to the house, which saves money for the provider.

What is the best connection type?

For the most part, this question is unanswerable as each connection type has its ups and downs but they are still comparable which means one has to be better by at least a margin than the rest. This is where the pros and cons of each connection type in addition to my own experience and testing plus the research done on each type comes in handy. Let us take a quick look at some basic questions that a person might ask similar to the main question:

1. Which one is the fastest at transmitting?
   This very much depends on environment and equipment. In one scenario one might be better where as in another scenario the previous good one might be bad. For the sake of getting an answer let us assume they are all done with mediocre equipment in a mediocre environment (meaning there might be several walls, the air might be humid or in another way worse than clean air to transmit through and cables are old copper wires, simply for the sake of a fair comparison). Speed wise the NFC connection would be the fastest as it is in essence a basic ping system. One part sends a ping and the other part pings back (this is not how it really works but is just a dumbed down version). Second place would be shared by Bluetooth and internet as they build on the same foundation using similar technology.

2. Which one can transmit the most amounts of data within X seconds?
   Assuming we are using the same environment as last question, the best connection type would be a shared winning by Internet and Bluetooth as they again function similarly. They can both transmit very high amounts of data very quickly and can infinitely mutate the data meaning that one second they can send one sentence and the next second they can transmit a different sentence whereas the NFC connection not only is limited to 4 kilo bytes at most, the data is immutable meaning that no matter when you ask a chip for data it will always provide the same data which has to be manipulated by an external source.

3. Which one is the least problematic to use/program with?
   This question is a bit tricky as it involves personal knowledge and skill as to how well a person can use the connection type, but from my personal experience Internet and Bluetooth are both very easy to use whereas NFC requires a lot more programming to work. The switch here is that NFC will always work once setup and does not throw errors and exceptions where Bluetooth and internet both have a lot of fail factors that can cause issues. Even with this in mind I would still claim that Internet and Bluetooth are shared winners as most of the issues can be handled fairly easily.

Now for the final question, which one is the overall best, based on all the above tests and comparisons, research done and tests performed and my personal experience I would overall claim that the internet connection is the winner as it provides near infinite range, very fast transfer rate, infinite possibilities for type of data send via the connection and simplicity of use. Bluetooth is a very close second as they share almost all positive assets but the one thing that sets Bluetooth back is its range. 100 metres at max range is a fair range but is still very limited. Bluetooth might be a solution used in a local store or small company as they might not need more than a 100 metre range, but for most other uses it simply is not enough. As for

NFC it is a far too specific connection type to be used in most data transfers. Limited data and extremely low range just does not cut it for a data transfer. Granted that NFC has some high potential for commercial and personal device use, it is not even close compared to Bluetooth or internet connections.

Conclusion

Throughout this document I have gone through several types of connection types that are available for android devices to perform interconnectivity with. The knowledge gained is highly applicable to my interests and to my "field of work". Interconnectivity is a growing need and knowing how each option works and how to use each is very valuable. Whether it is a small company or a major corporation, each may demand development of interconnectivity solutions which is still in its infancy as we are only seeing the beginning of what interconnecting devices can do for us. I believe I have worked to provide the answers for my initial questions through this document and have also answered the questions throughout the document, but I have also made a section further down where I state the answers quickly to give a simple answer in a easily understandable way in case I did not do this when I was initially answering the questions in the different sections of the document.

Reflection

After having completed all research, tests, document writing and is nearing the end of this entire process, have I learned anything that could help me do better in the future? For this I will answer 3 questions which will show whether or not I learned anything or I just went through facts and only confirmed my own original knowledge.

1. Could I ask new better questions now that I know all this?
   Yes, I believe I can. My original questions are fairly vague in regards to what they seek to answer. I originally did not know that much about interconnectivity but the topic interested me hence why the questions were fairly lightweight.

2. Could I have chosen better methods for the questions I made?
   Yes and no. I could have added an additional method which would be talking to a professional in the field which could have provided me with valuable insight into the topics. I did not initially do this as I did not know what I really wanted to know and I did not know where I would ask for such a person so I initially chose not to do this. Other than that I do believe I chose the correct methods for the "job".

3. Could I now have made a better plan?
   No. My plan worked well and I was able to complete my tasks on time and it also worked well on a personal level as I had given a few extra days to accommodate for unexpected happenings which did not occur which granted me some extra time to think about my work.

Direct answers to the questions

This section is made to provide a short and direct answer to the questions listed in the beginning of the document. These answers are not deeply explained and are only made to provide a fast reference as how I got the answers is by reducing the entire above document into short sentences. These serve as a quick answer instead of having to read the entire process of analytics and conclusion.

1. Modern phones provide NFC, Internet, Bluetooth, SMS/MMS and infrared connections (specific phones may provide more but these are the ones available in all newer phones). Infrared is not viable, SMS/MMS is slightly viable but only for very extreme solutions, Bluetooth is viable but have been replaced by newer methods, NFC is viable but is slightly specialized and internet is highly viable.

2. Many companies use a combination of NFC and internet solutions to provide for their needs.

3. It all depends on needed solution but for the most part internet is the winner of what method is best as it allows fast transfer and offers many ways of manipulation of data while being very easy to use.

References

Dawn Robotics
Talking to a Bluetooth serial module with a raspberry pi
http://blog.dawnrobotics.co.uk/2013/11/talking-to-a-bluetooth-serial-module-with-a-raspberry-pi/

Information from this site showed how to scan for external devices using the Bluetooth module on the raspberry pi which helped immensely as android would provide incorrect data regarding what channels the android device was listening on (Android uses "channels" instead of port numbers which are used in normal socket programming. For example: the Bluetooth service might be running on channel 2 which is then the number that external devices would use to send data via Bluetooth to the android device). In my case android would simply print that is was listening on channel -1 which obviously is incorrect as that means the channel info is simply null (This info was gained by using the .toString() method of the Bluetooth Socket), but when scanning on the raspberry pi I found that the android device was listening for Bluetooth traffic on channel 7.

Albert Huang
An introduction to Bluetooth programming
http://people.csail.mit.edu/albert/bluez-intro/index.html
I used this website to learn how Bluetooth worked and how to set it up on the raspberry pi. This was the main site I used for the raspberry code but I also used information from a dozen other sites that only provided small chunks of useful information, and combining these small chunks with this is how I made my code. The code they use in chapter 3.2 – example 3-3: rfcomm-client.py can be used at it has a similar structure to my code.

Android developers
Bluetooth
https://developer.android.com/guide/topics/connectivity/bluetooth.html
I used this site as the base for my android code as it demonstrates how to set up the basics for Bluetooth but the code they provide is strange and does not fit this project's needs so for the connection code itself I made my own code that is based on previous knowledge from TCP socket programming and android programming.