FluPhone Study: Virtual Disease Spread using Haggle

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ABSTRACT

This paper introduces the FluPhone project, where data collection of human contact, flu-like symptoms and virtual disease spread are experimented using various phones ranging Java phones to Android phones. FluPhone uses Pocket Switched Networks as base and exploits the framework of the Haggle project.

Categories and Subject Descriptors

I.6 [**Computing Methodology**]: Simulation and Modeling

General Terms

Measurement, Experimentation, Algorithms

Keywords

Contact Networks, Network Measurement, Epidemiology

1. INTRODUCTION TO FLUPHONE

In our Haggle project [2] we have worked on Pocket Switched Networks, a type of Delay Tolerant Networks (DTNs), which explored a proximity based communication. PSNs provide communication in highly stressed settings with intermittent connectivity, variable delays and high error rates in decentralised and distributed environments over a multitude of devices that are dynamically networked. A partitioned network can deal with disconnected operation using store-and-forward type of operations. In PSNs people carry devices in their pockets, which communicate directly with other devices within their range or with infrastructure. Because the device mobility is reflected by people movement, we have worked on understanding the social structure among the people who carry the devices.

We have started to work with epidemiologists who are interested in understanding human contact networks. It is important to understand why infectious diseases such as swine flu spread so fast. In many ways, the concept of PSNs is analogous to how infectious diseases spread. One key aspect of this is working out the numbers of social encounters and links in a chain of contacts between different people (i.e. similar to the idea of how many steps we are away from a particular person). One way to measure this is to record how often different people (who may not know each other) come into close proximity with each other, as part of their everyday lives.

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This brought us to carry out the FluPhone Project[1], which aims to bring together epidemiologists, psychologists, economists and computer scientists, with the goal of developing novel and innovative methods with which to measure, understand and predict how individuals change their social behaviour in response to infectious disease.

FluPhone provides a software that runs on the users' mobile phones which the users carry with them during their normal day-to-day activities. The main function of FluPhone is a simple client-server software consisting of a mobile phone application in the phone and a receiver as a PHP script in the web server. The mobile phone application is written in Java (J2ME), which collects proximity devices data by Bluetooth, GPS coordination data, and self-reporting flu symptom. The collected data is sent via GPRS/3G to the server. Also the user can upload the data via web interface. Communication between the mobile application and the server is based on https.

1. FluPhone Application: The FluPhone application requires J2ME MIDP 2.0, and CDCL 1.1 with JSR-82. To get location data, the phone has to have a GPS module. If writing to a file is supported, the application will be able to dump the database files, which could be uploaded via FluPhone web. Running application is fairly intuitive.

2. The application can be found at [1]. The GPRS/3G receiver is implemented as a PHP script that takes each packet from the phones running the sender version of the application and writes it to a file. There is also daemon job archiving the data in MS-SQL database.

The software also supports the android phones, where we have exploited the framework of Haggle, which made the rapid implementation of the FluPhone. Note that the software also let the users tell if they feel ill with any flu-like symptoms such as running nose, fever, headache and so forth (see Fig.1 for the screenshot).

There is also a function called 'virtual' epidemics on participants' phones, which will give us a real-time picture of the social network between participants from the perspective of infectious disease. See next section for further detail of 'virtual disease' experiment.

We have run a few experiments, where we asked volunteers to install a small software application, which can be downloaded from the web upon their registration and the authentication process. The data collection can be operated by three different methods such as 1) uploading via web, 2) real-time collection via 3G, and 3) post collection from the devices.

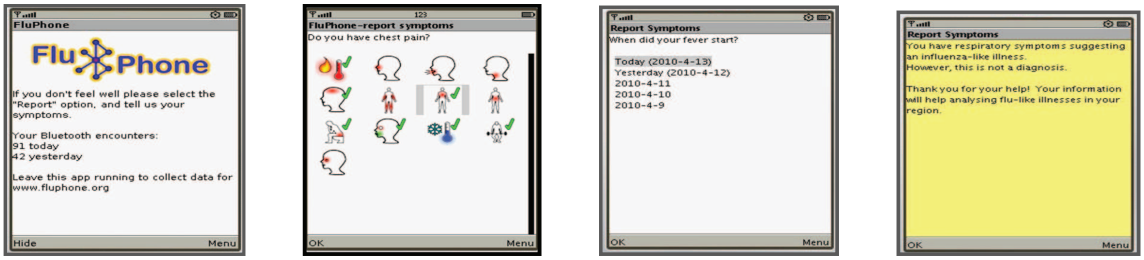

Figure 1: FluPhone: Encountering Statistics, Symptom Type and Time Entry Screens, and Brief Diagnostics

The collected information provides us a much better understanding of how often people congregate into small groups or crowds, such as when commuting or through work or leisure activities. Also, by knowing which phones come into close proximity, we will be able to work out how far apart people actually are, and how fast diseases could spread within communities.

2. VIRTUAL DISEASE EXPERIMENT

The virtual disease experiment is an Android application built to run on devices that support the haggle architecture. The application broadcasts information about virtual diseases. It is currently infected to all devices in range, and receiving devices are infected by these virtual diseases based on a simple probability calculation. The application logs all incoming diseases and stores information regarding how they are processed. It also regularly scans for Bluetooth and GPS, recording any Bluetooth addresses and GPS location data in a separate log.

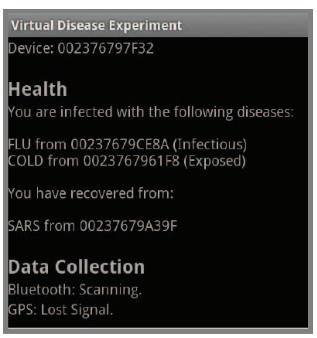

Figure 2: Virtual Disease showing Infection Status

2.1 Disease Model

The disease model with which the spreading of diseases is simulated is a simple SEIR model. In this model. Each device is originally susceptible to a disease. Once it is infected by another device, it becomes exposed for a specified time. Whilst it is exposed, a device has the disease but cannot yet infect other devices. Once the exposed duration has run out, the device becomes infectious for a specific time. Whilst it is infectious, the device can infect other devices. Each disease has an associated infection probability which indicates the likelihood that another device will be infected. Once the infectious duration has run out the device is recovered from the disease and cannot be reinfected. The SEIR model can be used to simulate SI diseases by setting the exposed duration to 0 and the infectious duration to a really large number (for example, 2000 years). we deployed three different diseases as follows, where beta=transmission probability, alpha=incubation time, and IP=infection period.

- SARS: fast (beta=0.8; alpha=24 hours; IP=30 hours)
- FLU: normal (beta=0.4, alpha=48; IP=60 hours)
- COLD: slow (beta=0.2, alpha=72 hours; IP=120 hours)

The above disease models can be simulated using the collected contact trace information. Figure 3 shows simulated results.

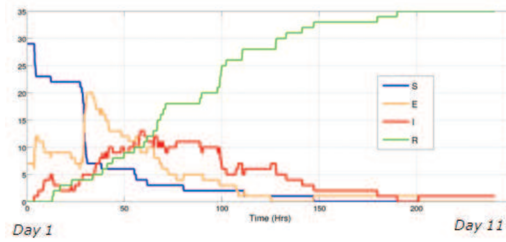

Figure 3: Disease Simulation: SARS

3. SUMMARY AND FUTURE WORKS

We have demonstrated the FluPhone project, which we aim at collection of human proximity information from the general population for building time dependent contact networks. This study project originated from our Haggle Pocket switched Networks, and PSNs share many issues with the epidemiological studies. The data collection along the symptom data from infectious disease is built over the framework of Haggle. The FluPhone project shows another dimension of human contact networks study.

The FluPhone project is currently extended towards human behavioural study. Individuals may change their behaviour for several reasons: through being ill themselves, having to care for others who are ill, or through changing their normal habits in the belief it will prevent or minimise their risk of infection. A recent study suggests that public transport usage may decline in the event of an influenza pandemic and that people may stay at home rather than go into work and risk infection. If such precautionary behaviour were to be adopted by a large number of individuals the economic implications may be profound.

Acknowledgment

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4. REFERENCES

[1] FluPhone. http://www.cl.cam.ac.uk/research/srg/netos/fluphone2/.
[2] Haggle. http://www.haggleproject.org.