SignalSense - Towards Quality Service

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Abstract

The craving to remain "connected" has exploded since mobile phones became popular a few decades ago and are now fully entrenched in our lives as we become more and more dependent on connected services for professional, daily and social needs. Despite the significant demand from consumers and the push towards improved mobile technologies, many services delivered to the average consumer exhibit poor performance and quality.

In this paper, we propose SignalSense, a highly interactive and novel mobile application that senses and records real-time mobile and wifi signal strength and quality for indoor/outdoor mapping. The application also uses mobile sensing to crowdsource signal information and intelligently combines them with geo-location data to make recommendations to users, leading to improved user experience. Initial evaluation demonstrates the need for such an application.

Author Keywords

Intelligent actioning, Personalization, Proactive support, Mobile sensing

ACM Classification Keywords

H.5.m [Information interfaces and presentation]: Miscellaneous

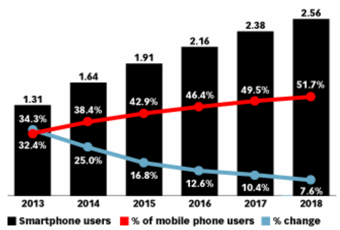

Figure 1: Growth of Smartphone users

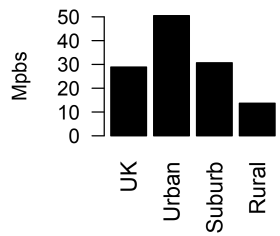

Figure 2: UK Broadband average speed

	Speed
Edge	400kbps
3G	14.4Mbps
HSPA+	21Mbps
4G	150Mpbs
LTE-A	300Mbps
5G	1Tbps

Table 1: Mobile data speeds

Introduction

Since the invention of mobile phones and its popularisation in the 1980-90's they have evolved significantly and are now an integral part of our daily lives. According to statista.com[1], the number of mobile phone users world-wide in 2017 is predicted at 4.77 billion. By 2018, 2.82 billion smartphones are expected to be in use. The popularity of smartphones (Figure 1) underlines the integration that it sees in our lives. These connected devices make extensive use of data connections through mobile/cellular services and wireless hotspots have created a new area of information sharing with many applications being heavily dependent on crowdsourcing (Waze[2]) and mobile sensing (Google Maps[3] and Citymapper[4]).

Although there have been significant technological improvements over the past few years in terms of mobile technology, resulting in higher theoretical bandwidth (Table 1), the actual speed depends highly on the network and the signal strength one receives. This is no different for broadband where the average UK download speed stands at 28.3Mbps (Figure 2), yet most consumers receive significantly less throughput than their actual subscription. Subscribers can receive up to 60% lower than their subscription with 15million households not getting their subscribed speeds. Often problems are also compounded by weak wifi signal strength due to misplacement of access points.

In this paper, we propose a novel mobile application called SignalSense, which helps users with three key activities. Firstly, it helps with access point positioning to get best coverage, secondly, it helps record the quality of the internet service for private and public access points. Finally, it helps users see the strength of mobile signals, quality and speeds of data transmissions in real-time or as collected through mobile sensing (crowd sensing) and make personalised recommendations.

[1] www.statista.com
[2] waze.com/
[3] google.co.uk/maps/
[4] citymapper.com/

Related Work

Crowdsourcing is a fairly well-known technique of gathering information by a crowd (a disorganised group of people) [4], where users actively participate and provide information. However, with the progress in mobile sensing [5], a new paradigm has been established called Mobile Crowd Sensing [6], which is widely adopted and shows great potential [7]. Instead of users actively engaging with contributions, data is collected directly and discretely from mobile devices without requiring any user intervention, an example is Google Maps (the most popular mapping and navigation application).

There are several other applications available that also provide some of the functionality offered by SignalSense. A thorough treatment of all these is out of the scope of this paper and we only include a leading application from each segment. Network Signal Info [2] is a general signal checker application which works for both mobile networks and wifi access points. It displays highly technical information about signal strength, which is often not required for average users and does not include any components for analysing network performance or data transfer rates. OpenSignal [3] is an application that measures the quality of service for the network via speed tests and is very popular. Other applications where we take inspiration from are Magic Plan [1] is an the application allows drawing of schematic diagrams and floor plans using the camera on mobile devices.

Although there are many apps available that can help the user either identify signal strength information or check speeds for data connections, there is no single app that combines these two aspects together. We believe that the average consumer

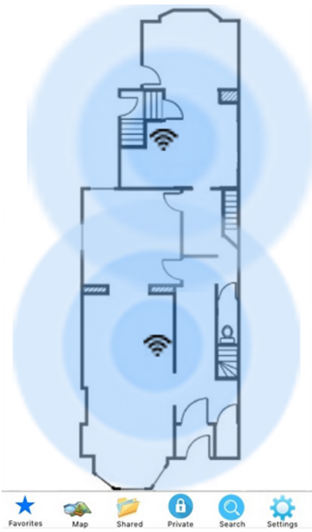

Figure 3: Indoor Wifi

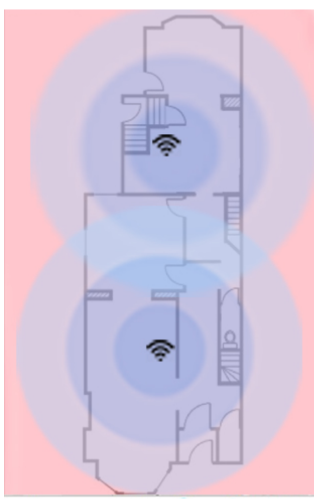

Figure 4: Indoor Mobile & Wifi

in their day-to-day life will be assisted immensely by having both of these features available under a single application, SignalSense. However, where SignalSense really differs from others is in the use of Mobile Sensing feature where it will automatically crowd sense network signal and quality information for sharing with the public and helping future research. More importantly, the application will combine this information with private mobile sensing data and geo-location information to make personalised recommendations regarding service providers to users.

Features and Implementation

Feature Highlights

The first major feature of SignalSense is its ability to allow users to draw or download schematics and layouts of buildings. This combined with the ability to add access points allows users to identify the coverage offered by existing access points or when laying out a network, deciding on how to best position access points. Figure 3 shows situation where the SignalSense is showing two access points and their coverage of the building. Users can also enable options where SignalSense periodically does the network quality (speed) test and stores the signal strength, geolocating and quality data for future reference. This data can either be kept private or anonymously added to the public database to help other users.

The second major feature is to provide real-time signal strength and quality information for mobile phone signals. This is also achieved by not only looking at the signal strength but performing an intelligent analysis of call quality, call drops and speed test to quantify the quality of the network, as the signal strength often does not correspond to these. Figure 4 shows a situation where the indoor wifi signals (blue) are overlayed to show the mobile phone signal strength using the red coloured circle. Users are encouraged to contribute the data regarding mobile network performance to the public database for SignalSense to help other users. It is also possible for users to add mobile signal masts/tower information in addition to those taken from actual service providers. Figures 5 and 6 give the outdoor view of the application where mobile signals predominate the view. It should be noted that the user has the ability to filter on any type of signal, location or particular access point.

Although the above two features are widely available from a plethora of applications, SignalSense stands out by providing personalised recommendations using crowd sensed data. Once enabled, SignalSense is able to correlate private geolocation data of frequently travelled routes or places and combine those with owner's own private network quality data along with those shared by the public to propose better alternatives. These alternatives are aimed at improving the end-user experience by using best networks available. So, if a user visits a place often or is moving to a new area which has poor mobile network performance, SignalSense can look at the public data and proactively notify users of alternatives that are better suited.

Implementation Considerations

There are several mapping options available which could be used as the basis of our mapping visualisation, some examples are: Bing Maps, Open Layers, Foresquare and OpenStreet. After careful consideration to the API features and limitations, we chose Google Maps as its API demonstrated the compatibility, reliability, flexibility and richness that was best suited to SignalSense. Geolocation is also another feature that is heavily used within our application to ensure the correct position of mobile masts and access points. Geolocation API from Google also provides support for this.

One consideration we have during implementation is to minimise the data usage for the users. Although, SignalSense will use data while crowd sensing features are turned on, we use caching minimise the data transfer over mobile networks. Fur-

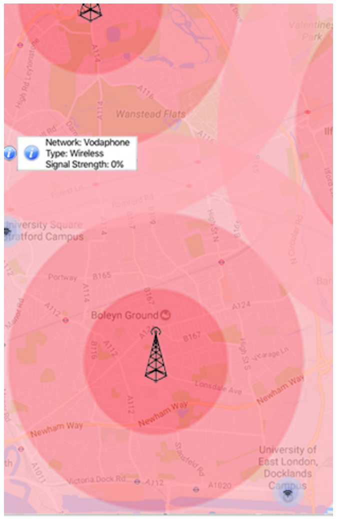

Figure 5: Strength Mapping

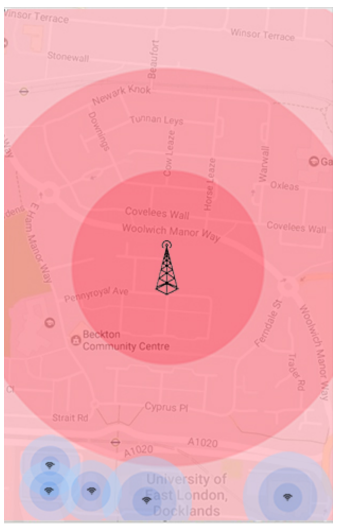

Figure 6: Strength Mapping

thermore, we use optimised metrics for quality of service determination to minimise the amount of mobile data traffic.

Evaluation

The user interface and the features of SignalSense is evaluated against Shneiderman's framework [8]:

- *Overview* - The Google Maps style map interface allows to get an overview of the signal strength for any recorded location.
- *Zoom* - The app allows for all modern map features like zoom, pinch and rotate.
- *Filter* - The app allows filtering of the views using signal types, location, access point types and service providers.
- *Details-on-demand* - As seen in Figure 5, users are able to view details for any access point or location.
- *Relate* - Geolocation data along with private and public information is correlated to show the user a holistic view and also make recommendations where necessary.
- *History* - History of recorded information is stored for future reference.
- *Extract* - It is possible to extract history data and forward the information directly from the application.

An initial user study where these features and the design was shown to potential users confirmed the need for such an application.

Summary and Future Work

In this paper we present SingalSense, a mobile application that allows users to identify the quality of their network connections for indoor and outdoors in terms of wifi access points and cellular mobile networks. Initial interface and feature evaluations highlight the needs for such an application.

Our application is the first to combine both internal and external mapping of wifi and mobile network quality data. We introduce the novelty of mobile crowd sensing which will enable the gathering of large-scale unbiased real-world data. The proposal to use crowd sensing and the addition of personalised recommender systems to help users identify the best network providers for their needs will be extremely useful. This data can also be used as a navigational constraint property just like traffic to ensure that a traveller takes the routes best serviced by their current provider when using navigation systems. The future extension could include making the crowd sensed public data available via Open APIs so that further research can be conducted to better understand the actual correlation between signal strength and data service quality.

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