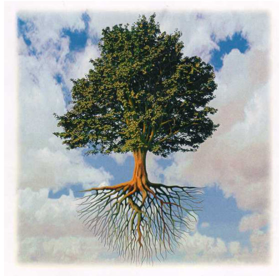

Project no. 265432

EveryAware

Enhance Environmental Awareness through Social Information Technologies

http://www.everyaware.eu

Seventh Framework Programme (FP7)

Future and Emerging Technologies of the Information Communication Technologies (ICT FET Open)

D3.1: Report on the EveryAware platform performance in the Pilot Studies

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Lead contractor for this deliverable: University College London (UCL)

Executive Summary

The main aim of this report is to provide a description of the work carried out as part of Work Package 3 (**WP3**) of the EveryAware project. **WP3** covers the recruitment and engagement of the people who will participate in the research undertaken, and represents the 'public engagement component of the project. Specifically, **WP3** will answer:

1. What motivates people to participate in community-based activities such as the sensing processes underpinning this work?
2. Does access to appropriate personalized sensor information lead to changes in behaviour?

WP3 also examines the usability and integration of the EveryAware platform. Thus, one of the preliminary objectives for the early phase of the project was to carry out end-to-end testing of the platform to ensure any tools provided to the public are both user friendly and scalable. Given that answers to the two key questions above can only be formulated once this is achieved, this report will focus on this initial phase of platform integration and usability.

As the EveryAware Annex itself notes "both the web-based information gathering of **WP3** and the community memories set up in **WP2** imply by their very nature disseminative activities". Rather than create an artificial divide between dissemination and participation fostering activities on the one hand and recruitment and engagement on the other, or extensively duplicate text, details about recruitment and engagement tasks and the Case Studies have been included as part of the **WP6** [UCL, 2012] report on "Participation Fostering Activities". The reader is kindly invited to refer to the **WP6** report, with the understanding that the activities described form a major component of **WP3**, and will provide direct input and evidence for the research questions to be investigated as part of this Work Package. This report, with a main focus on platform integration and usability, should be read in conjunction with the **WP6** report to permit the reader to gain a better understanding of the impact of the issues described here on the recruitment and engagement processes and on the participants themselves, as well as of the overall importance of the recruitment and engagement processes to the Case Studies.

The EveryAware Platform

The platform has been designed to facilitate the combination of sensing technologies, networking applications and data-processing tools that will enable citizens to collect and visualize environmental information. It comprises three main elements:

1. Sensor box: this element includes the sensors, energy source and communication elements which allow the information that was recorded by the sensors to be transferred to the smartphone. The communication is local, and the box has only minimal user interaction capabilities.
2. Smartphone: controls the data acquisition via bespoke software applications that collect and transmit data (using standard mobile data connections) and provide a user interface. It also

incorporates additional sensors such as location and noise, which permit it to be decoupled from the sensor box.

3. Backend: this component collects, processes and publishes the collated data.

In addition to the hardware and software components, the final integral component is the participants (end users) who will participate and contribute to the overall project. EveryAware has a clear goal to enable public participation in sensing activities and as such, genuine ‘citizen’ participation was sought in order to perform the beta test case studies.

It is important to note that in some parts of the project existing products were used as a basis for the EveryAware project (i. e. WideNoise) and therefore a significant part of the design was already completed and established. Therefore, for some elements of usability evaluation and integration, the process did not start from *tabula rasa* and had to adapt to the conditions in the project and the various limitations and constraints that already exist. In particular, this meant that only incremental changes could be made to the WideNoise app due to its pre-existing user base.

Summary of Significant Results

The various components of the EveryAware platform related to noise measurement have been very successfully integrated, and have permitted 23777 geographically located noise measurements to be taken world wide. The app itself has been downloaded by approximately 700 Android users and approximately 8000 different devices have captured noise measurements in total [1].

Given that the mobile app in use, WideNoise, pre-dated the project, incremental changes were made to its design as a result of user feedback. These included changes to the order of the noise capturing wizard to ensure that users were asked to guess the results prior to the reading being revealed, and the inclusion of methods (tagging and sliders) to capture subjective information.

User centred design highlights the importance of involving end users in any design and testing process, and this was done via two Beta case studies (noise and air quality). Additionally, the start of a large scale noise related study, around Heathrow airport in the UK, has been anticipated and provided additional feedback into the usability of the WideNoise app.

Key usability issues were highlighted as follows:

1. Registration proved to be problematic, and a relatively small number of users registered their devices. This limited the possibility of follow-up engagement in terms of asking users why they downloaded and used the app.

2. Provision of subjective information also varied, although 33.8% of users engaged in the dedicated large scale case study provided this information compared with 10.7% of other users.

3. The importance of being able to take continual measurements, rather than individual points, was highlighted by the users and would also assist in achieving better data coverage (see [VITO, 2012]).

4. A number of technical issues were encountered with the app, ranging from a total freeze where the phone battery had to be removed to issues with the small screen size, lack of understanding of the subjective information required and issues with the way the results are presented (sleeping cat, dragster and so forth).

[1] Download statistics for iOS were not available at the time of writing

5. In terms of gathering subjective information, difficulties were encountered entering text tags, and there was confusion over the meaning of the sliders. Indeed, 69% of readings did not make use of the sliders, and only 14% of readings are tagged.

It is important to note that ongoing changes have been made to the WideNoise app in response to feedback received, and that noted issues have also formed an important input into the design of the air quality app (AQA) for use with the EveryAware sensor box. It is also planned to examine the issue of continual measurement in greater depth during the remainder of the project.

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Chapter 1

Usability and the EveryAware Platform

1.1 User-Centred Design

To ensure participant engagement with the EveryAware platform, the elements with which they interact with need to be engaging and 'user-friendly'. This can be achieved through the use of User-Centred Design principles. User-Centred Design (UCD) is a framework for hardware and software development that emerged in the mid 1980s and since became one of the guiding principles for designing usable technologies. It is both a philosophy of design which can apply to digital as well as non-digital products, and also a framework for application development. To understand the concepts of UCD, we provide a brief background to UCD, followed by the main principles of this framework.

During the 1970s, computers started to spread in the workplace as they moved out of the specialized data processing centres, where expert programmers and operators were doing all the processing and providing the final outputs to the rest of the organization and into the general office environment (see Table 1.1). As a result, the people using these systems were no longer specialists who dedicate all their time to operating computing machinery, but people who undertake different tasks within the organization that can be supported and enhanced through the introduction of computers. Some of these first 'general' users include the people who dealt with numerical data such as accounting clerks, warehouse managers or engineers. For these users, the computer was not the center of the tasks that they were trying to accomplish. They were interested in entering ledger data, auditing the stock or designing a bridge, not learning how the computer works or what is the appropriate way to represent the ledger as a computer file. Thus, for these users the computer is acting as a support tool that assists in carrying out their job. Therefore, the ability to accomplish the task effectively and quickly is important as otherwise the automation that the computer facilitate does not improve productivity, but rather hinders it [Landauer, 1995].

As a result of this increased range of users, the importance of designing computer applications that take into account the skills, knowledge and abilities of the users gained prominence. Therefore, this period is marked with a growing interest in Human-Computer Interaction and the establishment of some of the first research centres that are dedicated to HCI research [Shackel, 1984]. Early research on HCI focused on developing techniques for the design of better applications and metrics to compare different design options – for example, the Keystroke-Level Model that allows scientific measurement and analysis of the performance of a task with a computer system.

By the mid 1980s, a more comprehensive theoretical framework for HCI design was starting to take shape. Of special importance is the work that Don Norman has carried out in his laboratory at the University of California in San Diego and which led to the publication of two books that are seminal in the development of UCD. The first is an edited collection of papers titled *User-Centred System Design: New Perspectives on Human-Computer Interaction* [Norman and Draper, 1986], as well as the highly popular *The Psychology of Everyday Things* [Norman, 1990], which in later

Table 1.1: Development of computers and usability issues (After [Shacke, 1997])

Period and type of computers	Users	Issues
Research computers – 1950s	Mathematicians, Scientists	Reliability, User is expected to understand the machine and programme it
Mainframes – 1960s & 1970s	Data processing professionals	Users of the output (business people) grow disenchanted with delays, costs and rigidity
Minicomputers – 1970s	Engineers and other non-computer professionals	Users must do programming and learn the technology, usability influences productivity and use
Microcomputers – 1980s	Almost anyone	Usability becomes a major problem
Laptops, PDAs – 1990s	Anyone and often in mobile situation	Complexity in providing usability, especially with new input/output modalities
Mobility – 2000s	Multiple devices, ubiquitous wireless network accessibility	Usability of multiple devices and in a connect environment
Pervasive - 2010s	Devices and sensors, wireless network accessibility in large areas	Social use of technology, interaction between sensors and devices, big data

editions was renamed *The Design of Everyday Things* [Abras et al., 2004].

In the following years, the concepts of UCD were promoted through academic papers, conference presentations and books. An example for such analysis is provided by Thomas Landauer in his book *The Trouble with Computers* [Landauer, 1995]. Landauer justifies the need for UCD on the basis of productivity and associates the productivity paradox with problems in HCI. The productivity paradox is emerging from the fact that despite the heavy investment in computing in the 1960s and the 1970s, the productivity of office workers in the US did not increase substantially. Considering the immense productivity gains of industrial and agricultural workers from the introduction of machinery, it would be expected that the automation of office work will lead to significant gains, too. Yet, this is not the case. Landauer's explanation to the paradox is to note that because of usability problems, many software products are not providing the needed support to their users and therefore the potential gains are wasted on the interaction with the computer. For example, he argues that the average software package contains about 40 design flaws. As a result, the loss in productivity can be up to 72% compared to properly designed software. Significantly, Landauer's argument justifies the investment in UCD on the basis of delivering productivity improvements which without it can harm the organization that uses the software.

As result of the efforts in the mid 1980s, UCD gained popularity, and has now become the central methodology and philosophy for software interaction design. Furthermore, UCD was also enshrined in international standards. The first standard that used UCD concepts was a German standard that considered Visual Display Units [Shackel, 1984]. Other standards and regulations that integrate UCD continue to emerge, culminating with the establishment of ISO 13407 *Human-Centred Design Process for Interactive Systems* [ISO, 1999]. The standard is aimed to achieve quality through the integration of a UCD process and defines it as a:

"multi-disciplinary activity incorporating human factors knowledge and techniques with

> the objective of enhancing effectiveness and productivity, improving human working conditions, and counteracting the possible adverse effects of use on human health, safety and performance" [ISO 13407, 1999].

The basic philosophy of UCD is to put the user at the centre of the development process. This means that when developing a new software product or an application, the designers and developers need to focus on what the real people who will use their product are going to do with it. Instead of considering the functionality of the application or an eye-catching gimmick in the way the software presents maps, the developers must take into account the real scenario of where the software is going to be deployed and for what purpose. A properly developed systems will take into account the skills and judgment ability of the user, and will directly support their work.

1.1.1 User-Centred Design in EveryAware

As Table 1.1 illustrates, the changes in context that occur over time with the development of technology are influencing the practice of computer application development and the requirements of user-centred design. Specifically for the type of activities that will be carried out within EveryAware, consideration should be given not only to the small scale task of the user (that is, starting an app on their smartphone to work with sensors) but also to the wider context of their daily activities before and after they participate in the data collection. Since the goal of the project is to explore behaviour change, both the hardware and the software need to be developed in a way that supports this mission. As this report will highlight, the considerations include the availability of devices, patterns of use, daily practices and interests of participants.

It is also important to note that in some parts of the project existing products were used as a basis (e.g. WideNoise) and therefore a significant part of the design was already completed and established. Therefore, the process did not start from *tabula rasa* and had to adapt to the conditions in the project and the various limitations and constraints that already exist.

1.2 Mobile Application Design and Usability

The mobile phone industry has been dubbed the industry of the decade, with over 5.2 billion subscribers globally [Ahonen, 2011], of which 1.08 billion are smartphones [Alexander, 2012]; compared with 1.2 billion personal computers, it seems that smartphones are rapidly becoming the most widely accessible computing platform [Ahonen, 2011]. Because of this growth in device use, the mobile application industry is predicted to be worth an estimated 25 billion dollars by 2015 [Markets and Markets, 2010]. With this boom, mobile phone functionality has expanded which has partly been driven by increasing user demand for mobile solutions that meet everyday personal and business needs. This has resulted in a surge in the development of innovative mobile applications to meet these demands. However, testing and evaluating the usability of mobile applications presents a number of challenges within both the research and commercial community.

Despite the relative maturity of the field of Human Computer Interaction (HCI), the mobile HCI domain is still a relatively new research area and usability testing within the field is still evolving and being refined. Early studies have found that in a number of cases, traditional well established desktop HCI methods and concepts are either insufficient or not applicable when evaluating mobile applications. As indicated by [Kjeldskov and Graham, 2003] mobile technologies introduce complexities and limitations for usability testing. Contextual usability, or context of use, is particularly important to understanding realistic behaviour of 'real' users in different environments and cannot be replicated easily in the laboratory. When considering how to design appropriate and usable mobile applications, four core variables need to be taken into account; the characteristics of the user, from their ability to operate the device to their dexterity; the tasks that they need to perform with the application, as well as the wider tasks that they are trying to carry out; the environment in which will be used and finally the technology and its capabilities and limitations.

The issue of mobility presents one of the most noticeable differences between desktop usability testing methods and those required for mobile devices. Mobility is very difficult to replicate in a laboratory setting and as such does not provide the real-world heterogeneity within which an application is used. Even where attempts to simulate mobility in laboratory tests using treadmills and other apparatus, this cannot replicate the ever-changing environmental context. 'Conventional' laboratory usability testing has however, been proven useful to test and improve user interface interaction [Kaikkonen et al., 2005]. The characteristics of mobile devices, such as small screen size, display resolutions, input/output systems, and wireless network features pose additional challenges.

1.3 Usability Evaluation and Testing

An important part of the user-centred design process is evaluation (see [Marsh and Haklay, 2010]). There are very few universal rules that work with every interface and application. Even definitions such as 'an application should respond within 2 seconds to provide users with a feeling of interactivity' cannot be applied universally and in mobile applications, 2 seconds is too long for an application that communicates with a driver in a vehicle. On the other hand, it is impossible in many situations to acquire the location from GPS satellites within this time limit. These cases do not make the application unusable, or not interactive. Thus, each application and product will develop in their own specific way with a mix of aspects that can be handled through the use of guidelines and principles such as those in the ISO standards, combined with functionality and operations that were developed specifically for the product and to which there are no easy to use guidelines. Therefore, there is a need to check if the application or the product is answering the requirements for which it is designed. Thus, evaluation is a necessary part of the product design process. It provides an empirical evidence for how end users are using the application, and, most importantly, of problems that are caused by difficult to use interfaces.

1.3.1 EveryAware Usability and Integration Testing

To evaluate the pre-existing WideNoise app, both from the perspective of end to end integration and usability, the team opted to apply several test phases using different user-types and different locations. As a result, Beta testing the platform was carried out in London, Rome and Antwerp and consisted of three elements, with the third and final element comprising the initiation of the large scale case study:

1. Internal project user testing, making use of expert evaluation input.

2. Beta testing the application with conference participants familiar with citizen science activities and mobile phone application use, which enables feedback beyond project team members and therefore allow for a wider range of users, devices and experiences.

3. Launch of case study with 'real' users, outside of the project team and unfamiliar with the application.

Each of these stages were designed to answer questions pertaining to acceptability, ease of use, data transfer and connectivity, effectiveness and comprehensibility. Additionally, integration testing occurred as a key consequence of these tests - could the EveryAware platform capture data on a mobile device, upload this data to a central database server and then serve the data to users via a web application?

As touched upon earlier, a full user-centred design approach was not possible in the case of the noise sensor application (WideNoise) that is used within EveryAware. This was primarily due to the fact that the application was previously developed, external to the project and only a limited range of adaptation was possible within the project's budget and time constraints. In addition, WideNoise is a 'live' application already in use by a fair number of users and therefore radical changes to the application were not possible. As such, the purpose of the review undertaken during the testing phase was to evaluate the changes to the application required within the EveryAware framework, whilst describing and defining desirable properties of the device in line with user feedback, with the view to make necessary improvements incrementally.

For the initial internal testing phase the UCL team acted as usability experts and applied their knowledge of 'typical users' and tasks guided by heuristics, to identify usability problems (this is known as heuristic evaluation). This knowledge is principally grounded in the team's experience in engaging communities to collect and share local knowledge and environmental information using a range of data collection methodologies and/or the use of interactive web-based community mapping platforms. UCL team members were acting as expert evaluators as they were external to members of the team developing the Android application and the consultants re-engineering the iOS version.

The project team utilized an iterative design and development process which is a well established approach in software engineering; iteration simply means to step through one design version after another. Feedback from each of the phases yielded valuable information that led the project team in a direction to adapt and optimize the platform. Equally, the results of these tests and the calibration tests described out in [ISI, 2012] provide useful input into establishing appropriate usage protocols for the WideNoise app and the platform as a whole.

The iterative process included a review of the project requirements, considering the process through which a user will complete a task of taking a noise sample, indicate using sliders their qualitative evaluation of the noise sample and potentially tag it. Experience from past studies of urban noise at UCL allowed an understanding of the context in which the App may be used in the street, and the likelihood of users entering tags and additional information. Finally, the way in which the application can be used as part of a wider social activity - making it easy to install, learn, register and explore - were considered as part of a local citizen science campaign.

1.4 Mobile Sensing Applications and EveryAware

Many new applications being released have been designed for mobile devices, to enable citizens to record environmental data by making use of embedded sensors, such as a microphone, camera, accelerometer, gyroscope and GPS receiver. For example, in order to create a crowdsourced map of the quality of the mobile network itself, the application OpenSignalMaps [OSM, 2012] is using the indication of signal quality that the smartphone receives from the local network, combining it with a GPS reading for identifying the location, and then sending the information to the server. The resulting analysis, which is done in aggregate, provides an indication of the quality of the signal in different parts of the UK, and suggests the best carrier in terms of quality of service. [Cuff et al., 2008] suggest that there is a wide range of applications in which participants can be engaged in mobile sensing and they expected a rapidly growing field and applications for urban sensing.

Of specific interest to EveryAware is the environmental sensing abilities of phones. Microphones are a standard component within all phones and as such provide an affordable way in which to facilitate community based environmental noise monitoring. Within the first phase of the EveryAware project the aim was to make use of readily available inbuilt sensors which is the initial Beta tests elected to focus on noise measurements. A number of noise-focused mobile phone applications currently exist and can be downloaded free of charge. NoiseTube [Maisonneuve et al., 2010], was created in 2008 at the Sony Computer Science Lab in Paris and is currently hosted by the BrusSense Team at the Vrije Universiteit Brussel. NoiseWatch, from Eye On Earth [Eye On Earth, 2012] set up by the European Environment Agency to monitor air quality, noise and water quality) allows the user to take noise samples for 10 seconds apiece. HabitatMap, a non-profit environmental health justice organization in America launched AirCasting in December, 2011. AirCasting [HabitatMap, 2011] is a platform for recording, mapping, and sharing environmental data using a smartphone and currently, allows users to upload sound level data recorded by their phone's microphone.

Other applications are using sensors that are not available with the phone, and therefore rely on existing sensor network with which the phone communicates, or on a specifically designed sensor box that works in tandem with the phone. In such cases, the sensing functionality is divided between the sensors in the box and the communication and storage abilities of the phone itself. The EveryAware sensor box is an example of this type of sensor.

1.4.1 Designing the EveryAware Platform

More generally, the EveryAware platform has been designed to handle both sensor and subjective data acquisition. It was designed to use both internal and external sensors so it can allow a wide range of applications. The platform is a modular system based on two hardware components: a smartphone controlling the data acquisition and a modular sensor box with several pluggable sensors. A central server collects, analyses and visualizes information sent from the Smart Phones. In addition to the hardware components software systems operating on mobile devices have been developed to allow users to upload their sensor readings and incorporate subjective information using both smartphone applications and personal computers via a web-based interface. Users must install the sensing applications on their smartphones and can access a range of visualizations and results of the analysis via both smartphone and the web.

Chapter 2

The EveryAware Platform

2.1 EveryAware Noise Sensing

This section of the report describes WideNoise, the application appropriated for use within the project, and outlines some of the initial design and developments changes made prior to the launch of the Beta test cases. WideNoise features access to and visualization of noise samples recorded by individual users. It consists of a smartphone application, described in Section 2.2 and a web application, described in Section 2.3. Both offer several options for the user to interact with noise samples from their immediate environment, wider community or from around the world. The platform also offers opportunities for users to share their WideNoise activity with friends via social networks or retrace their own historical noise exposure.

2.2 WideNoise Smartphone Application

The WideNoise phone application permits users to monitor the noise levels around them, making use of the in-built microphone on a Smart Phone. It was initially designed for the iPhone mobile operating system (iOS) by Widetag [Wide Tag, 2012], a mobile applications consultancy sub-contracted on the EveryAware research project. Their prototype was designed and developed for simple scalability and to test load on their WideSPIME infrastructure; a modern hardware and software architecture that can take advantage of existing cloud architectures and support the many sensors that are expected in the Internet of Things [Wide Spime, 2012]. Given the time-scales of the project, and the requirement to deploy the first sensors relatively rapidly, the project team wanted to take advantage of an existing application and as such opted to proceed with WideNoise to perform the required Beta testing exercise. An Android version of the application was developed internally by members of the research team. This decision was driven by current statistics which suggest that Android holds 61% share of the global smartphone operating system (OS) market [IDC, 2012], and thus would enable the potential for wider uptake of the application [Schusteritsch et al., 2007].

2.2.1 WideNoise End-User Features

When the WideNoise application is first opened, users are presented with a splash screen that closes after a few seconds (Figure 2.1). The application implements a store'n'forward paradigm when sending its reports to the server. This has been implemented to avoid loss of user reports when there is not a working connection with the server i. e. where network connectivity is not available readings are saved on the local device for upload to the server at a later time. For this reason, before the data capture wizard is started, the application checks whether there are reports to be sent to the server. If there is at least one report pending and if there is a working connection

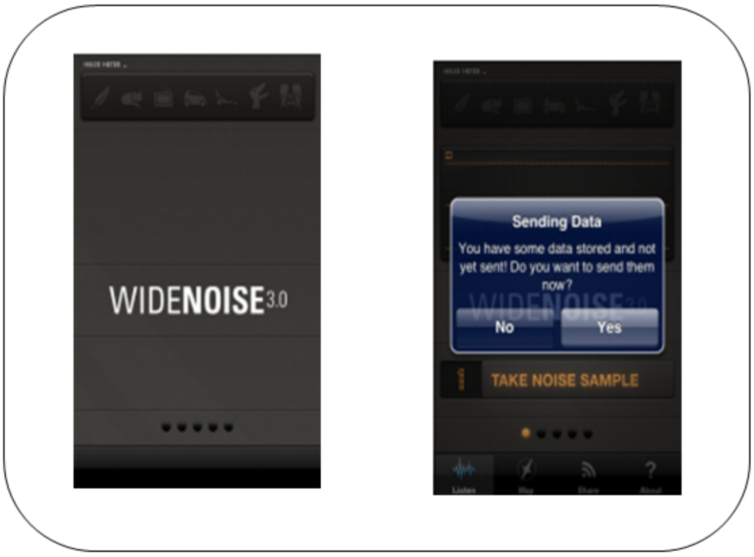


Figure 2.1: WideNoise start-up and store and forward interface

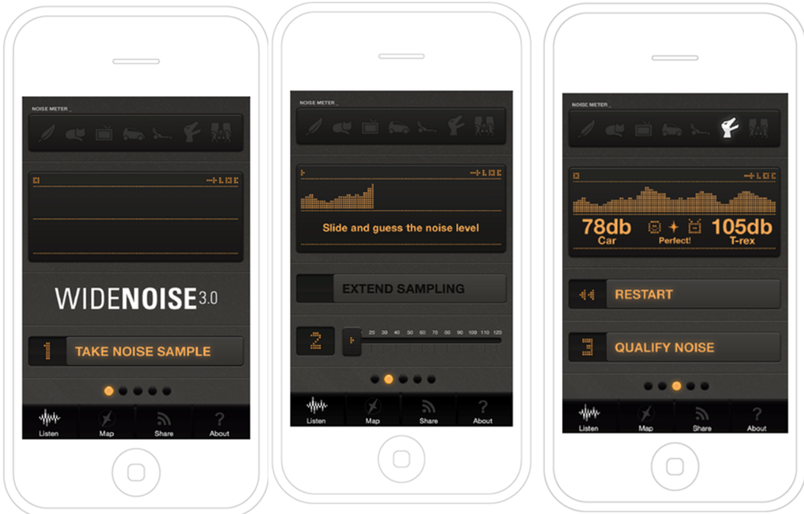
to the server, the application will ask the user to send this information (Figure 2.1). After the splash screen and transfer of any pending reports the application displays the welcome page of the noise capture wizard, asking the user to proceed with the first step: take a noise sample.

The first interactive screen allows the user to take a noise sample of up to 15 seconds duration. During recording, a graphical representation shows the change in sound volume (in decibels). The user is also able to extend the audio recording from the default length of 5 seconds in increments of 5 seconds each time. The option to incorporate subjective data collection was lacking in the original version of WideNoise. However, given that one of the novel aspects of EveryAware is to integrate participatory sensing with the subjective opinions of those participating, alterations to the initial design were required to incorporate this feature. The first was to introduce a gamification phase where users are given the option to guess the noise intensity value of the current sample being taken. The first implementation of this saw the guess phase incorporated at the final data capture stage (Figure 2.2). However, this was deemed inadequate as users were able to see the decibel (dB) value prior to making their guess. A further iteration resulted in the 'guess' phase being introduced as the second step and appropriate text was added to prompt the user to guess the sound level.

Once the user has finished recording their noise sample, a noise context rating is shown allowing comparisons e.g. a sleeping cat, rock concert area. The results of the user's guess are compared to the sample taken and the results displayed at this stage (see Figure 2.2). These features are all contained on the same page of the wizard.

To allow for further exploration of potential connections between user perception and noise sample additional annotation and subjective data collection capabilities were introduced. Initially, this provided users with the option of hitting a combination of 8 on-off selections (Figure 2.3). However, these binary options did not provide an adequate range for perception parameters and were therefore superseded by the implementation of four slider controls to allow for context prediction (see Figure 2.3). The slider starts in the middle position, as the default setting, to avoid anchoring effects. Users can apply context to a measurement using 4 dimensions: love vs hate; calm vs hectic; alone vs social; nature vs man-made. A maximum of four sliders were selected due to interface space constraints. The user rating comprises the next page of the wizard.

Figure 2.2: WideNoise Start Screen, Sound level display Screen and Qualitative Rating of the Noise



After the noise qualification, the application will send data to the server and present the last page of the wizard. From here the user can choose to take a new sample, share or tag the report. If the report cannot be sent, the application will ask the user if they want to send it later. Anonymized recordings are made public on the WideNoise section of the EveryAware website. On the phone, WideNoise provides a toolbar from which it is possible access other panels:

1. A map showing the readings of other users
2. A settings page from which it is possible to login to Twitter and Facebook
3. An about link showing information on the WideNoise application and Everyaware project.

The 'Share' icon on toolbar also takes users to an option to connect to their personalized page where they can view charts and statistics about their own measurements.

2.3 WideNoise Web Interface

The WideNoise web application aggregates, summarizes and illustrates noise related data collected by the WideNoise smartphone application discussed above. A detailed description of the WideNoise web application, which is used here in parts, and the entity of its functions can be found in [LUH, 2012]. The WideNoise web interface can be accessed via the following URL: `http://cs.everyaware.eu/event/widenoise`.

The WideNoise web page is composed of three main pages, namely 'Home', 'Map' and 'About'. A navigation bar for those pages is always visible aiding the user's movement through the site.

The 'Home' page, depicted in Figure 2.5, has been designed to provide user-friendly, easy access to the important aspects of and information about recorded "noise" events. It contains the following functions:

1. A logo linking to the EveryAware project, which helps to connect the two projects
2. Direct links to the map page (see Section 2.3.2) and the WideNoise smartphone application discussed above
3. Buttons to share the WideNoise web page on Twitter or Facebook (see Figure 2.8), which enables users to spread the site

Figure 2.3: Qualitative noise rating on-off control buttons, replaced by and slider controls

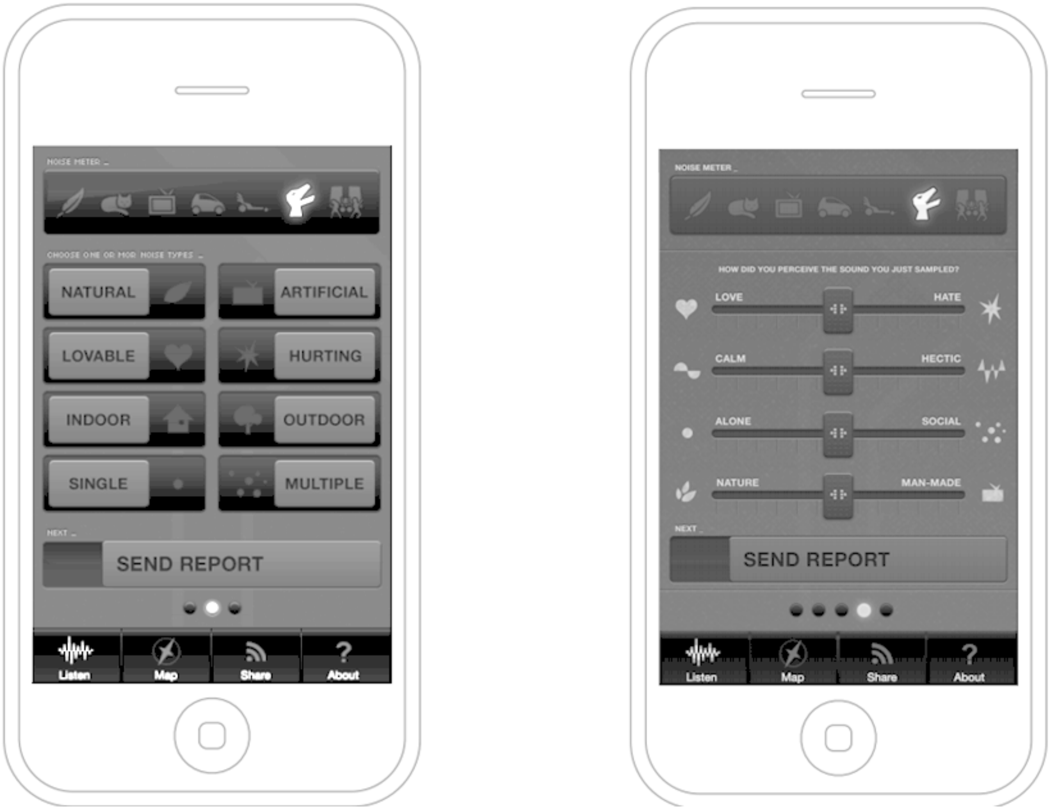


Figure 2.4: WideNoise Completion of Data Transmission and Next Step Screen, Add Tag Screen , Map Screen

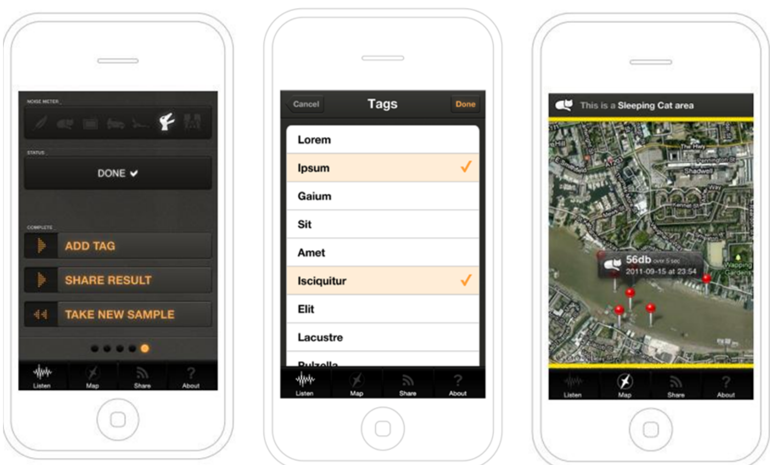


Figure 2.5: The EveryAware 'Title' Page.

4. A slide show of statistics on the use of WideNoise (see Section 2.3.1)
5. Information about the WideNoise project as well as EveryAware's Twitter Stream, by which the user gains a deeper insight into the project.

Detailed information about the WideNoise project is described on the 'About' page (Figure 2.7). It also provides user support for example by answering frequently asked questions. The third main page of the WideNoise web application, the 'Map' page, is shown in Figure 2.6. From a user perspective it probably contains the most interesting features and will therefore be described in detail in Section 2.3.2.

2.3.1 Statistics

The user can access several statistics through the WideNoise web application. Some of them are public and shown directly on the front page. Others are only visible to the user personally, if they possess a personal WideNoise account.

On the 'Home' page the user is provided with several public views on the data. These views are:

Figure 2.6: Displaying Results on a Map

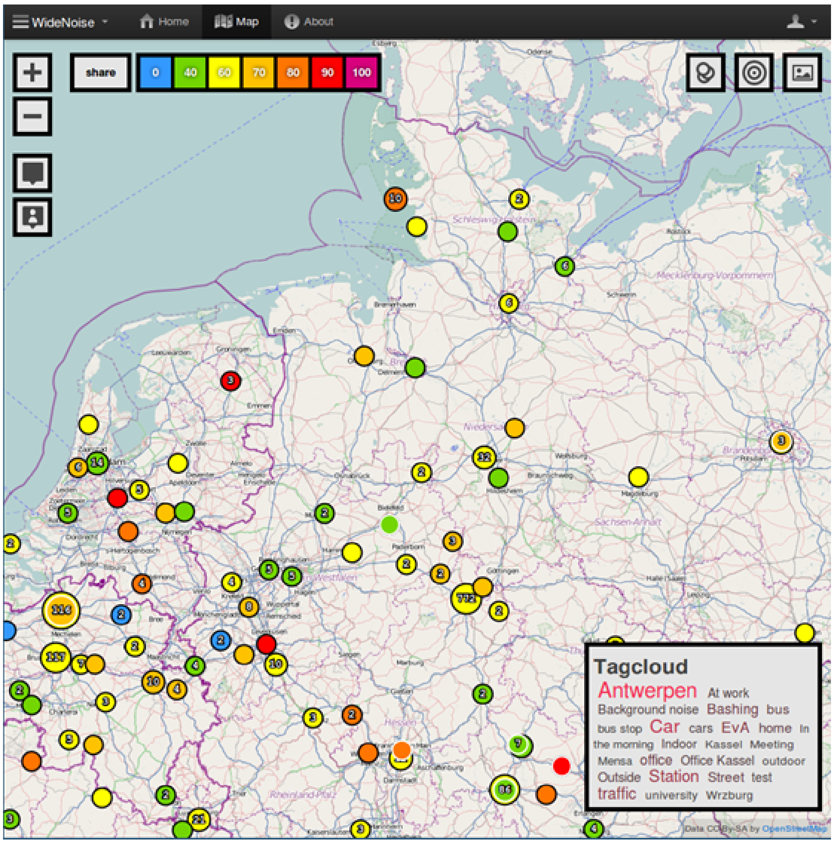
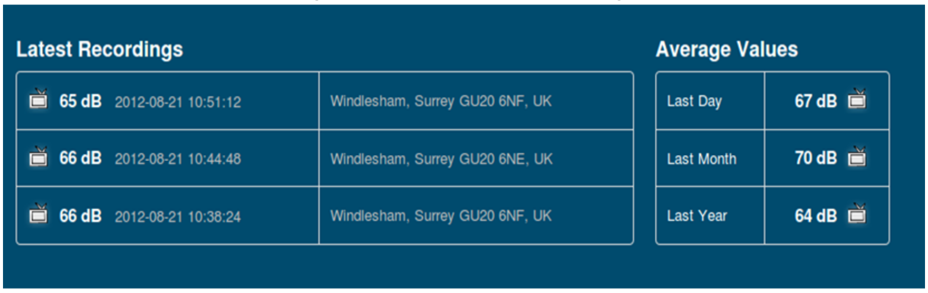


Figure 2.7: The EveryAware 'About' Page

Figure 2.8: Sharing WideNoise on Facebook.

Figure 2.9: Latest Recordings



1. A histogram summarizing the number of measurements for each continent for the last three day.
2. A table listing the registered users with the most samples overall as well as a table listing the registered users with the most samples covering the last two months. This might act as a stimulus for users to put more effort into taking samples.
3. A table showing the latest recordings and a table with average values for the last day, month and year (see Figure 2.9). This helps tracing current measurements and comparing one's own samples with the average.
4. A scatter plot showing the decibel values for the measurements spanning the last three days. The user can thereby visualize all the measurements taken in the last three days or zoom into the plot and depict for example only the last few hours.

These statistics are easily and quickly comprehensible, but refer only to short time spans.

The second type of statistics can be accessed by the user via their personal page. There they can view comprehensive information on their own measuring behaviour during the last three days. A screenshot of this page is shown in Figure 2.10. The page also provides a KML (Keyhole Markup Language) download containing all user's measurements to display for example in Google Earth (see “Down-load KML" in Figure 2.10).

2.3.2 Map

The 'Map' page is one of the main pages of the WideNoise web application. There the user can view a range of different spatial views on the WideNoise data. Figure 2.6 shows a screenshot of the 'Map' page. In its default view each marker on the map represents a cluster of noise measurements. The color represents the average decibel value of the cluster and the number on each

Figure 2.10: Screenshot of the User's Personal Page

marker represents the number of measurements the cluster contains. This helps the user to get an aggregated view on all the noise measurements spanning the whole world. When clicking on a cluster a popup is showing the user more details about the cluster including the average dB value, perception values as recorded by the WideNoise smartphone application and a list of tags assigned to samples contained by the cluster.

There are different controls that allow users to change the perspective and view mode of the map. Firstly they may zoom in and out of the map, zoom on all the data on the world or focus and zoom in only on personal data (if the user is logged in). Secondly, the user can share the current view on the map via Twitter or Facebook. Thirdly, the user can view different modes. For example she can select between an OpenStreetMap base layer (see Figure 2.12) or a base layer provided by Google (see Figure 2.11).
There are four overlays to choose from:

1. All, which shows all the data
2. Grid or clustering (see Figure 2.13)
3. Tag Area, which shows the tag area when a tag is hovered in the tagcloud box (see Figure 2.14)
4. Personal (only when logged in), which shows only personal measurements

Personal measurements are displayed with a white border instead of a black border, The leftmost button on the map allows the user to disable clustering, resulting in measurements shown as stacked upon each other where they occur in the same location. Finally, the middle button allows to track measurements as they come in, see Figure 2.14. When a sample is recorded the map focuses on that measurement and automatically displays the corresponding popup. At the bottom

Figure 2.11: WideNoise Online Map With Google Basemap

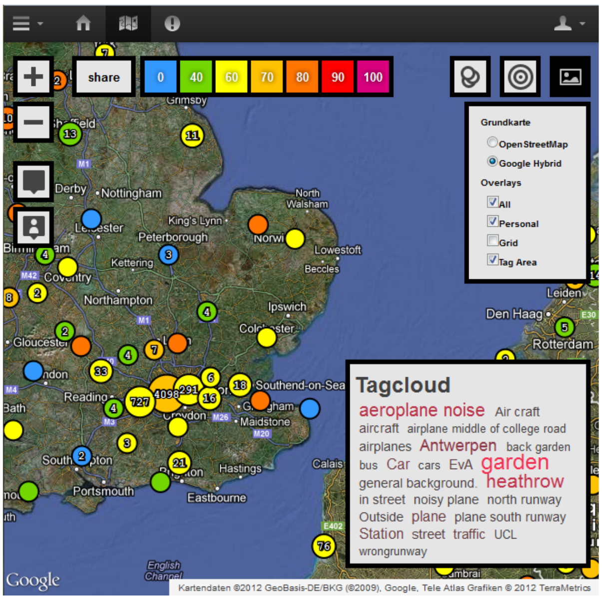


Figure 2.12: WideNoise Online Map With Open Street Map Basemap

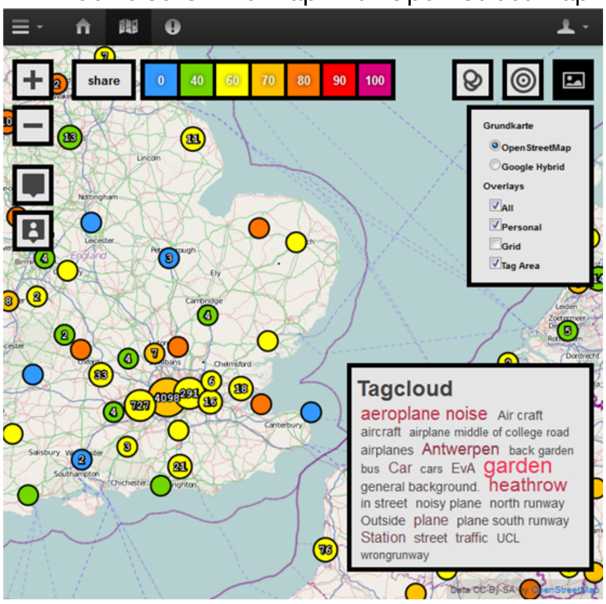


Figure 2.13: WideNoise Online Map Showing Gridded Data (a) and Clustered Data (b)

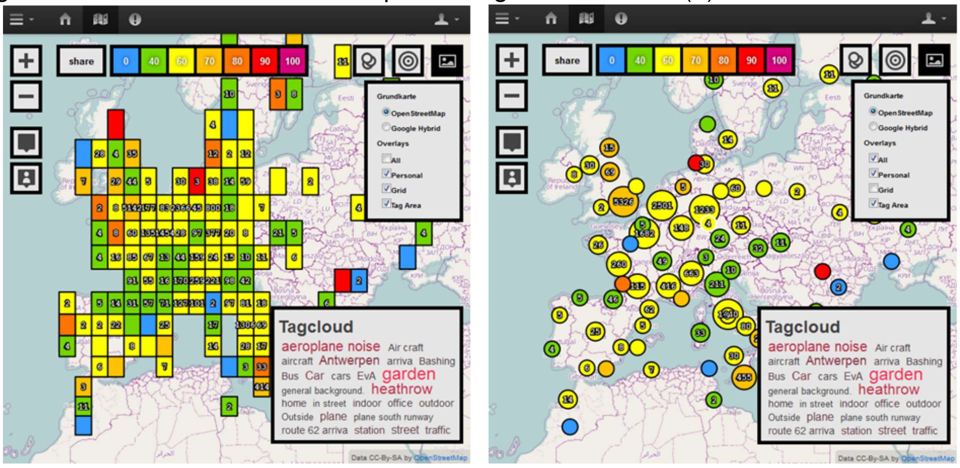


Figure 2.14: WideNoise Online Map Showing Tag Cloud

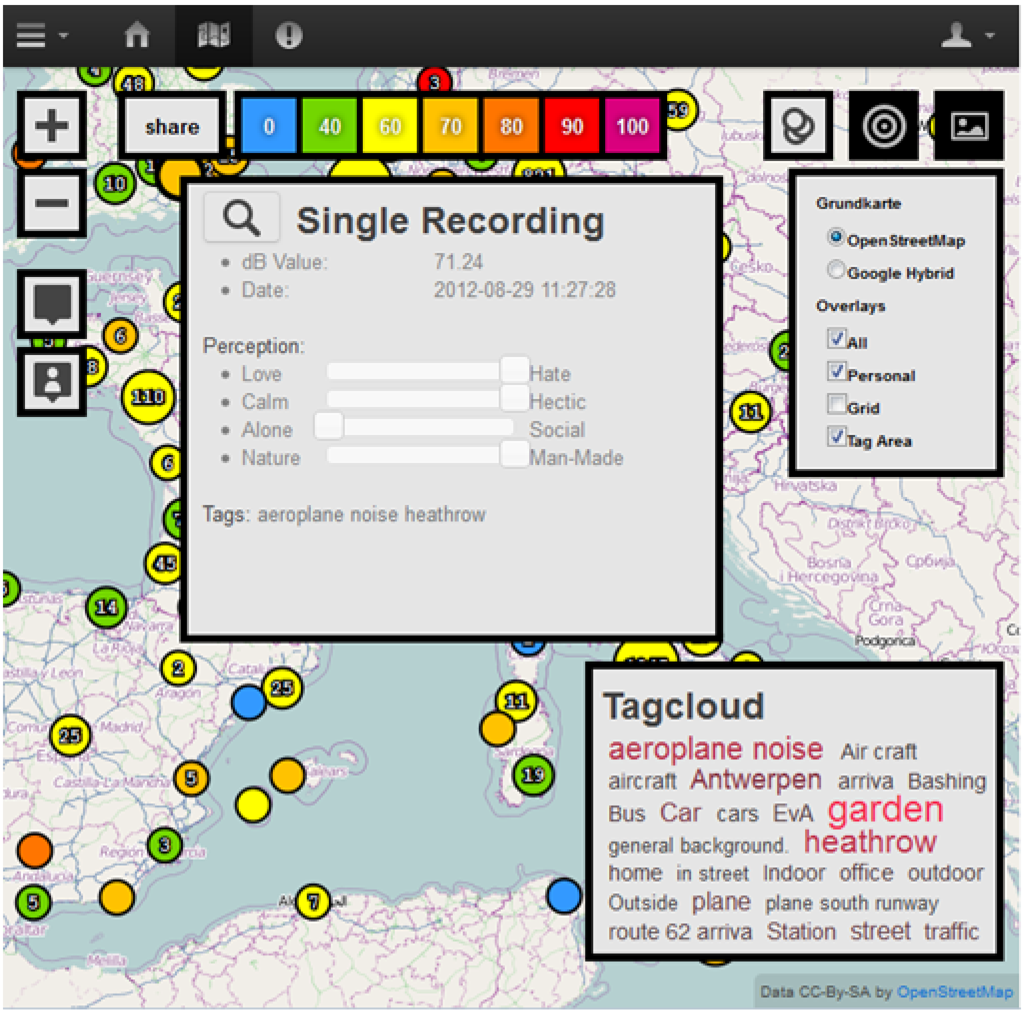
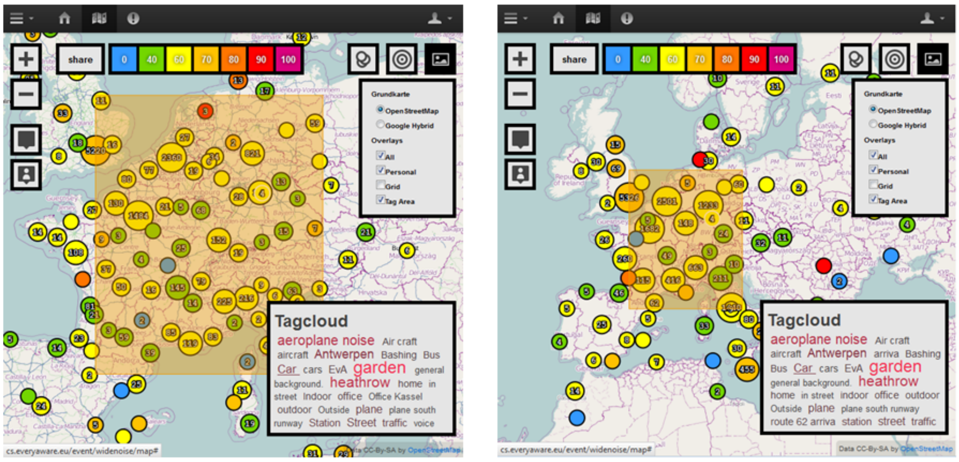


Figure 2.15: WideNoise Online Map Showing Areas Covered by Specific Tags



right a tagcloud is displayed which shows the tags assigned to samples in the currently viewed section of the world map (Figure 2.15). If the user hovers over a tag, an area is highlighted on the map showing where instances of this tag occur. When the hovered tag is clicked the map zooms into the highlighted area, as illustrated in Figure 2.15.

2.4 EveryAware Air Quality Sensing

2.4.1 Designing the Air Quality Smartphone Application - UCD

Unlike the WideNoise app, no pre-existing app existing for Air Quality sensing was available. This offered the opportunity to the EveryAware team to take a user-centred design approach to the development of the app, with members of the UCL team using their extensive experience in working with community groups interested in air quality issues (see [UCL, 2012] for a full description of work carried out in the context of the EveryAware project). Three key potential user groups were identified as part of this process - mothers with young or school age children, who make a regular journey to and from school gates every day, and cyclists or commuters, particularly those who again make a regular journey to and from a workplace. It was felt that these three user groups offer the opportunity to maximize repeated coverage of a small geographical area, and hence provide sufficient data for interpolation (as described in [VITO, 2012]).
Following the UCD process, key features required of this app include:

1. The ability to work with the EveryAware platform in 'hands free' mode, for example while cycling.
2. The start page of the app should be a map, where the user can click to see past readings
3. Readings should be presented as traffic lights OR values (measurements) depending on the context
4. Users should be able to go back and annotate readings at a later point in time
5. A graph detailing individual exposure over the past hour, day and so forth should be included
6. Coupling the mobile phone and sensor box should be easy, and automated if possible.

A full list of identified requirements and contextual information is given in Appendix 3.

Figure 2.16: The low cost air quality sensors mounted on the sensor shield contained in the SensorBox

2.4.2 SensorBox Hardware

The SensorBox is used to make air quality measurements (Figure 2.16). It interacts with the user's smartphone via a custom-built app, which also implements the user interface for data capture (see Section 2.4.3). The SensorBox itself can be powered with a mini-USB cable; this allows the SensorBox to be feed with an external battery or a laptop, as well as from the phone. Battery powered backpacks usually have this kind of plug, allowing the creation of a "green tool" consisting of a self powered solar backpack containing the box.

The current release of the SensorBox is a closed box with dimensions of approximately 10cm x 5cm x 4cm and a weight less that 100g. It incorporates holes for ensuring the required air circulation onto the sensors inside the box. Since in the box air flow is maintained by an internal fan, the user only needs to place it in such a way such that the holes are not obstructed. The box must first be powered and linked with the smartphone through a Bluetooth connection. Once this coupling is achieved, remaining interaction tasks are carried out via the phone.

Figure 2.17 shows how the SensorBox can be fitted in commercial solar powered backpacks in order to collect mobile data. The box only occupies one side pocket and therefore leaves the internal backpack space free for other use. In this case, the only requirement is the availability of a net (mesh) pocket that permits air flow to enter and leave the box. Importantly, this means that the box can be operated in 'hands-free' mode, a key requirement established by the user centered design process (see Section 2.4.1).

2.4.3 The Air Quality Smartphone Application

The air quality application (AQA) allows users to visualize, qualify and share readings from the external SensorBox. All the interaction is designed around the map/navigation metaphor where the user will have instant feedback about their current location and pollution exposure.

Once launched, the application will ask the user to connect to a SensorBox (the user must switch on the box before starting the application). The application shows a live list of boxes in the vicinity as soon as they are detected and will allow the user to stop scanning process and connect to a selected box (Figure 2.18). To make this step as simple as possible, particulary in situations hwere multiple boxes could be present, each SensorBox has its own name printed in a visible part of the device.

After the connection has been established, users are free to access the different application panels using a navigation bar on the top. As specified in Section 2.4.1, the key component of the app is

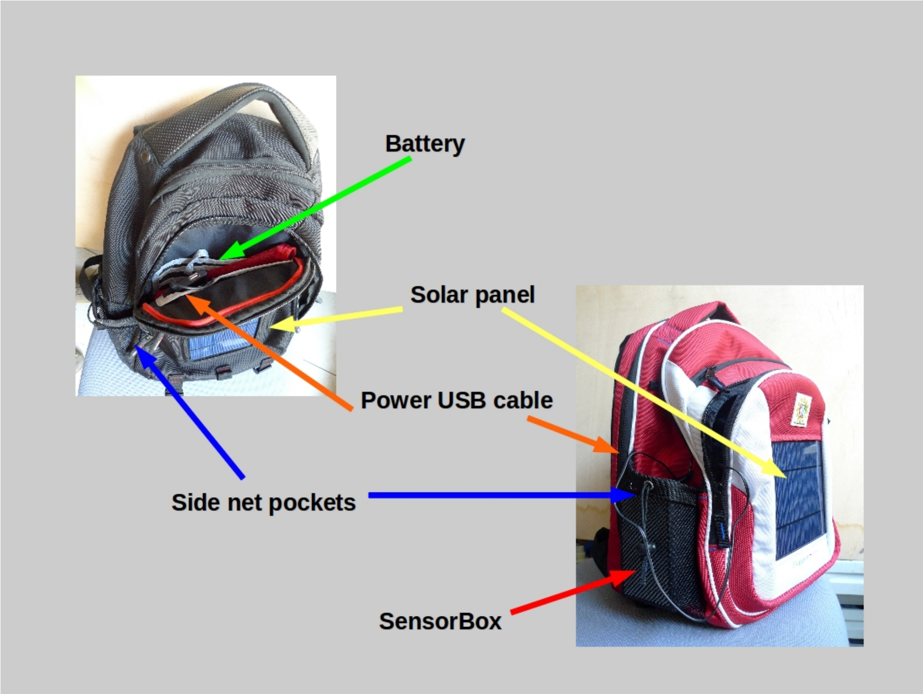


Figure 2.17: The easy SensorBox integration on commercially available solar powered backpacks

the map. It currently permits two different visualizations (Figure 2.19):

- “My Track”, which shows the each reading made by the SensorBox along the user track;
- “Community Map”, showing the summarized readings made by other users nearby.

Additionally, the map shows a status bar (on the bottom) that provides the connection status of the SensorBox and the validity of its GPS receiver. In “Community Mao” mode, the user can touch the map to visualize detailed indormation for a given point as shown in Figure 2.20. When in “My Track” mode, the user can touch any recording to make an annotation (Figure 2.21).

Among the other panels accessible by the toolbar on top of the application main interface, the user is also offered the option of viewieng a graph showing live data as measured by the SensorBox (Figure 2.22).

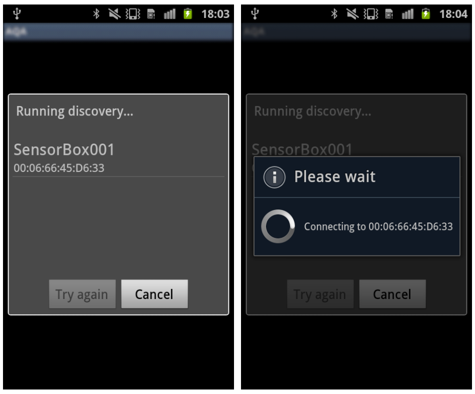


Figure 2.18: AQA: SensorBox connection

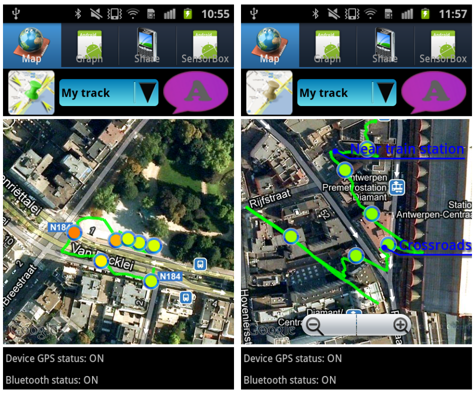


Figure 2.19: AQA: “My Track” (left) and “Community Map” modes

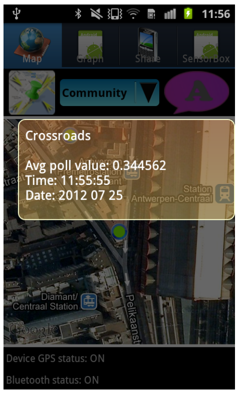


Figure 2.20: AQA: Community map details

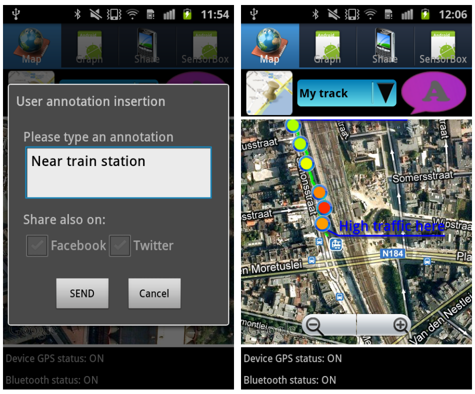


Figure 2.21: AQA: Annotation interface (left), annotated track with colors used to provide visual feedback on the pollution level

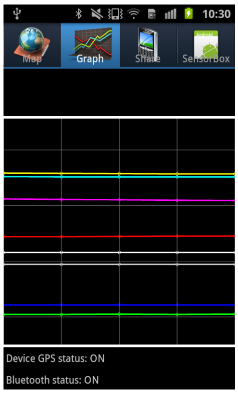


Figure 2.22: AQA: Live charting

Chapter 3

Usability and Integration Testing of the EveryAware Platform

3.1 Approaches to Testing

As described in Chapter 1, the importance of context in usability testing (in particular for mobile applications) should not be underestimated. Thus, much of the testing described here takes place with end users making use of the EveryAware platform in a real world setting rather than in a laboratory or test setting. Additionally, for noise monitoring, the app in question (WideNoise, from WideTag) pre-dated the EveryAware project. Given this, radical modifications to the app, which already had an established user base, were not possible, whereas incremental modifications were feasible. Therefore, rather than an end-to-end testing process followed by modifications and a release of new software, tests, feedback and modifications were iterative, although remaining within the context of the Case Studies. A full list of these modifications can be found in Appendix 3.

Usability and integration testing with the context of the EveryAware project is centred on two Beta Case Studies, the first of which tests the EveryAware platform, with a focus on noise monitoring, and the second platform and sensor integration, with a focus on air quality monitoring. However, it is also important to realize that a number of modifications were made to the App prior to the first Beta case study. This was to add functionality to support the capture of subjective data. These modifications were tested by the UCL team, who provided feedback based on their extensive work with community groups. Additionally, work on a large-scale noise-based Case Study around Heathrow Airport has been commenced in anticipation of the scheduled start date, as a result of contacts with an interest group in the area. Feedback on the usability of the WideNoise app has been gathered from this group, and has particular relevance given the diverse age profile of members (see [UCL, 2012] for details).

This chapter summarizes the overall results of the testing process, presenting both quantitative and qualitative evaluations of the EveryAware platform. Given its early availability in the project, a large part of analysis focuses on the WideNoise app, with qualitative methods apply in particular to participant interviews, feedback and observations provide additional data to support findings on the platform's performance. However, preliminary analysis on the usability of the Air Quality App is also presented.

3.1.1 A Comment on Data Quality

The data included in these analyses have not be cleaned, and as such contain contributions made by project team members. Additionally, the data snapshot was taken on the 12th August 2012. However, the results presented are indicative of the types of analysis that could be performed and provide an insight, with a limited dataset, as to how users are interacting with the EveryAware platform and the way in which the platform performs. Importantly, the results also demonstrate very clearly the successful integration of the EveryAware platform.

The number of readings taken by individual users has been calculated using the unique identifier of the device. In some cases however, particularly where phones were loaned from the project, there may be instances where an individual device has been used by more than one contributor. Based on the current information, it is assumed that these cases are rare and as such a unique identifier has been taken to represent an individual user.

Current system settings do not permit the identification of users who downloaded and utilized the application as a direct result of our efforts during the Beta test, nor those engaged in the larger scale case study around Heathrow. As such, a temporal query has been applied to the worldwide WideNoise dataset to extract data in reference to the first Beta test. To report on the early results from the Heathrow campaign, a spatial query comprising an area of 169km^2 has been applied which enables us to extract data from the area surrounding, and including Heathrow airport. Given the importance of location to the study, non geocoded entries have been excluded even where they have been identified as being contributed by members who contributed points in the specified location.

Given these factors, and the fact that work on the large-scale case study in Heathrow is very much ongoing, the quantitative results presented should be seen as indicative rather than absolute, and also serve to illustrate the potential of the data and the techniques available for analysis.

3.2 Usability and Integration Tests and Results - WideNoise

This section summarizes the results of the usability and integration tests on the EveryAware WideNoise platform, detailing outcomes from both the first Beta case study and interim results from the large-scale case study at Heathrow Airport. An overview of the context of the case studies is given first (more detail can be found in [UCL, 2012]), followed by quantitative results extracted from the EveryAware WideNoise database. These serve both to illustrate the successful end-to-end integration of the components of the EveryAware platform, as well as to highlight some usability issues. Finally, quantitative feedback from individual participants in the case studies is presented, and key usability issues enumerated[1].

3.2.1 Beta Test - Citizen CyberScience Summit

Participants in the first Beta test comprised delegates from the Citizen CyberScience summit (http://cybersciencesummit.org/), held at the Royal Geographical Society and University College London between 16th-18th February, 2012. The principle behind enlisting this audience, the majority of whom were familiar with citizen science initiatives, was to gain an insight into a specific mode of recruitment and to assess the application efficacy. The participants involved may not have formed a ‘typical’ user profile in terms of age and experience with technology, but some will have had previous exposure to mobile application design and will have utilized apps for use within citizen science projects. Based on this knowledge, it was deemed that any potential feedback would prove valuable prior to launching a full case study.

Participants were encouraged to download the WideNoise application using a bit.ly link to either Android or iOS operating systems. They were asked to perform representative tasks - i.e. make noise measurements - throughout the conference and beyond if desired. Reminders were issued throughout the proceedings by providing small slips of paper (mini business cards) with details about EveryAware and how to install the application, an announcement during a plenary session

[1] Note that an additional Beta test using WideNoise took place in Rome on the 9th June 2012. The results of this test are reported in [UCL, 2012] but not included here as the test did not focus on platform usability.

and general encouragement of participants to use WideNoise. Direct observations of individual users as they performed tasks with the application were not made during this phase. However, participants were asked to provide feedback of their initial views and perceptions in relation to the application and its ease of use. Although feedback was received from just four participants, research has found that usability testing can provide useful feedback and identify the most significant usability problems with only five users, where the usability problems found flatten out as you add more and more users [Nielsen, 2000].

3.2.2 Large Scale Case Study - Heathrow Airport

Following the Beta test, a decision was made to anticipate the next stage of the study, following on from contacts with HACAN (Heathrow Association for the Control of Aircraft Noise) an issue-based pressure group focused around noise and the Heathrow Airport extension (see [UCL, 2012] for details). To initiate the first large scale case study using the integrated hardware (smartphone) and software (the WideNoise app and the web-based interface) components of the platform, a local issue focused approach to environmental monitoring was applied. Communities surrounding London's Heathrow airport were recruited and encouraged to download the app. They were then instructed to take measurements over a four week period during the month of June. This was carried out with support from UCL through an Inclusion Award, which provided additional funding for advertisement and recruitment (see [UCL, 2012]).

To introduce the initiative and associated tools a launch event was held in the local community. Attendees were given an initial demonstration of the application and were provided with written instructions. Participants were given a smartphone device (HTC Explorer and iPhone 3) where these were not already pre-owned and were encouraged to download the application and trial it during the meeting. Where devices were loaned from the project, EveryAware WideNoise was preloaded and all other applications removed. In addition to encouraging participants to try-out the application they were also encouraged to register to the platform in order to access their personalized recordings.

3.2.3 Results - WideNoise Application Download Statistics

Overall, the WideNoise app has been downloaded a total of 696 times (statistics from Google Market Place/Play from original release date until 12th June 2012) on the Android operating system[2]. Prior to the initiation of the Beta test the App had been downloaded by 13 users and there were 14 instances of 'active' device installations. During the three day CyberScience summit, 24 unique users installed the Android version of WideNoise for the the first time; 17 of these installed the App on the first day of the summit from within the UK. In comparison, the launch of the large scale case study (19th June 2012) saw the largest number of user installations in a single day (79 downloads) since the release of the application in the Market Place. The number of device and user installations since the launch of the application; during the week of the summit, and since the launch of the Heathrow campaign are detailed in Figure 3.1.

3.2.4 Results - WideNoise Application Use

Since the implementation of the EveryAware web-based infrastructure 24,021 measurements have been recorded, with 23777 of these georeferenced. This validates the succesful integration of the components of the EveryAware platform. The map in Figure 3.4 illustrates the countries in which measurements have been taken, where data is available (22, 265 records, 94% of the whole dataset). Application usage is most prevalent in Europe and China, with China hosting the most

[2]Download figures for iOS were not available at the time of writing

Figure 3.1: WideNoise application installation statistics

Data			
Location	Worldwide	Heathrow	Worldwide
From	2012-02-16	2012-06-19	2012-02-11
Until	2012-02-22	2012-08-12 (on going)	2012-08-12
Application Installation Android			
Number of unique user installations[1]	31	355	696
Number of active user installations [2]	35	444	444
Number of unique user uninstalls	3	130	228
Number of active devices installations[3]	42	467	467
Number of unique device installations	32	394	717

recordings (8,317), then the United Kingdom (4,735) and lastly France (3,396) comprising the top three. Readings have been taken in over one hundred countries to date. Figure 3.5 shows the countries in which users most frequently use tagging as an additional mode to provide subjective data. This shows the largest number of contributions come from China but tagging is rarely used and is mostly frequently used in western countries, particularly in Europe. Currently, the web interface and application are only available in English, which might influence the way in which non English speaking users interact with both WideNoise and the web interface.

Over the course of the three day CyberScience summit a total of 460 geocoded measurements were taken. Figure 3.2 summarizes statistics on the way in which people interacted with the application, the number of measurements taken and the devices that were used. The graph in Figure 3.3 shows the activity of WideNoise users a week prior, during, and the week following the Cyberscience conference. The results suggests that there was little activity prior to the Beta test, and depicts a marked increase during the week of the conference, and the weeks immediately after. There was however an increase in the measurements recorded three days prior to the Cyberscience conference. This can be attributed, in part, to project team members increasing their activity before the launch of the first public trials, which accounts for approximately forty-one per cent of the measurements taken.

After initiating the large scale case study (19th June) in communities surrounding Heathrow, a total of 285 unique devices were used to take noise recordings over a period of five weeks; 298 have been used in the area since the project inception. This resulted in 3,007 individual recordings over the period. In comparison, a total of 5,518 measurements were taken globally over the same five week period with 1,147 unique devices.

WideNoise has been designed to enable users to take sound measurements using three different sample intervals, starting from five seconds and then rising in increments of five to a maximum of 15 seconds. The default setting for a single noise sample is five seconds. During the Beta test only a minority $\pm 7\%$ opted to extend the length of sampling beyond this default, as demonstrated in Figure 3.6. Early results from the larger case study in Heathrow suggest that users interact with the WideNoise application in a similar manner with respect to utilising the default setting. However, use of both the ten and fifteen second extensions shows a marked increase in samples from around Heathrow compared with that of both the Beta test case and worldwide application use.

WideNoise facilitates the capture of quantitative and user perception by way of four slider controls and tagging functionality. Figure 3.7 highlights they way in which the sliders were utilized during (a) the Beta test case (b) Heathrow campaign and (c) overall worldwide application use. The slider value ranges from 0 to 1 and each is set to a central default value of 0.5. This design feature does not allow for any differentiation between when a user has actively quantified a perception value and

Figure 3.2: How People Interact with WideNoise

Data			
Location	Worldwide	Heathrow	Worldwide
From	2012-02-16	2012-02-17	2011-12-08
Until	2012-02-22	2012-08-12 (on going)	2012-08-12
Measurements			
Number of measurements (with geo-coordinates)	1,013	3,159	23,777
Number of measurements with tags	58	1,067	3,272
Number of measurements with perception ratings	155	2,250	7,392
Number of measurements by Apple products	900	1,860	18,327
Number of measurements by Android products	113	1,299	5, 450
Durations:			
o 5 s	949	1,852	21,010
o 10 s	21	460	1,013
o 15 s	43	782	1,745
Devices			
	635	298	8099
Registered Users:			
Total			162
Not associated with Widenoise App			27
Unique			132
Multiple registration with one device			3
Overridden widenoise id			9
Registered Users Measurement :			
Number of measurements (with geo-coordinates)	55	1894	6,987
Number of measurements with tags	19	779 (19)	2,263 (64)
Number of measurements with perception ratings	45	1538	3,439
Number of measurements by Apple products	33	1037	2,896
Number of measurements by Android products	22	857	4,091

Figure 3.3: WideNoise use during, prior and after the Citizen Cyberscience Summit 16th-18th February, 2012

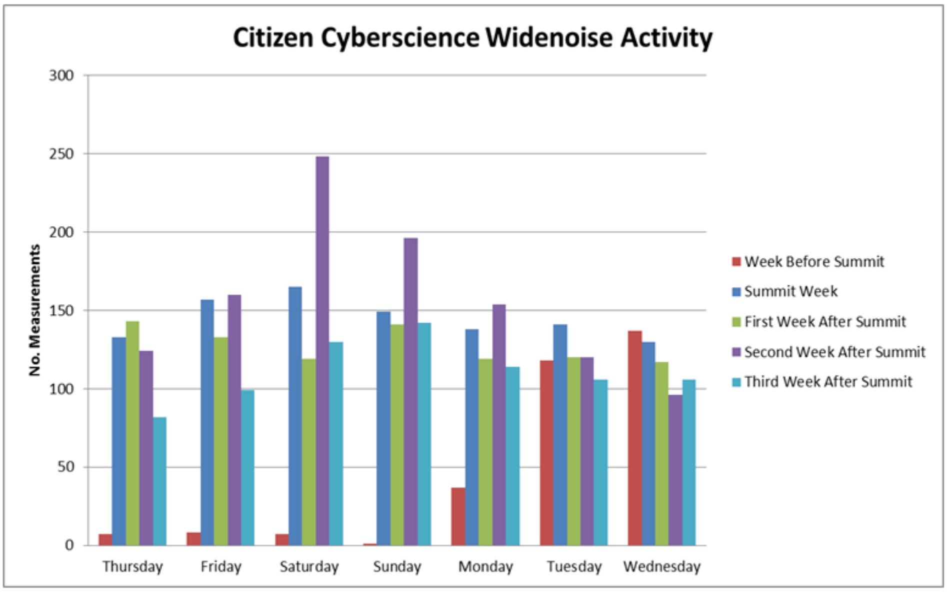


Figure 3.4: WideNoise application use (includes 94% of the total number or measurements recorded)

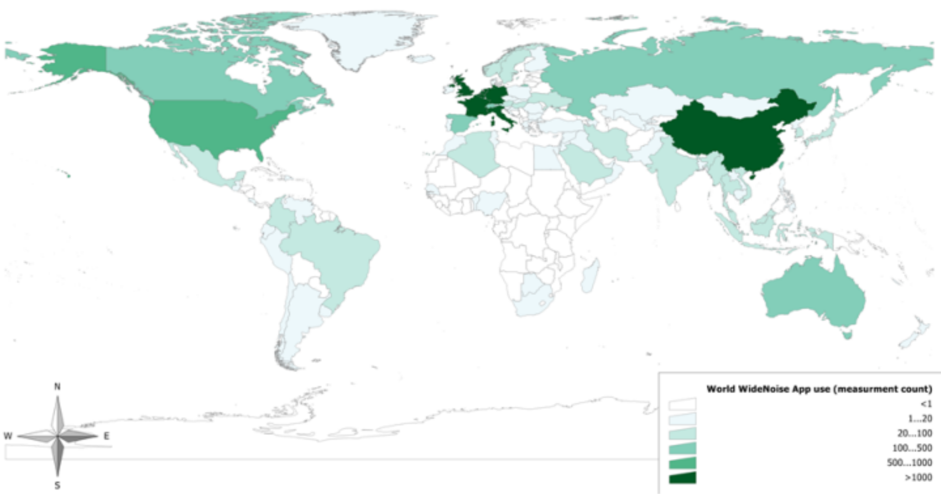
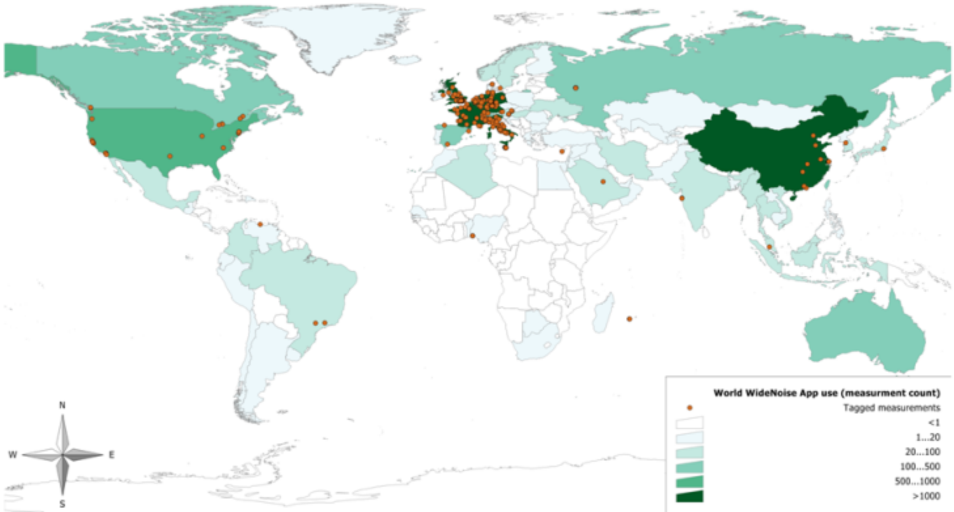


Figure 3.5: WideNoise application use point distribution of tagged noise samples



therefore no interaction is made, or, whether a user has elected not to qualify the sample taken. As such, for the purpose of these analyses slider values of 0.5 have been classified as no user interaction. Across all three datasets users have predominantly opted not to utilize slider controls. Where sliders have been used, the artificial qualifier (Nature - Man-made) is most frequently used across all datasets. The isolation qualifier (alone - social) is the least frequently used except for in the Beta test (Figure 3.8). During the Beta test, where users selected to use any of the sliders, there was much less variation on average (±203 stdev 10.3) between which qualifiers were selected. This was markedly different in measurements taken around Heathrow (±1259 stdev 569.9)

3.2.5 Results - WideNoise Web Interface Statistics

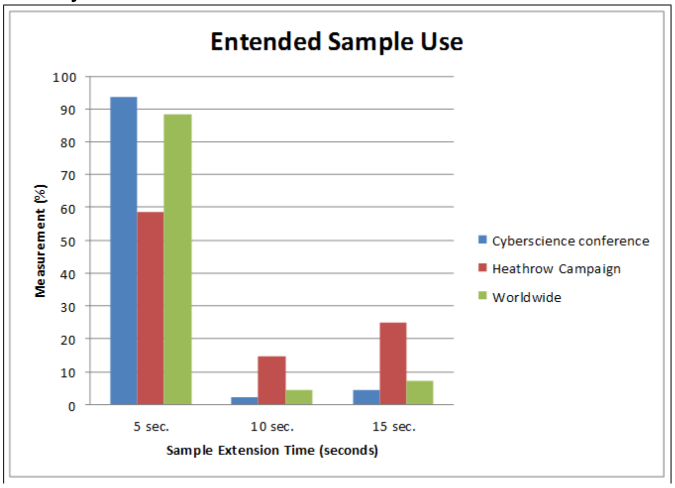
The web based interface for WideNoise is designed to provide the general public with access to noise measurements taken from the smartphone App. It also enables registered users to access their personal pages via the web as an alternative to accessing the information from their devices. Figure 3.9 provides an annual summary and monthly breakdown of website hits; site vists; page visits and bandwidth during the month of the Beta test and launch of the Heathrow campaign.

Excluding referrals from individual project partner sites, currently, people are most commonly referred to the web interface via websites linked to the Heathrow campaign (32% in July; 13.2% Jun). Of the pages accessible to the general public, via the interface navigation, the login (.../login); homepage (.../event/widenoise) about the app (...widenoise/about); and map(.../widenoise/map) comprise the most frequently viewed pages, respectively. This is followed by the registration page (.../event/widenoise/register). Details of the first pages accessed upon an individual's first visit is shown in Figure 3.10; the map and login pages are ranked the highest.The other pages listed in Figure 3.11 are not directly accessible to the public and comprise urls used to load data or communicate to the application .

Users accessing their personal pages increased from the month of April (51) with a maximum number of page entries 125 in July. This may suggest that users linked to the Heathrow case study have contributed to the increases recorded. During the Beta test phase a total of three users accessed their personal page.

Web page load times were tested using Pingdom [Pingdom Tools, 2012], which provides an easy-

Figure 3.6: WideNoise extended sampling functionality use during Cyberscience Beta test, Heathrow wider case study and full worldwide dataset



to-use site speed test that mimics the way a page is loaded in a web browser. The results are displayed in Figure 3.12. These indicate that the poorest performance within the site is associated with the process of rendering the map in various views i.e. grid view.

3.2.6 Results - Usage Patterns

Since the launch of the EveryAware platform, the majority of contributors have taken less than ten readings (see Figure 3.13). For comparison, approximately thirteen percent of users in the Heathrow area have taken over ten readings, whereas this falls to just under two percent where users' measurements are outside this area. This could suggest that in the absence of an environmental campaign, users are not motivated to maintain using the application and may do so only in an adhoc manner. Alternatively, the initial user experience may influence the frequency and regularity with which the App is used.

Figure 3.14 shows the usage pattern of those who have submitted over ten noise samples and provides a weekly average over a period of ten weeks; from the point of their first measurement in (a) Heathrow and (b) outside of Heathrow. Activity on the first day of use shows a marked difference, on average, between users taking readings around Heathrow compared with elsewhere. The decline in usage is more pronounced and rapid outside the Heathrow campaign area.

3.2.7 Results - Beta Test WideNoise Usability Feedback

To optimize the EveryAware platform beyond the initial Beta test, feedback was sought from engaged participants. We opted to allow feedback to be sent in an unstructured format and chose not to prescribe how and what should be reported. Four participants from the Cyberscience summit provided feedback on their views, which are detailed below, with an emphasis added to critical points:

> "**Participant 1**: I'm using Android on a HTC Desire and I have some background in HCI from my EngD studies. First of all I should say that when I first went to the bit.ly link you gave me, I clicked on the option to download rather than the market place. I made the wrong choice here as for some reason my Google password wasn't recognized, but anyway this wasn't too much of a problem. I just went back to the link and clicked Market Place instead, and from there the download process was easy

Figure 3.7: Use of WideNoise *perception* slider functionality across the scale of each subjective value during Cyberscience Beta test, Heathrow wider case study and full worldwide dataset.

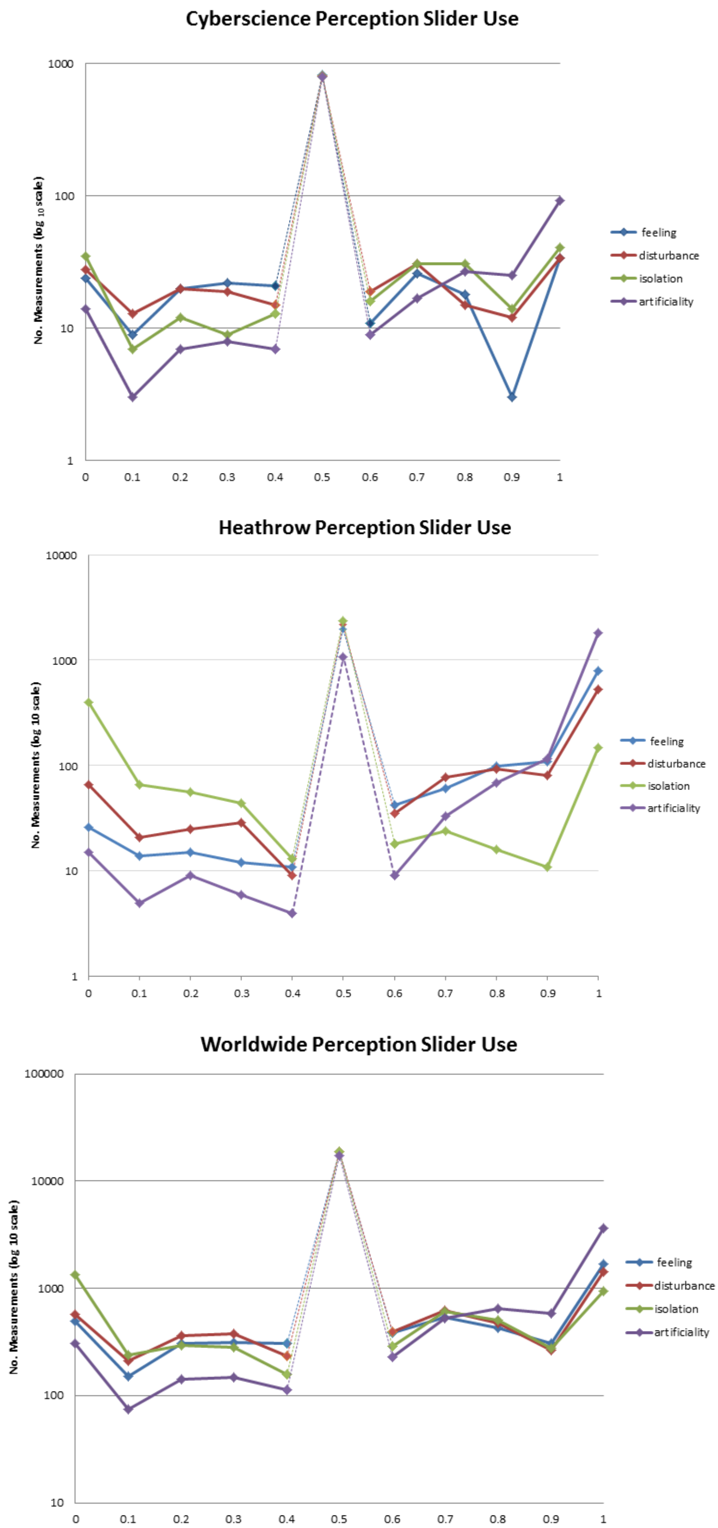


Figure 3.8: WideNoise qualitative slider use during Cyberscience Beta test, Heathrow wider case study and full worldwide dataset

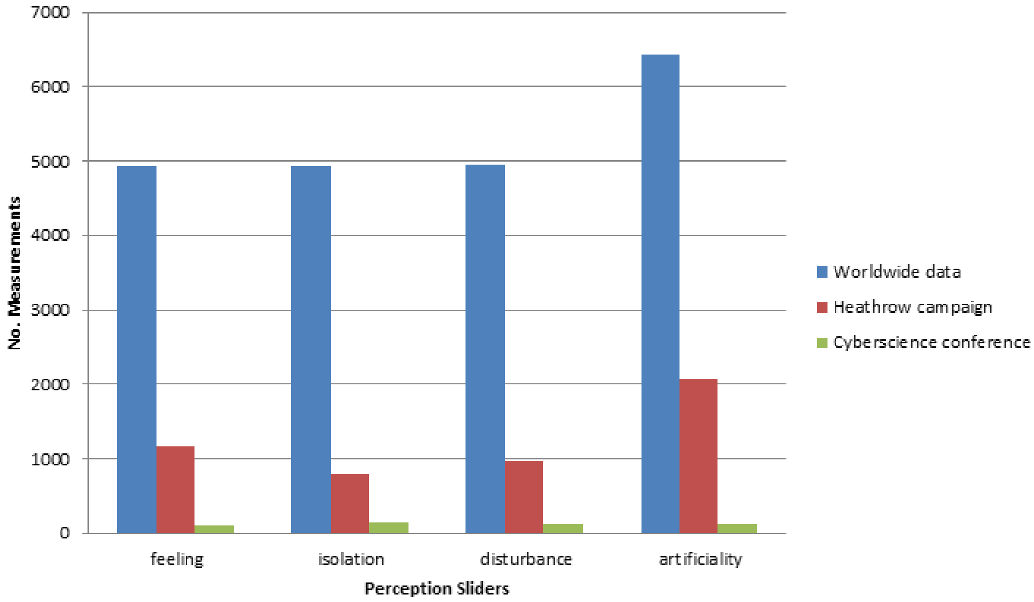


Figure 3.9: Monthly Web Interface Statistics

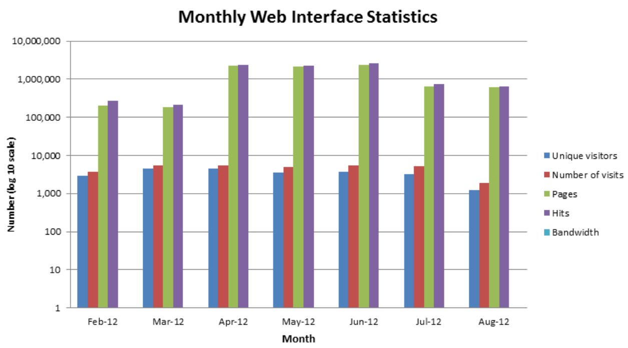


Figure 3.10: Annual summary of the top fifteen pages viewed and accessed

Entry				
Total: 53 different pages-url	Viewed	Average size	Entry	Exit
/api/WideNoise/measurements	35,189	264 Bytes	10,267	8,771
/api/WideNoise/noise	332,492	2.45 KB	9,606	10,146
/event/widenoise/map	9,628	11.48 KB	4,195	3,302
/login	278,957	3.77 KB	1,924	2,048
/event/widenoise	4,214	9.23 KB	1,672	649
/api/WideNoise/measurements/	8,725	286 Bytes	1,511	1,271
/api/WideNoise/noise/	20,482	3.11 KB	677	830
/event/widenoise/latestData	7,045,125	7.70 KB	534	1,389
/event/widenoise/register	2,234	4.12 KB	478	740
/event/widenoise/personal/entry	1,246	4.17 KB	445	579
/event/widenoise/kml	259,217	543.06 KB	200	1,256
/event/widenoise/coverage	1,011	6.79 KB	186	132
/event/widenoise/tags	33,749	4.13 KB	98	60
/	13,327	719 Bytes	66	52
/event/widenoise/about	13,632	18.71 KB	57	124

Figure 3.11: Number of page visits and duration spent on page

Visits duration

Number of visits: 32,322 - Average: 269 s	Number of visits	Percent
0s-30s	19,801	61.2 %
30s-2mn	5,459	16.8 %
2mn-5mn	2,772	8.5 %
5mn-15mn	1,782	5.5 %
15mn-30mn	811	2.5 %
30mn-1h	804	2.4 %
1h+	854	2.6 %
Unknown	39	0.1 %

Figure 3.12: Results from [Pingdom Tools, 2012] load time test ordered to included the 12 slowest response times

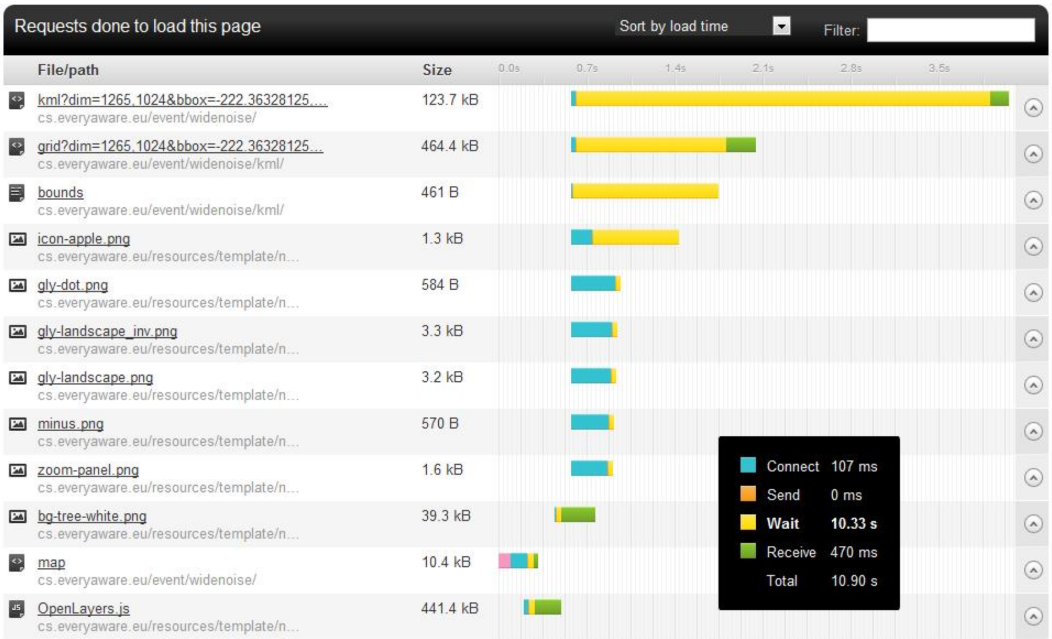
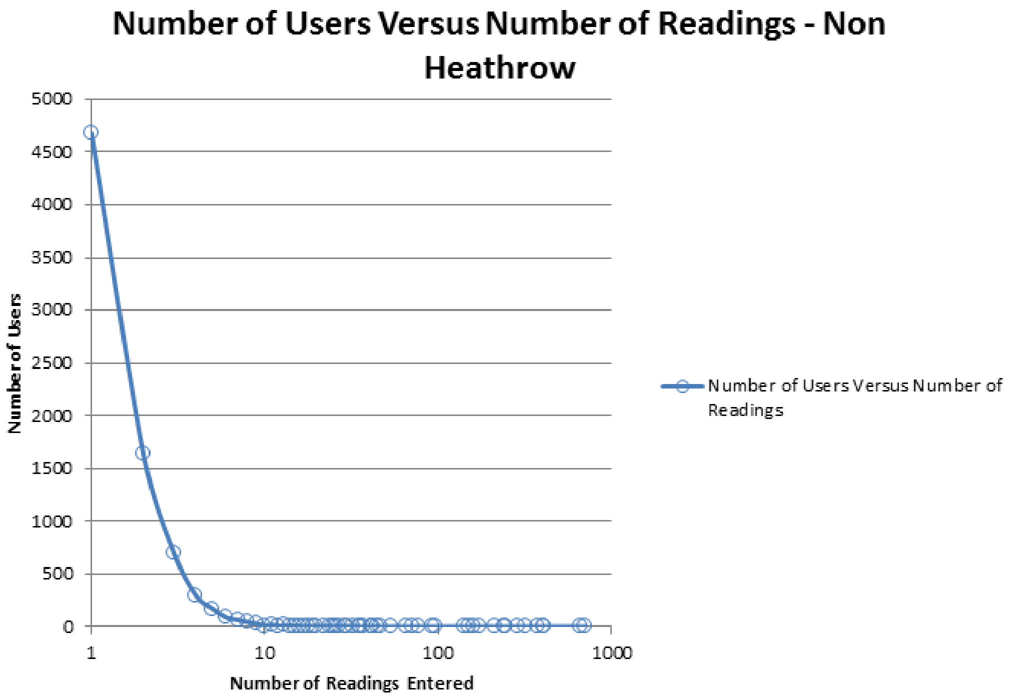


Figure 3.13: WideNoise user contributions in (a) areas outside Heathrow (b) Heathrow



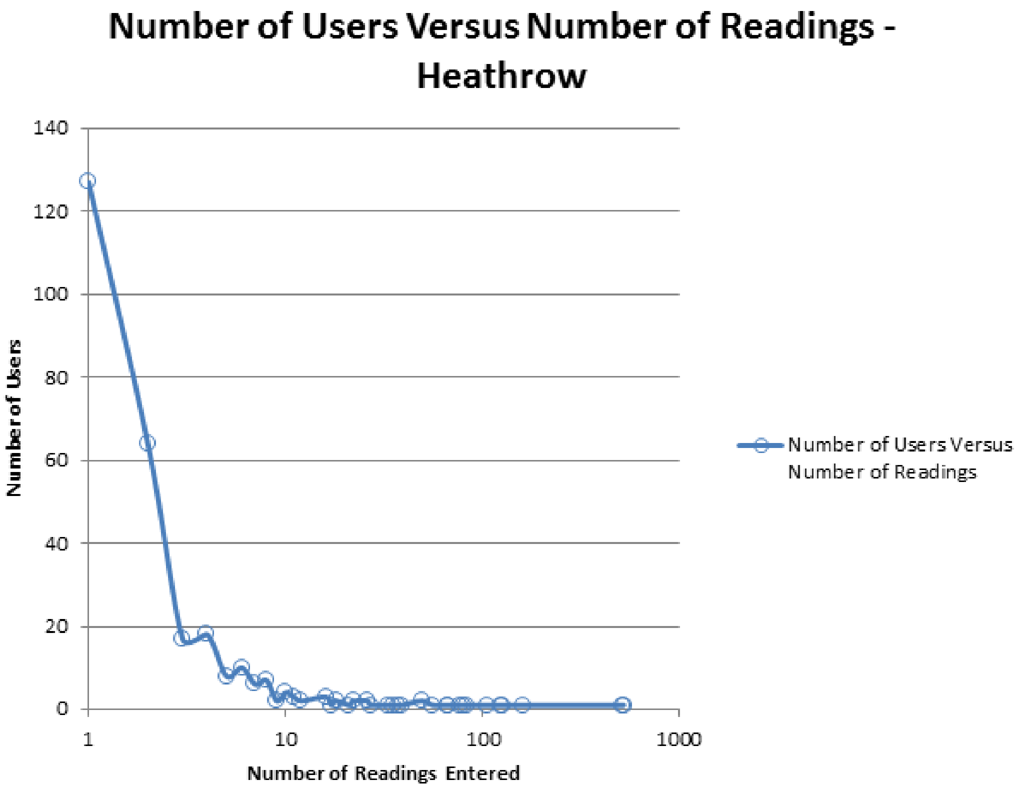
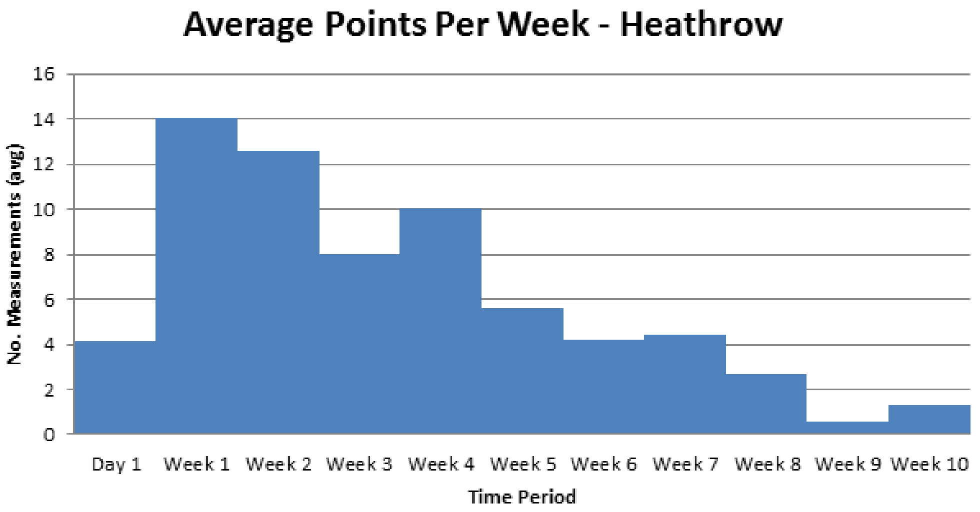
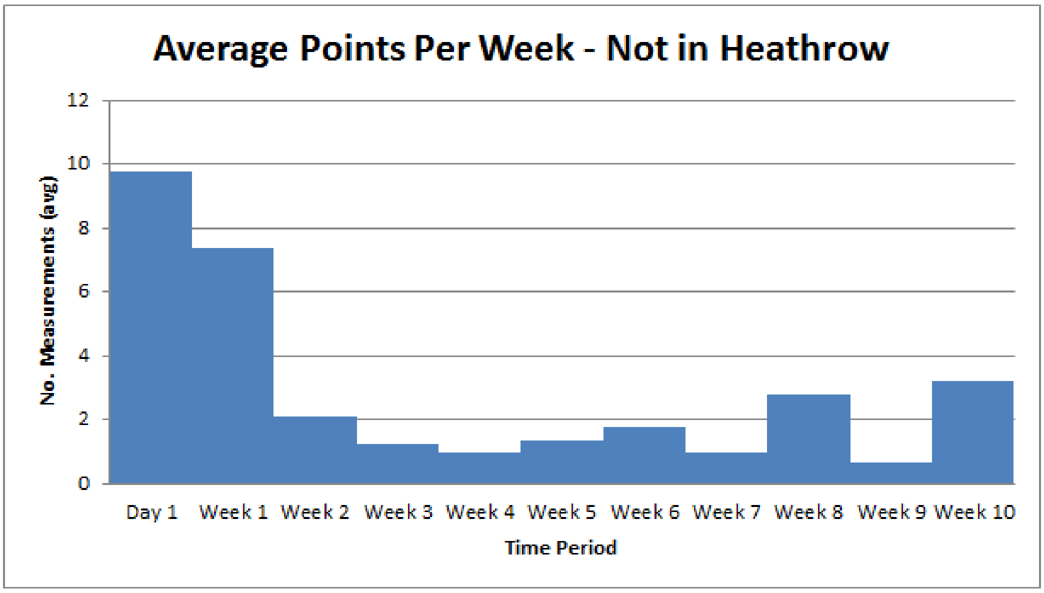


Figure 3.14: Number of user measurements taken, averaged and aggregated by week from point of first measurement in (a) Heathrow (b) outside Heathrow.





except for one stage. When I clicked download I was directed to what I now believe just to be a static figures/ucl/image of the Wide Noise application. This confused me though because there was nothing on this screen to indicate that the application was downloading and, until the "Application has downloaded" alert appeared at the top of my screen, I thought my screen had actually frozen so pressed the Home button on my phone to check!

From there i**t was easy to find Wide Noise in my applications. The first step of taking a sample was relatively simple** – it was very clear from the coloring on the screen etc. that "TAKE NOISE SAMPLE" was a button, and the number 1 next to it gave me confidence that this was the first stage of the process for taking a sample. (This was confirmed by the progress bar at the bottom, very useful.) Where the application falls down most I think is the second stage. **The text "Slide and guess noise level" is not next to the slider bar as you would expect. The "EXTEND SAMPLING" button also did not mean much to me at first glance.** This was the first thing I looked at on the screen because the text is so much larger and more prominent than the "Slide and guess noise level" instruction. This was to the extent that **I didn't realize I had to guess the noise level until my fourth sample** – and I am probably not alone in this.

The first step had led me to believe that the whole process would be guided by the Wizard so, because it wasn't obvious to me what I had to do here, I was looking for a button with a number to take me to the next step, only "EXTEND SAMPLING", which as I said didn't mean anything to me. **The other thing I would say about guessing the noise level is that unless you press "EXTEND SAMPLING" you really do not get very long to take your guess, and the slider bar is very small for large fingers, which makes this quite a stressful** (? maybe too strong a word but I'll use it anyway!) step for the user. From there, I wasn't quite sure what I would get by clicking "QUALIFY NOISE" but I was happy that this is what I needed to do to get to the next stage because of the number next to it. (And nice to have the restart option – good for users to be able to undo actions.)

On the next step, **unbelievably it has taken me a number of trials at taking samples (up to ten perhaps) to realize that I had to do anything! The writing is very, very small on my screen, especially the actual instruction to rate your perception of the noise sample you just took** (which I would guess is one of the main aims of the project, to take these measures?). I would need a magnifying glass to see that first time! I was much happier with the sliders on this step (although again I reiterate that the labels must be increased in size) because the accuracy is not so important – they are subjective measures. I'm actually interested to know why these particular measures are being taken although that information may or may not bias my response!

I do like the overall look of the application (the icons for example are nice because the decibel measure doesn't mean much to me, I couldn't tell you for example how many decibels a plane flying overhead would be– maybe the icons could be bigger?) though and I am pretty sure I will be using it in the coming weeks. Having grown up in the countryside I am acutely aware of how noisy London can be and it's fun to be able to measure it in an objective way. And it's very convenient to have it on my phone."

“**Participant 2**: "’Everything worked although **I was not quite sure what I was doing or where the measurements were going**! I guess in the normal way I would have come to the app from the EveryAware site and been a more conscious volunteer (and not sleepily on the train post dinner). But maybe it would be useful to have more ’about’ in the app itself, and/or a back-link to the mother ship info?

I’m using the Apple version. The other thing I have not figured out is "guess the noise with the slider below". What is it that slides? Why should I GUESS the noise? I KNOW what the noise is!”

“**Participant 3**: "’It may be just me but I do not seem to be able to get the Android version to let go of the GPS without removing the ’phone battery.”

“**Participant 4**: "’As I told you I like your application a lot, very well designed, good UX, etc. The only missed point for me (hey, I’m an open source geek ;)) is the license, but if you are working on it, that’s awesome. I have just one comment and I’m still sending you data samples (check Taipei for example). **My suggestion or idea is that from my point of view you should also consider to record samples even when there is no connection at all**. Obviously this will have an impact in the GPS location, but probably you can tag them to distinguish between the ones with coordinates and the ones without coordinates. When the user has a connection it can upload the samples and your application can ask the user to place them in the map. This could be interesting as you could have two layers in your map: one with the GPS coordinates: open spaces like parks, buildings, etc. and another one with places like the tube (a lot of noise usually, in Spain in some stations there is also connection but in others there is nothing), garages, bars, parking lots of mall centers, etc :) I mean, it could be even kind of fun for some people recording samples in the most inaccessible places. I’m suggesting this just as an outsider, so maybe it is not worthy even to take it seriously.”

3.2.8 Results - Heathrow WideNoise Usability Feedback

The Heathrow campaign marked the launch of the first large scale case study and further details on this are reported in [UCL, 2012]. Initial observations of participants from the Heathrow case study indicate that the general technical understanding of the device is low. Some attendees had their own Smart Phones, but in a number of cases these were newly acquired and had never been used to access the internet or download mobile applications. Further anecdotal evidence suggests a large number of participants either had difficulty registering their devices or opted to complete the process at a later point. Several reasons were cited, which included the size of the keys which caused problems with data entry requirements; lack of access to email accounts to complete the necessary registrations steps; confusion with the information requested during registration and difficulties in identifying the characters displayed by CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart), which ultimately required further data input steps. One participant, after over thirteen failed attempts, expressed the fact that her motivation for taking measurements was to contribute to the *‘collective’* data gathered and felt that being able to access her own recordings and data was of less importance, and as such thought that registration was not particularly necessary.

During the launch event an open discussion followed the trial of the application which we conducted on the roadside, outside the building. The discussion revealed that there was some degree of confusion as to how tags were associated with recordings that had already been submitted.

Participants believed the data collection process was completed and could not understand why this was decoupled from the use and input of tags. The submission of recordings then subsequent tagging and resubmission led participants to believe the two forms of data were not associated with one another.

An interim project meeting was held to assess how people were progressing with noise monitoring in the community and use of the application. A total of eight participants attended and their feedback when asked about their use of the device is summarized below:

1. Problems with phones locking
2. Problems with phone not being able to work out location
3. Difficulty with reading and navigating small screen. Also, getting used to touch screen difficult for those who have borrowed phones - “WideNoise is a particularly fiddly app”.
4. Slider options meaningless (alone-social etc) and annoying
5. Extending sample option doesn’t extend long enough
6. Wind a big problem which throws off the accuracy of the data collected
7. Tags more useful. They were used to describe the source of the sound.
8. The dB volume is the most important part of the technology for everyone - people didn’t bother sending recordings that were really low on a occasion.
9. Being able to make measurements indoors would be useful as this is where most amount of time is spent being exposed to plane noise.
10. Gardens are the easiest place to take recordings outdoors
11. Some recordings taken out and about on usual day to day activities
12. People really interested in having some technology that will measure more consistently
13. General feeling in the room that the app was more accurate than they had anticipated
14. If app could record actual noise itself to show what it sounds like that could be useful. Screaming of engines etc. as opposed to sleeping cat, car etc. categories

3.3 Performance of the EveryAware Platform - Usability and Integration

Work carried out as part of this Work Package has highlighted a number of usability issues which are in the process of being addressed by the EveryAware team. As discussed in Chapter 1, it is important to realize that in the case of WideNoise, incremental changes are required so as not to disrupt the work of existing users. This is of greater relevance as the EveryAware project progresses, and more users become familiar with the app and the website. A number of issues to be resolved are summarized here.

3.3.1 WideNoise Smartphone Application

Thus far, user registration has been particularly low and was cited as a problem by a number of users. Steps have been taken to address some of these issues, such as restricting the ability to overwrite the unique identifier field during the registration process. However, there are further steps that can be explored to enhance the usability aspects of the registration process. Altering the CAPTCHA technique, for example, to a system that employs the use of images, as opposed to distorted characters, is one way in which the process could be more suited to use on mobile devices. CAPTCHA is a human response test used in computing to verify that a response is generated by a person in order to block spam. However, the small screen size and keypads of most mobile and tablet devices pose problems with both the recognition of obscured characters and type-in operations. Alternative CAPTCHA techniques that do not require text input are available, such as Picatcha and Google; there are also audio CAPTCHAs available. A study by [Bigham and Cavender, 2009] demonstrated that some audio CAPTCHAs have been found to be more difficult compared with visual CAPTCHAs. In their study they developed a new interface that can be added to existing audio CAPTCHAS and found that participant success rate increased by 59%. [Okada and Matsuyama, 2012] propose an alternative technique that uses multiple noise figures/ucl/images, which when overlapped and positioned correctly, reveal hidden characters. The user can then verify without the need for text input. Future work should potentially explore alternative verification modes and should also consider the motivations that might increase user registration rates.

The Beta test and large scale case study have demonstrated that text input is clearly linked to issues other than just registration. This is a usability issue that arose with both sets of participants particularly in relation to contributing subjective data with noise readings. Keypad design factors have been shown to have a strong correlation with either positive or negative user perceptions [Balakrishnan and Yeow, 2008]. They measured thumb lengths and circumferences in their study and found that participants with a larger thumb circumference tended to be more dissatisfied with the key size and space between keys. This can be exacerbated where users are simultaneously executing other activities, such as walking or talking whilst entering text via a keypad. The emergence of multimodal devices that combine voice and touch as input mechanisms could potentially enable users to enter data more easily and thus reduce some of the frustration experienced by participants in the study thus far. However, the practicality of implementing this type of technology within the EveryAware budget may not be plausible. In addition, there are still a number of error rates identified with unconstrained speech input systems and language barriers poses additional constraints in the context of EveryAware.

The use of sliders was designed as an additional mechanisms with which to collect subjective data. However, several questions were raised as to their meaning and relevance. For example, one participant asked what the alone-social axis meant, and whether completion of that section every time matters. The selection of appropriate terms and their perceived relevance is something that may vary depending on the context in which the samples are being taken. Firstly, noise is generally associated with unwanted sound and as such is specific to a person at a particular point in time and place. Secondly, noise is difficult to describe, largely because the sounds that annoy people are subjective. In the case of the Heathrow campaign, where plane related noise is clearly the target for noise sampling, the options provided may not have always seemed relevant. In other instances, however this may not be the case. With a selection of only four pairs of descriptors, limited by interface space constraints, there is every likelihood that any given selection will not meet the requirements of all users. The idea was to select a set of terms that could be used to describe (a) how the individual feels about the noise source; (b) the environment in which the sample is being taken which might contribute to the sample intensity and (c) the natural or artificiality of the sound source. One possible solution to address any uncertainty as to the meaning and purpose of both slider use and associated terms, could be to explain this information via the WideNoise web interface. Furthermore, a general user guide, accessible online, may also support and address possible end-user queries.

Although not specifically mentioned directly by users, a requirement for continual noise monitoring has also been identified to overcome a number of the issues cited above, as well as in [UCL, 2012], which notes that users tend to measure only loud sounds, and [VITO, 2012] where issues of data coverage are described.

3.3.2 WideNoise Web Interface

Participants involved in both the Beta test and Heathrow campaign provided little feedback about the WideNoise web-based interface. Those involved in the launch of the large scale case study referred only to the absence of the tag cloud on the interface, which was added in the release of v1.2 (see Appendix 3). The other point of discontent related to the clustering functionality, which they felt averaged their readings, and therefore 'diluted' them. For example, one participant asked how far away they would need to go to record and get a new 'blob' on the map. This was not only seen as an inconvenience but was seen as also pointless if they will be 'stuck with a low average'. In line with a user centred design approach, considerations were made as to the interests of these active, and future participants, and it was decided to implement a "'disable clustering function"', which was released in August 2012 (v1.5, see Appendix 3).

As the project develops the number of samples submitted to the server are increasing, both through campaign driven and anonymous contributions. Web traffic has also increased. The latest platform update introduced a new coverage algorithm that has improved the system performance by a factor of 30. However, improvements can still be made to the current map load time (see Figure 3.12), particularly with the potential growth in sample submissions. As such, steps will be required to ensure an optimal user experience is provided at all times.

The web interface statistics, including the duration of time spent on the site, the number of hits, and the most commonly accessed pages, suggest that although visitors are coming to the site, the time spent in 61% of cases is under 30 seconds. Data visualisation via the interactive map and the personal statistics page form integral components of the website. However, the inclusion of additional pages that enable users to share their stories, learn about specific campaigns, or generally interact with other EveryAware 'citizen scientists' and interested parties, may increase the length of time users spend on site. Moreover, supporting web-based social interactions within the portal, as well as enabling users to integrate related content from their existing networks, might lead to a more 'engaged' and connected community of participants and therefore promote the 'spreading' phenomena sought after by the project.

An evaluation of the performance and the usability of the Air Quality smartphone application will be based on the Beta test in Antwerp. Results will be included in this section as soon as they are available (October - November 2012).

3.4 Interim Conclusions

The objective of WP3 in this preliminary phase was to undertake an end-to-end prototyping exercise to allow the developed technology to be tested in the field before being rolled out to the wider community. In addition, the prototyping exercise was aimed at refining the recruitment and participation processes reported on in [UCL, 2012]. Completion of the initial Beta tests have allowed us to explore the functionality and integration of the platform, the usability of both the web and smartphone applications, and to test the integration of platform and sensors. In addition, the process has supported data collection to explore modelling objectives set out in EveryAware.

The first Beta tests have thus amply demonstrated that the EveryAware platform was fully functional and could operate in a live environment. Although some usability issues were highlighted in reference to the efficacy of WideNoise, and the way in which data is visualized, the system performance was such that the first large scale case study was launched in anticipation of the planned date, and extensive preliminary explorations of the data were undertaken. In testing the end-to-end process, measurements and annotations were successfully recorded using the app, and these were submitted to the server, stored and processed. End users were able to view personalized measurement statistics, and were also able to access the global dataset via the interactive map.

Chapter 4

Appendices

4.1 Appendix 1 - WideNoise iOS Description

WideNoise is an application that can measure the level of noise using the microphone of the smartphone. The user interaction is based on a wizard that helps the user to report the reading through a set of well defined steps. Once started the application presents a splash screen (Fig. 4.1 left) that will be closed after few seconds.

The application implements a store'n'forward paradigm when sending its reports to the server. It is necessary to avoid loss of user reports when there is not a working connection with the server. For this reason, before the wizard is started, the application checks if there are one or more reports to be sent to the server. If there is at least one report pending and if there is a working connection to the server, the application will ask the user to send this information (Fig. 4.1 middle). After the splash screen (and eventually after the pending reports are sent) the application displays the welcome page of the wizard, asking the user to proceed with the first step: “take a noise sample” (Fig. 4.1 right).

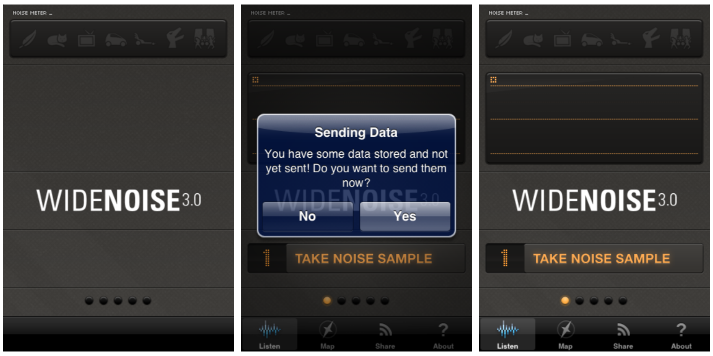


Figure 4.1: WideNoise: startup interface

When the user proceeds with the first step the application starts sampling the noise. During this phase the user may try to guess the noise level using the slide. She can also extend the sampling just to have more time to guess (Fig. 4.2 left and middle). After the sampling the application shows the noise level and allows the user to repeat the sampling or to move to the next step: “noise qualification” (Fig. 4.2 right).

To qualify the noise, users are asked to slide four bars left to right, each slider refers to a subjective parameter (Fig. 4.3).

After the noise qualification, the application will send data to the server and present the last page of the wizard. From here the user can choose to take a new sample, share or tag the report (Fig. 4.3 left and middle). If the report cannot be sent, the application will ask the user if she want to send it later (Fig. 4.3 right).

Alongside the wizard, WideNoise provides a toolbar from which it is possible to access other panels (Fig. 4.5):

- a map showing the readings of other users;
- a settings page from which it is possible to login on Twitter and Facebook;
- an about dialog showing information on the WideNoise application and Everyaware project.

4.2 Appendix 2- User Centred Design of the Air Quality App

4.2.1 About this document

Note that the requirements here relate mostly to the App rather than to the website. It can be assumed that any 'reporting' or 'annotation' functionality should appear on both. However, further consideration may be required as to additional website-only functionality if any is required. Note also the slightly different focus of the two groups has resulted in two approaches to requirements description. Rather than delay the circulation of this document further, we have chosen to circulate the notes as they were captured on the day.

4.2.2 User Types

The following potential 'personas' were identified during the discussions relating to the required software.

1. Cyclists
2. Community groups with an interest in air quality
3. People working in the same location
4. A group of mums that take their children to school along the same route every day
5. Users measuring air quality during specific events e.g. a situation where a road is closed for a marathon

A number of these are elaborated here (time did not permit full elaboration of all the personas)

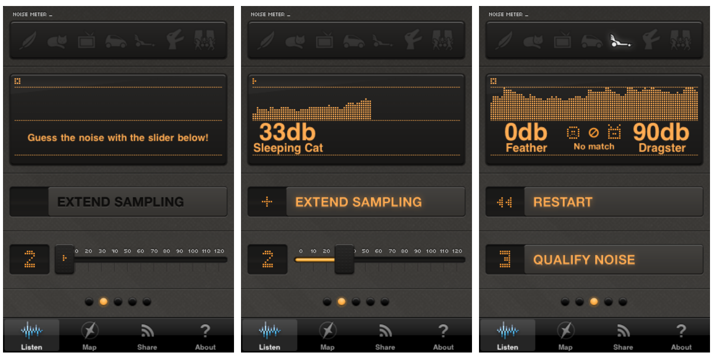


Figure 4.2: WideNoise: noise sampling and guess stage

4.2.3 Cyclists

The aim is to create a minimalist application that allows cyclists an easy unobtrusive way to

1. Check the current air quality
2. Mark points of interests along the journey as limited text entry or photograph
3. Record a trip for later further analysis via a web application

The whole point of the application is to make it quick and unobtrusive to use while travelling. It would be useful if the application could allow the cyclist to use the map for navigation purposes – look at GPS navigation metaphors. The notion is that the web application is where all the sophisticated analysis and review of the data takes place.

In general the App and website should use the track metaphor which is like the GPS metaphor. So a track is the journey one person took which is created when a person turns the device on and ends when the device is switched off. Along the way the user can add markers (waypoints) which are textual or photographic and which can be further annotation via the web-interface

A cyclist has the mobile phone attached to the handlebar of their bike and when they go past the busy crossing that they are concerned about, they can see the track coloured by the current pollution level. They can quickly tap the screen of the mobile to add a marker. When they come back to look at their trips on the web application, they login and they can see all their trips as well as any markers they have entered. They can then go back to a particular marker and enter additional text or further subjective context.

On another trip the cyclist is going past an incinerator and takes the phone out of the handlebar mount and take a photograph of the incinerator from within the app which becomes a marker and which is then part of their track.

At the end of the week the cyclist can login to the website and review all their trips. See how long they were, how far they cycled, see the track displayed on the map. See all the markers/photos they created along the track and add further textual annotations. In addition each route is coloured with the pollution level at that location as well as an indication of overall pollution exposure for the whole trip. The web interface should allow them to go backwards and forwards to view different tracks and compare them in terms of pollution exposure.

4.2.4 Group of Mums

This group represents mums (or dads) who have one or more young children of school age and undertake a repeated journey every day to walk their child/children to or from school. Each day, an

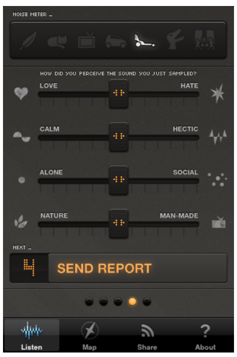


Figure 4.3: WideNoise: noise qualification

identical route is taken to the school and from the school. The mums/dads may be accompanied by one or more children of school age, but also by one or more children younger than school age, who may be in a buggy.

Once at the gates to the school, they meet other mums (friends of theirs). They may go for coffee with their friends after they have dropped the children off. The mums/dads may be working or may be housewives/househusbands.

Depending on the location selected, the mums/dads may be very familiar with technology such as iphones or ipads, or may not be so familiar or have access to these devices.

limitations - they are carrying bags, buggies, shopping. plus point - all in same geographical location at similar points in time at thes chool gates. and 3-3.30 every day. could be working or housewives.

Advantage of targeting this group:

1. As parents of young children they may have an interest in air quality as their children are exposed to any pollution every day. This group allows us to tap into a more general discussion relating to air quality around schools, particularly those in inner city environments.
2. They congregate at the same location twice a day, giving the opportunity to collect a denser set of readings in an aggregated area, around the same times of day (morning and evening)
3. As the journey to and from school is repeated 5 days a week, it should also be possible to examine the data over time.
4. The links to the school may provide a useful mechanism to recruit parents.

Limitations

1. They are carrying bags, shopping, buggies
2. They are responsible for young children which will be their primary focus – therefore the task must be made as easy as possible to integrate into their daily activity
3. They are under time pressure both in the mornings and afternoons to get their children to school on time or pick them up

Their Interests

1. They will be interested in seeing real time data as they are walking to school – what is the level of exposure at this time. This must be presented in a format that can easily be understood by someone just glancing at the data as they are walking with their children.

Figure 4.4: WideNoise: sending report and tagging

2. They will be interested in what are the differences in the levels that the adults and the children are exposed to (given their different heights) – for example, a child in a buggy is closer to the ground but also pushed out in front of the parent and therefore closer to cars, especially when crossing the road. So the option should be provided to mount the device on different objects (buggies, back packs etc) to allow this type of comparison.

3. Interested in comparing their exposure along different routes to identify the best route to take.

4. The will be interested in talking to their friends at the school gate and comparing readings – this could be done through a 'sharing' system to allow people to share readings e.g. via facebook, and to comment on each other's readings.

5. As they go for coffee/once they reach work, they may wish to tag/annotate their previous readings from that morning (on the device)

The data

1. This user group may not be concerned with actual values or PPM readings, but may be OK with high, low and medium as long as these are comparable with other readings from the same area

2. The user group will also be interested in an aggregated map for the area

3. The user group need real time data to view as they are walking

Technical Issues

1. The user will want to be hands free most of the time as they have children, shopping etc.

2. The user should just be able to pick up the device and phone as they leave the house, switch them on and the forget about them (unless prompted with a push request for information)

Subjective Data

1. This should be collected following a push request, whose frequency can be configured by the user

   (a) When the user is in a fixed location for a period of more than 5 minutes (e.g. a coffee shop)

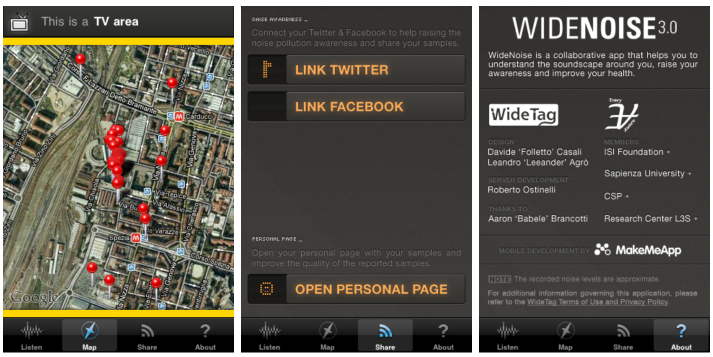


Figure 4.5: WideNoise: other application panels

   (b) At certain times of day
   (c) When certain events occur (e.g. readings over value X, readings under value Y)
   (d) A maximum number of pushes per day can be set
   (e) Specific geographical locations for push alerts can be set by the user
   (f) A more general geographic location (bounding box) in which alerts should be generated

2. The phone should vibrate to tell them that a push request has occurred.
3. They may not respond immediately to the push request, but could respond later when they have time/their hands are free.
4. They should be able to cancel the individual push request
5. They should have the option to annotate something other than the data that triggered the push – i.e. to work backwards through the data (using a timeline function) and annotate data at earlier points in time. This should be available on the device and on a PC.
6. The push request should include 6 buttons/icons that the user can chose from whilst they are on the move, plus the OPTION to annotate using text/typing if their hands are free.

Interface

1. The user should be shown a map of their data when they start the App. This will show their current location but will also allow them to move back in time and/or click on their data and add annotations (using the same mix of button/text as described previously)
2. Some sort of generalization algorithm should be identified so that the system does not have to display 20,000 points of data. Perhaps the system should only display a data point for every 5 minutes of information?

4.2.5 Joggers

It was agreed that this would not be a practical use case for the sensor boxes, as the equipment will be too unwieldy for someone to carry.

4.2.6 Building Sites

People looking at specific air quality issues to see if they vary due to the presence of construction. This would involve the sensor box being in one or a few locations for a long stretch of time.

4.2.7 Commuters

This group represents people who make the same journey to and from a place of work every day. The journey may be made using public transport – such as buses, trains or metro (underground) systems.

Advantage of targeting this group:

1. This group of people make a similar journey every day, allowing data capture over space/time
2. As they are using public transport, they may be able to annotate data more frequently than other groups, as could will be sitting down during their journey

3. They congregate at the same location twice a day, giving the opportunity to collect a denser set of readings in an aggregated area, around the same times of day (morning and evening) – assuming that workers in the same organisation can be targeted
4. They will be able to recharge the sensor box and the mobile phone during their day at work.

Limitations

1. They may wish to work while travelling, which could limit the number of possible annotations
2. Their travel may involve underground journeys, when both phone and GPS signal could be lost.

Their Interests

1. They will be interested in seeing real time data as they are travelling to work – what is the level of exposure at this time. This will require a hands-free option to mount the sensor box.
2. They will be interested in what are the differences in the levels experienced on different routes, or on the same routes on different days. Interested in comparing their exposure along different routes to identify the best route to take.
3. They will be interested in sharing data with colleagues at the same workplace.
4. They may have the option to tag data during their lunch break or in the evening.

The data

1. This user group will be interested in specific PPM measurements, with appropriate indications of error. The user group will also be interested in an aggregated map for the area
2. The user group need real time data to view as they are travelling
3. Results should be shown with an appropriate level of error margin if the sensors are not able to produce results matching those of a high quality sensor.

Technical Issues

1. The user will want to be hands free most of the time as they may be working
2. The user should just be able to pick up the device and phone as they leave the house, switch them on and the forget about them (unless prompted with a push request for information)
3. The user may be away from a mobile signal and/or a GPS signal for large parts of their journey
    (a) The system should be able to record data and store it locally for later transmission
    (b) The system should be able to present data that is not location tagged (see below for suggestions as to how to achieve this)

Subjective Data

1. This should be collected following a push request, whose frequency can be configured by the user

(a) When the user is in a fixed location for a period of more than 5 minutes (e.g. a coffee shop)
(b) At certain times of day
(c) When certain events occur (e.g. readings over value X, readings under value Y)
(d) A maximum number of pushes per day can be set
(e) Specific geographical locations for push alerts can be set by the user
(f) A more general geographic location (bounding box) in which alerts should be generated

2. The phone should vibrate to tell them that a push request has occurred.
3. They may not respond immediately to the push request, but could respond later when they have time/their hands are free.
4. They should be able to cancel the individual push request
5. They should have the option to annotate something other than the data that triggered the push – i.e. to work backwards through the data (using a timeline function) and annotate data at earlier points in time. This should be available on the device and on a PC.
6. The push request should include 6 buttons/icons that the user can chose from whilst they are on the move, plus the OPTION to annotate using text/typing if their hands are free.

Interface

1. The user should be shown a map of their data when they start the App. This will show their current location but will also allow them to move back in time and/or click on their data and add annotations (using the same mix of button/text as described previously)
2. Where positional information is not available for data points (as the user has been underground) two options should be considered
   (a) Present the user with a different 'layer' that draws a line between their last known GPS position and then the GPS position when they emerge from the underground. The data is then attached to this line in proportion to the TIME it has taken them to traverse the route.
   (b) Present the data as a point on the map where the GPS signal disappeared / emerged. Clicking on this point will take them to a graph showing the data for the time there was no location information.
3. They should also have access to graphs and other means of presenting their data
4. The admin tool should allow them to configure push requests and also to register with the system
5. Some sort of generalization algorithm should be identified so that the system does not have to display 20,000 points of data. Perhaps the system should only display a data point for every 5 minutes of information?
6. The user should have the option to manually correct the GPS position (as part of the annotation process) – either on the device or on the PC/internet.
7. The trace on the map is coloured depending on the readings, perhaps using a scale of 5 categories.

8. The user should be able to annotate points on the data graph too – especially to handle the situation where the sensor box is in one location for a long period of time.

9. A clear explanation should be given of the categories as far as possible – even if it is 'this reading equates to standing behind a bus for 5 minutes'.

10. The App should have the following options as buttons (image clicks) at the top of the startup map

    (a) MAP will take the user to the map view, showing their current position but also allowing them to go backwards in time and/or annotate previous data

    (b) ABOUT THE APP will give the a link to the webpage for the project, and give details of the developers

    (c) SHARE will allow users to tweet results or share them to Facebook

    (d) MORE INFO will take them to contextual information about the values they are seeing, as well as links to web pages about air quality. This will also show a graph of their recent data along with an appropriate error measurement (both positional and air quality errors)

    (e) CONFIGURATION – will allow registration and also push configuration

11. The map needs to be an App NOT an HTML page as is currently the case in widenoise. I.e. the design should be App size not web browser size.

12. The calibration strategy needs to be written up in a user-friendly format. This will allow participants to understand the limitations of the sensors (perhaps this is web only?). Also need to have some general guidelines as to what the results mean – and in particular if / when they indicate levels that could be more dangerous.

4.3 Appendix 3 - Modifications to the EveryAware Platform Following User Feedback

Following feedback from internal project user testing, the Beta test phase and from discussions with participants in the Heathrow case study a number of platform alterations have been made (see Table 4.1 for details).

Further modifications have currently been frozen and change requests will be compiled and prioritized for future releases.

Table 4.1: Modifications to the EveryAware Platform

Version	Availability Date	Changes
1	13.01.2012	Official EveryAware WideNoise Release Date
1.1	27.01.2012	* Interface and usability cleanup * Extended personal data view* Improved mobile access* Map: Extended aggregated cluster information* Map: Introduced color coding for clusters
1.2	11.05.2012	* Feature (home): Continent Histogram* Feature (map): Tag cloud* Improved user experience* Map: Switch to OSM maps
1.3	15.05.2012	* Feature (map): Record tracking
1.4	10.06.2012	* Feature: Coverage page
1.4.1	24.07.2012	* Feature (map): Improved color schema interval and colors.
1.5	09.08.2012	* Feature (home): Twitter widget* Feature (map): Grid view (beta version)* Feature (map): Clustering can be disabled* Feature (map): Tag cloud in cluster summaries* Feature (coverage): Display not-registered users* Feature (profile): Personal data download* Feature (info): Added support page* Changed user names (removed @TLD from user name)* Refactoring of database structure
1.5.1	21.08.2012	* New coverage algorithm improving performance by a factor of 30* Personal data crash fix

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