Deliverable 1.2

Case Study Design and Development V1 (Birmingham)

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1. Summary

The following document provides a detailed report on the designing and implementation of the solutions for the Birmingham Case Study. The system design phase followed an implementation phase where, by means of workshops, interviews and discussions, services and tools offered by other work packages were developed. Data collected via the different data collection and generated as a result of analyses are integrated into the SETA system architecture.

2. Glossary of Terms

Annex I	*Otherwise known as the DoW*
CA	*Consortium Agreement*
DoW	*Description of Work*
GA	*Grant Agreement*
WP	*Work Package*
BS-P	*Birmingham - Personal Mobility Planning category*
BS-PM	*Birmingham-Professional Mobility Planning and Monitoring category*
BCC	*Birmingham City Council*
BCR	*Birmingham Cycle Revolution*
OD	*Origin Destination*
CO	*Citizen Observatory*
USFD	*University of Sheffield*
RSSI	*Received Signal Strength Indicator*
GPS	*Global Positioning System*
MAC	*Media Access Control*

3. Birmingham Case Study

Birmingham is the largest and most populated city in the UK outside London, with a population in 2015 of 1,111,307 (based on the 2015 mid-year population estimate 1). Birmingham is a youthful city, with more people in the younger age groups compared to the England average, in part due to students coming to study at the City's Universities. 45.7% of Birmingham residents are estimated to be under 30, compared with estimates of 39.4% for England. In contrast 13.1% of Birmingham residents are over 65, compared with 17.6% nationally.

Birmingham is also growing at a very high rate: Since 2004 the population has increased by almost 100,000 (9.9%), with an average of 0.9% per year. The publication of the Office of National Statistics revised population projections show that Birmingham's population will grow by up to 150,000 between 2011 and 2031. The population increase over the last decade is associated with more births, fewer deaths and international migration. Linked to this is the high diversity found in Birmingham, where according to the 2011 Census around 42% of residents were from an ethnic group other than White; 46.1% of Birmingham residents said that they were Christian, 21.8% Muslim with 19.3% having no religion. Compared with 14% in England, 22% of Birmingham residents were born outside of the UK and 11% in the West Midlands region.
Birmingham is one of the most deprived Local Authorities in England, with high variation between districts.

In such a growing city, transport is crucial as a means by which people engage in economic, social and recreational activities. It underpins the business life of the city. Transport connects the many separate strands of the life in the city - where people live, work, shop and take their leisure; where businesses of all sorts operate, obtain goods, services and the labour they need for successful and profitable operation.

The process of development in SETA is an iterative one, with a user-centered approach being employed in the Birmingham case study, as presented in Table 1.

	Requirements Analysis	**Design and Development**	**Deployment**	**Evaluation**
Phase 1	M1-M6	M6-M15	M15-M16	M16-M18
Phase 2	M19-20	M20-M33	M33-M34	M34-M36

Table 1

The first six months of the project was covered by conducting requirements analysis. The next 9 months involved designing and developing technologies. At the time of writing this report, the design and development stage is currently concluding, with the deployment and evaluation period to be followed. The next month will be spent mostly on deploying the technologies and making them available for use. Finally, the evaluation period will involve conducting user studies, releasing the tools and technologies in a variety of mechanisms as will be detailed in this report. The Phase 2 of development will follow a similar process, as presented in the table.

3.1. Summary of requirements

Several requirements were collected from questionnaires provided to decision makers and citizens. The focus groups organised with decision makers also highlighted requirements for the Birmingham Case study (BS). These can be grouped into two categories:

1. Personal Mobility (P)
2. Decision Maker's platform (PM)

These two primary categories formed the bases for the development of technology specific to the Birmingham area. The technologies were realised into a mobile application and a web-based decision maker's platform. The two-phased development process employed in the project enabled separating functionality into two parts, where the Phase would provide the foundation for the development in Phase 2.

The personal mobility planning requirements are summarised in Table 2:

Id	Cat	Type	Data	Description
BS-P1	P	Personal Mobility Planning	Models Traffic Demand Data and Traffic Data Observations Bicycles and Pedestrians, Contextual Data	Multimodal journey planner that works by specifying Origin Destination and provide results based on contextual data/user needs (i.e. targeted for disabilities, environment consciousness etc.).
BS-P2	P	Multimodal Parking Planning	Parking data	Provide means to plan in advance multimodal parking by having real-time occupancy information
BS-P3	P	Events Planning	Public Transport Parking Bicycles and Pedestrians Contextual Data	Awareness of planned/unplanned disruptions/big events and how they can impact personal mobility.
BS-P4	P	Predictive Planning	Models Parking Traffic Demand Data and Traffic Data Observations Bicycles and Pedestrians Contextual Data	Predictive engine that can notify a user of the probability of a specific outcome for a journey (i.e.,. journey time) using contextual data.

Table 2

These requirements are further described in more details in D1.1, to provide more context

around the various aspects of BS-P1 to BS-P4.
The professional mobility planning requirements are summarised in Table 3:

Id	Cat	Type	Data	Description
BS-PM1	PM	Real-time mobility dashboard	Models Traffic Demand Data and Traffic Data Observations Bicycles and Pedestrians Contextual Data	Dashboard for decision-makers to see real-time information about traffic, number of people moving/on the streets and public transport occupancy and status. Ability to use the dashboard to send contextual and personalized information to citizens about their journeys.
BS-PM2	PM	Real-time Parking Monitoring and Planning	Parking	Dashboard for decision-makers to see real-time information about parking. Ability to use the dashboard to send contextual and personalized information to citizens about their parking.
BS-PM3	PM	Real-time Events Monitoring and Planning	Public Transport Traffic Demand Data and Traffic Data Observations Parking Bicycles and Pedestrians Contextual Data	Dashboard for decision-makers to see information about disruptions/big events and how they can impact mobility. Ability to use the dashboard to send contextual and personalized information to citizens about transport/route alternatives.
BS-PM4	PM	Real-time incident detection	Traffic Control Plan Traffic Demand Data and Traffic Data Observations Public Transport Bicycles and Pedestrians	Real time traffic incident detection and planning in case of emergency (accident...)
BS-PM5	PM	Planning	Public Transport Parking ITS Bicycles and Pedestrians Generic Contextual Data	Dashboard for decision-makers to use historic and current data to optimise mobility in the city.
BS-PM6	PM	Real-time environmental Monitoring and Planning	Public Transport Traffic Demand Data and Traffic Data Observations Bicycles and Pedestrians Generic Contextual Data	Dashboard for decision-makers to use historic and current data about people movements and environmental conditions (e.g. pollutions) to inform citizens about environmental status and

				to inform planning.

Table 3

The requirements are presented in more details in D1.1 to provide more context for the various aspects of professional mobility (BS-PM1 to BS-PM6).

3.2. Use Case Technologies

Requirements are then translated to features which are developed for Phase 1. The remaining features will be developed in Phase 2. During the evaluation stage, three primary technologies will be evaluated, categorised into Non-motorised mobility tracking, Citizen Observatories, and Motorised mobility tracking. The non-motorised mobility tracking will include the deployment of a SETA mobility app to the public. The SETA App will also facilitate the creation, operation and curation of citizen observatories by providing means for citizens to inform decision makers of incidents. All information will be made available to decision makers via web interfaces. The decision maker side of non-motorised mobility tracking will involve an online system for analysing Origin-Destinations for journeys and a separate citizen observatories portal to view the data provided by citizens as observations. Motorised mobility will involve an analysis of the motorised mobility data made available to the use case. This aspect will also be involving the study of how bluetooth and wifi sniffing sensors can be exploited in the Birmingham area.

The following section presents an overall plan for the evaluation of technologies. This report then discusses individual technologies and evaluation plans specific to each technologies.

4. Plans for Evaluation

The evaluations for the Birmingham Case study for Phase 1 is planned to encapsulate two primary forms: a short-term study with users/decision makers and a longitudinal study. Different technologies will be involved in either or both of these forms of evaluation. This section provides an overview of how the technologies will be released and evaluated under different evaluation settings.

The focus of the non-motorised mobility will be primarily with the biking communities, where the SETA mobile App will be released to several bicycle users. Birmingham City Council (BCC) has already identified a potential release during June 2017 targeted toward cycling groups. Several other events will be identified in the next weeks that could be used as release points to encourage citizens and user communities to start adopting the SETA App. Birmingham City Council through its Birmingham Cycle Revolution team (BCR) are having a HSBC UK City Ride 2017, which will be held on Victoria Square on 11th June 2017. This will be the 3rd year of this event which is completely free which aims to encourage and inspire the city of Birmingham to get active, but also to entertain, by hosting some world-class bike performances. This year, to emphasise the importance of an active family life, there is a 5km closed road ‘Family Ride’,

starting and finishing at Victoria Square. BCC foresee the key launch event to be HSBC British Cycling event on 11 June 2017. The event is expected to involve 5k - 10k people, and the project is optimistic about a significant uptake of the app by citizens. There will be multiple events happening around the Cycling event, and the project will be presenting the technologies in such events. This will help in firstly disseminating the project activities to general members of the public and also provide a platform to approach different user communities to adopt the technologies and generate interest.
The initial process of engaging with users and communities is to make available the SETA App to be installed in the user's mobiles. The app will be suited to different communities - for e.g. bikers would most likely be interested in tracking cycling activities, while regular members of the public will be interested in tracking all activities. Citizens will be requested to install the app from online app stores and provide their email addresses as a part of the registration process. Once installed, the app will provide regular updates on user activities, locations and times. This will provide further details on the context of users, which will be used in further analysis and will form the bases of longitudinal study.

App user feedback will be collected in various formats via different means. Firstly, the apps will be delivered to the users via the standard Google and Apple app stores. This will provide the first means to collect feedback from users - however, the information collected will be limited with the possibility of a rating and some comments. Citizens willing to be more engaged in the SETA project would be invited to provide their opinions and feedback of their experience using the app. This would be an online survey, delivered to the users via regular communication channels by BCC or via Social Media. Further opportunities of promoting the SETA App will be utilised through the ongoing summer activities of Big Birmingham Bikes, Active Parks and Active Streets which all are BCC schemes that promote movement and active health.

Citizens who would be interested in collaborating with the project in a much more engaged manner would also be invited to a focus group session at BCC. The aim of the focus group would be to identify users who would be able to provide critical information, be available for discussions and also provide important feedback directly to the project. The envisaged focus group could be designed to be a short activity spanning under 2 hours, as detailed in the next section.

The non-motorised mobility data from the users is collected in the background, which is processed and analysed for various purposes. Critical to the task of decision making is to understand how citizens are currently using infrastructure and conducting daily travel. This includes understanding walking, cycling and running journeys. To support this task, the project has developed techniques to identify journeys, understand points of origins and destinations for the journeys and visualise them in a web based application. Given the difficulty in gaining access to decision makers, the evaluation of decision maker's interface is planned to be a focus-group based one. The focus group is designed to have a structured and unstructured component and will be discussed in more details in the next sections.

Motorised mobility tracking will involve understanding public service usage by citizens. This will be done primarily by using sensors deployed on busses and bus stops. The sensors passively collect the number of bluetooth and wifi enabled devices that are in it's vicinity, which is aimed at providing estimates of the number of passengers availing the bus service or waiting for a bus. The data collected in this process will be sent to a server, which will then be analysed. The evaluation for the public service usage estimation will involve two main components: an on-field evaluation of the public services, where a participant (researcher/project member) will collect observations of occupancy; and an expert analysis where decision makers will be invited to review the data collected.

The expert analysis will involve presenting the data in a user interface, providing bus routes and the associated occupancy data. Additionally, feeds of live camera will be automatically analysed by processes in WP4 to provide counts of vehicles, pedestrians, cycle parking spots as well as vehicle classification, speed etc. Currently, one camera is installed to monitor traffic and incidents. The information collected from the camera feeds will also be presented as a further layer in the decision makers interface.

We also have another camera planned to be installed at the library which will be used for cycle parking monitoring and space availability reporting.

With a set of structured and unstructured questions, the decision makers (experts) would then be able to provide their feedback on the data collected.

Citizens Observatories of mobility involves understanding issues and reports submitted by concerned citizens. This aspect, while integrated in the SETA mobile App will be evaluated independently as a separate technology. The primary reason for an independent evaluation is to understand how well the concept of citizen observatories is perceived by citizens as well as how the information flow results in decision makers understanding local issues and concerns. As a result, the app evaluation will be extended to provide a set of structured and unstructured questions to the public participants. At the same time, a separate decision makers interface will be provided to the decision makers to gauge their impressions on the citizen observatories. The technologies and more detailed plans for evaluations are presented in the following two sections, based on the two types of users participating.

5. Evaluation of Citizen Participation Mechanisms

Data on non-motorised mobility will be collected via the SETA App, which will be further analysed to understand various activities of users. The SETA App has been developed as a part of WP2 and WP5, on the basis of requirements collected over the first six months of the project.

Fig 1: SETA App design for tracking activities.

As presented in Fig 1, the SETA App developed as an Android as well as iOS app provides several features available to users. Users, upon downloading the app will need to register using their email addresses (left screen). The app supports awareness and self-monitoring of mobility behaviours by providing a daily snapshot of the movements of a user, distinguishing them between: walking, cycling, driving and public transport. In order to achieve this, the app monitors the users' movements using activity recognition technologies developed in WP2. Upon logging in, the user is presented with a dashboard showing the different types of mobility and a summary of their behaviour for each mobility category. The app also supports self-awareness by displaying for each mode of transport, the total amount of time that mode has been adopted (for a given day), the amount of calories consumed (if relevant), the cost (saved or spent) and the emissions (caused or saved). Drilling (clicking further) into each category, the user can see more details for each activity. Finally, upon selecting a type of activity, the user can visualise where the activities have taken place and how they have travelled throughout the day.

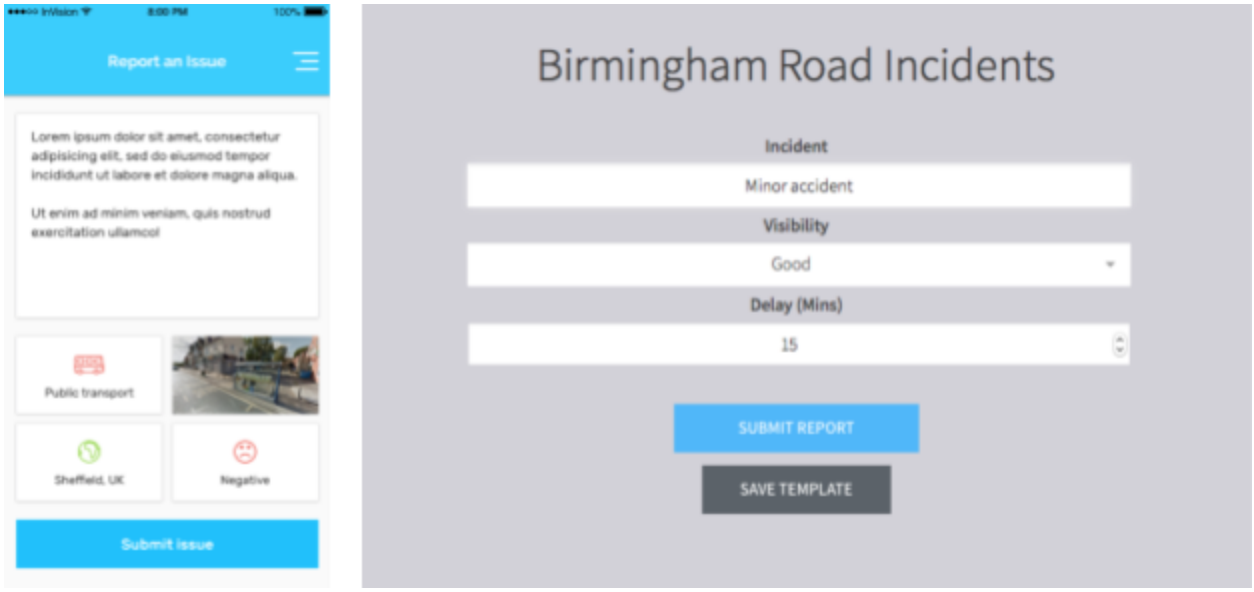

Fig 2: Citizen Observatories interfaces for public

Citizen Observatories mechanisms are also developed to enable the continued participation of citizens and communities. The mobile app offers an environment to empower users and allow them to contribute to the knowledge base of mobility. The application will offer its users the possibility to send structured location based reports to describe any problems they have seen in their day-to-day travels. The user can send reports about mobility issues or generic reports, attaching images or videos as evidence (see Figure 2). Their reports will be visible to decision-makers using the web interface and to other citizens as location-based notifications in the app. This will help create an environment for citizens and communities to interact with decision makers in communicating information regarding situations on the ground.

5.1. Description of Task

As presented earlier, the SETA App will be released to the public via several dissemination activities, shared with events organised within Birmingham. One of the main events targeted by the project is the HSBC British Cycling Event on June 11 2017. This event will mostly involve cycling enthusiasts as participants, who could be a larger user community for the SETA App. While the project estimates most of the participants from the event would be interested in tracking cycling activities, the app will enable tracking other events such as walking, running, vehicle and so on. The users will be presented with the option of being more engaged with the project as part of an extended user community to provide further information on or as stakeholders at a focus group organised by BCC. Several other events will be identified in the next few weeks where the app will be released to other citizens, requested their continued participation and engagement. Further opportunities of promoting the SETA App will be utilised through the ongoing summer activities of Big Birmingham Bikes, Active Parks and Active Streets which all are BCC schemes that promote movement and active health.

Along with the passive sensing data collection, the users will also be encouraged to provide participatory sensing data via the implemented citizen observatories mechanisms.

5.2. Experiment Setting

The app will passively submit activity information from the date of registration. This data will be analysed in a variety of mechanisms to provide inputs for other Work packages. While data collection will be a longer term process, the primary evaluation will involve collecting user feedback via a variety of mechanisms - app store feedback, questionnaire feedback and focus groups. Feedback will be sought on different features and functions of the apps as well as overall experience.

5.3. Selection of participants.

Based on the events being targeted for app release, the primary user communities would be predominantly cyclists and cycling enthusiasts initially. The case study expects this to be a highly interesting community since the variety of use would be key to study mobility within the Birmingham region. Particularly so, since cyclists would cover a larger area and cycling activities are likely to encapsulate a wide variety of use such as recreational as well as regular commutes. With the ability to track other activities, the identified user group would be an extremely important set of users to study within the Birmingham case study. BCC have kept their stakeholder and interested organisations informed of this SETA project with a few organisations willing to be early adopters of the technologies for us to select and evaluate.

Providing feedback to the project is a purely voluntary task, hence the case study expects participants to be highly engaging, providing a large amount of feedback to the developers. This is further expected to provide interesting insights and ideas for the project. Utilising the Big Birmingham Bikes Scheme in where the city donated 5,000 free bikes to people living in disadvantage areas of the city BCC have a potential willing audience for the SETA App. Promoting the possible health indicators of the SETA App could help us to target the Well Being Panel (3,000) subscribers who are willing and active citizens who will be targeted. There may well be other planned activities around Big Birmingham Bikes, Active Parks as well as promoting the SETA App within BCC departments through competitions and events.

5.4. Data to be Collected

Users will be able to provide their feedback directly with the app store feedback mechanisms. This feedback provides two types of data: an objective score of user rating of the app (typically varying between 1-5) and a subjective assessment of the user's experience. Typically such feedback is extremely useful for developers to understand how the app performs. However, this process is not ideal for all conditions - often, this is alleviated by the inclusion of more specific questionnaires, aimed at gauging a large variety of parameters. Finally, a more engaging process would be to involve citizens in a focus group to collect further feedback via structured

questionnaires, personalised interviews and discussions. The focus group, with the permission of participants will also be recorded during the event. The recording (audio and video) will be analysed post-event to ensure all points of discussions are collected and fed back to developers of the technologies. All data collected will be anonymised, archived and made available to project partners for analysis.

5.5. Questionnaires and Feedback Process

The questionnaire will aim at collective subjective and objective feedback from participants, including usability questions e.g. Brooke, 1996. There will be three questionnaires to be provided to the citizens, with relevant questions as follows -

1. Mobile app feedback questionnaire
2. Focus group questionnaire
3. Citizen Observatories questionnaire

All the feedback from these questionnaires would be collated,analysed and the insight gained from this process would be fed back to the SETA consortium team.

6. Evaluation of Decision Makers Platform

Decision Makers are provided with two primary interfaces that will help them analyse data collected by the project. The first interface (Origin Destination analysis, OD) provides analyses of the activity data collected via the SETA App, while the second provides details on the data submitted by citizens via citizens observatories. The OD analysis is primarily designed to provide decision makers the ability for decision makers to refine/select areas of interest. The interface provides details on how users travelled to and from the regions selected and specific details about their journeys. The OD tool provides various interaction mechanisms for decision makers to filter and sift through large volumes of data. The OD tool is presented in three different sections: filters, geographical map, graphs/charts. Fig. 3 shows the developed tool for analysing journeys users have made.

Three sections are provided in the interface: in the top, the filters provide means for users to select a particular subset of the data. Selecting a particular journey time/day of the week refreshes the visualisations to reflect the new selection. The charts summarise all the data points that have been recorded within journeys. The first pie chart presents a summary of the number of times different activities have been observed in all the journeys. The second chart is a stacked bar chart which presents a distribution of the different activities, over different days of the week. The third provides a distribution of the activities in different times of the day.

Fig 3 : The OD tool provided to decision makers for analysing origin destinations.

The geographical map serves as the primary point of interaction for decision makers. The map also provides multiple layers of interaction, mainly the postcode layer which serves to provide high level overviews as heatmaps. The map also provides road segments and trajectory data points. Clicking on a postcode highlights the relevant postcodes which are associated with the selected postcode. Selecting associated postcodes presents the routes taken for journeys as well as the road segments where activity points have been recorded. The map will also present results from automated analyses of camera feeds as a further layer.

The decision maker's platform for citizens observatories in the SETA project provides the possibility for users to view the data submitted by citizens and distribute news/information to citizens as notifications on the mobile app. Upon submission of reports, the data is automatically displayed on the decision-makers dashboard, to be visualised via various means such as tables, charts or maps.

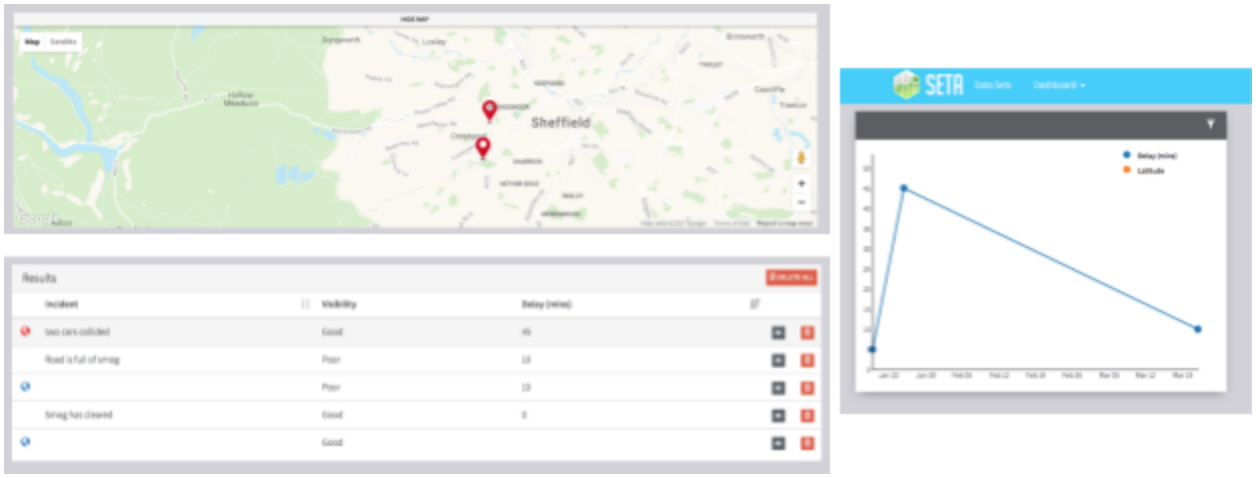

Fig 4: The decision makers' platform for viewing citizen observatories data

6.1. Description of Task

Following the data collection process with users, stakeholder groups and decision makers will be invited to attend a user evaluation. The evaluation is planned to be a two-stage process: The initial part of session to demonstrate the apps and get some feedback from the perspective of decision makers. The web apps will then be presented to decision makers to help analyse origin-destination of journeys and citizen observatory data, by making use of simulated tasks. Examples of tasks (grouped as OD / CO) would involve answering simple and complex questions such as:

OD: Which are the areas most visited by citizens?
OD: Which are the routes most often taken?
OD: Which journeys are most often taken ?
OD: If you have to make any infrastructure changes, which changes would you make based on the data?

CO: Can you identify reports sent by citizens that are traffic incidents?

The second part of the evaluation will involve a focus group discussion, driven by a set of key questions. These questions will be asked as seed topics for discussions. Examples of such questions are:

How did you find the process of identifying individual routes for travel between two regions?
What are the most travelled routes?

6.2. Experiment Setting

Upon collecting a significant amount of data by the users following the release of the app, the decision makers will be invited to a day long workshop. The workshop will be organised as follows:

Duration	**Item**
10 mins	Introduction to the project and goals of the workshop
10 mins	Round-the-table introduction
20 mins	Presentation on the decision makers OD application
10 mins	Trial of the system guided by a basic task to familiarise users
30 mins	Participants evaluate the OD system
10 mins	Presentation of decision makers interface for citizen observatories
20 mins	Participants evaluate the citizen observatories interface
20 mins	Filling questionnaires
20 mins	Discussing first impressions on the system
Break - 30 mins	
10 mins	Organisation into focus group
10 mins	Presentation of the focus group goals
1 hour	Focus group participants are asked to reflect on three primary questions and share their views individually
10 mins	Conclusion, feedback and summary

As mentioned earlier, the first part of the workshop will involve participants trying out the different components

6.3. Selection of Participants

Initial stakeholder interviews have already identified several communities of users who are interested in participating in the project activities. As a result, some stakeholders are expected

to be participating in the evaluation. The total number of participants are expected to be around 12 to 20, with the evaluation day being organised as a full day event.

6.4. Data to be Collected

The evaluations will firstly collect video and audio data, which will be recorded to capture the evaluation, upon permission from the participants. Questionnaire responses for participants will also be collected and integrated to facilitate analysis. Screen grabs will also record how participants use the system, particularly to understand user interface, interaction and performance issues.

6.5. Questionnaire and Feedback process

There are two primary questionnaires that will be used to gauge how decision makers judge the developed technologies: (1) a questionnaire on evaluating the OD analysis and (2) questionnaire on evaluating the citizen observatory interface. Both questionnaires will involve subjective and objective questions aimed at capturing usability and interaction issues, understanding general feedback on the interface as well as newer ideas on how to visualise and analyse the data collected.

7. Public Transport occupancy – people counting.

Within WP2, USFD have developed sensors to monitor the presence of bus passengers on buses and at bus stops through passive sensing, where information is obtained indirectly through mobile devices signals. Nowadays, the majority of the mobile phones provide three signals: Bluetooth, Wi-Fi and cellular network. Considering the technical difficulties in decoding the signals and the ethical and legal issues involved, we choose to monitor Bluetooth and Wi-Fi signals. Media Access Control (MAC) addresses are unique identifiers and have been used for various wireless communication e.g. Bluetooth and Wi-Fi. Therefore, they can be tracked and enabled a series of applications related to people counting/tracking. MAC addresses unlike mobile phone numbers add a level of anonymity, however are also considered as personal information. Hence, MAC addresses are hashed while storing in databases to preserve anonymity of the users being tracked.

Two types (see Fig. 5) of presence sensors using low cost architectures have been developed that can be deployed in public spaces (including stations, buses and public squares) at an affordable price. The sensors are based on low cost mobile phones (older models that are currently available at a fraction of the cost of more expensive smartphones) and Raspberry Pi.

Fig. 5 (left, center) Raspberry Pi based Presence sensor (fixed form) (right) Mobile phone based Presence sensor (mobile form)

By utilizing Bluetooth and Wi-Fi passive monitoring technologies, timestamped (hashed) MAC address of sensed Bluetooth/Bluetooth LE and Wi-Fi devices and the Received Signal Strength Indicator (RSSI) are recorded, along with geographical locations of where the observations are recorded. The data is stored in a MySQL database. The data collected by the presence sensors is sent to the database. Data aggregation and filtering algorithms are then applied to get the estimated number of the passengers on a bus or at a bus stop. During evaluation phases, addition information (e.g. manual observations) will also be recorded in the database.

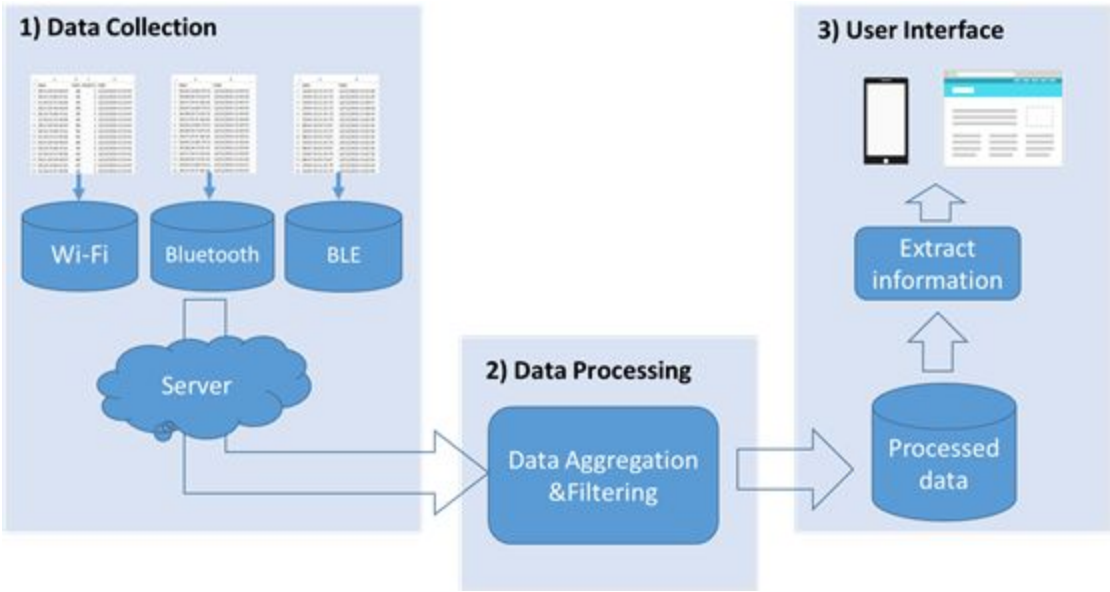

Fig. 6. System Structure of Presence sensors

It is to be noted that the Wi-Fi passive sensing/ Bluetooth sensing may under- or over-estimate the actual number of devices on buses/bus stops. When monitoring passengers waiting at a bus stop/ on a bus, users walking-by will add noise to the measurement. The assumption is made that the passengers who wait for bus are usually close to the bus stop (a few meters distance) and stay there for a while (at least one minute). Therefore the filtering is based on both RSSI (e.g. RSSI < -85) and detection duration. In addition, the relationship between the actual number of the crowd/passengers and the number of devices sensed. Users carrying multiple devices with the Wi-Fi turned on, and users without any of these devices (or Wi-Fi switched off) contribute toward noisy/incomplete data. However, the principle of the prediction method is to find the scale factor between the number of sensed devices with the number of the actual devices (based on large number of experiments) as well various conditions and factors that can influence sensing the number of passengers. After removing noise and aligning the data, the final estimated number of the passengers will be compared with the actual number of the passenger to obtain error rate or accuracy.

7.1. Description of Task

7.1.1. Initial evaluation scenarios

Initially, in order to validate the feasibility of presence sensing utilizing Bluetooth and Wi-Fi passive sensing and explore the relationship between the sensed devices and the real devices, some initial evaluation will be done by the testers who carry the sensors to make different bus journeys while at the same time manually counting the number of the bus passengers as the ground truth. Different bus routes and bus types (including both single decker bus and double decker bus) will be considered.

Planned tasks:

- Select a few bus routes during a week period test
- Choose the bus journeys covers city center or suburb areas
- Select buses with few passengers or many passengers

7.1.2. Validation of approach via Focus Group

The data collected during the initial evaluations will be analysed and presented back to the decision makers via an online interface. The decision makers will be invited to participate in a short evaluation that involves understanding the data collected and the subsequent analysis. The online interface will provide timestamped geotagged location points, presented as trajectories of bus routes where the data had been collected. The focus group is aimed at validating the sensor outputs via a scenario-based approach.

7.2. Experiment Setting

There are two primary experiments planned for the public service usage estimation:

The first being an on the field experiment, requiring an individual (researcher/project member) to take several routes of busses across the Birmingham area. There are three types of routes considered: a bus route primarily through the city center (populated zones); a route primarily through the outskirts (sparse population) and a combined route (bus travelling through populated and sparsely populated routes). The researcher will carry the developed sensor, together with an observation tracking mobile app. The sensor will passively collect number of unique bluetooth and wifi devices and send timestamped, geotagged data back to the database. The mobile app, on the other hand is developed to take manual inputs from the researcher that indicates visual counts of the number of passengers on the bus and submit it to the backend database. The observations are timestamped as well as geotagged to enable follow up analyses. A backend process will integrate the two datasets (manual observations via the app and automated observations via the sensor) and align the observations. Once aligned, the observations will then be analysed to understand how the sensor performs when aligned with "gold standard" manual observations.

The second experiment will involve decision makers and will serve as a validation mechanism for the approach used to estimate public service usage.Decision makers will be invited to a focus group, where they would be able to provide their feedback on the data collected. The planned focus group could either be combined with the decision makers app evaluation or be an isolated evaluation involving a fewer number of decision makers. In order to aid understanding, the decision makers will be provided with an online interface that would present bus journeys as trajectories, along with counts of number of devices sensed. The aim of the experiment is to understand if the number of devices sensed could provide a reasonable estimate of public service usage for the decision makers.

7.3. Selection of participants.

The presence sensors are developed to monitor the presence of users through passive sensing, where information is obtained indirectly through mobile devices signals. Therefore there is no need to recruit any participants in the initial evaluation.

In the following focus group session, decision makers will be invited to participate and provide their insights. The initial evaluation results (including the functionality and the accuracy of the sensor) will be presented to the decision makers. The decision makers will then be provided with demonstrations of the web interface developed to visualise the analysed data, which will be made available for use.

7.4. Data to be Collected

The focus group will be organised to include the decision makers to get the feedback about the performance of presence sensors through specific questionnaires or interviews. Focus group sessions will be recorded (audio and video) with the permission from all participants.

7.5. Questionnaires and Feedback Process

Questionnaires will be provided to the decision makers to provide their subjective and objective assessments on the data being analysed.

8. Motorised Mobility: Traffic Management

The data released by the Floow of motorised mobility for the Birmingham region will be made available to BCC. This is mostly related to decision making, and will be primarily aimed at understanding traffic flows in different parts of the city. This data will be primarily used for the activities in Phase 2. In this phase, BCC will analyse the data to understand the quality of the data, as well as provide inputs to the tasks in Phase 2. The Phase 1 work on data analysis will aim at deriving simple insights and basic analyses based on the data.

In terms of analysis, BCC will compare against their existing, ground based sensors, which comprise mostly of traffic loop sensors and traffic cameras. This process will primarily involve visual comparison and validation, in addition to basic tools like Excel. Based on the needs of analysis, other partners will also provide more complex tools as and when required. At the time of writing this deliverable, WP4 partners (TSS) are conducting analysis of the data from a modelling perspective. The different aspects of mobility that will be analysed are understanding congestion levels and patterns. BCC will use the data to understand the locations, severity and duration of traffic incidents occurring.

9. References

Brooke, J. (1996). SUS-A quick and dirty usability scale. Usability evaluation in industry, 189(194), 4-7.