Fieldtrip GB: Creating a customisable mapping and data capture app for the HEFE community

Ben Butchart[1] , Addy Pope[1], Murray King[1], George Hamilton[1]
Panos Terzis[1], Michael Koutroumpas[1]

[1]EDINA, The University of Edinburgh, 160 Causewayside, Edinburgh, EH9 1PR
Tel. (+44) 131 651 7712 Fax (+44) 131 650 3308
Addy.pope@ed.ac.uk, www.edina.ac.uk

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Fieldtrip GB is a mobile app for iOS and Android smartphones. It has been designed to allow users to take high quality basemaps into the field and capture spatial data against them. Fieldtrip GB is part of a suite of tools that connect through a Personal Cloud API (PCAPI) which allow users and developers to create custom data forms and manage the creation and flow of data captured through the app. This paper introduces the app and explains the concept of the PCAPI. It also describes some of the difficulties in developing apps in the current fragmented mobile sector and details the use of open data to create a suitable basemap for the application.

1. Introduction

This paper describes Fieldtrip GB [1], a smartphone app and related web interfaces from EDINA[2] which allows users to view cached maps on their mobile phones and capture data in the field, using their own data collection forms. The application attempts to overcome several challenges with using mobile technology in field for education and data capture.

Location aware technology is increasingly carried in people's pockets in the form of a smart phone or similar mobile devices [3]. These devices connect people to the world-wide-web and carry a wide array of sensors including GPS. Such is the ubiquity and rapid adoption of mobile sensors, we find ourselves entering a new era of human connectivity, that Butchart (co-author) has dubbed the "Sensed World Web" [4]; a condition where as humans we begin "to enhance our own human senses and connect those senses to networked databases". Location Based Services based on spatial sensors such as GPS, digital compass and accelerometer are the first class of Sensed World Web applications to be widely adopted. Popular apps for navigation, social networking and data visualisation have harnessed geospatial awareness to drive the rapid growth in smartphone adoption.

Increasingly, educators and researchers are investigating how to respond to this trend in sensor proliferation to enhance learning and collect data for research. The Centre for Enhanced Fieldwork has produced a number of reports and guides on how to exploit smartphones and tablets for fieldwork [5, 6]. There has been significant uptake of smartphones apps for research, as outlined in UK Environmental Observation Framework's comprehensive report on citizen science [7], which discusses several smartphone applications such as Birdtrack[8], Leaf Watch[9] and Project Budburst [10] (among others) where smartphone have been successfully used for obtaining research data. The report also summarizes some of the challenges in developing smartphone applications for data collection (repeated below)

- *Relatively high cost in the development of smartphone apps.*
- *Rapid advances in technology…, so can become redundant quickly.*
- *Requirement for apps to be developed for multiple operating systems.*
- *Requires good mobile phone signal for live communication with the internet…*
- *The quality of signal coverage is patchy and focussed on areas of high population density.*
- *Versatile apps for data collection… do not allow apps to be 'branded' thus limiting their use in mass participation projects, while a proliferation of standalone apps could create clutter and be self-defeating.*
- *Users expect apps to be intuitive and have high usability, which can add to design costs.*
- *Apps for iPhones currently need to be vetted before acceptance to the App Store (for iPhone apps) or Google Play (for Android apps).*
- *People who do not have smartphones are automatically excluded from participation.*

from UKOF Citizen Science Report (2012) pp48-49 [7] (abridged)

In this paper we describe how Fieldtrip GB has attempted to address these challenges.

The next generation Sensed World Web apps will build on the foundation of geospatial capabilities to include computer vision and speech recognition capabilities. Capabilities such as natural feature detection, visual identification of objects, voice and sound detection and natural language processing are already a feature of many new applications and we expect this to grow as devices acquire greater processing power. We intend the Fieldtrip GB application to follow this trend so that it can be a future platform of choice for educators and researchers to experiment and exploit the power of the Sensed World Web for teaching and research.

1.1 Related Work

Several other data capture apps are already widely used and respond to the challenges outlined above in different ways. Photo geo-tagging apps such Flickr [13] , Panoramio [14] as well as specialised data capture apps such as Evernote [15], EpiCollect [16], WildKnowledge [17] and Fulcrum[18] are all potentially extremely useful teaching and research tools. Of these, WildKnowledge, Fulcrum and EpiCollect allow users to create custom data collection forms in a similar way to Fieldtrip GB. The main distinctive feature of Fieldtrip GB is the provision of its own basemaps optimized for fieldtrip use cases and its ability to link to the user's existing Cloud provider.

2. Fieldtrip GB

Fieldtrip GB (Figure 1) allows users to stream Ordnance Survey (OS) [19] maps to their mobile phones providing access to high quality background mapping in the field. In addition, several data capture forms allow users to take notes and create digital assets such as photographs and audio notes during field exercises. The user can create custom data capture forms for a specific field exercise objective through a web authoring tool.

The app was designed and built around the following user requirements:

- The app must work on iOS and Android phones
- The app design must be optimized around a 4inch screen
- Users must have access to quality cartographic products
- Maps must be available in off-line mode (where there is poor, or no, 3G network coverage)
- Users must be able to capture basic location information against a variety of media (text/audio/images)
- Uses must be able to export the data that they collect into a standard format
- Users must be able to upload simple spatial data to the device

Achieving these requirements in the current fragmented mobile technology space is challenging and ensuring the app was intuitive to use for both novice and expert smart phone users added to design costs. Analysis of Digimap users [20] has revealed the wide ranging abilities of users and the design has to reflect this variation in user sophistication.

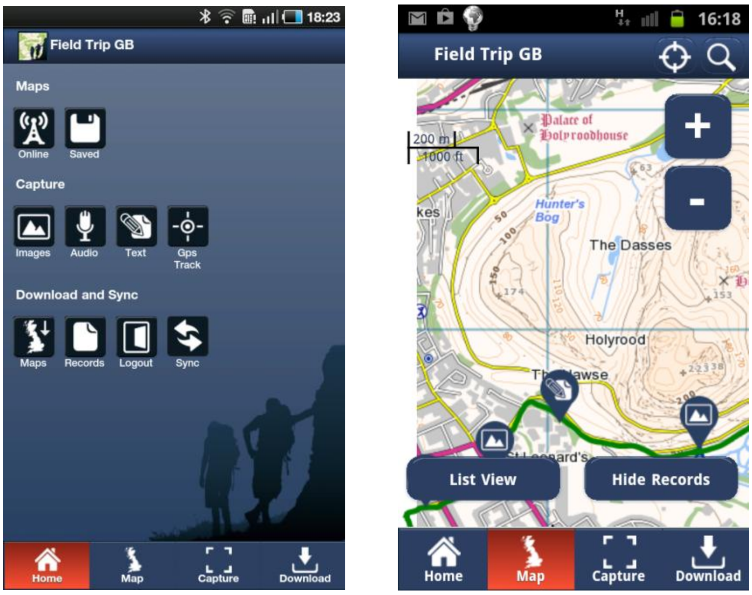

Figure 1: Fieldtrip GB screenshots showing the main home screen (left) and the main map screen (right)

2.1 Background Mapping

Clear cartography is a key component of any mapping app. However, there is a trade-off between cartography and engineering concerns such as reducing bandwidth. Producing maps that meet the needs of different users in different environments (urban vs. rural) is also a challenge. For Fieldtrip GB, we identified two broad user groups:

1. Those working in more rural environments may well be more interested in topographic features such as slopes, watercourses, field boundaries and paths.

2. Users working in urban areas will be interested in streets, street names, buildings and urban green space.

Ensuring that the mapping in Fieldtrip GB met the needs of both these user groups was a goal that required some compromise between engineers and cartographers. The Fieldtrip GB map stack uses a mash up of mostly OS Open data products [21] to create more richly featured maps in rural sparsely populated areas. These areas are often visited as destinations for fieldtrips and are not well catered for in freely available digital mapping products such as Google Maps [22], OpenStreetMap [23], Digimap Openstream [24] and Ordnance Survey's OpenSpace [25] (Figure 2).

2.1.1 Cartographic Mash Ups

For Fieldtrip GB an attempt was made to mash up OS Open products such as Strategi [26] , Vector Map District [27] (which is a beta product still in development) and Land-Form PANORAMA[28] in a way that would add more topographic features and place names to these locations. In addition, footpath, cycle ways and other path networks were included using data from OpenStreetMap[23]. As illustrated below (Figure 2), these additions enhance the VectorMap District base data and result in a crisp, clean map suitable for use in rural areas.

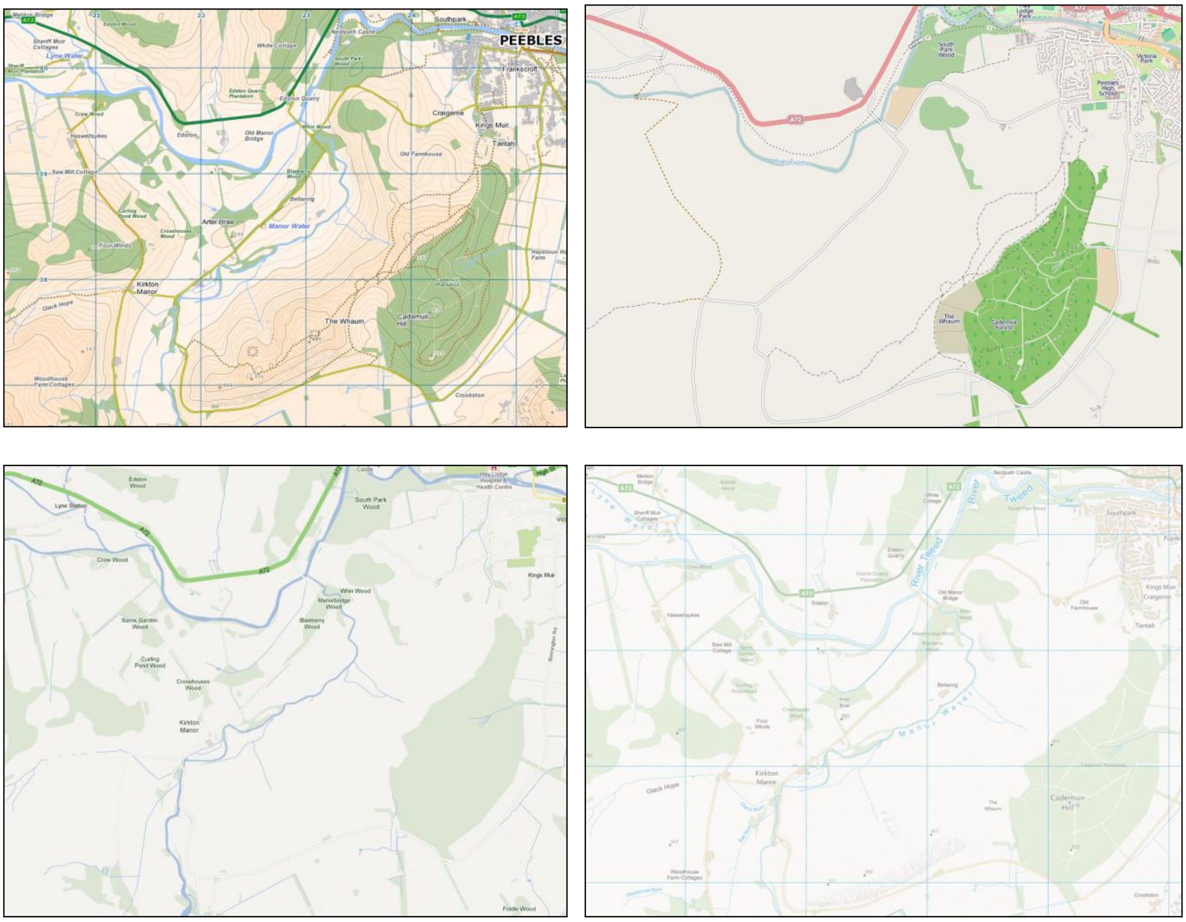

Figure 2: Examples of freely available mapping in Peebleshire.EDINA FieldTrip GB (top left), OpenStreetMap (top right) Google Maps (bottom left), OS Open via EDINA Openstream (bottom right)

While adding value to the base data, mixing products originally designed for different scales and purposes in the way we have done has consequences. The Fieldtrip GB map has many cartographic anomalies and conflicts, many of which are expensive or impossible to rectify. For example, some text label features in the Strategi dataset are designed to be placed on a map at its natural scale of 1:250,000. This includes national park labels where the text “Snowdonia National Park” is broken up in source data into two separate entries “Snowdonia” and “National Park” with cartographic positions for each that causes conflicts with other features from other datasets. This leads to a situation where one part of the text is rendered, but not the other (Figure 3). Manual work on the raw data is required to realign the text against a single geographic point so that rendering applies to the full text of the feature (Figure 4). In contrast, sometimes the data available is not adequate for the cartographic use we are applying. Water features such as names of rivers are available in Vector Map District but do not have information on the angle of characters at the point in a line feature. This leads to less appealing labelling where the text is not aligned to the direction of the feature it describes (Figure 5)

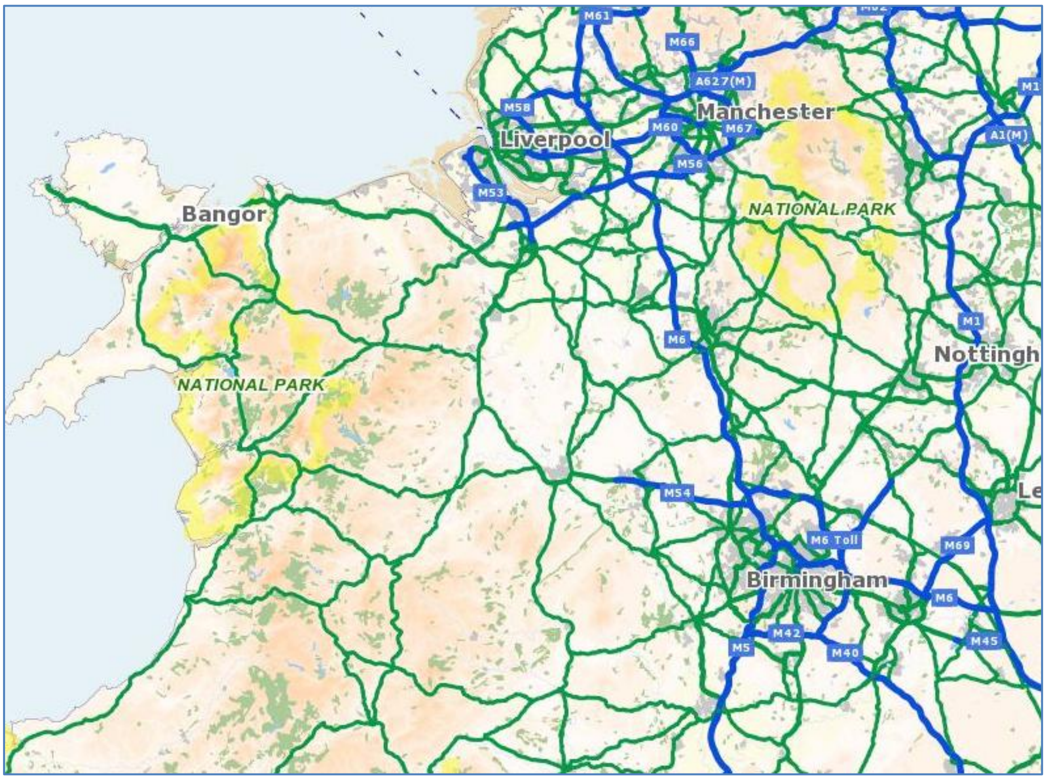

Figure 3: Some cartographic challenges when diverging from intended scale resulting in orphaned National Park Text Labels

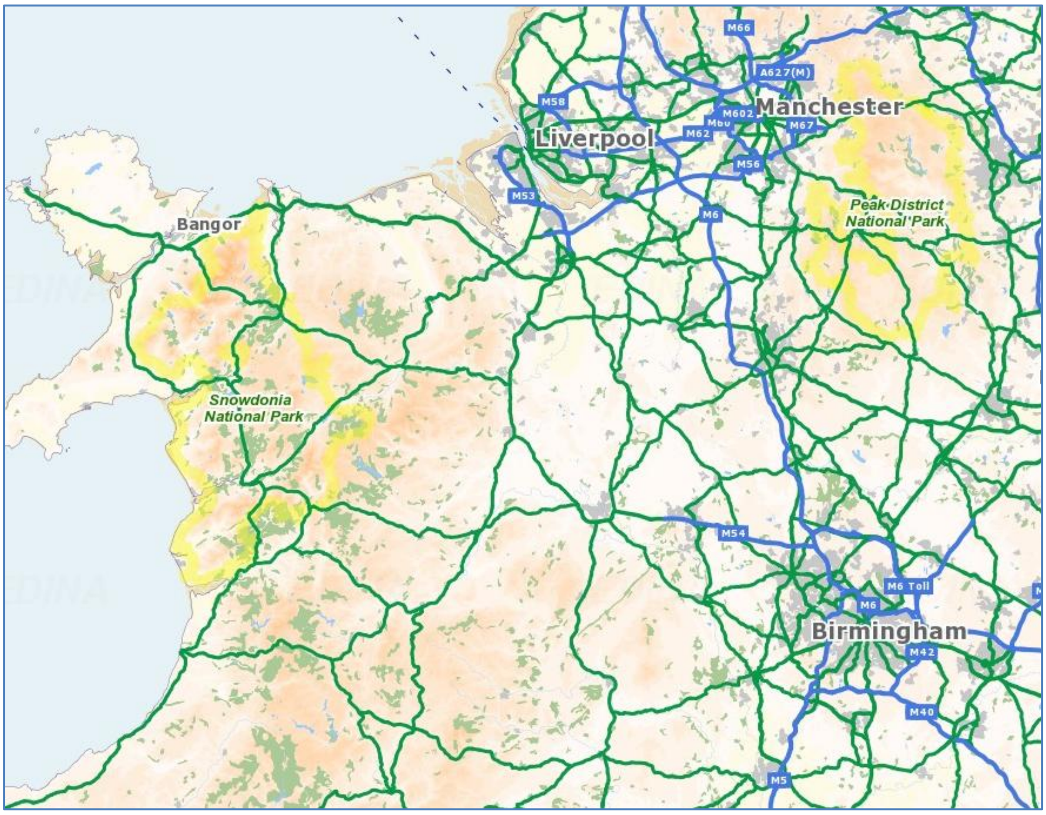

Figure 4: Manually Corrected National Park Text Labels

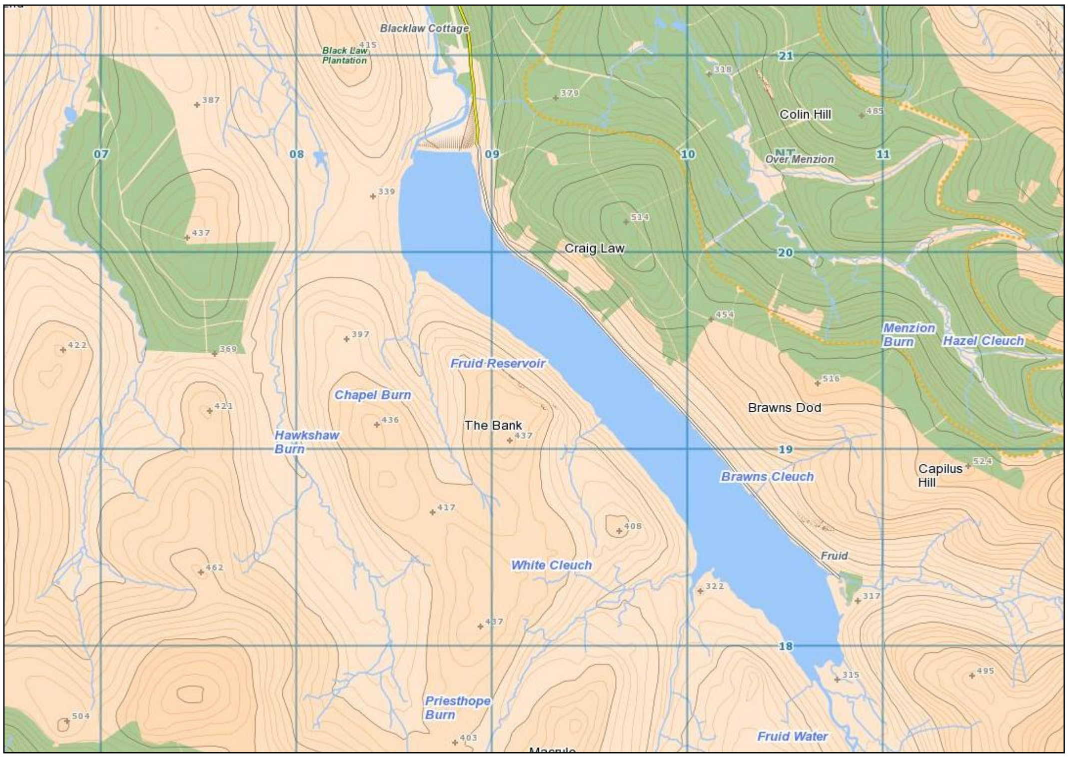

Figure 5: More cartographic challenges resulting in water labels not aligning to corresponding line features .

2.1.2 Urban and Rural Mapping

A key challenge in satisfying both user groups was finding a compromise between styling that worked well in both rural areas and urban areas. We found that VectorMap District (VMD) works well in rural areas but for urban areas lacks building detail and only shows street names for major routes. The OS Street View raster product is better suited to mapping in urban areas but lacks topographic features we sought in rural areas. To satisfy both our user groups, we employed Mapserver 6.2 [29] masking feature to make an urban mask that we could stamp onto the VMD data. This replaces the VMD tiles with Street View data in urban areas (Strategi Major Urban Area [30]). The contrast is slightly rough at the boundary of the urban masks, but this is outweighed in our view by having the most appropriate mapping available for the environment you are working in (Figure 6).

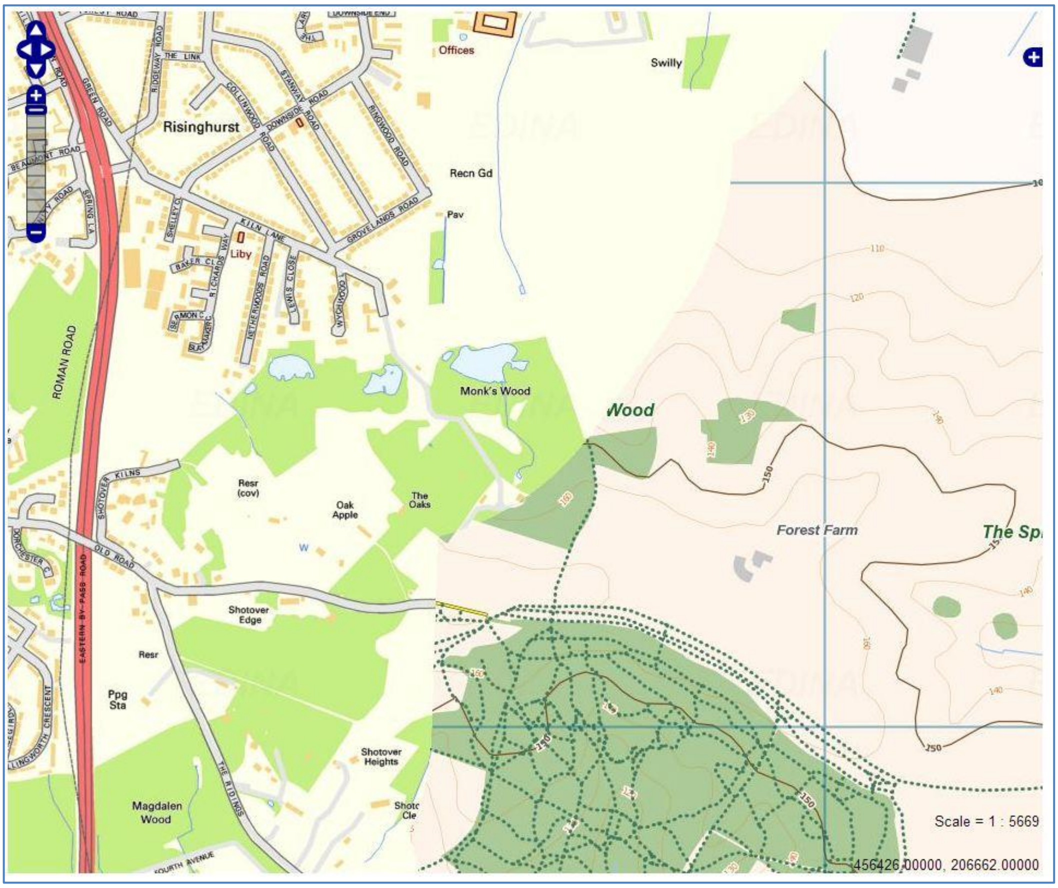

Figure 6: Example of the Urban Mask showing Street View data on the left and VectorMap District data on the right

We anticipate a second mapping stack will be made available that allows users access to OS products available under the Digimap agreement, such as 1:25k mapping and MasterMap. This adds the complication of authentication on the mobile device and optimizing very large dataset for mobile. While a proof of concept has been built and demonstrated, some more work is required before we can release the Digimap Fieldtrip GB version.

2.2 Offline mapping

A key user requirement was the availability of maps when mobile network connections are poor. To achieve this, maps must be downloaded to the device when it is connected to a reliable WiFi network. The download interface (Figure 7) allows users to select areas to download to their device. User will be able to decide how much data they store and can remove existing cached maps to free up disc space on their device. When a user selects areas to download they define the number of mapping levels they receive, tailoring it to fit the requirements of their project. The number of levels will have a significant effect on the size of the data request.

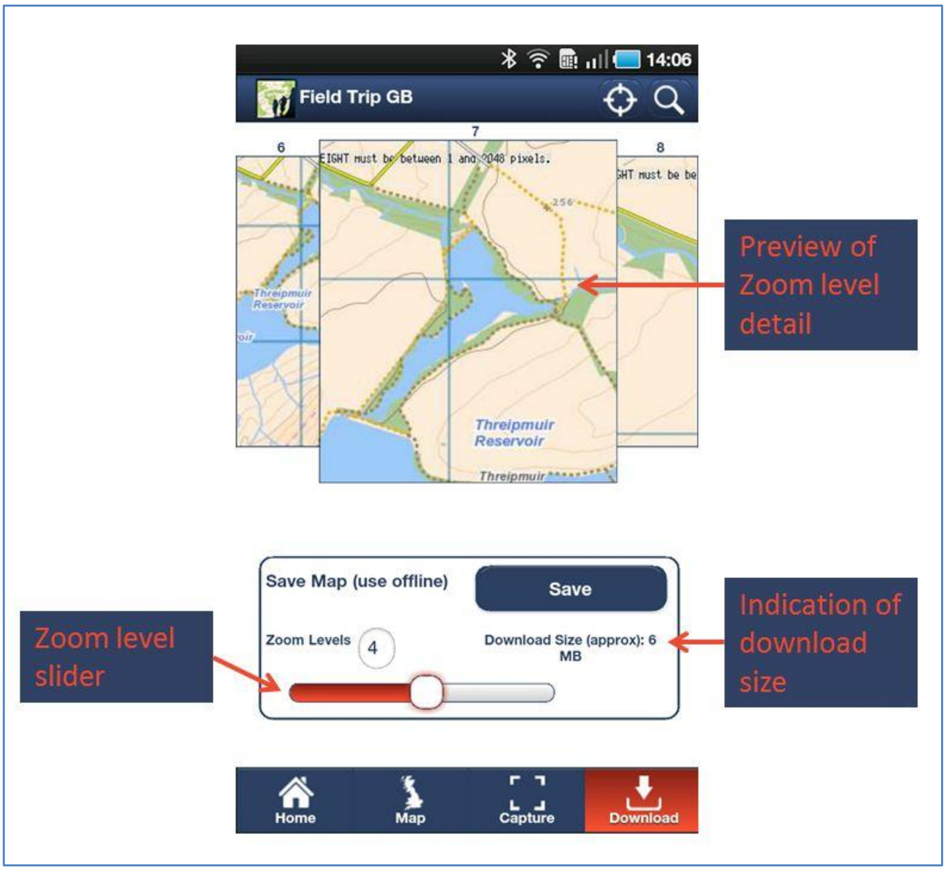

Figure 7: Map Download section of Fieldtrip GB

2.3 Data Capture

What sets Fieldtrip GB apart from many mapping apps is the ability to capture data. Users can currently add points and associate text, audio and photographs with them. Users can capture GPS tracks and annotate them with way markers which can also have media (audio/images) associated with them. This basic data capture will enable users to record features in the field to support their projects. The ability to have accurately positioned notes and images is often a great help and removes the onerous task of sorting out which photo or filed note relate to a particular location. For users who have specific data capture requirements, custom data forms can be created through the Authoring Tool described below (Section 3.1).As the product evolves, further data capture features such as pad sketching, “dip and strike” clinometer measurements are envisaged. Eventually users will have access to the full “sensed world” capabilities of the device, allowing many ways to capture information such as natural feature detection, 3D reconstruction, optical character recognition and speech processing.

3. Personal Cloud API

The backbone of Fieldtrip GB is the PCAPI. The PCAPI connects the App to the Authoring Tool through Cloud Storage Services such as Dropbox and Google Drive. The use of 3rd party cloud services gives the user control over their data and removes the complicated terms of use and licences that would be needed if EDINA stored user data. At present, PCAPI only interacts with Dropbox, but it is hoped that it will communicate with other cloud services in the near future. The PCAPI essentially manages the flow of data to, and from, the Fieldtrip GB app and also allows users to export their data in useful formats such as geoJSON and KML. Future enhancements plan to allow users to publish their own base maps to the cloud storage and serve maps to the clients via the API and increase the range of cloud services that PCAPI can interact with (Figure 8).

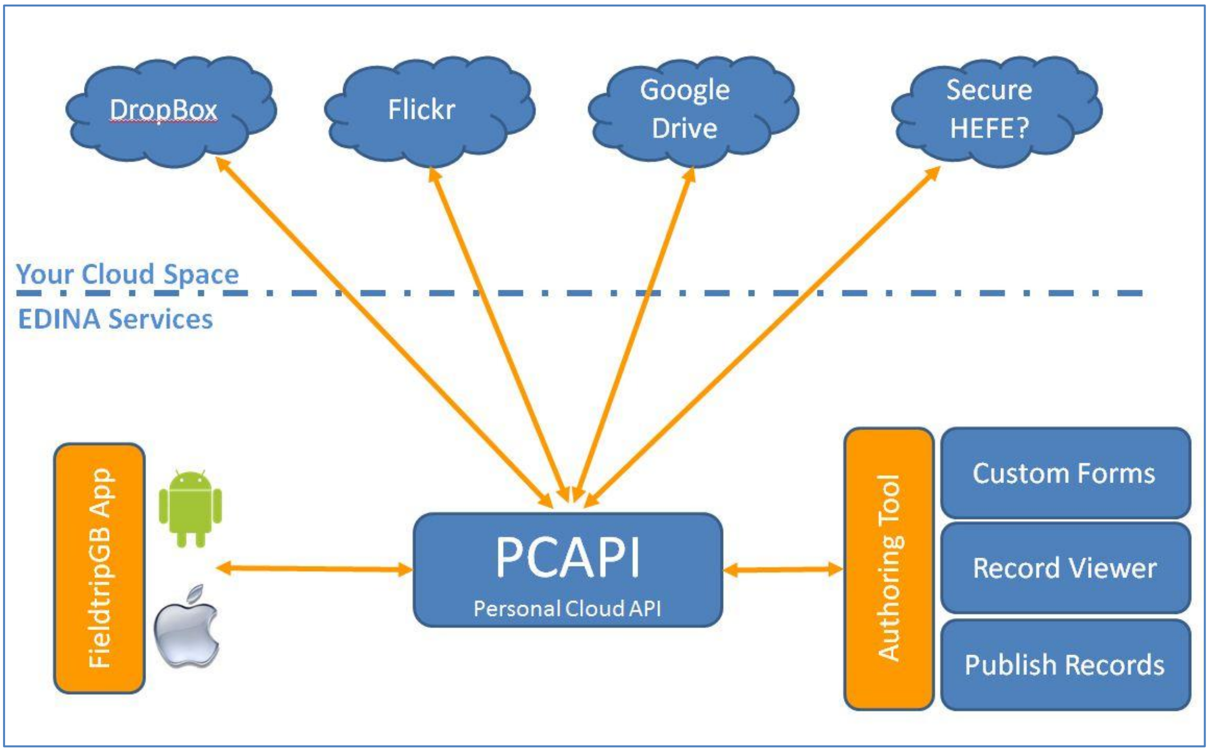

Figure 8: How PCAPI connects Fieldtrip GB to Authoring tools through the cloud

3.1 Fieldtrip GB Author

The web-based authoring tool allows users to create custom data capture forms that can then be deployed to their mobile devices. The custom forms are created through a web interface by dragging elements onto a workspace (Figure 9). You can then:

- give elements a title
- specify measurement units
- define dropdown lists
- define radio button options
- create sliders to select numerical values

- add camera and audio prompts
- make fields mandatory or optional

Figure 9: Fieldtrip GB Author used to create custom data capture forms

Custom forms are then uploaded through the PCAPI to the users cloud storage provider and can be accessed through the app when the user synchronizes with their device with the PCAPI (Figure 8).

3.2 Record Viewer

The record viewer is a simple web-interface that allows users to search and visualise the data they have captured. The record viewer connects to the users cloud storage through the PCAPI and allows them to filter or edit the data. The data is visualised through a simple OpenLayers [31] web interface using the EDINA Openstream WMS [24]. Some support is provided for creating simple charts and generating statistics.

3.2.1 Export

Data can be exported through the Record Viewer. Filters are available that allow users to specify temporal constrains and export the records they are interested in. Users will also be able to select the data format that they wish to receive their data. Data conversion will be handled by the PCAPI (Figure 8).

3.2.2 Publish Records

Users may find it useful to publish the data they capture. Using the Record Viewer users can select and filter the records they are interested in and then create a clone of the record viewer web page and selection in their cloud. They will obtain a URL to the resource on the cloud (i.e. a link to the new web page on their Dropbox account) and others can then view this page and interact with records displayed on the map without accessing the Fieldtrip GB Author website. We intend to add enhancements so that the user can add their own logos, titles, branding and base maps so that they can fully make the output of the data capture exercise their own.

4. Architecture and engineering

Compared to standard web application development, we found developing a mapping application for mobile challenging. During the project we worked for some time on an iOS version of the app, using native APIs and libraries. At the same time, we developed a version for Android using the PhoneGap [32] web/native hybrid solution, where the bulk of development is done in a web browser embedded within the app using more familiar web technologies such as HTML, CSS and Javascript. Having worked with both native iOS and the PhoneGap [32] framework, it is clear now that hybrid is a better option for an app such as Fieldtrip GB. We found that reusing existing well established web mapping technologies such as OpenLayers [31] was more versatile than native map frameworks, with support for multiple projections and protocols making it easier to adapt to changing requirements. This outweighed the impact on the user-experience that using a hybrid app creates. With the dizzying speed of change in mobile technology this versatility pays off, even if a native solution seems a less bulky and more appealing at first. The embedded web browser also worked best for including custom data forms, allowing us to use HTML5 Forms in both the mobile client and the desktop based Authoring Tool. Attempting to render user defined data forms using a native UI seemed to be re-inventing core aspects of the web browser, so embedding a web view in the app proved less of an overhead than originally thought. Overall, these small differences add up to a huge difference in cost of ownership and make running a service such as Fieldtrip GB a more sustainable proposition.

Another way we simplified the architecture of the application was to pre-cache all tiles so that front facing servers had no dependencies on databases or map server middleware. The maps were generated using Mapserver 6.2 [29] with PostGIS [33]. These components were deployed on multiple instances to a cloud infrastructure using OpenStack [34], so that tile generation could be scaled without committing long term hardware infrastructure. The MapCache seeder [35] process was configured to send requests to multiple cloud instances. Once cached, the cloud instances could be dispensed with, leaving Mapcache the only backend component. We can replicate, load balance and scale the Mapcache relatively easily reducing costs, dependencies and points of failure.

5. Conclusions

There are many mobile apps being developed for specific data capture tasks. It is clear to us that data capture will grow in popularity as mobile devices get ever more powerful. Soon tools for recognizing faces, places, generating 3d point clouds, augmenting sketches and precise field measurement will be available in millions of pockets. We found a hybrid web/native approach is the most affordable and flexible option for creating data capture applications that work on multiple platforms, especially when the app integrates with an HTML5 web site for managing data. We have outsourced parts of the application (e.g. digital asset storage) and simplified the architecture to bring down cost of ownership.

Given the difficulty in developing products for an ever more fragmented mobile technology space, we believe an approach that allows users to customise generic apps is preferred to an ever increasing proliferation of standalone apps with similar functionality. While apps running in a general purpose web browser are not likely to meet user expectations, we believe an app that covers a particular theme such as field exercises or citizen science can be made flexible enough to support several different projects. In the case of Fieldtrip GB project, the Authoring Tool appears to be the key to our mapping app becoming a genuinely useful educational resource. People we have demonstrated Fieldtrip GB are more excited about the possibilities of the Authoring Tool than they are about the app itself. It seems that empowering users to make the app do what exactly what they want it to do, rather than design an app for a generic "user story" is the route to ensuring adoption. Therefore the FieldtripGB Author tool has become the focus for future development of Fieldtrip GB.

6. Acknowledgements

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Biography

Addy Pope *– is a member of the geo team at EDINA and has over 10 years' experience as a GIS professional. Prior to this he was involved in research in glacial remote sensing.*
Ben Butchart *– is head of geo-engineering at EDINA. Ben has over 15 years of software development experience in both commercial and academic sectors.*
Murray King *– is a senior developer in the geo team and has over 10 years' experience of developing technical solutions in the commercial sector*
George Hamilton *- is a senior developer in the geo team and has over 10 years' experience of developing technical solutions in the commercial sector*
Panos Terzis *– is a developer in the geo-team with an MSc in GIS he has focused on developing GIS tools*
Michael Koutroumpas*– is an experienced web developer working in the geo team at EDINA*