Geotagger: A Collaborative Environmental Inquiry Platform

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***Abstract*—Geotagger is a collaborative environmental inquiry platform that enables children and adults alike the opportunity to observe the world around them, document that observation, share it, and encourage discussion around that tagged item of interest. The main objectives are to leverage the rampant use of and affinity for technology to encourage people to observe the natural world around them and to share and discuss that information with peers and colleagues. We present the Geotagger platform, share some initial feedback from various users, and we discuss how Geotagger has evolved based on that feedback.**

Keywords—mobile, cross-platform, collaboration, exploring, sustainabiltiy, environment, ecology, science

I. Introduction

Technology is an integral part of our modern day-to-day activities. While adults are the general purchasers of technology, children are using technology more and more each day. In fact, in the United States about 66% of 8-18 year olds have cell phones, and consume 7.5 hours of entertainment media each day [1]. As technology use has increased, children tend to explore and interact less with the natural world around them [2, 3]. This observation has motivated some organizations to call for dramatic restrictions of technology use by children, some even suggesting that nature and technology as being in opposition to one another [4]. In contrast, our goal is to take advantage of children's interest in technology, and encourage them to explore their environment as well as connect with peers as they create, share, analyze, and inquire about the world around them.

Getoagger is a collaborative environmental inquiry platform that enables users to tag items of interest in the world around them. Geotagger users can see tags created by their friends or groups to which they are associated. They can then have conversations about tags through a comment feed associated to each tag. In Geotagger, tags can be grouped into collections called adventures which can have a specific purpose, like investigating a certain insect, plant, or habitat, or even for creating a treasure hunt for children to explore.

The Geotagger platform allows users to actively engage in collaborative, constructive, and generative activities. Geotagger was originally developed to encourage and engage children (primarily ages 6-11) as they explore the outdoors while also opening the lines of communication and enabling them to connect and collaborate with other children so they can ask and collectively start to answer questions about the world around them. Since its first iteration, Geotagger has grown to support a larger base of users than just young children. The active engagement within real world spaces encourages users to move and play, which are crucial to the social and cognitive development of children [5-7]. Geotagger supports these activities as well as engages children through peer discussions, collaborations, and competitions which are beneficial to children's development and learning [8]. The hands-on construction of artifacts and observations, coupled with a public and semi-public sharing of these artifacts provides an environment for deep learning experiences per Piaget's constructivism [7] and Papert's constructionism [9].

An initial overview of the Geotagger Android mobile app prototype was presented as an interactive poster and short paper at CSCW [10]. The current work goes beyond this earlier paper by providing an overview of the platform that has grown out of the initial prototype. This updated platform includes a centralized repository, a common access mechanism via a PHP framework, and multiple clients (web, Android, iOS).

In the next section we discuss related work. We then present an overview of Geotagger and its various components, including a brief description of its initial design. In Section IV we share some initial feedback from users who used the Android Geotagger app, and in Section V we share how the initial Geotagger Android app has evolved into a larger platform that addresses some of the intial concerns shared in the Android app feedback. We then share conclusions and discuss current and future work.

II. Related Work

There are many research projects that deal with citizen science, sustainability, and big data [11], here we will share only a few within the realm of citizen science applications, collaborative big data, crowd sourcing, and configurable collaborative user interfaces.

We thank PSEG for helping fund some of the initial development of the Sustainability Toolkit which has now been incorporated with Geotagger.

A. *Citizen Science Applications*

Citizen science applications are a platform where research scientists collaborate with citizens to work on a certain project [12]. There are several ways that citizen scientists can participate in the research. One concern with citizen science platforms is how to sustain volunteer participation. Previous research suggests that gamification is one possible solution for making the task more enjoyable and engaging the volunteers. An example of such a project is *Old Weather* [12]. In *Old Weather*, volunteers visit the website and transcribe the handwritten weather logs so that the scientists can use the digitized data. The *Old Weather* team would award recognition to the volunteers after they achieved a certain number of contributions. The volunteer begins as a *cadet* and is promoted to *lieutenant* after completing 30 transcriptions. The final recognition level is to be a *captain*, which is achieved only by those who contribute the most to the project [12]. Large proportions of participants who take part in traditional citizen science projects contribute in small quantities [13]. While Geotagger currently does not employ recognitions and badges for encouragement, thus far, users have been excited to add and share their observations with their peer groups.

The *Bee Lab* project is mixture of citizen science with open design [14]. The project looks into designing citizen science tools, which can also solve a specific individual problem but does so by using open design plans [14]. For example, by engaging beekeepers in design workshops, scientists were able to design hive monitoring kits, which were tested for their effectiveness in a subsequent workshop. The purpose of these kits is to periodically record the activity of the beehive, with the intention of helping beekeepers not to over inspect the hive so the health and functioning of the bees is not affected [14]. Geotagger is a more general-purpose platform that allows users to observe any phenomenon, but does not have these protective measures built-in.

B. *Collaborative Big Data*

More than three quintillion bytes of data are generated every day [15]. This vast expanse of data has been termed 'Big Data' and is characterized by the vast volume and velocity at which it is collected. Big data is comprised of both structured and unstructured data including vast amounts of text, numbers, images, audio, video, etc. Much of this data is unstructured which is impossible to analyse using traditional software techniques [15]. In order to make sense of or to investigate and analyze this broad spectrum of data, it must somehow be organized and have some structured imposed on it or inferred by people or some automated process. Big data and citizen science relate through the concept of crowdsourcing – which leverages the power of the crowd to find and impose structure in data. One potential use of Geotagger is to gather citizen data after disasters so that trends can be analyzed and discussed which could potentially influence policy makers. For example Geotagger could be used in a situation like hurricane Sandy, where there are various sustainability issues like hurricane evacuation and sheltering, human and infrastructure systems for hurricane evacuation, etc [16]. We believe Geotagger may be a solution to helping address big data in sustainability which can provide an opportunity for further research for handling these situations in a better way.

C. *Crowdsourcing*

One of the popular means of acquiring data where the groups of people are involved for analyzing the data is crowdsourcing. The computation may involve image tagging, entity resolution, and sentiment analysis [17]. In citizen science or crowdsourcing projects, people are recruited to collaborate and contribute in scientific investigations [18]. Some successful citizen science projects where participants had significant impact include classifying astronomical photographs [19] and sighting birds [20].

Mobile phones and smart phones are equipped with sensors that help detect the environment and these have empowered citizens to take more active roles in collecting and culling data. Many established services get data from the crowd and generate usable content. For instance, the OpenStreetMap project was started from the vast quantities of human generated content [21]. In order to build and maintain an accurate map, the volunteers provided geographic information for the OpenStreetMap project which was successful and the information provided was accurate [22]. The information produced was manually stored by the user in the database system, and was first described by volunteered geographic information (VGI). Nowadays using electronic sensors are more widespread than using humans as the sensors and generating the data manually [21].

By using sensors in the smartphones the user can log activity as an input. GPS and network positions provide the geo tags the data sets which are referred to as geo reference. Geo data projects include GPSies (www.gpsies.com), OSM-3D (http://osm-3d.org), Wheelmap (www.wheelmap.org), and OpenStreetMap (www.openstreetmap. org), whose primary job is to store the data in the database and via the web provide the data and visualizing it with user interfaces [21].

D. *Configurable Collaborative User Interfaces*

Research is also being conducted to create new applications that are user-friendly to support citizen science, including providing tools for those that may lack technical knowledge. One example of this is Sensr; which is an environment that allows non-technical people to easily create a mobile data collection and management tool for crowdsourcing data. Five design issues were considered while developing Sensr which was devised by reviewing pre-existing projects and user-acceptance factors. These factors included: the ability to sense, distribute, quality assurance, privacy, and authoring type or tools [23]. Supporting interactivity can change the scope of who can participate in the citizen science projects. While not the focus of this paper, it is envisioned that Geotagger will become a more configurable platform so that end users can design it to conform to their specific needs and accommodate varying structures of data.

III. The Geotagger Platform

Geotagger is a mobile, cloud-based system that supports collaborative environmental inquiry. In this section we briefly discuss the design process for the system, and then we give an overview of the system.

A. Design Process

Geotagger has been iteratively developed using the Cooperative Inquiry method where children and adults work together as design partners [24, 25]. This intergenerational and interdisciplinary design team is called Kidsteam. Over the course of several Kidsteam sessions over a two year period, the Geotagger interface and platform were developed through design activities and techniques that include low-tech prototyping, in field explorations with paper and medium fidelity prototypes, and sticky note activities.. Through these sessions two things became very clear: (1) tagging was fun; and, (2) that there was a need to not only share these tags with the world (as many citizen science systems do) but also to share them with close friends, and small groups (unlike other systems). This allows for the de-anonymization of the data enabling a level of identification and personalization that is generally not revealed in such systems. Through these design sessions, this theme of being able to connect with the data and make it personal and relatable was a very important aspect of the system. The design team emphasized the need to allow individual contributions to be seen, not just lost in the sea of data. Fig. 1 shows some pictures of the children using initial prototypes in the field during some of the design sessions as well as some of the results of sticky note formative evaluation sessions which formed the basis for the creation of Geotagger.

Figure 1. Illustrations of design sessions with Kidsteam, an intergenerational design team, showing children using prototypes in the field, and sticky notes that were used for informal evaluation of the prototypes in the lab.

B. System Overview

Central to the system is the ability to create, edit, and view tags. These tags can be organized into sets called adventures. The system also includes user profiles. The mechanisms of tags (or data points) and users is typical of many citizen science projects, what is novel in Geotagger is the integration of social connections where users can have friends or collaborators and share a more intimate connection between each other and the data. Geotagger also supports dialog about this data through a comments mechanism. See Fig. 2 for a high level overview of the Geotagger system. The following subsections describe the major components of the system along with some screenshots of the mobile application being used by children.

Figure 2. Overview of major features of Geotagger.

1) Profiles

Each person can create an account, which can be tied to a phone. Users log in using their username and password credentials and can opt to have these credentials stored locally on their phone so they are automatically logged in each time the app is started. Users have the ability to provide some profile information including a username and a picture as well as a quote which Kidsteam felt would make it more personable.

2) Tags

Tags are the central aspect of Geotagger and can be added by the various users of the system (see Fig. 3). Currently users can add a name, picture, description, GPS location, and a location description and/or categorical facets that can later be searched. Tags are the primary mechanism used to store observations made by users. In future iterations of the system, we envision allowing users to customize the data formats for tagged items, enabling the user to specify fields and various data types to be entered dynamically to meet the specific data needs for a project. Tags can only be directly edited or deleted by administrators or the author of the tag. While the current implementation of tags only supports limited data for each tag, it is the model and mechanism of sharing, commenting, and collaborating with friends and groups that are of particular significance in the current version of Geotagger.

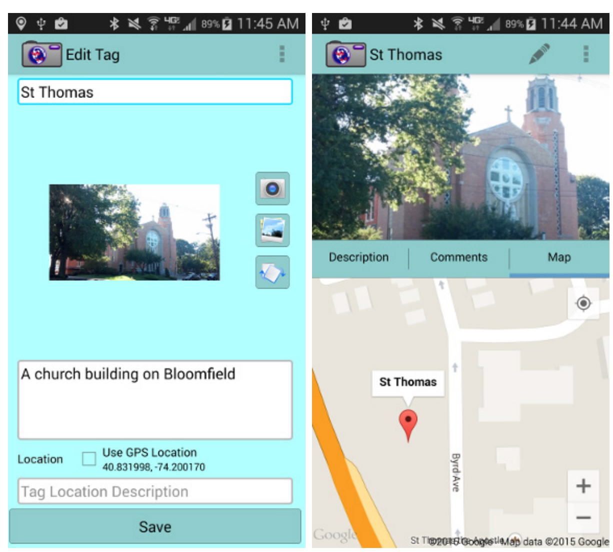

Figure 3. Tag views: *left*, adding/editing a tag; *right*, viewing a tag.

3) Comments

Comments allow users to have a conversation about a specific tag (see Fig. 4). Comments can only be deleted by the tag owner or comment author. In addition to text, comments can also include a picture so that further information can be shared via these two mechanisms. We are looking at adding other media options including audio and possibly video. Users can also implicitly comment without a textual entry by giving a star rating for a tag. The rating gets aggregated over time as users rank the tag. This is used to identify and prioritize more reputable or "interesting" tags.

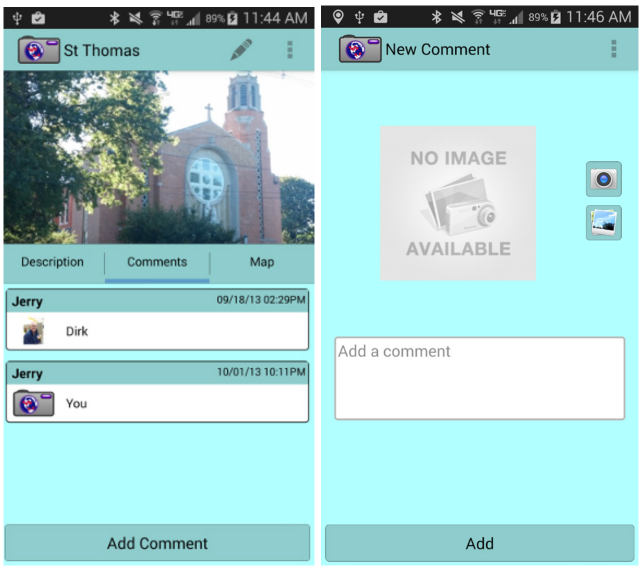

Figure 4. Tag comment views: *left*, viewing comments associated with a tag; *right*, adding comments to a tag.

4) Adventures

An Adventure is a set of tags accessible by individual users or groups of users (see Fig. 5). An example adventure is a group of locations that a teacher wants children to visit and discuss, such as an activity to visit different kinds of trees in a local park. Adventures have their own access controls so they can be configured for additional or limited functionalities. Anyone who is a part of an adventure could be granted the ability to add tags, or the ability to only view tags and comment on those tags. Adventure members can add brand new tags straight to an adventure, or they can choose from their existing tags and add those to the adventure. The basic tag access rules apply, but the adventure owner has the ability to remove any tags from the adventure, in order to keep the contributions on topic. Adventures can be created specifically for groups, thus granting all group members access. Again, this could functionality could be utilized in a class activity setting where a teacher has created an adventure and wants the full group of students to have access to this adventure (see subsection 6 for more about Groups).

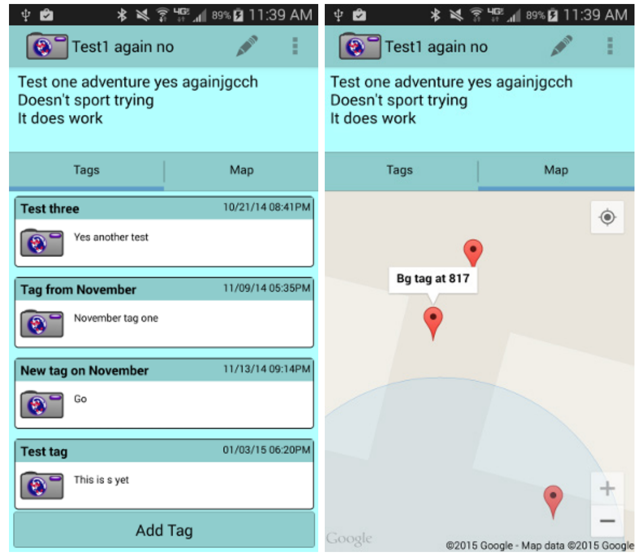

Figure 5. Adventures including the name, description and associated tags: *left*, shows the list of tags; *right*, a map view of the tags in the adventure.

5) Friends (Collaborators)

A unique aspect of this citizen science system is the ability of users to specify friends or collaborators. While collaborators is a more technical word, the original designers of Kidsteam felt that "friends" provided a more natural connection to people and the data that was being shared. Users can view and comment on friends' tags, thus enabling conversations about each tag amongst friends.

6) Groups

Groups allow people to be grouped together, such as around classes or interests (see Fig. 6). This allows all grouped users to be subscribed to tags and adventures (see sub section 6) and any correlating comments enabling collaboration among a community of users. Through groups users can share comments and tags within a specific group environment. Members of the same group are able to view the same tags and add new tags as well. User can add adventures to the groups, enabling users to manage larger numbers of tags and members within a group. Within groups users can manage tags, comments, and adventures among friends and collaborators. Group members are able to add new tags to the group, or they can choose from their existing pool of tags and add them to the group. The basic tag access rules apply, but only the group owner has the ability to remove any tags or adventures from the group. A specific example for using groups could be to set up a class fieldtrip. A teacher could add all class members to a group so each student would be able to see each other's tags, and their comments. Specific adventures could be added to the group so that the students could explore multiple adventures on their field trip and comment on the tags in those adventures all the while seeing the comments of their fellow group members allowing them to collaborate with one another.

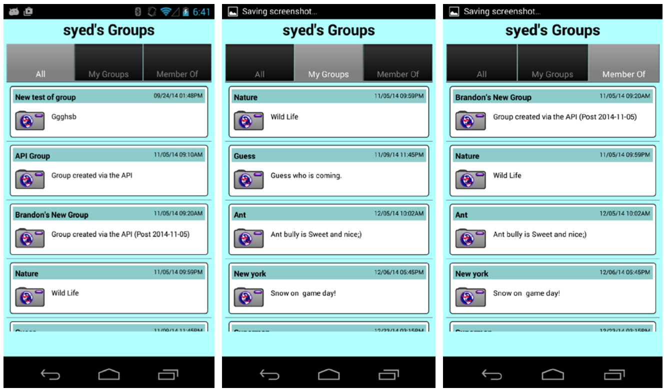

Figure 6. Viewing groups (*left*, all; *middle*, my groups, *right*, one I am a member of).

Groups and adventures differ in that groups are more general communities of users, such as New Jersey bird watchers. Adventures are specific sets of tags that may be created and deleted over time, such as a collection of sitings of rare spring birds in northern New Jersey.

7) *Categories*

Categories are a way to group – and in future iterations of Geotagger search – tags based on the content of the tag. Tags can optionally be given one or more categories, and categories can be nested, for example – a category for Cedar trees could be under the category of Evergreen trees. This categorizing or tagging of the tags with faceted textual categories can help organize, while likely prone to erroneous data entry by citizen scientists, will provide a wealth of information which may enable relating tags and adventures to one another in unique and interesting ways beyond the structured mechanisms of adventures.

8) *Requests*

A *request* is a general term we use for several pieces of functionality. Initially, requests were used only for friend requests – so that a user could request that they be connected to a friend/collaborator. More recently we have expanded the function of requests so they can be used as notifications as well. Being added to a group or adventure is only the initial attempt at extending the functionality of requests. The ultimate goal will be to notify users when their friends post new tags or comments and when groups and adventures receive new content (new members and new tags). This functionality will allow for expanded collaborative opportunities.

IV. Initial Feedback

The most recent round of feedback from the intergenerational design team, Kidsteam, was very positive. Kidsteam members continue to enjoy tagging items of interest and sharing them with their peers.

Geotagger was also deployed to introductory Ecology courses at two local universities. The professors of those courses defined set adventures that included tags of key locations where an ecological phenomona or example could be seen. The professors also included prompting questions in the tag descriptions in order to engage the students in thought and to spark dialog between the students as they visited each of the tags in the different adventures. The professors also requested that students add a comment with a picture of the group as they visited the site as proof they visited the site as well as to facilitate the identification of who was adding to the discussion. The response from the professors was very positive as it helped them guide the students to important aspects of the learning that they felt were important. Students (n=120) feedback was luke warm, using a seven point Likert scale from negative (1) to positive (7). The students indicated that they liked the the adventure mechanism (μ=4.83; σ=1.52), and thought that Geotagger allowed them to collaborate with their fellow students (μ=4.79; σ=1.61). Analysis of the open ended comments ranged from postive to “The fact that it had exact locations is pretty cool” to negative “Some functions did not work well such as the posting”. In analyzing these open-ended responses, we have were able to learn aspects that needed improvement, but many liked that it “brought the team together”.

V. Multiple Ways to Access

One of the major deficiencies of the prototype that was deployed with the class was that it was primarily for Android, and that it required an active data connection in order to communicate with the server both to retrieve information and post information. In the next section we discuss the progress we have made in addressing these issues, mainly enhancing access across other platforms and providing better caching of data for access and posting on the client side. For the latter, we have focused primarily on the Android client implementation of Geotagger.

A. *Cross-platform Design Considerations*

While Geotagger started out as an Android application, it has since grown to include web and iOS versions. Due to this, it is very important to maintain identical functionality among the various applications. Central to this is an API (application programming interface) so that all of the applications can provide the same functionality. Any tags added via the Android or iOS apps are also visible on the website, allowing users to choose which method of access suits them best.

In order to facilitate cross-platform collaboration, we needed to select a flexible model that could be consistently reproduced across the platforms. As such, while a NoSQL approach allows for more flexibility and is often used for Big Data applications, we selected a MySQL database implementation due to its increased reproducibility in mobile environments using the analog SQLite implementations that are available for the predominant mobile operating systems: Android and iOS. Currently, Geotagger uses a Symfony PHP framework design that uses MySQL as the backend, and serves data to the mobile clients (Android and iOS) as well as the web implementation (traditional and mobile web).

While the Android Geotagger client is more advanced than the iOS version, the iOS version has the basic functionality of being able to login to Geotagger and view adentures and tags, and make textual comments on the tags. Fig. 7 below shows a few screenshots from the iOS version of the app.

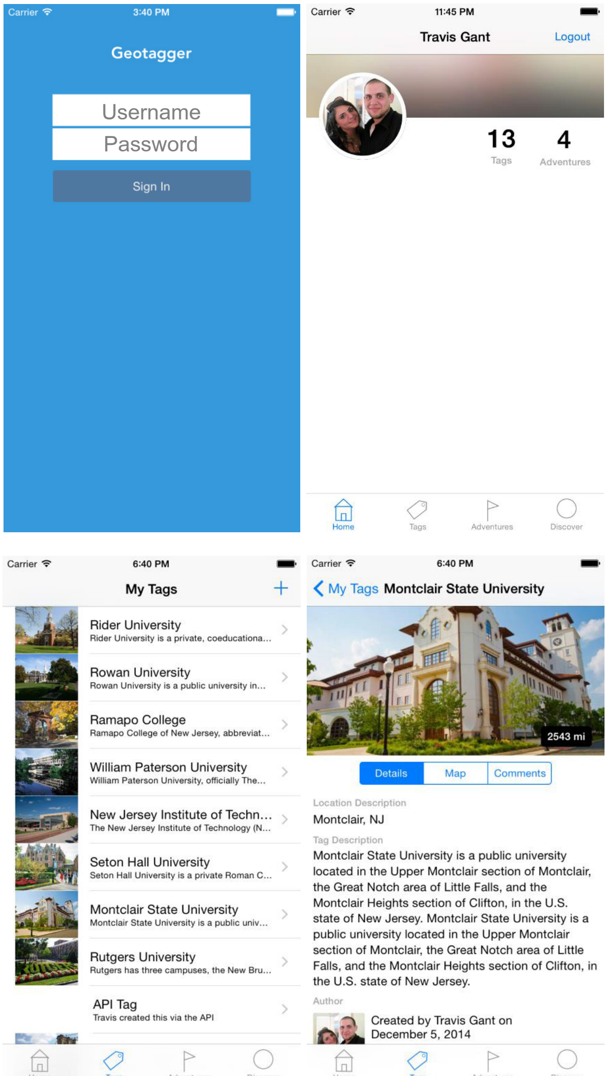

Figure 7. Screenshots of the iOS Geotagger client: *upper left*, login screen; *upper right*, user home view; *lower left*, list view of user's tags; *lower right*, tag view.

We believe this cross-platform approach is essential to not only improving increased accessibility to the website, but also allowing users to extend their experience with the locations, data, groups, users, and adventures within Geotagger as they access the Geotagger Platform before, during, and after their visit using their technology platform of choice.

B. *Off-line Usage via Caching*

As described earlier, an important aspect that needed to be improved was to provide for access to Geotagger data and allow user adding of data even in low connectivity settings. These additions have been made to the Android app client since the Ecology course deployment that was reported on in section IV.

The main goal of the Geotagger caching is the ability to provide reliable, fast, uninterrupted access to the data necessary to perform the desired Geotagger functionality. This capability is provided in such a way that does not modify the user's interaction with the Geotagger application. See Fig. 8 for a graphical overview of how the Android app accomodates data exchanges between the server, and in particular how the controller mechansim interacts wit the model (which abstracts the local and remote data repositories).

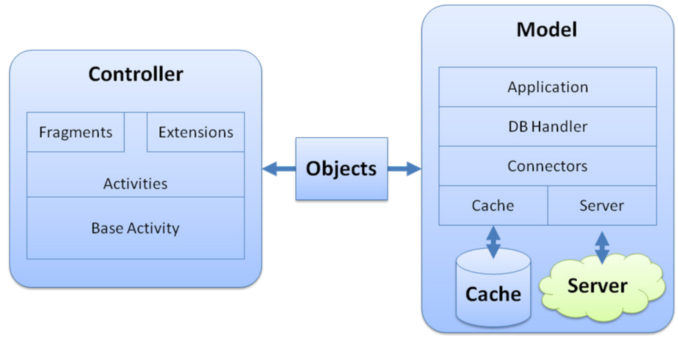

Figure 8. Controller model interface, illustrates how Android controller classes interact with the data model.

Improving the user's access to the application data via caching is key to improving the user's experience. The Geotagger cache will cache all types of data transacted between the mobile client and the server. As the user interacts with the server database, these records are cached on the mobile device. The cached records are kept as close to a mirror image of the server database records as possible. When the server database is not accessible then the cache database is used to access the desired data. In some cases the cache is used while the mobile device waits for a response from the server.

If the application cannot communicate with the server database for extended periods of time, then the actions to be applied to the Geotagger server database are also cached so that they can be performed on the server when the server is accessible again. Actions cached include all database operations, including adding records, deleting records, as well as uploading images. Retrieval actions are not cached, but the retrieval is performed on the data cached on the device. This is particularly important as the application is intended to support scientists (young and old) while they are out exploring their environment. Data connections are not reliable in several nature preserves making such a caching mechanism crucial for this platform. Data cached on the device can be removed if space is needed but cached actions should not be removed.

If conflicts arise due to a cached action being pushed to the server after it was originally created, we allow additions of data by normal users (e.g. adding a comment), but edits to a tag or an adventure will be resolved via a last-write policy. We are looking into enabling prioritizing edits based on the user's role, such as an owner of a tag or adventure given priority over a member of a group, irrespective of who wrote last.

The caching portion of the Geotagger software is part of a larger module of software that makes up the model component of the MVC model. All data operations, whether they are interactions with the server or the cache, are contained within this software module. A simple well-defined interface was implemented to interact with the data. This module can be easily extended or replaced if another data store is desired.

Adding caching capability to the Geotagger application had immediate positive results. The user sees improved response times when performing repetitive operations and seamless uninterrupted operation when roaming.

Interaction with the database server and the database cache is implemented using an abstracted database handler. The database handler(s) are started by the application component and run on multiple threads, independently from the activities. Activities are typically running on the main thread. Database and network operations need to be performed on background threads so that they do not adversely effect the GUI operation. The following image, Fig. 9, depicts the interaction between an activity and the database handler:

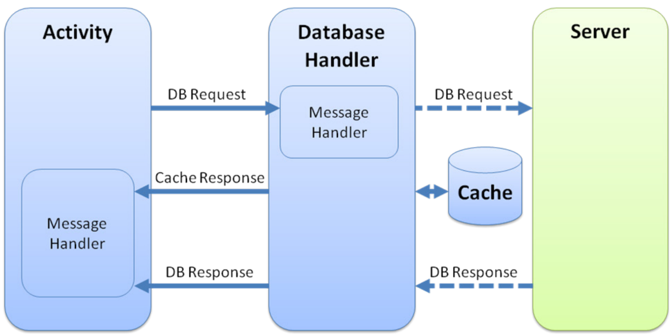

Figure 9. Component interaction between Android activities (screens) interact with the database handler which in turn interacts with the cache and server.

Interaction between the activities and the database handler is performed using message handlers. These message handler interfaces are implemented in the extended application class context. Again, this restructuring to support cached operations and data addresses one of the primary issues experienced by users during our initial piloting of the system. We will be deploying this again later this year in multiple Ecology courses and hope to see a positive impact in their experience using Geotagger.

VI. Conclusions & Future Work

In this paper, we presented Geotagger, a platform for environmental inquiry. While originally designed with and for children, it has now been used by college students as well. We presented the overal system design of Geotagger, shared initial feedback, and presented important developments that address the issues identified in our pilot study. Geotagger now works on multiple technological platforms including Android, iOS, and the web. We have also implemented a caching mechanism that enables interaction with the Geotagger system even in limited connectivity settings.

While many citizen science systems provide support for data collection *or* data analysis, our system provides support for *both* of these tasks with the addition of a social component where friends and groups can see the individual contributions. This de-anonymization of individual contributions and the structural support for building and maintaining an active social community provides motivation for contributing as well as an added measure of accountability. Through this social community, Geotagger enables continued *in situ* and *ex situ* conversations about tagged areas and items. We feel that such a system better supports collaborative and participatory environmental inquiry and enables users to leverage technology to better connect with one another and their environment.

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