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Android Smartphone Relevance to Military Weather Applications

by David Sauter

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14. ABSTRACT

Mobile computing devices can provide invaluable information to dismounted Soldiers on the battlefield when desktop or laptop computers are not readily available. This report summarizes the usefulness of Android operating system based smartphones for providing weather and weather effects information to the lower echelons. Both connected (to a remote computer) and standalone (not connected) applications (apps) are investigated.

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Android, mobile computing devices, weather effects

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Contents

List of Figures

1. Summary

Android Smartphone devices provide a mobile, powerful, versatile and relatively inexpensive computing platform that is potentially well suited for use by the military. Applications ("apps") are relatively easy to develop and deploy for tailored military use. An additional benefit to the military is that many of today's Soldiers are already familiar with the operation of these types of devices so little training is required. On the downside, screen sizes can be relatively small, so design of input and output screens must be carefully thought out. This report will discuss the Android Smartphone capabilities as relevant to the military for providing weather and weather impacts. An actual app that has been developed to provide heat stress guidance will be examined.

2. Introduction

There are situations when Soldiers do not have access to computer workstations or even laptops but still require intelligence regarding weather and weather impacts on their missions. Remote operations in Afghanistan or elsewhere would certainly qualify as such a situation. Under these circumstances, handheld computing devices may be able to provide critical information with only simple locally available inputs (negating the requirement for a network connection). While there are numerous mobile computing device platforms that could provide this information (e.g., personal digital assistants [PDAs], smartphones, Apple iPhones and iPod Touch devices, etc.), this report will focus on the Android operating system based smartphone. Earlier tech reports (*1*, *2*) specifically discuss PDA and iPhone iPod Touch capabilities and relevance.

In 2009, the U.S. Army Research Laboratory (ARL) Battlefield Environment Division was requested to support the Army sponsored All American Bowl (AAB) high technology exhibit in San Antonio, TX in January 2010. Although existing applications existed on the PDA (including the fielded Mobile Artillery application), it was felt that demonstrating an application on the fairly new and very popular Apple iPhone or iPod Touch would generate additional interest from both the military and the general public (the AAB exhibits were open to the public). Thus, the prototype Hot Environment Assessment Tool (HEAT), was designed and developed as a test application to host on the Apple iPod Touch. During the AAB, MG Justice (Research Development and Engineering Command [RDECOM] Commanding General) was given a demonstration of the HEAT application. He was impressed with the capability, reached into his pocket to retrieve his Android device, and asked if the application would run on it. Thus, the impetus later that year to acquire an Android based development phone and host the HEAT capability on it.

3. Development Environment

As Android applications are written in the Java programming language, it is fairly straightforward to develop them. At least one Integrated Development Environment (IDE) for a Windows based platform (Eclipse, Galileo release) includes the capability to download and install an Android development tool (ADT) plug-in. The ADT extends the capabilities of the IDE such that a coding text editor, debugger, compiler, graphical user interface (GUI) builder and Android Smartphone simulator are available. The simulator includes several versions of the Android operating system as well as various screen sizes, thus code can be developed and tested independent of an actual device. However, it is always best to test a “final” application on one or more devices, thus two Android Developer Smartphones were purchased for development and testing purposes. Unlike Apple iPod/iPhone application development, it is not necessary to purchase an annual user license. Instead, the apps can be uploaded to the smartphone via a Universal Serial Bus (USB) cable connected to the device. It is also possible to attach the application Android Package (“apk” file) to an email and then open email on the smartphone and directly install the app.

For development, two identical Android Developer 2 Smartphones were purchased. These phones came with a recent version of the Android operating system but without a subscriber identity module (SIM) card which is required for cell phone calls. The developer phones purchased include the following features:

- 3.17-inch diagonal touchscreen with 480 x 320 pixel resolution
- 2.2 x 0.6 x 4.5 inch size
- WiFi 802.11(b/g) and Bluetooth wireless communication
- Web browser
- 528 MHz processor
- micro Secure Digital (SD) memory slot
- 3 mega-pixel auto focus camera
- 192 megabyte (MB) random access memory (RAM); 512 MB FLASH memory
- Android version 1.6 operating system

Although the processor speed and amount of RAM available are certainly more than adequate for simple weather apps, there are considerations that must be accounted for when designing the software. The primary issue has to do with the screen size and the fact that all screen input is via a user's finger tips. Thus, in designing the GUI, care must be taken regarding the size of input fields. Also, output screens must not contain too much information or use too small of a font.

4. Considerations for Military Use

There are a number of advantages in developing and deploying apps on the Android based smartphones:

- *Low cost*. A new Android Dev Phone 2 can be purchased for less than $400. Compared to mobile devices that may be custom designed and developed for military operations, this is a very reasonable cost. Although these devices may not be as ruggedized as other devices currently in use by the military, it would seem that the low cost per unit justifies their use. Due to their light weight and size, they logistically have a small footprint and it seems likely that spares could be readily available.
- *Soldier familiarity*. It is likely that a significant percentage of Soldiers (especially new recruits) are familiar with the use of Android Smartphones and their operation. This translates into reduced training costs. Also, being familiar with the devices means that the Soldier is more likely to use the device and associated apps.
- *Relatively large storage space*. The Android Dev Phone 2 comes equipped with 512 MB of memory as well as a micro SD card memory slot which can accommodate an additional 32 gigabyte (GB) of memory. This amount of storage provides the capability to store large weather related gridded databases, satellite imagery, and even video. Gridded weather or weather effects databases can be used to provide high resolution (both spatially and temporally) input data required by some weather related apps.
- *Built-in rechargeable battery*. The Android Dev 2 Phone has a built-in lithium-ion battery that may be replaced by the user (unlike Apple iPod Touch devices), thus spare batteries can be carried. If there is only sporadic use of the device, a single charge can last for many days of operation.

On the other hand, there is at least one potential concern about the use of these devices:

- *Lack of secure and long range wireless communications*. The effective range for Bluetooth communications is on the order of several meters while Wi-Fi (in an open environment) may be several hundred meters to up to a few kilometers. This is obviously not sufficient for military communications back to a remote server which may be tens of (or more) kilometers away. Thus, receiving and transmitting critical information is a concern. This can be mitigated to some extent by developing apps that only require simple locally entered weather inputs (or possibly using one of the available high quality handheld weather sensors). Or, in the case of apps that require more complex input (e.g., high resolution gridded data), it may be possible to download an entire database of weather or weather effects information to the device while at the garrison or tactical operations center (TOC) for use during the day. Ideally, however, there will eventually be longer range secure wireless communication capabilities. Note that this is also a shortcoming of PDAs and Apple iPhones and iPod Touches without cellular service as well.

5. Prototype App

Attesting to the relative ease in learning the Android Smartphone development environment, a prototype HEAT was ported from an iPod Touch implementation in just a few months. This involved a complete rewrite of the GUI to the smartphone using the interface builder. While not difficult, it did require the majority of the time due to starting from scratch with different GUI elements (to a certain extent), and the "callbacks" to the computational algorithms. Additional effort was required related to learning the IDE and making minor modifications to the algorithms. There were no issues with switching from the smartphone simulator environment to the actual Android Dev Phone 2.

The HEAT app was initially developed to address the issue of heat stress injuries in the military. A recent study (*3*) indicated that annually, there are over 200 injuries requiring hospitalization from heat stress resulting in an average of almost 2 deaths. Hence, the rationale for developing such an app and making it available on a mobile device. Current plans are to initiate a validation study of the Wet Bulb Globe Temperature (WBGT) algorithm (*4*) as implemented in HEAT and then transition to the Army Marketplace for evaluation and transition to the Soldier (the WBGT parameter is critical in determining the HEAT output values). Following are the various input and output screens with a discussion of the various GUI elements and potential future enhancements.

5.1 Launch Screen

Figure 1 below is the initial screen that is displayed upon startup of the Android Smartphone. Each app is represented by an icon. Simply tapping the icon launches that application. The HEAT app is the second icon from the left in the third row from the top.

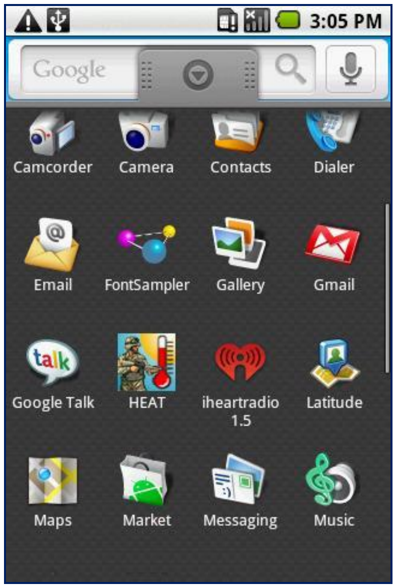

Figure 1. Initial startup screen.

5.2 SITE View

The first screen (known as a "view") of the app that is displayed upon tapping the app icon is the Site view. The HEAT app is a multi-view application with a tab bar (top of screen). The user enters the required inputs (default values always available) by tabbing through the various views and selecting the fields that he wishes to modify. Numeric inputs are checked for appropriate values with a pop up warning in the event that a value is out of range or invalid (e.g., null). Upon exit, default values are assigned to the values that were last entered via data persistence. These values are displayed to the user the next time the application is invoked. Text field inputs (latitude and longitude fields), labels ("Latitude", etc.), "Spinners" (latitude and longitude hemisphere fields), a DatePicker and TimePicker, and GUI elements are all used in this view. A picker functions by the user tapping the "+" or "–" selectors above and below the displayed values to increment or decrement the values. The date/time defaults to the current device time as initially set up by the user.

If the device had a GPS capability, the default altitude and longitude values could be automatically filled in.

5.3 MET View

The next view in the sequence of tabs is the MET (meteorological) view shown in figure 2 below. This view is used to input local weather conditions. As with the SITE view, this view consists of labels, text fields and a spinner (cloud type). Handheld weather sensors would typically be used in the field to determine the weather input values (wind speed, temperature and relative humidity) while a simple visual observation would provide the cloud input information. As the smartphone device utilized has a Bluetooth wireless capability, automated ingest of the weather data via remote connection to the sensor (also equipped with Bluetooth) will be investigated in the near future.

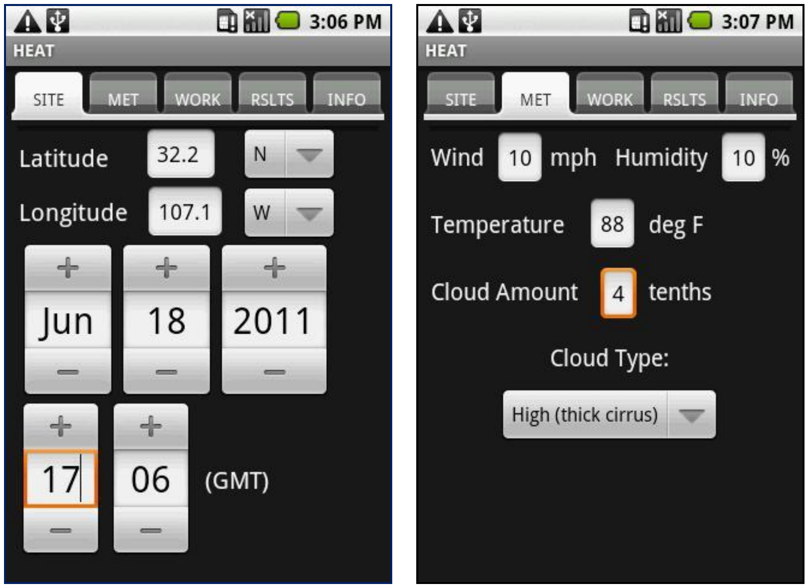

Figure 2. MET tab view.

5.4 WORK View

Next is the WORK view (figure 3), used to input the details about the Soldier's work rate and clothing configuration. Obviously the higher the work rate, the shorter the work/rest cycle and continuous work time will be, all other inputs being the same. Note that spinner controls are used for both of the inputs. Descriptions of the various work rates are available in the bottom half of the screen.

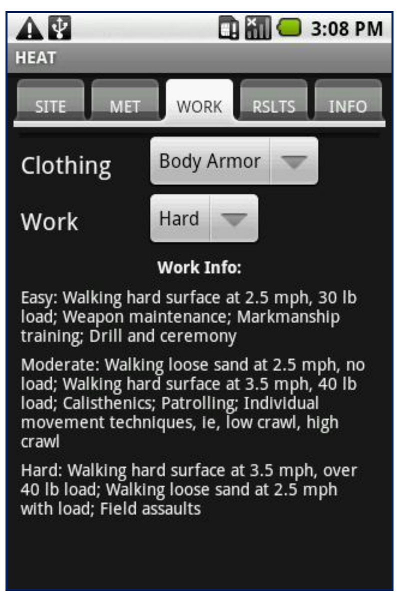

Figure 3. WORK view.

There is one notable difference between the Android and Apple tabbed view (as well as of Windows Mobile devices (e.g., personal digital assistants)). Instead of having a “More” entry to indicate additional views as with the Apple layout, the Android developer is limited to the number of tabs that will fit into the tabbed region at the top of the screen. Windows Mobile devices have right or left arrows to indicate additional choices. Both the Windows Mobile and Apple setups are more flexible than the Android implementation of tabs.

Adding GUI elements to the view(s) can be done either via dragging and dropping elements from the GUI pallet or by directly editing an xml file associated with each view. The xml file provides the user with more control of the size and location of the widgets than the drop and drag method. The xml file also specifies the internally used name of the widget(s) which are then referenced in the Java code to access and set variables (if any) associated with the widget (e.g., the numeric input elements). Having the GUI portion of an application independent from the computational algorithms, aids in the maintenance of the code. It also leads to reusability of the code.

5.5 RSLTS View

After completing input for all desired parameters, the user can then select the “RSLTS” tab to initiate the internal computations and display the results. This view contains the heat stress output parameters as seen in the figure 4 below. These values are computed based on the user selected inputs via the previous views. The computation and display is instantaneous. Output text fields in this view are read only, i.e., the user cannot modify the values by tapping those GUI elements. As shown, output variables are extensive and provide useful guidance to the user. The WBGT represents an estimate of the WBGT that is a legacy parameter that has been used by the Army for many years to estimate heat stress susceptibility.

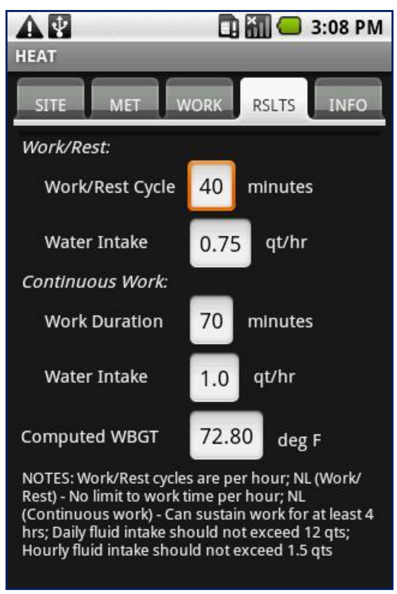

Figure 4. RSLTS view.

The work/rest cycle is based on a 60 min period while the continuous work value represents the maximum time that is advised for a one time work effort (after which the Soldier is given a sufficient time to fully recover before being assigned a work load again).

5.6 INFO View

The last view available is the info screen shown in figure 5. This provides a means to display background information, caveats, acknowledgements, etc., about the product. It is straightforward to add custom logos (e.g., the ARL logo in the top center) to any view by simply creating and saving your graphics as portable native graphics (.png) images and then inserting and positioning them via the GUI builder or specifications directly in the xml file as previously referenced.

Figure 5. INFO view.

6. Browser Capability

The smartphone used has a Web browser capability built in which will allow access to any number of browser applications over the internet, assuming there is an internet connection (e.g., via WiFi). Many developers/companies tailor their Web pages so that a specific configuration is automatically loaded for mobile devices and their smaller screen sizes. An internally developed browser application based on the Adobe Flex framework will be tested by ARL on the smartphone later in 2011 which will determine whether the device is compatible with the application.

Although no attempt was made to consume a Web service on the device, an internet search of the capability turned up a multitude of sites indicating that it is certainly possible to do so. Although Android does not appear to support web service calls directly, there are readily available third party solutions (e.g., kSOAP) that will allow Web services to be consumed by the Android device. Web services represent one of the latest and most widely accepted client-server technologies for running processes remotely or retrieving remote data. ARL is currently developing an enterprise application that will utilize Web services for the client-server interaction. Once complete, ARL will test and evaluate on the smartphone device.

7. Relational Database

Storing and retrieving data to/from large datasets is more efficient when utilizing relational databases as opposed to simple text files. More than one of Battlefield Environment Directorate's weather related applications rely on relational databases, thus, if it is desired to host any of them on an Android Smartphone, a relational database capability would be necessary. Fortunately, the Android Smartphones include the SQLlite relational database. Thus, in theory, large databases such as the Integrated Weather Effects Decision Aid (IWEDA) rules database and the Gridded Meteorological Database (GMDB) could be hosted and used. SQLite even supports the storage of binary large objects ('blobs') which the GMDB makes use of. The advantage of having this capability on the mobile device means that the IWEDA and/or GMDB could be synchronized locally on the Android Smartphone so remote wireless communications would not have to be relied upon. Then IWEDA, as well as any apps that require access to the GMDB (e.g., weather or weather impacts visualization, chem/bio diffusion models, etc.), could be run locally. It is desirable that development of a simple app to test and benchmark the database capabilities (e.g., blob create, read, update and delete, table creation and query, data entry, etc.) be undertaken at some point to evaluate the potential for weather app support. Certainly the storage capabilities (up to 32 GB on a microSD card) of the devices will support large relational databases.

8. Conclusion

A number of mobile computing devices have flooded the consumer market over the last decade. These include PDAs, Apple iPod and iPhone devices, and smartphones (e.g., running either the Windows Mobile, the Android operating system, or other). This has created an opportunity to leverage this technology for military advantage, particularly for dismounted Soldiers. A number of applications have been developed for one or more of these devices (one has been fielded). With increasing options and capabilities, the opportunity to provide even more advanced applications for the military exists and will continue to be exploited. In FY11, an Android based tablet device will be purchased and its capabilities evaluated by ARL.

9. References

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3. Carter, et al. Epidemiology of Hospitalizations and Deaths from Heat Illness in Soldiers. *Medicine & Science in Sports & Exercise* **2005**, *37* (8), 1338–1344.

4. Liljegren, et al. Modeling the Wet Bulb Globe Temperature Using Standard Meteorological Measurements. *Journal of Occupational and Environmental Hygiene* **2008**, 645–655.

List of Symbols, Abbreviations, and Acronyms

AAB	All American Bowl
ADT	Android development tool
apps	applications
ARL	U.S. Army Research Laboratory
GB	gigabyte
GMDB	Gridded Meteorological Database
GUI	graphical user interface
HEAT	Hot Environment Assessment Tool
IDE	Integrated Development Environment
IWEDA	Integrated Weather Effects Decision Aid
MB	megabyte
MET	meteorological
PDAs	personal digital assistants
RAM	random access memory
RDECOM	Research Development and Engineering Command
SD	Secure Digital
SIM	subscriber identity module
TOC	tactical operations center
USB	Universal Serial Bus
WBGT	Wet Bulb Globe Temperature

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