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# MOBILE PHONE APPLICATIONS IN THE WATER DOMAIN

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Abstract

This paper presents experiences with development of mobile phone demonstrator applications in the water domain in different application areas such as water distribution, hydrological data collection, flood management and water quality information dissemination. A brief overview of technologies for developing mobile phone applications is presented, with focus on those used in the demonstrated case studies: Short Message Services (SMS), Java Micro Edition (Java ME) and Android Operating System for smart phones (Android OS). SMS applications are presented for supporting operational management decisions in a water distribution system and for gathering and dissemination of user-recorded water level data for purposes of flood management. Java ME applications are demonstrated for designing advice serving systems for farmers in developing countries and urban flood forecasting and warning. Android OS smart phone applications are presented for dissemination of water quality information obtained from a catchment model and for monitored location-based water quality information of surface water bodies used for recreation and swimming. Some of the applications presented are integrated web–mobile phone applications, following the increasing trend of merging these two originally separate platforms into one that is universally accessible from different devices. The kinds of application areas suitable for harnessing the potential of mobile phone applications which coud be used in Uzbekistan together with advantages and disadvantages of different technologies.

Key words: Android, flood forecasting, flood warning, Java ME, mobile phone, SMS, water distribution, water quality

During the last couple of decades the spread of wireless communication technologies in general, and individual mobile phone usage in particular, has been noting short of revolutionary. The explosive growth of the wireless communication and mobile phone industry started in the early 1990s with the transition from analog to digital mobile phone networks, also known as a transition from 1st generation (1G) to 2nd generation (2G) of such networks. This coincided with the introduction of the Global System for Mobile communications (GSM) standard (which enabled mobile phone communication across different countries) and with rapid development of small size mobile phone devices-made possible by improvements in battery technologies. Short Message Services (SMS) were also introduced with 2G, as well as possibilities for transfer of small amounts of data with limited rates (10-15 kbps). These characteristics of 2G were already sufficient for very fast spread of this technology across the world. With the introduction of the so-called 3G mobile phone networks and devices (after couple of intermediate backward compatible generations), in the first decade of this century the growth was not only sustained but also exponentially increased. Much faster data transmission speeds (at least 200 kbps) and increasingly powerful and sophisticated mobile phone devices have led to spreading of this technology beyond imagination (Rysavy Research, 2010).

By the end of 2010 the number of global mobile phone subscriptions has surpassed 5.1 Billion, and majority of the networks have already been converted to 3G (ITU, 2011). Most of the mobile phone devices which are globally in use are not yet taking the full benefit of 3G capabilities, due to relatively high prices of latest devices (the so-called smart phones), but it can be forecasted that over the next 5-10 years this situation will change and many more users will in fact start benefiting from the high speed mobile broadband. The so-called 4G technology is already in development which will enable data transmission rates potentially up to 10 Mbps, which will certainly be followed by development of even more powerful and versatile mobile devices (Rysavy Research, 2010).

An Android application has been developed for accessing modelled results on water quantity and quality for the Dommel catchment located in the southern part of the Netherlands. The water quality problems in this catchment are associated with uncontrolled spatially distributed release of nutrients used for agricultural production and releases of untreated waste water from some municipalities. A catchment model was developed (for the period 1994/1995) with the Soil Water Assessment Tool (Gassman et al., 2007) for purposes of assessing the status of water quality in the catchment and investigation of possible measures for improvement, such as construction of waste water treatment plants or buffer strips.

Results from the developed model are deployed on a web server and via PHP server side application they are delivered to client applications deployed on Android phone. No special programming component development is required for this client- server interaction, except the standard web programming approach using HTTP protocol. Access to full fledged mapping interface is provided on Android phones, similar to the one available on Google Maps available in browsers. All standard functionalities are available, such as zooming, panning, different map views such as standard, satellite or hybrid, etc. Elements of the model are embedded in this interface for accessing spatially distributed model results. Time series results for different points in the catchment are delivered as images that are generated by PHP scripts on the fly, based on specified request (location, type of data requested, period etc). The components of the application are presented in Fig. 1.

This application served as initial exploration with the Android environment and there were no further tests beyond those for basic technical functionalities. Possible extensions can be in merging monitored with modeled data on water quality, possibly combined with provision of GPS-based targeted information to the mobile phone user, as exemplified by the application presented in the following section.

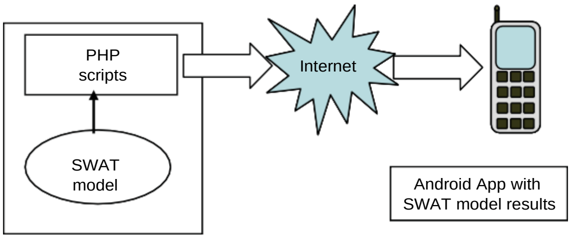


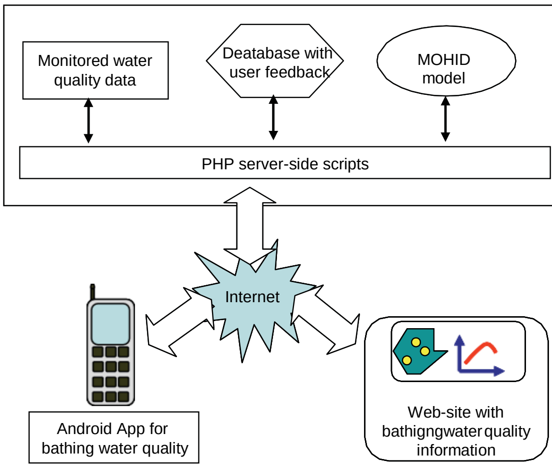

Fig. 1. Andriod App for obtaining SWAT model results via Internet

Bathing water quality dissemination via Android mobile phones

In the catchment area of Brabantse Delta (covering an area of around 1,700 km2), part of the Province of Noord Brabant, The Netherlands, numerous small lakes and ponds exist (around 40) that are used by residents and visitors for swimming and other recreational activities. Many individual citizens, as well as user groups, such as surfers, hikers and bikers, would benefit from location-based information on the status of water quality of these small lakes. In collaboration with the Province of Noord Brabant, which provided the necessary data, a native Android demonstrator application was developed for 15 locations of small lakes in the area. A map-based user interface, together with time series data of the measured water quality parameters was developed in a manner similar to the previous application.

The same information is also provided on a dedicated web site, via a browser application. From their phones citizens can also provide feedback on qualitative observations of water quality as textual information. This information is continuously updated on the web site. Registered staff,

responsible for field observations, can use the same applications for sending updated in situ measured water quality data, which are also visualized on the web site, with annotations that the data are sent by phone.
A model for forecasting water quality, developed by MOHID modelling system (Neves et al., 2002) was also developed for one lake, to exemplify the possibility of merging measured and forecasted data. One final feature of the application is embedding of all targeted locations as a layer within an augmented reality browser accessible via the phone camera. A third party augmented reality browser was used, named Layar (www.layar.com). This application uses the GPS and the phone compass for current location and orientation of the phone and presents geo-referenced points of interest (in this case, locations of lakes and points where water quality measurements are taken) within an intuitive user interface embedded in the natural landscape viewed through the phone camera. The water quality records for the points so visualized are




again accessible via the touch screen of the phone. The components of this integrated web–mobile phone applications are presented in Fig. 2.

Fig. 2. Integrated web- mobile phone application for bathing water quality information sharing

The application has been successfully tested in collaboration with data providers from The Province of Noord Brabant. The application is still being developed further, in preparation for future tests with citizens and user groups from the area. Further elaboration of the Android demonstrator applications, including the context within which they were developed is provided in Jonoski et al., (2010), and Jonoski and Almoradie (2010).

## Conclusions and outlook

The presented demonstrators cover diverse application areas, which is a clear indication of the wide applicability of mobile phones in the water domain.
Each example application is specific for the identified problem. Nevertheless, we can extract some generic characteristics of application areas which make them particularly suitable for implementation of mobile phone solutions. Firstly, mobile phones are truly personal devices (in some sense more personal than PCs), which means that any application that aims at knowledge delivery and sharing at the level of individual citizens, should consider this as a potential solution. It is at this level that such knowledge exchange matters most, as it addresses most immediate concerns of individuals in their own environment, and, can therefore have potentially the highest impact. Secondly, the fact that this device is available to a mobile user, particularly in combination with location-oriented features available on latest phones, enables very high level of customization of knowledge exchange to the current spatial local context of that user. To a varying extent, these two aspects are demonstrated by all presented examples in previous

sections. The location-oriented nature of the mobile phone can bring additional benefits in generating aggregated knowledge from information provided by many spatially distributed phone users, as particularly demonstrated by examples given in sections 3.2 and 5.2.

One clearly suitable category of application areas for mobile phone solutions is emergency management. We have demonstrated applications related to flood management (case 3.2-monitoring using SMS messages, and case 4.2-flood warnings via mobile phones) and water quality management (case 3.1-SMS messages for managing water distribution networks, and to some extent case 5.2-bathing water quality). These examples just point towards the possibilities of mobile phone solutions, and certainly more emergency situations, not only water-related, can utilize such solutions. Again, the possibilities of delivering fast, targeted, customized and location- specific information are key aspects that bring value to these applications. In addition, the large number of mobile phone offers interesting opportunities for using them as data collection devices that form large environmental monitoring networks, which could capture data at convenient temporal and spatial scales, as demonstrated in section 3.2 (monitoring using SMS messages).

Provision of advice services via mobile phones is another generic area with very high potential for future applications. This advice can be for leisure activities, as demonstrated in 5.2 (bathing water quality), but it may also be for important subsistence- related activities, as shown in 4.1 (advice services for local farmers). In fact, the potential impact of advice services that target individuals and communities in developing countries is very high, but such developments, especially in the water domain are yet to be realized. The required technologies are already available, and with suitable social and institutional arrangements (including financing), we believe that such applications can be developed with very high development benefits.

Finally, expert and citizens involvement in planning and design activities is also an area where mobile phone applications can bring benefits, just as computer applications. Here, the added value of the mobile phone application is the possibility to access on location invisible or not yet existing information. Applications from this domain were in fact not presented in this article, although some aspects of the examples 3.1 (SMS support for managing water distribution networks), 5.1 and 5.2 (bathing water quality), give possible directions. Similarly to water quality information, one can imagine mobile users on certain location accessing other invisible information, such as underground, soil, or vegetation conditions, or anything else related to a particular design problem. Together with proper visualization and the augmented reality possibilities, like those demonstrated with Layar, newly proposed designs for interventions in the environment can be ‘observed’ in-situ. Given all other capabilities of mobile phones discussed earlier, it is possible to imagine experts and citizens as stakeholders becoming engaged in collaborative planning and design processes. Here again, like in other domains, mobile phones can enable emergence and sustenance of communities, gathered around issues of common concern.

Considering the technologies used for development of the example applications (SMS, Java ME and Android OS), we believe that all of them will be available for application development in coming years, albeit each with some advantages and disadvantages. SMS messaging is the oldest technology, but as demonstrated by the examples, it can still provide very useful applications, both in the direction from mobile phone users to central computer applications and vice versa. The widespread availability and the simplicity of the solutions are the main advantage of this technology, whereas disadvantages are the absence of sophisticated mobile phone user interfaces and the fact that mobile phone numbers need to be used/registered for functioning of these applications.

The user interfaces of the presented Java ME applications are also not very rich, but the reason for that is the fact that they were developed about 5-6 years ago, when this technology was still in relatively early stages of development. With this technology much richer and more sophisticated user interfaces can nowadays be developed, that come close to those of latest smart phones. Main advantage of this technology is the fact that most existing mobile phones are Java-enabled (including some smart phones), and large number of potential users can be targeted, especially in developing countries, where sales of smart phones are slower. The disadvantage is that Java ME applications cannot be run on popular smartphone platforms. Apple's iOS does not support Java in any form. Android apps are programmed in Java but the Android libraries are incompatible with those of Java ME.

The future of mobile phone applications is, however, with smart phones, and the most popular platforms currently seem to be iOS and Android OS. In presented applications we have successfully tested only Android OS. The platform certainly offers many more features than those used in the example applications.

The competition among the mobile phone platforms is fierce, but the fact that Android becomes increasingly available on many more, different hardware devices, suggests that this platform may become most widespread in near future. The disadvantage of the platform is only in the fact that currently the number of Android phones is still smaller compared to other platforms.

It needs to be stressed, however, that other platforms, not tested in our examples, are also available and remain in competition. Symbian OS, Windows Phone 7 and RIM Blackberry are examples of such competing platforms. The fragmentation of the mobile phones platforms market is the main reason for development of mobile phone browser applications, which are portable across platforms. As discussed in section 2, however, native applications are still best in utilizing the versatile functionalities available on latest hardware devices.

In conclusion, even though the presented applications in this article cover diverse areas from the water domain, we think that they only point to the potential for mobile phone application development. Regardless of the development in mobile phone technologies and the outcomes from the competition in the market for mobile phone platforms, this technology is here to stay, with unprecedented potential for delivering content over mobile broadband networks. In the water domain, we are still at the beginning of harvesting the benefits offered by this technology, and we can certainly expect a future in which many more new applications will be developed.

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