More notspots than hotspots: strategies for undertaking networked learning in the real world

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Abstract

Much of the mobile learning literature implies that connectivity between devices can be taken for granted. This is not clearly not true with patchy network coverage and variable signal strength even in well developed urban areas. In this paper, we describe strategies devised for overcoming the challenges of variable connectivity quality to ensure mobile learning in authentic field locations and also bridging contexts (home, school, work). We consider three approaches: the use of Wi-Fi, 3G phone networks, and working locally with post-activity synchronisation. We conclude with recommendations for practitioners and researchers.

Keywords

Networking, Connectivity, Wi-Fi, 3G, Schools, Fieldwork.

1. INTRODUCTION

Mobile learning is often built on the assumption that the underlying technologies "…'afford' real-time information whenever and wherever learners need it" (Luo et al., 2010). This draws from Mark Weisners's vision of Ubiquitous Computing (1994) and the idea of tools that don't intrude on the users' consciousness, but let them focus on the task rather than the tools themselves. In networked learning, therefore, this includes the ability to connect to remote services, resources and users whenever and wherever the learner desires.

However, away from the research laboratory the reality is that networks are more likely to be characterised by patchy network coverage, fluctuating signal strength, deviations in positioning and variable data rates (Broll, Benford and Oppermann, 2006; Girardin et al., 2008) leading to poor quality service and variable levels of reliability. In urban areas, 'shadowing effects' can limit the quality of Wi-Fi and phone coverage, and 'urban canyons' of high buildings can affect the accuracy of GPS dependent devices. In rural areas, network coverage can be low to non-existent; for example Scotland has better 3G mobile phone coverage in the seas around the mainland (by area) than on the mainland itself[1]. It could be said there are more 'notspots' than radio 'hotspots' when supporting mobile learning in the real world.

Undertaking mobile learning in authentic environments therefore requires practitioners and researchers to explore a range of networking strategies. In this paper we describe our experiences in the TEL-TLRP funded Personal Inquiry (PI) project in the UK (www.pi-project.ac.uk). We have carried out seven trials over three years with 300 students (aged 12-15 years) and seven teachers, supporting inquiry-based learning that bridges different environments including a fieldwork component. We describe a range of strategies that we have employed to enable technology enhanced learning with mobile devices to be successfully carried out while moving between contexts (school, home, field sites). Using Asus Eee PC netbooks as the central computing device, we have taken three networking approaches: Wi-Fi, 3G phone networks, and local only (non-networked) with post-activity synchronisation. We will describe how each of these approaches has been applied in trials and summarise our learning outcomes and recommendations for other researchers and practitioners.

2. THE PROBLEM

We have developed the web based nQuire toolkit, a software tool that can be configured by researchers or teachers to provide a learning environment that helps students to plan and undertake their investigation (www.nquire.org.uk). Access to this tool throughout the investigation is essential for successful completion of the work. The key problem, therefore, was to find a means of achieving connectivity to the central server during their investigations in different settings: at school, at field locations, and at home and other unknown locations outside formal educational contexts.

Investigations were led by a teacher and undertaken by a number of students, working either individually, in groups, or as a class, and often moving between these groupings during the course of the investigation. It was important that students could access the software tool across different educational contexts during the investigation and could view other students' work at particular stages of the investigation (e.g. devising group or class hypotheses, sharing the task of collecting data, viewing others collected data to build analyses). The software architecture was therefore based on a central server model, where participants could access and upload to a central database and view other participants' data in real time.

[1] Ofcom 3G coverage maps, published 8 July 2009: http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/broadband/cellular/3g/maps/3gmaps/coverage_maps.pdf

To enable the students to experience a consistent interface throughout the investigation, the decision was made to build a web based tool, capable of display and operation on any device supporting a web browser. During the trials this meant school PCs in the classroom, Asus netbooks for fieldwork, and a variety of school and home PCs and netbooks for writing up.

3. THE APPROACH

In order to understand the challenge, we applied the following procedures when approaching each investigation:

Identify investigation requirements through discussion with school teachers and students. Research has been carried out throughout the project in collaboration with students and teachers. At the beginning of each investigation we worked with teachers, and as the investigation continued we interviewed students about how and where they were working and if our model of connectivity was adequate.

Site surveys where possible to identify network connectivity. On establishing locations where students would be undertaking their work, we would undertake site surveys where possible, using netbooks and 3G enabled phones to identify existing levels of network connectivity. Network connectivity at students' homes or locations they visited independently could not be feasibly surveyed.

Configuring equipment to utilise existing networks, and improve networks where possible. For locations where we had information about the existing networks (in school through discussion with IT staff and network surveying, and at participants' homes through interviews with students and teachers) we were able to configure equipment to utilise existing networks where possible. Where the network was unknown, the netbooks were set up to run 'locally', accessing a mirror of the remote network services running on the netbook itself. For inquiries on school premises, we were able to work with the school IT staff and extend their existing network to provide network coverage for places we wished to visit. A fallback strategy of working with no connection always has to be assumed and planned for.

Communicate the solutions and possible challenges to the participants and allow them to plan their work accordingly. Ubiquitous computing ideally expects perfect network connectivity; whereas the reality is that coverage is patchy, inconsistent, and of variable quality (Broll and Benford, 2005). Having identified the strategies for network connectivity and possible problems in each environment, the technical research team communicated this information to the participants. As Oulasvirta (2008) has noted, if participants know there is a limitation, they can evolve strategies to adapt to local circumstances and do not problematise it.

4. SOLUTIONS

We used a number of different networking configurations to support students' learning across the investigations and will now discuss examples of each configuration and the associated strategies.

4.1 802.11b/g wireless networking ('Wi-Fi')

802.11b/g standard wireless networking, commonly known as 'Wi-Fi', was considered as the default networking option wherever possible. It is a known and standard protocol, and the central device issued to all participants (the Asus Eee PC netbook) comes with built in Wi-Fi networking. Wi-Fi is familiar to students and teachers, and is already available in schools. Connecting to Wi-Fi on most networks comes at no cost.

This was the chosen option for a Year 8 'Microclimates' investigation, when students aged 12-13 walked around their school grounds visiting a number of locations and entering climatic readings into the software toolkit on the netbooks in groups. Each class went around the school with their teacher and collected data in groups of three or four students. The netbooks were set up so students would use them as thin clients with the web browser directed to the URI of a remote server. Data was directly uploaded in the field and made available immediately to all students and teachers.

The school has a wireless network covering most classrooms, and a site survey showed that a proportion of the grounds were also covered. The IT support staff at the school agreed to set up additional network access points to provide coverage to all the locations the students wished to visit. Technical trials proved critical as these revealed the authentication method the school used required the netbooks to be configured to help them reconnect as they moved between access points. One location, the multi-user games area, needed students to upload their data once they had left, as this had a metal mesh fence which blocked all Wi-Fi radio signals. This approach to connectivity worked well; 150 students in five classes carried out fieldwork and uploaded data successfully.

Two problems were encountered, and resolved. The first was very localised network fluctuations (a few metres across) resulting in poor connectivity in very specific locations. This was resolved by the researchers explaining to the students that we did not have perfect coverage, and they would need to move around to find a better connection. Students, made aware of the 'seams' in the connectivity were able to rationalise the challenge and overcome it, and articulated this to researchers as being similar to the challenge they had with finding a good signal for their own mobile phones. A second unexpected issue was the school encountering power cuts during the week of the trials, meaning that the school's networking equipment could not be powered or connected to the remote server elsewhere on the internet. However, in another project, Enabling Remote Activity, we have devised a portable, battery powered networking configuration which allows us to provide Wi-Fi connectivity between devices in the field (Gaved et al., 2008). With a member or staff carrying this equipment and a mirror of the remote server on a laptop in a backpack alongside the class, students could carry out their data collection by pointing their web browsers to the URI of this laptop. At the end of this session, the researchers synchronised the content from the local laptop database with the main remote server and in the next lesson students were able to continue with their data analysis, returning to the original remote server's URI.

4.2 3G mobile phone networks

3G mobile phone network connectivity is gradually becoming more commonly available across the UK. This offers high speed data connectivity via mobile phone networks, and computers can use this form of network connecting either via: 1) an onboard 3G radio (found in some netbooks, with a slot for a phone SIM card), 2) a USB 3G dongle, containing a phone SIM card attached to a computer, or 3) a 'MiFi' router, offering Wi-Fi connectivity to local devices up to approximately 20 metres and a backhaul connection to and from the internet via 3G.

We tested MiFi routers during an Open Day trial at the University of Nottingham. The investigation was a small version of the Microclimates trial described above, and focused on data collection of climate data around the university campus. Four groups of three students walked around the campus with one netbook per group, each connecting to a MiFi router carried by a member of the research team walking with them. Configuration of the netbooks was similar as to connecting to Wi-Fi, pointing the netbooks connection settings to the name ('SSID') of the local MiFi router. From here the MiFi router handled the connection.

The speed of connection was similar to that of Wi-Fi while downloading web pages and uploading images. Data transfer is charged by the telephone providers, however, so this may not be a suitable mode of connection on investigations where funds for such consumables cannot be released, particularly if there is an expectation of high quantities of data being uploaded and downloaded (e.g. video, audio, high resolution images). Connectivity varied from place to place and even in this urban area there were 'notspots' where no connectivity could be achieved. Furthermore connectivity varied from one service provider to another: we tested three phone providers' networks (Vodafone, 3, Orange) and found quality of service could vary radically between providers, potentially ranging from very good to no signal whatsoever. We also suspect that the the two models of MiFi router we used may have performed differently, though this will require further testing. 3G connectivity was highly variable inside buildings, and for data analysis we switched to the university's Wi-Fi network.

4.3 Services run locally on each machine and synchronised later

In many authentic fieldwork locations, particularly those which the teachers or researchers are unable to visit thoroughly before an investigation, the availability of network connectivity is an unknown. For these environments the safest option is to assume no network and plan for participants to work locally on their own devices and then allow for post-activity synchronisation of data.

This has the advantage of reliability, however it requires that the remote services can be run locally on each device, that no interaction is required between participants during this period, and that data can be synchronised with the remote central server before it is later required (e.g. before the students' next data analysis lesson in the classroom).

This approach was used for an investigation exploring Urban Heat Islands, which required students to walk across two towns, one in the morning, and the second in the afternoon collecting climate data and take supporting photographs. Two groups of students carried out the investigation on two concurrent days, requiring the support team of researchers to install the software on 12 netbooks. At the end of each day researchers had to synchronise data from each netbook and upload associated photographs to the remote central server, ready for the students to access their data either using the school's ICT suite, their own home computers or the netbooks operating as thin clients, and connecting to the now updated remote server.

This approach was reliable, and we have used it several times in situations where we cannot rely on the network connectivity or need a fallback position. However it requires that the mobile devices are capable of running all the services participants require from the remote server, that the support team has time to set up the software locally, and time to synchronise and upload data from the devices to the central remote server before the participants later need access to it. This is a very time consuming process, even if scripts to automate the tasks are available. Furthermore, while participants are operating in this mode, they are unable to share data with any of their colleagues, and the teachers are unable to view their progress.

5. SUMMARY

We have undertaken a range of strategies to ensure network connectivity for participants in the PI project over the last three years; Wi-Fi, 3G, and local services have each been tested and found to have benefits and disadvantages (see Table 1).

To undertake successful fieldwork trials with students and teachers, we have found it is important to recognise that network connectivity cannot be taken for granted and procedures to identify and best utilise existing services must be employed. Where possible we have extended existing network provision, but for locations where this is not possible or the sites are unknown, we have ensured mirrors of the remote services are provided on each student's netbook. This approach requires factoring in significant time for post-activity synchronisation of the data from these netbooks to the central server, which in itself is a risk, as this may not be possible for some investigations. 3G phone networks have proven to be a reasonable substitute for Wi-Fi networks, however their coverage is currently limited and usage incurs ongoing costs.

Table 1. Affordances and limitations of connectivity options

Type	*Affordances*	*Limitations*
Wi-Fi (802.11b/g)	Free to use High bandwidth Commonly deployed in schools	Needs access points set up
3G phone network	Expanding coverage Utilises cellphone networks	Limited coverage Costs for data transfer
Localising services (post-activity synchronisation)	No need for connectivity No bandwidth or data limits	No synchronous communications between participants Requires post-operation sychronisation

We have learnt however that users are able to plan strategies around variable connectivity. Familiar with the inconsistencies of mobile phone connectivity, students and teachers are able to recognize that mobile learning may also suffer the same variability of service. By presenting this issue, and making it plain, participants do not problematise it but rather accept it as a limitation of the system and work around it, often appropriating the system in unforeseen ways in the process.

6. CONCLUSION

Despite the claims of mobile learning optimists, connectivity cannot be assured when undertaking investigations in authentic fieldwork locations. The current real world network infrastructure is "messy", and "regularly mutates" (Girardin et al. 2008). Practitioners and researchers should prepare a number of strategies and be ready to consider different networking solutions for different environments, including always having a fallback to run services on each participant's device where possible. The networking environment is likely to change in the future, and some of the current challenges are likely to be overcome. We can expect better and cheaper 3G phone coverage, leading to possibly a decreasing emphasis on the need to set up Wi-Fi networks. Higher speed wireless networking technologies can also be expected to appear in the near future. However new challenges are likely to arise, such as higher contention ratios (large numbers of people trying to share the same network coverage), and it is likely that areas with poorer network infrastructures will continue to lag behind (e.g. rural areas and those with lower population densities) so the need to adopt multiple strategies to ensure successful networked learning while in authentic fieldwork environments is likely to be of importance for the foreseeable future.

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