A GENERAL FRAMEWORK FOR CHARACTERIZING THE BEHAVIOR OF MOBILE LEARNERS

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ABSTRACT

The purpose of this article is to provide an efficient approach to more understand and analyze learners' behavior in wireless environment. In such situation, students may move from a location to another one carrying mobile devices (laptop, PDA, 3G phone or card). The comprehension of their mobility seems crucial in order to better develop, deploy, and manage future wireless networks in a training context. For this reason, we propose a general approach to analyze the learners' mobility patterns by the integration of statically (e.g.: infrastructure, Access Points position) and dynamically (e.g.: users' itineraries, accessed data) extracted data in unique dashboard interface. The developed program makes it possible to track real users by providing, in addition to their graph of mobility, various graphics on their space-time behaviors. Moreover, it allows the comparison of behaviors evolution over several periods of time.

KEY WORDS

Mobile learning, wireless analysis, mobility.

1. INTRODUCTION

Mobile Learning is the use of mobile or wireless devices for learning on the move [CTZ05]. Indeed, it reduces the space and time restrictions and gives to learners more autonomy in acquisition of knowledge. So they can work both closely together but also discussing with their teachers when they are geographically separated. In the last decade, the exponential growth of mobile technology has accompanied and, in certain cases, reinforced the nomadism of learners by offering various very powerful handheld devices (smart-phone, PDA-phone, ...), an advanced multi-modal mobility (roaming between several wired and wireless networks) and different functionalities such as text and voice messaging. This progress towards increasing mobile accessibility has also brought new challenges for wireless (networks and applications) designers and managers. For example, the question of learners' localization, which was most of the time known with fixed technology (such as desktop computerized), becomes an unknown factor in situation of mobility. Therefore, contrary to the fixed communication, which is especially a technical problem, the mobile learning must take into account physical data. This will provide location-based information which can be used to improve application software, operating systems and network infrastructures which are intended for more conventional wireless environments. For example, it is not enough that learners have mobile devices to be joinable; they must be, for example, in a coverage area.

From other hand, there is another emerged aspect which is the connection between learning, work and leisure. An article appeared in Freedom magazine [FRE05] outlines "Leisure is only a problem in a society in which education is aimed at adjusting the individual to society instead of bringing out and developing the potentialities in him...". So in mobile environment, this aspect has a great relation with learners' mobility by the fact that they can join and be joined wherever and whenever by any one of their classmates and acquaintances. Also, they can use their devices for entertainments.

This link between the physical mobility and the altered exchanges tends to show a certain space coherence of the communication act. This coherence worth a careful study to more understand learners' behaviors, but also to consider new services related to mobile learning.

In this context, we have developed a model which allows us to visualize tendencies in the itineraries followed by the learners in a wireless network. This tool also makes it possible to obtain synthetic indicators making it easy to extract conclusions on usage patterns. For example, for an identical frequency of movements among access points, some users move at more significant distances, whereas others do it at short distances. This difference can be observed when we notice that some limited movements are done around many access points whereas in certain cases the same number of movements is done around very few ones.

Our tool is tested on short distance wireless technology which is 802.11 wireless LAN (WiFi) but we can use it for other wireless systems like long distance wireless technologies such as GPRS, 3G, and Satellite systems. Because Access Points (APs) are defined by their coordinates and the background can be dynamically changed.

This article shows these various points by locating them in the context of research. We start by giving a progress report on the work completed related to mobile learning and users mobility. Then, we describe our tool before finishing with some elements of discussion and prospects.

2. RELATED WORKS

Over the last decades, there have been a lot of studies and researches on mobile learning. The majority of theme deals mainly with the efficiency and effectiveness of learning processes and try to understand learning models which can help obtaining better learning processes. Other categories of researches look for services which can be useful for mobile devices and which affect the wide diffusion of mobile learning.

For example, Chang and Sheu [CHA02] try to develop a wireless platform for building an Ad Hoc classroom and eShoolbag systems. Their idea is to help teacher and students to create a classroom and take lesson anytime and anywhere. While Seppälä and Alamäki show experiences how mobile technology was used in teacher training in [SEP02]. In the project WELCOME (Wireless E-Learning and Communication Environment) at the University of Regensburg, Lehner et al outlines the contribution and limits of mobile devices in mobile education [LEH02].

All these previous works deal with the enhancement and the effects of mobile technologies in the educational area. Until now, there are limited studies on how the learners take advantage of these systems and how they behave in such situation. We believe that the study of learners' behavior is essential to more develop these new educational techniques in the future. It's the reason why we have developed the current tool which allows the learners displacements visualization and analysis. But before we begin its presentation, let's talk firstly about the completed works in this area.

Recently, several researches on users' mobility have been done on several wireless networks in order to understand usage patterns and performance. Kotz and Essien [KOT02] studied a university campus used by 1706 students throughout 11 weeks. Their study deals with the terminals activities, users' mobility and traffic characteristics (the most used protocols). Lay et al. [LAI98] characterized the uses of mobility by carrying out a study limited of 8 laptops during 8 days. This study focused on the number of times that a laptop moves from a fixed network to a mobile one. In another article, Tang and Baker [TAN00] present a 7 weeks trace study on a wireless metropolitan network composed of 177 access points with approximately 1366 users. In another study, Balachandran et al. [BAL02] examine the behavior of mobile users during the three days of an international conference (SIGCOM of ACM). The objective was to characterize the behavior of these users to facilitate future planning and deployments (see also [BLZ03]).

To take into account and to synthesize the results of these studies, researchers developed visualization tools which facilitate the interpretation of the large volume of traces obtained. These tools can be classified in 2 main categories. Firstly, cartographic applications associated with real or simulated

moves like NAM (Network AniMator) [NAM05] and metrological applications which rather give quantitative syntheses.

Each one of these applications allows the visualization of a particular sub-problem of comprehension under a specific angle. It is difficult to find an application which gathers up the visualization of users movements (in an individual or in group way) by accompanying them with descriptive statistics. The aim of our work is to improve the understanding of learners behavior in wireless environment by giving a realistic visualization tool which allows the integration of statically (e.g.: infrastructure, APs position) and dynamically (e.g.: users mobility, accessed data) extracted data.

3. DESCRIPTION OF CONTEXT

The tool presented here is composed of two main modules: first one for traces extraction and second one for visualization and analysis. The architecture of the whole is given in figure 1. The extraction and the management of the traces are done in relation to a data base where the Syslog events generated by the WiFi APs are stored. These messages indicate that a user is associated or dissociated from an AP or that he roamed towards another one. The following sections present these two modules with more details.

3.1. Trace collection

The experimentation proceeded from August 2004 to February 2005. We have tested the tool by studying about 300 employees and trainees of a company. The majority uses individual wireless devices (such as laptops and PDA). These users reach on 17 WiFi APs distributed between the ground floor and the two floors of a building which represents a surface on the ground of approximately 3000 m². The orientation of the building makes it possible for the users to move in a very easy way from any AP towards almost all the others.

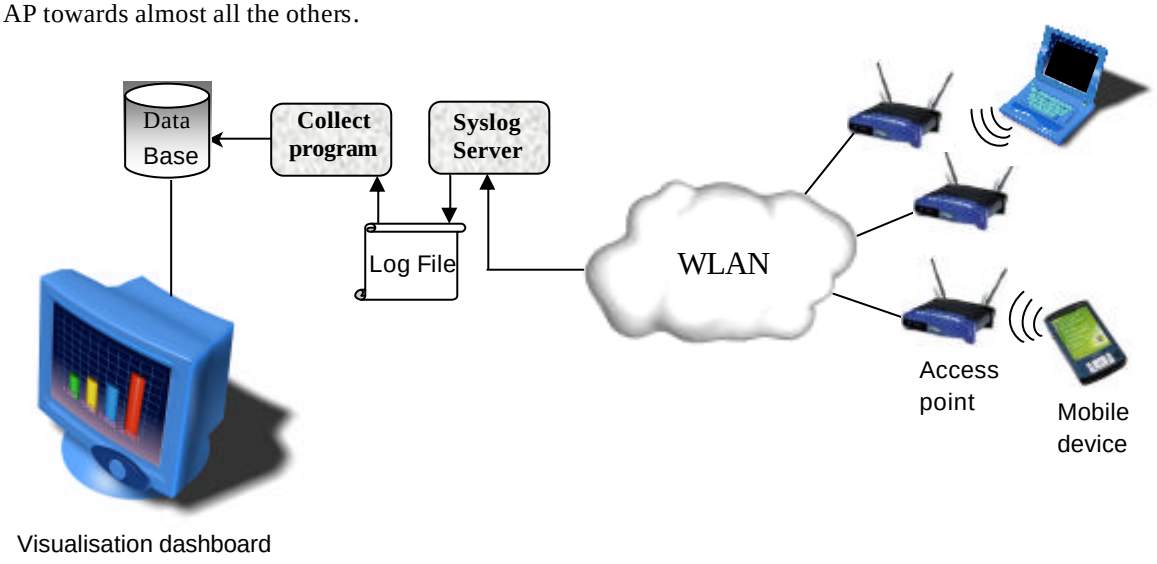

Figure 1. Architecture and context.

Taking into account the fact that users have personal devices, we identify them by their MAC address. This also allows preserving anonymity because we do not exploit the links between the MAC address and the users' identity. Therefore, the Syslog messages which we obtain contain the MAC address of the Access Point, the MAC address of the user terminal, the day, the date and the hour and of course the type of message. This last one can be:

ASSOCI: Sent during the association of a wireless terminal on an AP.
DIASSOC: Sent when a terminal leaves the AP to connect on another one or leaves the network definitively.

ROAMED: This message is generated when a user leaves an AP to join another one. Generally it is generated immediately after DIASSOC. It contains, moreover, the MAC address of the new AP.

3.2. The analysis tool description

This analysis tool makes it possible to visualize individual learners' routes or routes of a group of them, and gives at the same time statistical results related to these movements. The tool is made up of four main parts:

The first part (part A in the figure 2) is intended for the selection of the context of study and makes it possible to choose the WiFi APs which we want to integrate into the analysis, the group of learners (a group of classmates for example), as well as the period of visualization. This variety of choice authorizes various visions of the practices. Initially a microscopic approach of a learners behavior (or a particular community of them) for a given period, and a comparison between the others results over a more or less limited period. It is also possible to have a more macroscopic view clarifying the main tendencies of movements. In our case, we highlighted the privileged routes for all the participants between certain APs in a relatively limited number, as well as regroupings of particular users in some localization (figures 3 and 4).

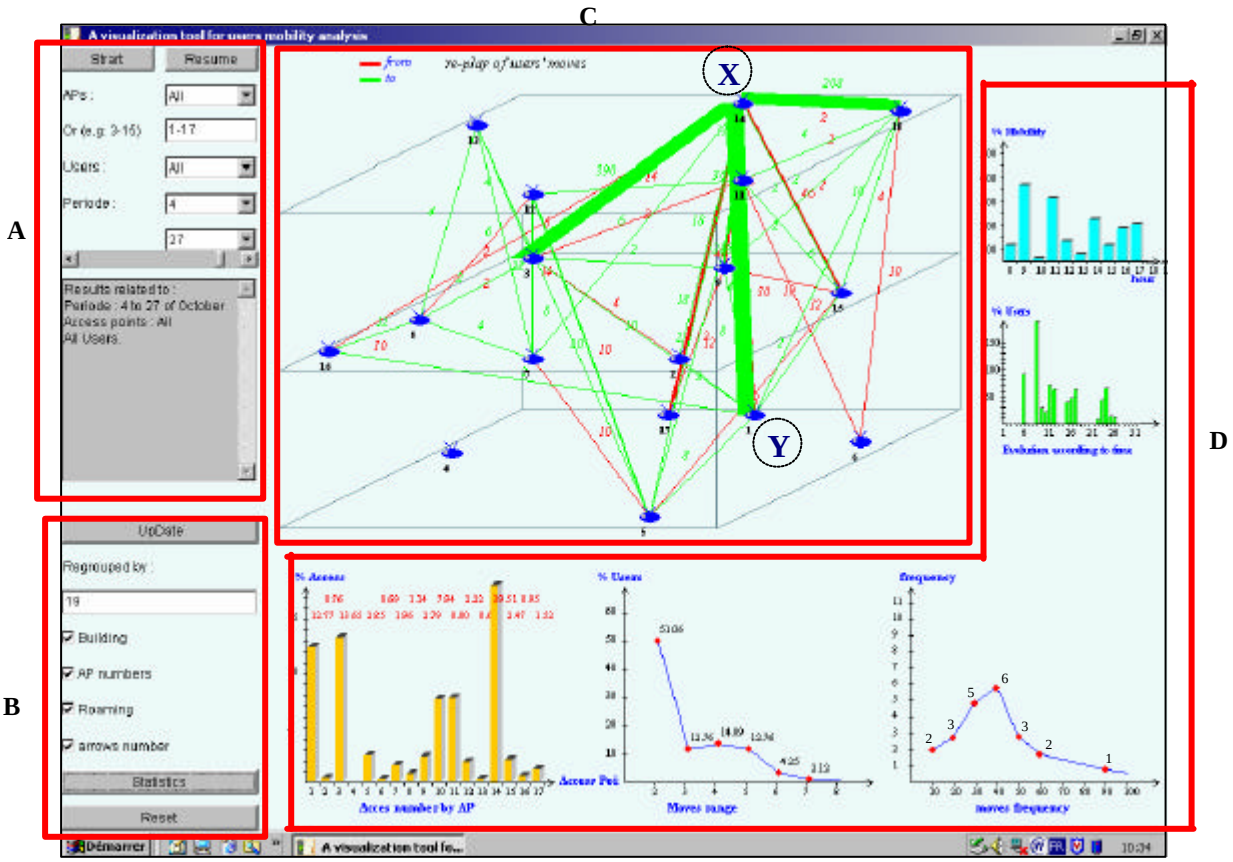

Figure 2. The tool's user interface

The second one (part B in figure 2) allows one to configure the visualization of the routes, i.e. the illustrating or not of the roaming between APs, counting the movements and displaying of APs numbers with or without the building... It is a simple manner to make clear the visualization of movements for example by removing the APs numbers, the drawing of the building or the roaming between APs. For example in figure 4 we can see details on the roaming as well as information on the APs and the frequency of mobility, whereas in the figure 3 we focus on the graph in order to better clarify the concentration zones and the most common paths.

The third part (part C – figure 2) allows redrawing the real routes in an accelerated manner, which normally gives a dynamic vision of mobility tendencies. This approach makes it possible to highlight behaviors which we cannot or are very difficult to distinguish on a static layout. It is the case in

particular of the evolution of a collective behavior (ways often attended for some period of the month or the week). The placement of the APs on the diagram corresponds to their real co-ordinates. Each terminal is defined by three parameters (X, Y, Z): Z represents the floor in which the terminal is located whereas X and Y represent its localization on this floor. What makes it possible to adapt the graph according to the modifications of APs or the deployment of new ones.

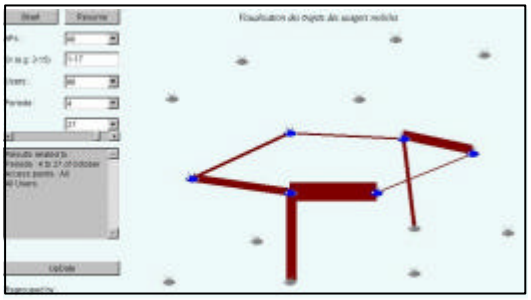

Figure 3. Concentration areas

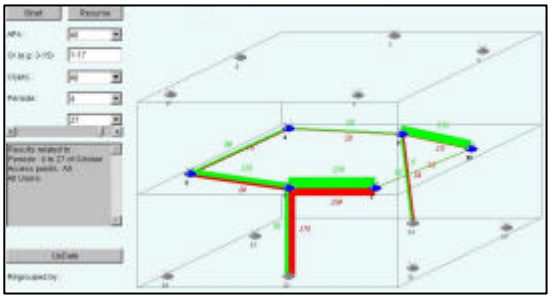

Figure 4. Roaming between AP

Finally the fourth (part D – figure 2) displays some diagrams and statistics related to the analyzed period. The diagrams are updated automatically when the elements represented change (coupling with the dynamic routes described previously). It is possible to stop the progress of the Re-play at any moment and compare the statistics with other periods (just start on two screens in parallel). The majority of the graphs are calculated according to access or users percentages, which give a clearer vision and allows a fast interpretation of the results. For example, the zone of concentration which we see between X and Y (figure 2), can be explained when we see that 46% of access are completed via the AP X and that the majority of accesses comes from the AP Y.

4. CONCLUSION AND PROSPECTS

Previous research in mobile learning deals specially with technological and pedagogical problems. It seems important to us to highlight a particular problem related to this subject which is the learners' behavior in the wireless environment.

For that reason, we developed a tool destined specially for the analysis of the communication between individuals in a context of mobility. We insisted on the fact that an objective analysis required a various elements which should be available together in the shape of a dashboard. The interest of this approach is to facilitate comparison of several views of learners behavior (isolated or in groups, temporal dynamics, movement areas, etc).

We have showed some briefs results of preliminary analyses which we could carry out, but it is especially the description of the tool and its context for use which we wish to develop here.

In the continuation of our work, we will think about the use of this tool on a more significant population and over a longer period. Our goal is to get more detailed information on the link between the mobility routes and other forms of activities (meeting of learners, exchange and access to the data, etc).

REFERENCES

[BLZ03] M. Balazinska and P. Castro, 2003. *Characterizing mobility and network usage in a corporate wireless local-area network*. In Proceedings of ACM MobiSys. pages 303–316, San Francisco.

[BAL02] A. Balachandran et al, 2002. *Characterizing user behavior and network performance in a public wireless LAN*. In ACM Sigmetrics, pages 195 – 205, Marina Del Rey, California.

[BEC95] R. Becker et al, 1995. *Visualizing Network Data*, In IEEE Transactions on Visualization and Computer Graphics, 1(1), pages 16-28.

[BEN97] B. J. Bennington and C. R. Bartel, 1997. *Wireless Andrew: Experience building a high speed, campus-wide wireless data network*. In ACM Mobicom, pages 55–65.
[BOS00] R. Bosch et al, 2000. *Rivet: A Flexible Computer Systems Visualization Environment*. Computer Graphics, p. 68-73.
[BYE03] S. Byers and D. Kormann, 2003. *802.11b Access point mapping*. Communications of the ACM, pages 41-46.
[CAM02] T. Camp et al, 2002. *A survey of mobility models for ad hoc network research*. Wireless Communications and Mobile Computing (WCMC), pages 483–502.
[CAR99] S.K. Card et al, 1999. *Readings in Information Visualization*, eds. Morgan Kaufmann.
[CHA02] C. Chang, J. Sheu, 2002. *Design and Implementation of Ad Hoc Classroom and eSchoolbag Systems for Ubiquitous Learning*. Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'02).
[CLV88] W. S. Cleveland. R. McGill, 1988. *Dynamic Graphics For Statistics*, eds Wadsworth & Brooks.
[CTZ05] m-Learning and MOBIleam Projects, http://www.learningcitizen.net/mobile_learning.shtml
[FLI 97] P. FLICHY, 1997. *Une histoire de la communication moderne*, La découverte.
[FRE05] Freedom magazine web site, http://www.freedommag.org/
[GIS05] GIS and Mapping software, 2005. http://www.esri.com/software/arcgis/
[GPS05] GpsMap : GPS navigation software, http://www.kraftvoll.at/software/index.shtml
[ITT04] The ITTC web site (Information and Telecommunication Technology Center) of the University of Kansas, 2004. www.ittc.ku.edu
[JAR03] A. Jardosh et al, 2003. *Towards realistic mobility models for mobile ad hoc networks*. In ACM MobiCom, pages 217–229.
[KIS05] Kismet web site http://www.kismetwireless.net/
[KOT02] D. Kotz and K. Essien, 2002. *Analysis of a campus-wide wireless network*. In ACM MobiCom.
[LAI98] K. Lai et al, 1998. *Experiences with a mobile testbed*. In Worldwide Computing and its Applications, number 1368 in LNCS, pages 222–237.
[LEH02] F. Lehner and H. Nösekabel, 2002. The Role of Mobile Devices in E-Learning - First Experiences with a Wireless E-Learning Environment. WMTE 2002: 103-106.
[LEN03] C. Lentz, 2003. *802.11b Wireless Network Visualization and Radiowave Propagation Modeling*. Technical Report, Dartmouth College, Computer Science.
[MAP04] Mappoint web site http://www.microsoft.com/mappoint/default.mspx
[MCN03] M. McNett and G. M. Voelker, 2003. *Access and mobility of wireless PDA users*, ACM SIGMOBILE Mobile Computing and Communications, Pages 55 – 57.
[MPC05] Mapcenter site, 2005. http://gps.chrisb.org/
[NAM05] Network Animator (ns2) web site, 2005. http://www.isi.edu/nsnam/nam/
[NET05] NetStumbler web site, 2005. http://www.netstumbler.com/
[NS05] The network simulator: ns-2, 2005. http://www.isi.edu/nsnam/ns/
[TAN00] D. Tang and M. Baker, 2000. *Analysis of a local area wireless network*. In ACM MobiCom 2000, pages 1-10.
[TAN99] D. Tang and M. Baker, 1999. *Analysis of a metropolitan area wireless network*. In ACM MobiCom, pages 13–23.
[SEP02] P. Seppala, 2002. Mobile learning and Mobility in Teacher Training, Proc. of IEEE InternationalWorkshop on Wireless and Mobile Technologies in Education(WMTE 2002),(p.130-135),Vaxjo,Sweden,
[WAR05] Wardrive software, 2005. http://eyecannon.com/wardrive.html
[YOO03] J. Yoon et al. *Random waypoint considered harmful*. In IEEE InfoCom, pages 1312–1321, 2003.