Indoor localization during installations using Wi-Fi

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ABSTRACT

The position of a participant during an installation is a valuable data. One may want to start some sample when someone cross a line or stop the music automatically whenever there is nobody inside the main area. GPS is a good solution for localization, but it usually loses its capabilities inside buildings. This paper discuss the use of Wi-Fi signal strength during an installation as an alternative to GPS.

Author Keywords

Mobile, Wi-Fi, Indoor localization, Installation

ACM Classification

C.2.6 [Computer Systems Organization] Computer - Communication Networks — Internetworking, C.5.3 [Computer Systems Organization] Computer System Implementation — Microcomputers, J.5 [Computer Applications] Arts and Humanities — Performing arts (e.g., dance, music)

1. INTRODUCTION

Lots of installations have permitted interaction through web sites, touch screen, camera, sensors, and other actuators, and used physical interaction or wireless technologies otherwise. Some works have already evaluated the use of Wi-Fi on indoor localization with robots [2, 4] and had good results with 1 meter of precision. One can consider that Wi-Fi interface is more suitable for indoor installations than GPS, because Wi-Fi interface searches antennas without draining the battery while GPS has a high power consumption and is not a reliable source of position in this case due to some constraints on indoor environments.

Every time a device searches for available networks, the user receives a list with level, frequency, SSID, BSSID, and security capabilities of all networks that were found. The level is a value measured in dBm and represents the signal strength of the network depending on the power of the transmission antenna, but it also relies on the distance between wireless devices. The Wi-Fi level varies normally between -100 dBm to 0dBm when the device is getting near a transceiver antenna.

The Wi-Fi network level has some stability problems including interferences caused by other wireless networks on the same channel. Mobile devices can have different protocols for communication like 802.11a/b/g/n and also 802.11ac, the newest one at the time of this paper. If the mobile device uses a different protocol from a wireless router, these devices won't find each other and cannot establish a communication. The devices need to search wireless networks using many channels and protocols, and the routers need to transmit data through many protocols in order to be compatible with a selection of devices. These facts imply that some devices will not find all the networks available all the time.

2. EVALUATION OF WI-FI QUALITY

Our evaluation was made with Sensors2PD, a mobile application developed by the authors to load Pure Data (PD) patches on Android devices and send sensor information to patch receivers on real-time [3]. You just need to create PD patches with receivers for sensors and use the application to load the patches.

We used the Wi-Fi SSID sensor and created a patch to use the level value as input on a receiver. An example of a patch used on our tests is presented on the Figure 1. In this example, every time the device receives an update about the networks available, the level of the network *eduroam* is sent to the receiver [r sensorW-eduroam]. As the level is always negative, its value is inverted before being evaluated as a MIDI note and converted to a frequency. In order to evaluate indoor localization with Wi-Fi, we set up some mobile devices as hotspots with different SSID and created PD patches with the Wi-Fi level attached to some the volume sliders. The hotspots were positioned with a minimum distance of 10m from each other and the decided to walk around with one mobile device and record the interaction with our testbed installation.

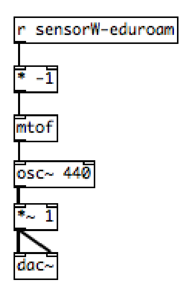

Figure 1: Example using Wi-Fi SSID sensor

We have noticed that each request of available networks takes from 200ms to 1s on these Android devices. In this case, the Java Virtual Machine is responsible for the frequency of this sensor and can control how many times this information can be retrieved per second. It may be possible to reach better values using lower level calls. Another result was that we can only use the Wi-Fi signal as a real input when the level is greater than -45dbm. While the level is lower than this threshold, it became very poor and one may have frequent drops due to the oscillation of the values. An important point is that the position of the antennas will make a great difference while using routers.

3. INSTALLATION DESCRIPTION

We had a mobile music installation considering these results. A semi-open hall was the main area used to distribute the hotspots in a large area in order to permit lots of people to walk freely. We created an application using Sensors2PD with an embedded patch previously configured to interact with the SSID of our hotspots. The patch was prepared to play different sound patterns depending on the position of the participants on the main area and we also defined some regions with silent.

A Ruby on Rails webserver was created to receive and send data between the participants during the installation. We considered that most of the devices would be online during the installation and they could send some data through the Internet. The application was configured to connect to the webserver and send the list of Wi-Fi networks found by each device. On another point, the hotspots would pull down this data from the webserver and identify how many users would be walking nearby its own antenna. A PD patch was created to each hotspot with different music patterns. We used the 3G interface to connect the hotspots to the Internet, since the Wi-Fi interface was being used as a hotspot antenna. The Figure 2 represents the installation with the hotspots and the participants while Figure 3 shows an example of network communication between the mobile devices. In both images we have the hotspots with a circle representing its best signal strength area.

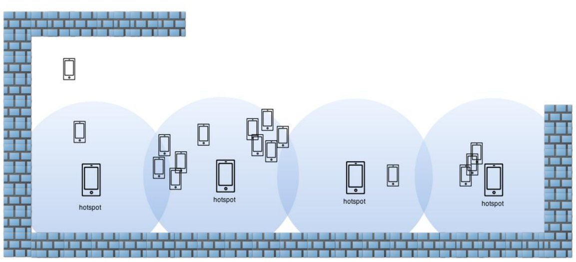

Figure 2: Installation with four hotspots

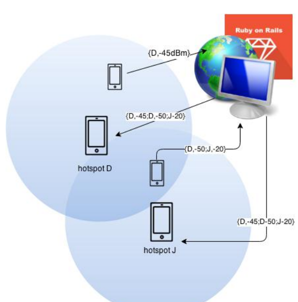

Figure 3: Representation of a network communication during this installation

At the beginning, the participants installed the application and started to walk around. We have noticed that during the installation most people was going to the same place as the crowd, and some groups were playing together near the same router. This social aspect was not predicted before the installation concept and may have affected the audience experience. Some participants were using earbuds and headphones during the installation, what made their sound experience personal in this way. An aesthetic discussion about this installation and other experiences with this Sensors2PD can be found at [1].

4. CONCLUSIONS

In this paper we have presented an idea to use Wi-Fi for indoor localization on mobile music installations. The main advantage of this approach is the fact that the audience can help with its own devices and there is no need to care about any additional artifact. Although GPS can be a solution for outdoor installations, we believe that Wi-Fi will fits better also in this way. Wi-Fi consumes less battery than the GPS system and we can assume that the Wi-Fi antenna will be always enabled on mobile devices due to the *always on* actual paradigm. Another advantage of Wi-Fi is that we may have 1m of precision [2, 4], instead of 10m that we have on GPS system. This precision is also important for performances on stages where someone can also implement the indoor localization using Wi-Fi.

The main drawback of our approach is the diversity of wireless antennas and protocols. We had some devices that could not interact during the performance, and we noticed that most of them had incompatible antennas with the installation hotspots. In this case, we can substitute the hotspots with routers that support all protocols in order to improve the number of devices that can interact with this kind of installation. Furthermore, the frequency of data information regarding the available Wi-Fi networks needs to be improved and we are still working on this point for the next version of Sensors2PD.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] A. D. Bandeira and A. D. de Carvalho Junior. Notes on the elimination of the mobile music audience. In *The Fourteenth Biennial Symposium on Arts and Technology*, 2014.

[2] J. Biswas and M. Veloso. Wifi localization and navigation for autonomous indoor mobile robots. In *International Conference on Robotics and Automation*, pages 4379–4384, 2010.

[3] A. D. de Carvalho Junior. Sensors2PD: Mobile sensors and WiFi information as input for Pure Data. In *Joint Conference: 40th International Computer Music Conference and 11th Sound and Music Computing Conference*, 2014.

[4] H. Liu, Y. Gan, J. Yang, S. Sidhom, Y. Wang, Y. Chen, and F. Ye. Push the limit of wifi based localization for smartphones. In *Proceedings of the 18th Annual International Conference on Mobile Computing and Networking*, pages 305–316, 2012.

[1]NuSom: `http://www.eca.usp.br/nusom/`
[2]Compmus: `http://compmus.ime.usp.br/`