The WiSe Box : a Multi-performer Wireless Sensor Interface using WiFi and OSC

Emmanuel Fléty
Performance Arts Technology Group
Ircam - Centre Pompidou – 1 pl. Igor Stravinsky
75004 Paris – France
+33/1 44 78 48 43
emmanuel.flety@ircam.fr

ABSTRACT

The Wise Box is a new wireless digitizing interface for sensors and controllers. An increasing demand for this kind of hardware, especially in the field of dance and computer performance lead us to design a wireless digitizer that allows for multiple users, with high bandwidth and accuracy. The interface design was initiated in early 2004 and shortly described in reference [1]. Our recent effort was directed to make this device available for the community on the form of a manufactured product, similarly to our previous interfaces such as AtoMIC Pro, Eobody or Ethersense [1][2][3]. We describe here the principles we used for the design of the device as well as its technical specifications. The demo will show several devices running at once and used in real-time with a various set of sensors.

Keywords

Gesture, Sensors, WiFi, 802.11, OpenSoundControl.

1. INTRODUCTION

The development of digitizing sensors for Live Performance has been explored since the beginning of Computer Music. Now that computer programs are powerful enough to do real-time analysis on gesture data, we need more than ever cost-effective and versatile tools for motion sensing and digitizing. Recently we developed the Ethersense platform which takes advantage of the *OpenSoundControl* protocol (OSC) from CNMAT[4] and Ethernet as a fast transport layer. This device responds to the need of high resolution (16 bit) and high sampling frequency (1kHz), but requires wired connections.

In response to this limitation, we started the development of a wireless version of *Ethersense*, featuring the same quality and speed of sensors sampling but wearable and pocket-sized. The device is designed to be able to directly send wireless OSC messages to the computer.

2. RELATED TECHNOLOGY

2.1 Radio Broadcast

Most of the existing wireless digitizing devices suffer of an important limitation: a very limited number of devices can be used simultaneously, typically one or two.

Thus, typically at most two performers can be equipped with wireless sensors. The technical reason of this limitation has been discussed in reference [1].

In summary, this constraint is related to the fact that wireless devices are submitted to local regulations limiting the number of usable channels. Some manufacturers might offer some selectable radio channels, providing several stations to emit simultaneously but with only one receiver per transmitter[2]. This technique cannot be generalized since the number of channels is not extendable.

2.2 Carrier sharing

The main line of our design is to combine the share of a single radio channel between multiple emitters and a unique receiver in order to simplify and reduce the number of peripherals needed.

This purpose is achieved by the CSMA-CA method standing for *Carrier Sense Multiple Access with Collision Avoidance*. A "listen-before-transmit" mechanism provides the collision avoidance on the media by randomly waiting before trying to transmit, offering a statistical potential to all the stations to send their sensors data.

3. HARDWARE DESIGN

After experimenting CSMA-CA with some radio modules from *Radiometrix* (small and low consumption but far from our expectation of data rate) we quickly oriented our design toward wireless computer network technology 802.11 standard also known as **WiFi** (the Wireless Fidelity certificate).

802.11 adapters are now embedded in most laptops or can be added to a computer with inexpensive hardware. WiFi is based upon the CSMA-CA protocol discussed before and features 13 frequency channels on the 2.4 GHz band (in which 5 are non-overlapping). The channels have been defined by an international organization, ensuring that WiFi hardware can be used all over the world (With exceptions on some channels, depending on local FCC regulations). This technology enables thus the use of several devices simultaneously.

The combination of multiple channel and CSMA-CA makes the system architecture flexible and adaptable to many stage and/or computer configurations. Moreover, the 802.11 infrastructure mode with autonomous access points discharges the computer from handling radio packets. The access point is put on stage, maximizing the S/N ratio of the RF communication. Ethernet / OSC can be wire-forwarded to the host computer in a very convenient and reliable way using a long RJ-45 cable.

At the same time, a solo laptop performance can be accomplished in ad-hoc mode with the embedded WiFi adapter of the portable computer.

[2] www.linxtechnologies.com

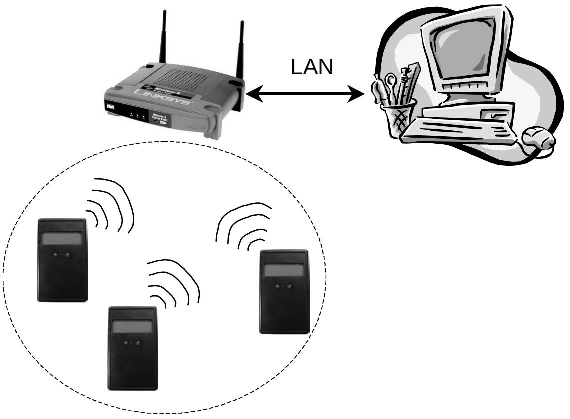

Figure 2 : 802.11 infrastructure mode example

4. THE WISEBOX*

We oriented our choice toward a small Compact Flash WiFi card embedding an Intersil™ compatible firmware. After working out the Compact Flash communication layer, derived from the PCMCIA standard we wrote a custom driver for the WiFi chipset [5] and a UDP stack in a Microchip 18F microcontroller. A 16 bit multiplexed ADC from Burr-Brown™ (ADS8320) and rechargeable batteries were added to the device to turn it into a pocket-sized WiFi sensor to OSC digitizer.

Figure 3 : The WiSe Box LCD prototype

5. SPECIFICATIONS

The devices fits in a plastic housing of 110 x 55 x 28 mm and weighs 180g (6.35 oz.) with the four AAA batteries used as power supply. We initially used an on-board configuration with keypad and LCD, that are particularly useful to monitor the device startup (network and WiFi) as well as sensors level. Unfortunately, such small LCDs were not available for reasonable quantity retail, we thus integrated a Serial-over-USB connection with a configuration software written in Max/MSP. Serial messages are documented so that a custom piece of configuration / diagnostic software can be implemented. A serial bootloader makes firmware upgrade possible. The USB also provides power supply to the device during testing phases, avoiding battery wasting. Autonomy (without sensors) was measured to 125 minutes with 900 mAh rechargeable batteries, and 140 minutes with good alkaline batteries. An inexpensive external 2100 mAh AA battery pack can be made with a USB cable and a battery holder and will extend autonomy to more than 4 hours.

The device uses the 802.11 stack handled by the CF card. The microcontroller transfers UDP formatted packed to the card. Outgoings UDP packets contain an OSC message that export the sensors digitized values. The WiSe Box behaves as a network peripheral and therefore supports ICMP & ARP and will respond to *ping* commands.

Minimum sampling period is 3 ms, refreshing all 16 inputs at once. However, the standard use of the WiSe Box enables to have 4 devices connected to a single WiFi Access Point and sending data every 5 ms. Since 3 or 4 fully separated WiFi channels coexist in the 2.4 GHz band, multiple Access Points can be used and might provide up to 16 devices on stage. Decreasing the data rate to 8-10 ms will drastically extend the number of WiSe Boxes transmitting in the same space.

As in any wireless medium, risks of data drop exist, however, the 802.11 standard manages error correction and corrupted packet cancellation. In case of RF perturbation, the packet will either be suppressed or re-transmitted with some delay thanks to the retry mechanism. Experiments showed less than 0.1 % of packet drops while maximum latency was 1 sample (i.e. 5 ms in our case).

The 16 bit range simplifies sensors calibration and scaling, and a true 12 bit value is easily obtained. The sensors' data are exported with similar OSC syntax as with the *Ethersense*. Data can be received in any *OpenSoundControl* compliant software, such as PureData, PD, Max/MSP or EyesWeb.

Since there is no more onboard setup, we implemented several OSC messages to remotely configure or monitor the device. In particular, we can ask the station to send the WiFi connection status (signal and noise level, bit rate) and the 10 bit sampled battery voltage, which is useful during rehearsal.

To reduce power consumption, the unit works in 3.3V, which requires thus using 3.3V sensors. Nevertheless, except really few active sensors that will work only in 5V, a majority of existing and commercially available sensors (accelerometers, any resistive sensors…) perfectly work at this voltage, and actually consume less current.

Quality of sampling was also measured with fixed voltages on several inputs (100 kΩ voltage dividers). An average S/N ratio of 86 dB is achieved over more than 1,300,000 samples (132 minutes experiment).

6. CONCLUSIONS AND FUTURE WORK

The general performance of the WiSe Box is excellent. We are currently using it for a 5 dancers performance with a single access point. To our knowledge, this is the first WiFi OSC device without any embedded computer. We currently consider a smaller and faster version using another WiFi card (not CompactFlash). As a matter of fact, our device is still 3 times slower than the Ethersense, and we wish to improve it using all the capabilities of WiFi.

7. REFERENCES

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