

# Ambient Wood: Demonstration of a Digitally Enhanced Field Trip for Schoolchildren\*

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## ABSTRACT

This demonstration shows parts of the Ambient Wood experience project which has taken place in an English woodland setting during the past year. The project provides a playful learning experience for schoolchildren on a digitally enhanced field trip. A WiFi network was installed in the woods to enable communication with PDAs and a collection of innovative devices was designed to aid interactive exploration of the woods. Most of the devices that were employed are available for conference attendees to use along with a facilitator's terminal. A video of the schoolchildren using the devices in the woodland is also shown.

## Introduction

The Ambient Wood project is a playful learning experience which takes the form of an augmented field trip in English woodlands. Pairs of children equipped with a number of devices explore and reflect upon a physical environment that has been prepared with a WiFi network and RF location beacons. The intention is to provoke the children to stop, wonder and learn when moving through and interacting with aspects of the physical environment (see Figure 1). The children are able to communicate with a remote facilitator using walkie-talkies and are sent questions and information by a remote facilitator using the network and handheld PDAs.

A variety of devices and multi-modal displays were used to trigger and present the added digital information, sometimes caused by the children's automatic exploratory movements, and at other times determined by their intentional actions. To this end, a field trip with a difference was created where children discover, hypothesise about and experiment with biological processes taking place within a physical environment.

Two spaces were designed for the initial trial run, and each activity space offered its own aims with focus on the different kinds of technologies and activities that have an overall link into habitat distributions and dependencies. These aims are: Exploring, Consolidating, Hypothesising, Experimenting, Reflecting. Pairs of children around the age of 10 years



**Figure 1: Using the probing device to find (i) moisture and (ii) light levels and (iii) reading the resultant visualisation on a PDA screen**

collaboratively discover a number of aspects about plants and animals living in the various habitats in the wood during a visit lasting around one hour. Their experiences are later reflected upon in a 'den' area where both pairs of children share their findings with each other and the facilitators. The children hypothesise about what will happen to the wood in the long term under various conditions e.g. drought or lack of light through the trees.

Following on from a successful run late in 2002, the experience was enhanced for children visiting the wood in June 2003. Building on the experiences of the previous year we continued exploring our theme of augmenting the experience with digital tools. An 'Ambient Horn' was added to enable the children to have more control over when the sounds within the wood were heard. The Horn provided a way to access sounds representing processes invisible to the eye or events that had happened at a different time.

## The Demonstration

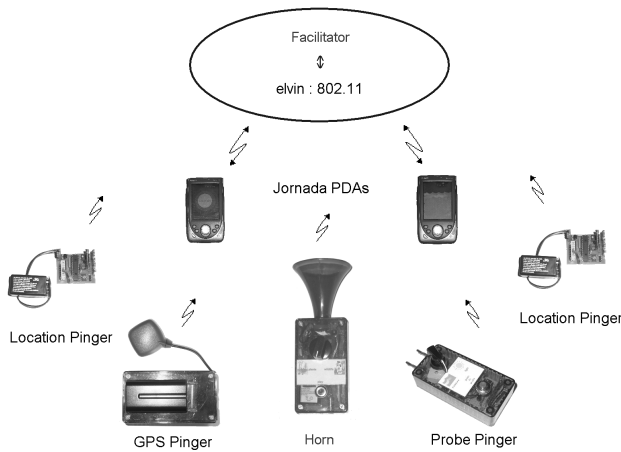
The demonstration consists of most of the devices which were used as part of this project; a simplified wireless network which enables the facilitator's application to be shown in conjunction with handheld Jornada PDAs; and a display showing a video of the children using the devices in the English woodlands. The devices, laptop and Jornadas are all interconnected and functioning as designed and used.

## The Network Infrastructure

The project required that data should be collected by the children; their positions in the woods be monitored; and that location based information could be triggered. This was achieved by the use of 418MHz license exempt transmitters with

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Funding for this work is received from the U.K. Engineering and Physical Sciences Research Council, Grant No. 15986, as part of the Equator IRC. Further support is provided by Hewlett Packard's Art and Science programme.



**Figure 2: Ambient Wood Device Architecture.**

limited ranges broadcasting to receivers attached to handheld Jornada PDAs. We call these devices ‘Pingers’ based on the simple design proposed by Hull et al [1].

A wireless personal area network (PAN) based on this Pinger technology was provided for each of the pairs of children as well as an 802.11b WiFi local area network accessed through WiFi CF Cards in the Jornadas. The WiFi network assisted communication from remote facilitators, and enabled real time monitoring of the children’s activities. In the woods we experimented with 3 WiFi access points strategically located with extension antenna in the trees. An area of approximately 4 acres had good coverage though this varied according to season and climate. In our demonstration we are using a single access point.

As well as a Jornada and a small Pinger receiver, the pairs of children carry with them various pinging devices including a combined moisture and light Probe, a ‘Horn’, a Dead Reckoning Pinger and a GPS Pinger (see descriptions below). In addition the receiver was able to detect proximity to Location Pingers situated at interesting places in the environment. The contextual information was processed locally to create notifications of events to a network server as they happened. For the original trials wireless loudspeakers, and an unusual interactive display, the Periscope [2], were deployed in the woodland. The system architecture employed Elvin (a content based notification and messaging service [3]) originally connected to a MUD environment [4, 5], and later to a bespoke application. This architecture is illustrated in Figure 2.

### The Remote Facilitator

Each of the pairs of children had a remote facilitator who they could relay information to using a walkie-talkie. The facilitator in turn could send the children information in the form of ‘cards’, which were displayed on the PDA, and sounds, also played by the PDA. These were sent from the facilitator’s

laptop PC using the WiFi network. The cards showed images of plants and wildlife; illustrations of natural processes such as photosynthesis; or alternatively could pose questions to stimulate the children. The facilitators were also able to monitor the progress of the children through the woods using a GPS tracking system.

### The Pinger Devices

The design issues for a ‘Pinger’ are size, cost, power consumption, range, transfer capacity and error rate. In its simplest form our Pinger design consists of a single PIC microcontroller connected to a FM transmitter module operating in the 418MHz license exempt band. It’s footprint is 3cm x 3cm; it costs less than \$20 in small quantities; it has a six month battery life when powered by two AA batteries; it has an adjustable range between 2m and 100m; it sends an 8 byte packet at 1Hz; and it is 95% reliable i.e. approx one packet in twenty is corrupted or lost. The pinging devices were all designed to be stateless with varying degrees of redundancy based on the level of interaction required with each device. Five types of Pinger were employed in this project:-

- **Location Pinger** This is the basic design, providing a location beacon. A datapacket is constructed containing a location identifier. This is then Manchester encoded at 2,400baud and transmitted. The ping packet has a RF transmit time of 35ms. The range of the transmitter is governed by the antenna configuration. It extends from 2m with no antenna to over 100m with a quarter wavelength whip antenna. For our applications a helical antenna with a range of around 10m is normally used. The Location Pingers were set to transmit at slightly greater than 1Hz to avoid periods when contention might occur with the GPS Pinger (see below). This guaranteed a ping being received within two seconds of the user entering the 10m radius location. Ten of these location Pingers were deployed at points of interest in the environment such as in thistle patches and reed beds.
- **GPS Pinger** The GPS Pinger uses an Garmin GPS25 oem board with an antenna on a short cable. The output of the GPS receiver is decoded using a PIC and a minimal datapacket containing the local position data is constructed whenever a valid fix is obtained, usually at 1Hz. This too is encoded and transmitted in the same way as the location beacon. A GPS Pinger is carried by each pair of children in a small backpack. The data provides a timed record of the children’s movements and is further augmented by the Dead Reckoning Pinger.
- **Dead Reckoning (DR) Pinger** The GPS positioning signal was frequently degraded by the tree canopy. To compensate for this a dead reckoning system was devised which used an accelerometer to detect movement, and a two-axis electronic compass to sense heading. Whenever movement above a threshold value was detected, a ping datapacket was transmitted containing heading, amplitude and sequential identifier bytes. The sequential bytes helped to

identify when pings had been lost. This enabled a simple form of dead reckoning to be implemented to augment the GPS data [6].

- **Pinging Probe** A Pinging Probe was designed to provide interaction between the physical world, by sensing moisture and light levels, and the digital world by graphically displaying the results on the PDA. Again a simple data-packet is constructed with bytes representing the values measured and which type of measurement the children were interested in as indicated by a rotary switch. The Pinging Probe was set to transmit at 10Hz to ensure that there was no detectable latency in the interaction.
- **Ambient Horn** A novel audio player, the Ambient Horn, was designed to play tracks cued by Location Pingers, and to transmit ping notifications each time a sound is played. During the first run of Ambient Wood experiments with hidden loudspeakers failed to generate consistent interaction with the children - the sounds were **too** ambient. This device was subsequently designed with the intention of providing the children with a greater level of stimulus by the prerecorded audio effects. The audio tracks were stored on a sound chip and then cued when a location trigger was received. The Horn produced a 'honking' sound and LEDs flashed when the new track was cued; the track played when a push button was activated. A physical horn extension provided both an organic metaphor for the device and encouraged the children to listen to, and to probe for, sounds (see Figure 3).

#### Device Performance

The Pinging Probe device - used for both collecting and subsequent viewing of the data - provided a thoroughly engrossing experience. The pairs of children made frequent probes for both moisture and light, usually with one child doing the probing and the other holding the PDA, reading off the visualisation. Sometimes both children would look at the PDA screen together, and other times the one holding it would tell the other what they had seen on the screen. The probe design was particularly successful as the digital information resulting from the children's activities was tightly coupled with the activity, and the children readily understood the connection between the two.

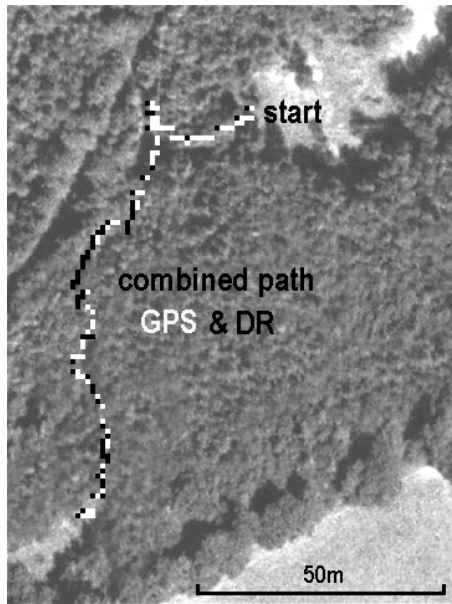
Initially the Location Pingers were less successful. While the technology performed as intended, we had engineered the digital information to be presented to the children in a more pervasive way i.e. where their bodily presence in an area triggered the digital information to appear on the PDA, or sounds to be played through nearby wireless loudspeakers. In these contexts, the children did not have control, but relied on the serendipity of their movements as to whether they passed in the vicinity of the Location Pinger. The children were never quite certain when this would happen and were often surprised when they heard a sound or saw an image on the PDA screen. Part of our intention of using this pervasive technique was indeed to introduce an element of



**Figure 3: Children using the Horn, PDA and Walkie-Talkie.**

surprise and the unexpected. Another reason was to augment their physical experience, by drawing their attention to certain aspects of the habitat they might not have noticed otherwise, and providing relevant contextual knowledge that they could integrate with what they saw. Sometimes this approach worked, and the children related the digital information that was being sent to them on the PDA with what they saw in the wood in front of them (e.g. a real thistle). However, at other times, the children were too engrossed in doing something else and so would miss the beginning part of a voice-over or not even notice a sound. In these moments, the children were often reluctant to switch their attention to what was happening on the PDA from what they were already doing. The audio playing Horn device was designed to address this problem and was successful in giving control of the sound playing to the children. While this was less 'ambient' it still gave the opportunity for the serendipitous triggering of sounds and also enabled the children to replay particular sounds on request. The similar physical design of the Horn and Probe encouraged the children to seek sounds associated with locations by probing with the Horn. We repeatedly observed the children associating sounds with locations.

The GPS Pinger performed well enabling positions to be recorded for all the children's activities. The local position data was adequate for these trials, though it would not be difficult to encode a larger dataset into the eight byte packet. The need for the Dead Reckoning Pinger was largely obviated by the use of a high gain active patch antenna with the GPS receiver. Nevertheless initial results from the DR Pinger indicated that this approach could be useful in situations where poor GPS reception is experienced. Figure 4 illustrates the combined positioning performance of the GPS and DR Pingers. We also experimented with virtual location beacons created using the GPS data however these were found to be unsatisfactory due to inaccuracy, drift and occasional spurious readings.



**Figure 4: Aerial Photograph showing Position Sensing using GPS and Dead Reckoning. The white pixels represent the readings from a GPS receiver, the black pixels show the positions estimated by dead reckoning.**

The PAN, though simple with no protocol stack or handshaking, worked well largely due to the redundancy inherent in the design. By setting the transmission rate of the Pinging Probes to be significantly higher than for the GPS and Location Pingers, it was ensured that the Probes appeared to function with no latency and took priority over the other Pingers. Any delay in receiving a location ping was not critical as the user interaction appeared to be serendipitous in any case. The GPS pings provided a monitoring function and were not critical to the progress of the trials. While we estimate that around 5% of the pings were lost, in practice the users of the system were not aware of any latency or data loss in the PAN.

### Contribution

This project is notable for its location away from any infrastructure whatsoever. It required careful consideration of power requirements and the effects of woodland on RF propagation under differing climatic conditions. It also benefited from a lack of any possible external RF interference.

The range of uses of the Pinger technology is unusual and its integration to form a PAN for collecting minimal data packets extends the concept of using devices such as Smart-Its [7] and the Berkeley Motes [8] for the collection of pervasive data. The Probe and Horn devices both had great appeal to the children who enjoyed using them constructively to learn about the environment. We believe that these inventions may inspire others to develop further interesting ways of interacting with ubiquitous computing systems.

### Acknowledgements

The Ambient Wood is an Equator IRC project and we thank our collaborators especially Eric Harris, Sara Price, Paul Marshall, Hilary Smith, Mia Underwood and Rowanne Fleck of the School of Cognitive Sciences (COGS), University of Sussex; Mark Thompson, Mark Weal and Danius Michaelides of the Intelligence, Agents, Multimedia Group (IAM) at the University of Southampton; Henk Muller of the Department of Computer Science at the University of Bristol; Danae Stanton of the School of Computer Science at the University of Nottingham; and Danielle Wilde of the Royal College of Art. Thanks also go to the children and teachers of Varndean School who approached this project with such enthusiasm and without whom it would not have been possible.

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