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# ERA (Enabling Remote Activity)

## A KMi designed system to support remote participation by mobility disabled students in geology field trips

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# ERA: A KMi designed system to support remote participation by mobility disabled students in geology field trips

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## Abstract

This paper describes the design and field testing of the ERA (Enabling Remote Activity) system - a mobile wireless network devised by the Knowledge Media Institute to support participation by mobility impaired students in geology fieldwork trips. We describe our approach and its relevance in educational and network research. We describe the set of tools implemented to facilitate remote learning, report on trial tests and lessons learnt. Finally we suggest future possible developments for the system and how it may be more widely applied.

Keywords: wireless network, mobile learning, ubiquitous computing, disability access, geology

## 1 Introduction

The recent availability of low cost and powerful digital technologies allows the augmentation of teaching and learning environments with ubiquitous computing (Harris, Price, Phelps, Smith and Weal 2004; Rogers, Price, Randell, Weal and Fitzpatrick 2005). The arrival of the 802.11 network protocol (”wi-fi”) in 1997 has led to low cost, standardised wireless networking equipment becoming widely available and flourishing in home, office and education environments. Grassroots community networking groups such as Consume[1] and Seattle Wireless[2] have been able to develop city-wide community wireless networks enabling local people to share resources and internet connectivity (Bina 2005; Gaved and Mulholland 2005). It has therefore become possible to develop relatively low cost, powerful, mobile digital networked applications to support learning. These networks can support a wide variety of teaching scenarios, and may be particularly useful in supporting the inclusion of mobility impaired students in fieldwork trips, an issue that has become of higher profile in recent years (e.g. training days on “ Inclusive Fieldwork and Expeditions Practice” held by the Royal Geographical Society and the Institute of British Geographers[3]) and must be considered by universities due to recent legislation (The Disability Discrimination Act 1995, Special Education Needs and Disability Rights Act May 2001).

[1] http://www.consume.net
[2] http://www.seattlewireless.net
[3] http://www.rgs.org/NR/rdonlyres/C33FAEBF-3EFC-4DF8-A1BE-589C150C571D/0/Inclusiveexpeditions.pdf

Our system, ERA (Enabling Remote Activity), is based on standard 802.11b 'wi-fi' wireless networking and commonly available hardware and software and enables the remote participation of mobility impaired students on fieldwork trips without requiring a high level of technical expertise or support, or expensive custom equipment. The system consists of laptops connected via a mobile wireless network, with a remote web video camera offering sense of presence for participants, and the ability to upload and transmit high resolution images via digital camera. Audio communication is supported by independent walkie-talkies, and aided by the video stream this enables the participants at the 'base location' to direct the 'field team' to specific locations of interest in real time. The system has been designed for rapid setup and shutdown, allowing multiple sites to be visited in the same day, and for the participants using the ERA system to participate in an existing fieldwork itinerary.

# 2 Background

In January 2006 the course manager for the Open University Earth Sciences' course SXR339 (Ancient Mountains) approached the Knowledge Media Insitute (KMi) to find out if it would be possible to devise a system to support fieldwork participation by a mobility impaired student:

> *"I am a Course Manager in Earth Sciences, and I look after the SXR339 Residential School which is based in Scotland. We are trying to make the fieldwork components of the residential school programme more accessible to students with severe mobility impairment. Currently the fieldwork involves walking distances of several kilometres across moorland and on coastal sections, all inaccessible to students in wheelchairs.*
>
> *We would like to set up an alternative learning experience for students in wheelchairs that matches as closely as possible that experienced by the other students. We envisage the possibility of using two-way audio and video communication between the student (positioned on the nearest roadside) and a tutor (on the hill/beach). A similar (but more basic) scheme was put in place for a mobility-impaired student on SXR369 last year, using a laptop, a digital camera, a mobile phone and a pair of binoculars - which worked very well in those circumstances. However, we have additional complications. We could not guarantee "line of sight" between the two people and the distances might be up to 1km as the crow flies, so running backwards and forwards between the two locations would be too time consuming. Also, mobile phone coverage is not good (or in some cases, even available) in all the fieldwork locations, and so we think that satellite transmission is probably the only solution."*

KMi has an extensive track history of developing applications deployed by Open University courses (for example BuddySpace[4], a geolocation-based instant messaging

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[4] http://buddyspace.sourceforge.net/

tool; Lyceum[5], voice-over-IP groupchat and shared whiteboard used by language students; and Magpie, a prototype semantic web browser[6]), and undertaking research into wireless and mobile technologies (e.g. CitiTag[7], SUbTLE[8]), including working alongside grassroots community networking groups such as Consume, Free2Air[9], and the Community Broadband Network[10]. Development of a system to support the SXR339 course therefore offered a great opportunity as a collaborative venture for both KMi and Earth Sciences. Initial discussions led to an outline proposal to act as path for system development. The following key points were noted:

- Mobility impaired student with a course tutor at a base location (e.g. car by roadside) to be provided with data by a remote, mobile field team
- Communication by IEEE 802.11 standard (wi-fi) network via access points – cheaper than satellite phone and offering greater data transmission rates
- Use of a repeater station to provide contact with the field team when out of line of sight (802.11 only works in line of sight)
- Digital camera and video web camera to capture remote data
- Laptops as the user interface device for all participants, with as little custom software as possible
- Battery powering of all equipment to allow mobility away from mains power supplies
- Audio communication via separate walkie-talkies

Initial meetings with Earth Sciences and KMi staff resulted in approval for the project and KMi staff moved forward with its development.

# 3 Architecture

Our approach has been to use domestically available equipment to reduce costs and to allow for rapid replacement of faulty equipment, and to allow future replication of the system by others. The network operates over standard internet protocols, and devices have been chosen for their ruggedness and ease of use. All equipment is powered by batteries to enable ERA to be fully mobile and deployed in remote locations. A dynamically routed meshing network protocol has been used to afford flexible configuration and future expansion. The ERA system consists of three teams (or locations) connected by a wireless network:

[5] http://kmi.open.ac.uk/projects/lyceum/

[6] Magpie is able to automatically identify concepts described in web pages and provide contextualized, concept-specific functionalities to users, e.g., to support the interpretation of the information provided by the current web page. In collaboration with Prof. Spicer from Earth Sciences and the climateprediction.net project partners from the University of Oxford a proof of concept semantic application was developed for the S199 short course on weather, climatology and climate modeling. In the context of S199 Magpie is rolled out as an on-the-fly domain glossary, which students can use to highlight and explain key course concepts they may encounter in third-party web sites or course materials. In addition, concept-specific functionalities can be invoked, which for example can bring up relevant sections from the course, which are needed to understand the concepts encountered in the web browsing session.

[7] http://kmi.open.ac.uk/projects/name/Cititag

[8] http://kmi.open.ac.uk/projects/subtle/

[9] http://p2pfoundation.net/Free2Air

[10] http://www.broadband-uk.coop

**Base Team**
(Mobility impaired student with course tutor base location, e.g. in car by road side)

- Laptop with web browser
- Wireless access point
- Directional panel antenna mounted on tripod
- Battery power supply
- Inverter for recharging laptop

**Field Team**
(Field studies group with ERA field worker)

- Laptop with web browser
- Video web camera
- Stills digital camera
- Wireless access point
- Directional panel antenna mounted on tripod
- Battery power supply

**Mid Station**
(repeater station to be used if above teams are out of line of sight)

- Wireless access point
- Omnidirectional pole antenna mounted on tripod
- Battery power supply

We will now look at the specific aspects of the equipment in each location.

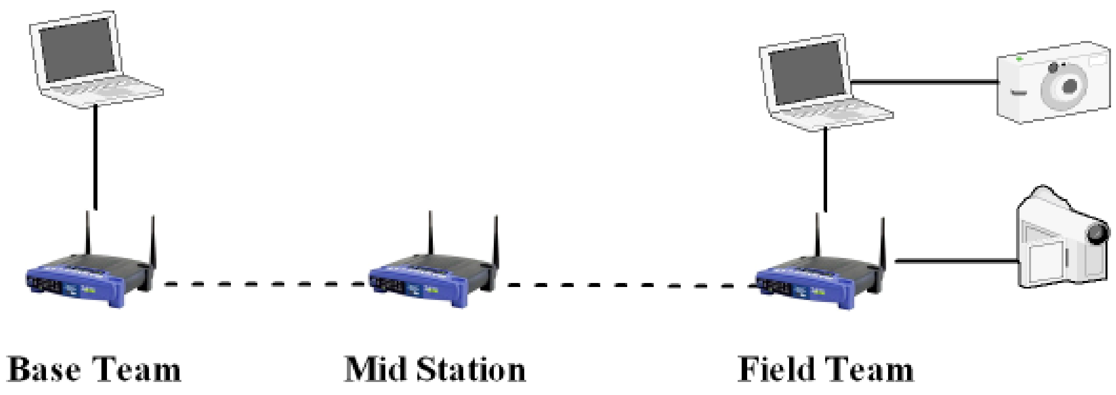


Figure 1: Simplified ERA network schematic

## *3.1 Network*

Devices on the ERA network communicate by wireless over distance with local devices using Ethernet or USB cables. The wireless network, connecting each of the teams, operates using the IEEE 802.11b standard to communicate between nodes. IEEE 802.11b ("wi-fi") standard is a network protocol used commonly by commercial wireless networking equipment, operating in the 2.4GHz unlicenced spectrum. This requires line of sight communication between devices on the network. With high-gain antennae, the protocol permits communication over long distances in point-to-point arrangements, typically up to 8 kilometres[11]. 802.11b cards can operate at 11 Mbit/s, but will scale back to 5.5, then 2, then 1 Mbit/s (also known as “Adaptive Rate Selection”), if signal quality becomes an issue[12]. This protocol was therefore considered very suitable for the ERA network and chosen as the operating standard.

Equipment using 802.11 is readily available, requires no operating licence and operates at low power levels (no more than 100mW in the UK, one fortieth of the power of a mobile phone) so does not pose any particular health and safety issues. This is increasingly used in domestic environments so many of the ERA participants will already be familiar with the technology and using it in their own homes and offices. Much ‘wi-fi’ networking equipment available supports both IEEE 802.11b and the higher transmission rate IEEE 802.11g standards, however London community networkers[13] advised that the lower 802.11b standard performed more reliably under field conditions, so access points were configured to communicate solely by this standard.

The SXR339 field studies trip requires a network capable of both line of sight and non-line of sight communication. Generally, all participants will be able to see each other but in one location the students will travel over the lip of a rock outcrop into a dip in a hillside, and in another location students explore the bottom of a cliff face on a beach. The network therefore has been designed with the ability to add in a middle access point (“Mid Station”) to pass on communications out of line of sight.

Devices on the network communicate using TCP/IP, with the exception of the digital stills camera that is connected to a laptop via USB cable and is ‘seen’ as a remote hard drive. Fixed IP addresses have been allocated to each machine in a private address space; ERA equipment will not be used on the public internet.

## 3.2 Audio Communication

Audio communication is enabled between the participants via independent walkie-talkies. These are provided by the field studies trip organisers. Initially we considered supporting audio communications within the ERA network, implementing an audio software tool on the ERA laptops, and considered such tools as the KMi developed Hexagon[14] conferencing tool. However, we decided to separate audio communication out from the network in order to assure an independent means of conversing in case the ERA system fails for any reason. Supporting an audio channel via the laptops and wireless network would also increase the load on the system and might reduce the quality of video or the speed with which images could be transferred.

## 3.3 Devices

### 3.3.1 Access Points

Wireless connectivity is provided by Linksys WRT54G wireless access points. These are readily available domestic devices commonly found in small office and home

[11] http://en.wikipedia.org/wiki/802.11b#802.11b
[12] Ibid.
[13] Thanks to <san> and James Stevens of Boundless for their technical advice
[14] http://hexagon.open.ac.uk/

environments. These communicate with other devices wirelessly via the 802.11 protocol. Additionally, four LAN (Local Area Network) ports enable wired communication with devices attached by Ethernet cables. Two small antennae are fitted to the access points, and these are detachable, allowing the attachment of higher powered replacements. These access points are widely used by community network groups because their firmware (onboard software that holds its settings when the access points are switched off) can be easily upgraded to enable more powerful functionality. The KMi team already had prior experience working with Linksys WRT54G access points: a workshop had previously been run in KMi by London community networkers, supported by the European Learning Grid Infrastructure (ELeGI) project[15].

### 3.3.2 Friefunk Firmware

The WRT54G access points have been upgraded ('flashed') with Freifunk[16] firmware, an open source project developed and maintained in Germany and used in German and UK community networks, based on the popular OpenWRT firmware[17]. This firmware provides a broad range of additional functionalities, some common with the OpenWRT firmware base distribution, and others specific to the Freifunk firmware. Of particular interest to the ERA project is that the Freifunk firmware allows the access points to be configured using OLSR (Optimized Link State Routing Protocol).OLSR allows the creation of mobile ad-hoc networks, sometimes called wireless mesh networks. It is a link-state routing protocol that collects data about available networks and then calculates an optimized routing table.

By creating a mobile ad-hoc mesh network, rather than a defined point-to-point network, we can create a network that will tolerate the addition of the third 'middle station' repeater access point without requiring the ERA system users to carry out any configuration of the access points. This method will also to support the rapid replacement of any of the access points with a spare back up unit. Furthermore this will allow future experimentation of a larger network with more access points, and deployment in highly mobile configurations.

### 3.3.3 Antennae

The SXR339 project required a network capable of communicating "up to 1km", beyond the reach of the small omnidirectional antennae provided by default with the WRT54G access points. The project team replaced these with higher gain antenna connected via low loss antenna cables, and experimented with different antennae configuration during field testing.

Initially we tested 7db omnidirectional antennae – these would give a 360 degree signal and require little directional adjustment by the users. However these did not provide enough power, and we then considered 8db directional yagi antenna at each end of the network, with an omnidirectional antenna for the middle access point. Test with these yagi antennae were also unsatisfactory, with the power again not appearing sufficient over long distances, so we replaced these with 14db panel antennae that the supplier claimed had a range of up to 4km. Field testing at 1km worked well so these

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[15] http://kmi.open.ac.uk/projects/name/ELeGI
[16] http://wiki.freifunk.net/Freifunk_Firmware_(English)
[17] http://openwrt.org/

were chosen as the final specified end antennae for the ‘field team’ and ‘base team’ with a 7db omni antenna at the ‘mid station’ access point. The panel antenna would have to be pointed at each other, while the omnidirectional antenna would need little adjustment.

All antennae are mounted on lightweight aluminium lighting tripods using brackets purchased from DIY stores. The lighting tripods provide portable mounts that can be extended to up to 3 metres height. To ensure stability, light guy ropes and weighting of the tripod bases will be used in exposed locations.

### 3.3.4 Laptop computers

The active participants in the ERA system – the student and tutor (‘Base’ team) and the mobile remote data collection team (‘Field’ team) - interact primarily through laptop computers. The laptops run Windows XP, and the system uses Firefox web browsers as the central software tool. This offers a familiar work environment; no custom software or hardware will be required, and we can assume familiarity on the part of the users.

The Field laptop is running an Apache web server software package, and this has been configured to run automatically when the laptop is switched on so the Field team do not have to manage or configure this software. The Field team have been instructed to load images from the digital camera onto the Field laptop into directories held within the web server, so they can be viewed over the network by the Base team via a web browser and downloaded there without the need for any other file transfer software.

A critical issue for the laptops is power consumption. Laptops will have to operate for a complete working day with limited opportunity to recharge batteries. Laptops have been chosen that consume lower than average power, and have been configured to minimise their power usage. For example, the laptops connect to the wireless network via Ethernet cable to their local access point rather than via wireless network cards which draw additional power. Each laptop is supplied with a back up battery, and the base team has been provided with a power inverter that will allow recharging of laptop batteries from a car power supply (via cigarette lighter socket) when the laptop is not in use. We have been informed that the Base team will be working from a car so we are expecting that the Base laptop will be able to be recharged during breaks in Field team activity, for example when moving between fieldwork sites.

### 3.3.5 Video web camera

A video web camera connected to the Field access point provides remote “sense of presence”. The video camera is a D-Link DCS900 which has an inbuilt web server. This has been given a fixed IP address so the Field and Base teams can view output from the camera through a web browser. The camera has been set to provide 320 x 240 pixel video at 20 frames per second which provides “sense of presence”: the student at Base will be able to view the footage to better understand the field location and ask the Field team to pan or focus on specific areas, before requesting high resolution still images of specific details.

The video camera is connected to the Field access point via Ethernet cable, additionally it requires 5v power. To allow a ‘roaming camera’ with few trailing cables and little weight, a Power Over Ethernet (POE) injector/ splitter set carries both power and data down a single 5 metre Ethernet cable. The power is provided by the same battery that powers the Field access point, situated next to the access point.

#### 3.3.6 Digital camera

A key aspect of the ERA project is the ability to provide the Base team with high resolution digital images of items of interest. This is achieved by a digital stills camera carried by the Field team. The camera chosen is a Nikon Coolpix P2; a small camera able to take high quality images. Once photos have been taken the camera is attached via USB cable to the laptop, and images loaded into a directory visible to Apache web server. This allows instant access by the remote “Base” team using a web browser.

The Coolpix P2 camera was in part chosen as it has wireless networking capability via 802.11b protocol; however this proved problematic to configure and operate and we have reverted to using a USB cable to connect the camera to the laptop.

### *3.4 Batteries*

A significant challenge for the ERA project was providing power away from mains electricity that could power the access points and video web camera for a whole day in the field, while still remaining portable. Initial suggestions of running equipment from car batteries were discarded as such a power source would be too heavy, unwieldy, and provide a health and safety risk.

Testing by KMi staff identified power usage and a battery system was developed to power the equipment. The system is based around 12v maintenance free sealed lead-acid batteries, with a custom adaptor unit providing sockets for leads to equipment, a charging socket, on/off switch, LED power light, and a fuse. These weigh approximately 2 kg each and can provide power for approximately 25 hours. The construction of these devices was a major breakthrough for the project, providing reliable and mobile power units.

## 4 Lessons learnt: trial testing

Based on the initial proposal, the equipment was purchased for testing between January and June 2006. Field tests were carried out to test components and assure the infrastructure worked as a whole. Device tests were carried out within KMi, while wireless network tests were carried on in and around the Open University campus and nearby locations. Key lessons learnt:

**Wireless capability of digital stills camera problematic to configure**
The Nikon Coolpix P2 digital stills camera was in part chosen because of its wireless connectivity function: theoretically it could connect to a network using the 802.11 “wifi”protocol. However, this proved highly problematic to configure and we reverted to using a USB cable for loading images onto the laptop.

**High gain antenna required**
Initial tests with an 8db yagi antenna connecting to a 7db omni antenna over 500 metres were not successful. The 14db panel antennae offered a great increase in

capability. The furthest test between two access points was approximately 1km, from Holy Trinity Church, Old Wolverton, to the Cosgrove Spur of the Grand Union Canal.

**Directional antenna very tolerant of poor network visibility**
802.11 wireless networking requires line of sight, however with the 14db panel antennae we have found the network is very tolerant of poor line of sight, including some tree cover.

**Laptops are the slowest link when establishing connectivity between teams**
The laptops running Windows XP define the time it takes to make a network connection between teams, taking 2 or 3 minutes to boot up. The video web camera and access points boot up within 60 seconds.

**Access Points and the network configuration are highly tolerant of loss of contact**
Forcing failures in the network during testing has shown that access points powered down (by pulling their power plugs out) and rebooted reconnect to the network and re-establish connectivity within 30 -60 seconds. If an access point is removed from the network, the remaining access points will reconfigure their settings to connect to each other within seconds.

**Powering equipment is a major issue**
One of the greatest technical challenges was devising portable power supplies that could last for a full day’s field study trip, ready to be used again the next day for a second trip. The battery systems developed provide the power and are portable, but must be recharged each day and are still quite heavy (2kg each).

**Configuration of access points hindered by poor documentation**
Little documentation is available on the Freifunk firmware, so configuration of the access points was highly time consuming.

# 5 Discussion

Currently (July 2006) the ERA system has been packed and shipped to Scotland for the first of the field study trips, and we are awaiting news from the Earth Sciences team on how the equipment performs. Documentation has been provided for the participants: a general user guide, an equipment connecting guide, and kit lists with photos. One of the ERA team will observe and act as technical support on the first day of the field trip with the participating students. From this trip we hope to gather data that can help us develop the system for future applications, outcome of the field trip will be reported in further papers. Possible developments of the ERA system include:

**Further testing and configuration of the system**
The current SXR339 field trip is a first test of the ERA system. Based on feedback from the participants, we expect to revisit the current configuration and consider possible improvements.

**Wireless connectivity for the digital stills camera**

In principle, operating the digital stills camera as a wireless device rather than via USB cable will allow greater roaming capability. Images could be transferred automatically to both the local and remote laptops.

**Video web camera for the Base team**
The current ERA system works as a one way broadcast system from Field Team to Base Team. The Base Team are in effect invisible to the other students participating in the field studies trip. A video web camera in the Base location would offer 'sense of presence' in both directions enabling video conferencing and helping the mobility impaired student at Base to interact more fully with their peers on the trip.

**Multiple video cameras for the Field team**
Multiple video cameras would allow multiple perspectives of the field location.

**Multiple Field teams operating as a peer-to-peer mesh**
Currently the system operates as a point-to-point network between two teams. The configuration of the access points with freifunk firmware offers the opportunity to extend the network into a multiple node, dynamically routing mobile mesh network. Several groups of students could explore across an environment and communicate and transmit data to each other during their field work. Different groups could take on different roles, for example data collection, and collation and interpretation.

# 6 Acknowledgements

Thanks to; Marc Eisenstadt for his ongoing support of wireless experimentation in KMi and providing ELeGI funding for the 2005 KMi wireless workshops and purchase of access points; Trevor Collins for proof reading of earlier versions of this paper and his valuable comments; Paul Mulholland for support as Mark Gaved's PhD supervisor ; the community networkers who have provided valuable advice in the choice, setting up and configuration of the equipment (Saul Albert, Helen Anderson, Tony Briden, Rob Dyke, <san>, James Stevens, vortex).

# 7 References

Bina, M. (2005). Building the next-generation wireless network: Community-based WLANs. Hermes Newsletter (30).

Gaved, M. and Mulholland, P. (2005). Grassroots initiated networked communities: a study of hybrid physical/virtual communities. Proceedings Of The 38th Annual Hawaii International Conference On System Sciences. Big Island, Hawaii, IEEE Computer Society.

Harris, E., Price, S., Phelps, T., Smith, H. and Weal, M. (2004). Data recording and reuse: Supporting research and digitally augmented learning experiences. Position paper for EQUATOR Record and Reeuse workshop, 12-13 February 2004.

Rogers, Y., Price, S., Randell, C., Weal, M. and Fitzpatrick, G. (2005). Interaction design and children: ubi-learning integrates indoor and outdoor experiences. Communications of the ACM **48**(1): 55 - 59.

# Appendix One: General User Guide

The following connecting guide was issued when the ERA system was sent to the SXR339 Summer School in July 2006.

## SXR339 Wireless Network How to User Guide

***Last updated 05 July Lewis McCann, Mark Gaved m.b.gaved@open.ac.uk***



## 1 Introduction

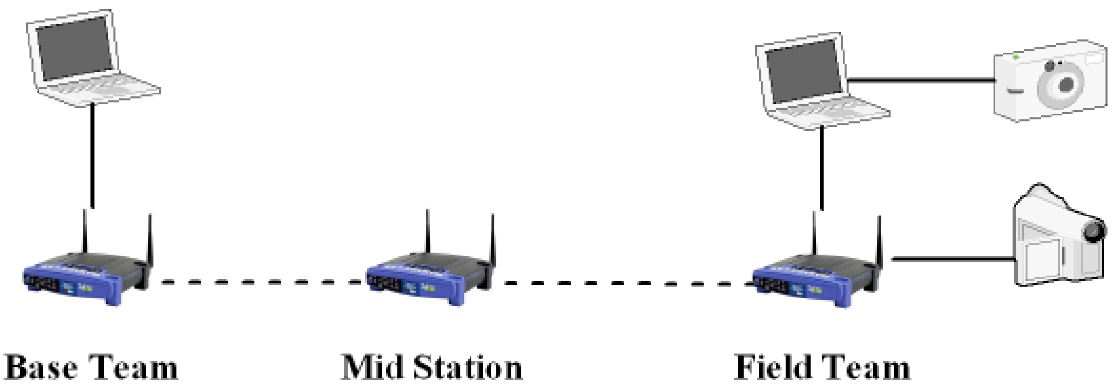
Welcome to the SXR339 Wireless Network. This document will tell you about the equipment, how to use it, how to troubleshoot it and who to call if you get stuck.

## 2 Intention

The network is intended to support remote working by two groups for the SXR339 field study course, allowing two groups to communicate via a wireless network.

We'll refer to the group at the roadside as the **Base Team**, and the group roving the mountains as the **Field Team**. In situations where the Base Team and Field Team are not in line of sight, there may be a third wireless station required to pass on the radio signals, known as the **Mid Station**.

The network is intended to support a video stream from the Field Team to the Base Team to give a low resolution video “sense of presence” and provide the opportunity to transfer high resolution stills camera images across the network. The Field Team will have a high resolution digital stills camera, and will take photos and load these onto a local laptop that can then be accessed by the Base Team across the network.




# 3 Wireless Network

The wireless network is based on standard wireless networking equipment; “Wi-Fi” (802.11b standard). We will now look at the equipment and its settings

## 3.1 Access Points

The ‘backbone’ of the wireless network consists of three Linksys WRT54G access points (APs) running Freifunk firmware. These have been set up as a dynamically routing network, which means it doesn’t matter which order you set them up in, as the firmware will talk to any neighbouring access point. However for simplicity’s sake, we’ve named the three APs **Base**, **Mid** and **Field**. For this project it’s best to keep them in that order.


***Linksys WRT54G wireless access point***

The Access points require 12v power, so those in the field will be powered by battery, and the Base Team will use a mains inverter via a car cigarette lighter.

To switch on the APs, plug them into power. There is no on/off switch on the APs. The APs will automatically boot themselves, no settings need to be changed. The APs will be ready to be used in approximately 60 seconds after they've been powered up. To test if the AP is working, you can send a ping signal test via one of the laptops. Open a command window and type in the "ping" command and the IP address of the AP, so for example:

```
ping 192.168.1.2
```

This will send a ping command to the AP at 192.168.1.2 and if the AP is running, you should receive something like the following:

```
Reply from 192.168.1.2: bytes=32 time 2ms TTL=64
Reply from 192.168.1.2: bytes=32 time 3ms TTL=64
Reply from 192.168.1.2: bytes=32 time 2ms TTL=64
Reply from 192.168.1.2: bytes=32 time 2ms TTL=64
```

If you receive a 'timed out' response then your laptop can't see the remote equipment. You'll experience something like the following:

```
Pinging 192.168.1.2 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 192.168.128.1:
Packets: Sent = 4, Received = 0, Lost = 4 (100% loss)
```

If you get this response it's time to troubleshoot the network:
Is all the equipment switched on?
Are the antennae pointing at each other?
Can each of the teams see their own access points?
If it appears each of the teams can see their own equipment but not the other team's equipment, the wireless signal isn't getting through. Try setting up closer, and if this succeeds it may be the wireless signal is having problems over the original route. Are there trees in the way? It may be the mid point access point is required to help maintain line of sight, or boost the signal.

If there is still a problem ask the onsite techie or contact the support team identified at the end of this document.

## 3.2 Freifunk firmware

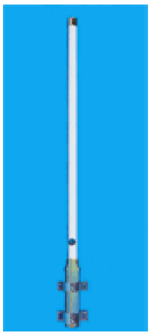
The WRT54G access points are running Freifunk firmware. This gives us greater control over the access points. You shouldn't need to access the firmware or log in to the access points, but there is a supporting technical document **freifunk_settings.doc** in case you wish to explore further. The access points can be logged in to by opening a web browser and typing in the address of the wired LAN address, for example **Base** is http://192.168.1.4 The login is **root** and the password is **admin**.

## *3.3 Antennae*

We are using two types of antenna to extend the strength of the network signal.

**Important:** These must be attached to socket B on the back of the access points. The other socket has been disabled.

At the **Field** and **Base** Team ends, we are using Panel Antenna. These are directional, and must be aimed within approximately 40 degrees. In reality this means pointing the antennae at both ends so the plastic dimpled faces point to each other should be good enough. The antenna should be set up so the cable connection is at the bottom. The antenna cable is screwed into this socket.



If the two Teams can see each other (line of sight) you may only need to use the two panel antenna facing each other.

If the two Teams are not in line of sight, a third access point will be needed in the middle - **Mid**, and this will use an omnidirectional antenna. This pole shaped antenna receives and sends signals in all directions in approximately 30 degrees on the elevated plane. It must be set up in a vertical position, with the cable coming out from the bottom.

### 3.3.1 Antenna mounting – lighting tripod

The antennae are mounted on a standard camera tripod by two bolts. These will be transported to the field in the tripod bag, and the tripods mounted at the beginning of the day. We have included two adjustable spanners in the kit for this purpose. Once mounted, the panel antennae can be moved through the vertical by loosening the mounting bolts and rotating the antenna on the mounting plate, then retightening when in the desired position. You may need to angle the antenna or tripod if the two Teams are at different elevations.

# 4 Video camera

The video camera for the network is a D-Link DCS900. This will be used to provide a "sense of presence" video stream from the Field site to the Base team.
**(Caution, this runs on 5 Volts only, make sure its does not get 12V!)**


The video camera displays via a web browser, so you don't need to open any special software, just open a web browser and go to **http://192.168.2.21.** You will be asked for a login and password. These are both **sxr339**.

When you view the video camera home page, you will see a still image and three buttons on the left hand side – Java, Active X, and Setup. Click on **Java** to activate the video stream.

### *4.1 Summary of settings*

To see the video camera, laptop users need to open a web browser and type in the address http://192.168.2.21

## 5 Digital Stills Camera

The digital stills camera for the network is a Nikon Coolpix P2. This is a lightweight camera which will be used for taking high resolution images at specific locations.


### *5.1 Summary of settings*

The camera will be set up before being issued for the project. Below we discuss the settings.

### 5.1.1 Taking Photos

When taking photos, set the camera to “A”. The camera has a motorised lens.

### 5.1.2 Loading images to the laptop

Once images have been taken, copy the images from the camera to the laptop. (The camera has a wireless function but we are not using it for this project).

The camera comes with a USB cable – plug the small end into the camera carefully and the USB end into the USB port of the laptop. On the laptop, double click on My Computer and you will see the camera appear as a new hard drive. From here you can drag images from the camera onto the laptop. Drop these into the images folder on the laptop so they can be seen by the Base Team.

### 5.1.3 Things to be aware of

Make sure you charge the camera battery every night!

# 6 Powering the equipment

Each team will power their access points from the dry cell batteries (and the Field Team video camera). These batteries should last a day of continuous operation but must be recharged each night.

The Field and Base Teams are provided with two laptop batteries. We expect the Field batteries to last half a day each. The Base team may need to charge their laptop batteries during break times.

# 7 Base power for recharging

In normal operation we anticipate the Base Team in the car will power their equipment via battery, the same as the Field Team and the Mid Station. However the Base Team is provided with an inverter (see picture) to allow recharging of one of the laptops as their batteries are most likely to run down within a single day.

The base laptop batteries will not last for a full session, they should be recharged during the lunch break. Turn the laptop off and connect to Inverter using the Sony power adapter. Connect the Belkin 12v DC to 240v AC Power Inverter to the vehicles cigarette lighter socket. Ensure cigarette lighter socket is powered; turn on vehicles ignition to auxiliary position. Turn on the Inverter and the power light should show Green. If the inverter bleeps than you have exceeded its load capacity.

To prevent overloading the vehicle supply, and blowing fuses only one laptop should be charged at a time. The Sony laptop should be turned OFF while charging. The Maximum load should not exceed 150 Watts.

As spare 35A ‘spade’ type fuse is attached to the Inverter lead.
Please see separate Belkin Inverter user instructions if problems arise.

# 8 FAQ and Troubleshooting

Here are some basic first line solutions, if you get really stuck look at the equipment manuals or call us. If you’re in the field – use the walkie talkies to talk to each other, keep the other people posted about what’s going.

## *8.1 Main thing: charge all the equipment every night!*

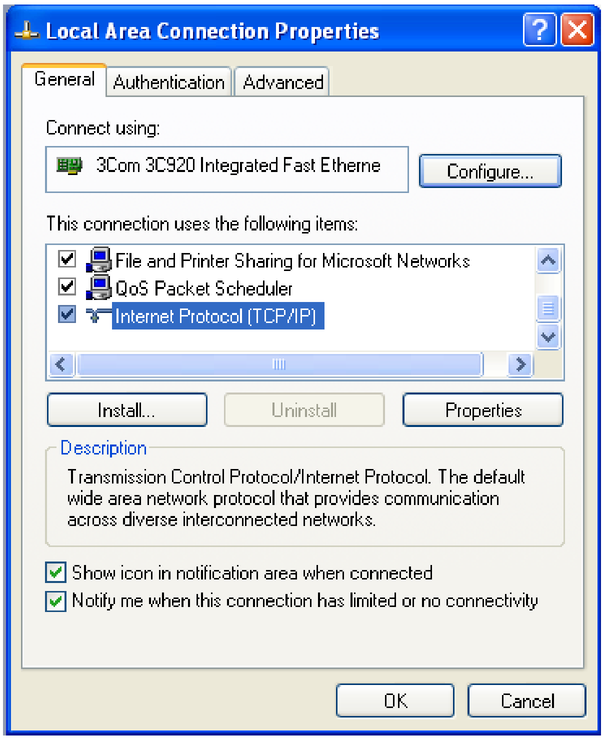
Some of the equipment batteries will last longer than one day, but best be safe…

## *8.2 Network*

**How do I test to see if the Access Points are working?**

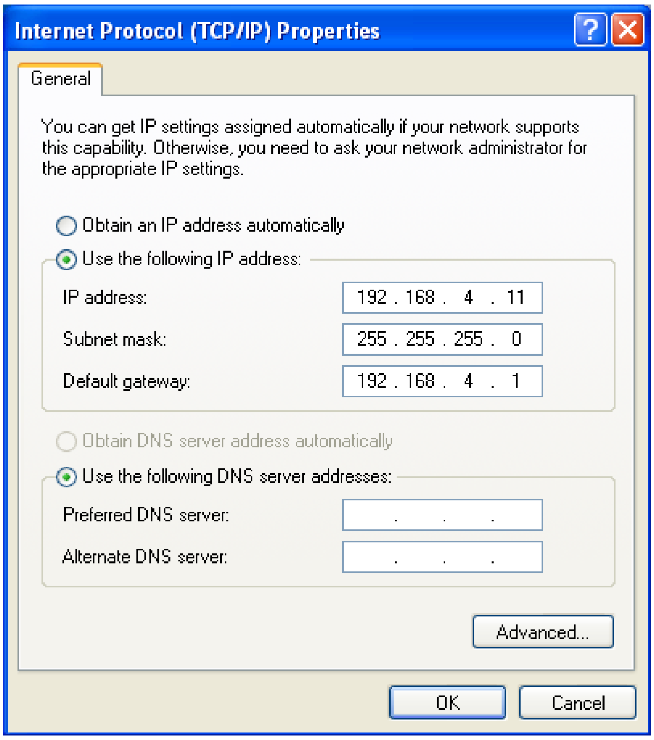
1. Check green lights on the front panel of the APs
2. Can you see the web page of the access points from the laptop’s web browser?

Make sure the IP address of the laptop is correctly set up. Go to the Start Menu, Settings, Control Panel. Double click on Network Settings. Double Click on Local Area Connection. Click on Properties.




*Check the Local Area Connection Properties*

Double click on Internet Protocol (TCP/IP). Check the settings here.




*Sample setting for laptop TCP/IP Properties*

These should be set similar to the above screenshot from the Base Team laptop.

2. Ping the APs.

3. Check the web interface for the access points again.

### *8.3 Stills camera*

Call Chris Valentine!

### *8.4 Video camera*

Occasionally we've found that the first time you go to the video camera web page, the page needs to be refreshed once or twice to see the camera.

### *8.5 Access points*

**Do we need to use all three access points each time we do a field trip?**
No, in many cases you will find that you won't need to set up the Mid Station, but will find the Field and Base equipment will talk to each other just fine. Indeed it seems to be very tolerant of situations where line of sight isn't perfect.

### *8.6 Laptop*

Sometimes we've found the laptop's can freeze. If the usual methods of restarting fail, the drastic solution is to pull the battery out of the back (though don't do this unless all other options have been tried…)

### *8.7 Spare equipment*

We have included a spare set of leads and a spare access point in case of equipment failure. Swap out the damaged equipment and make a note of what went wrong so we can fix it when you get back from the field trip.

## 9 Who to call

Call these people if you get stuck!

Mark Gaved [details removed]
Lewis McCann [details removed]
Chris Valentine [details removed]

Technical specifications

**Access Points**
Linksys WRT54GL
CPU Speed: 200Mhz
RAM: 16Mb
Flash Memory: 4Mb
Power: 12v

**Friefunk Firmware**
Version: 1.2.5
Website: http://freifunk.net/wiki/FreifunkFirmwareEnglish
Based on OpenWrt: http://wiki.openwrt.org/OpenWrtDocs

**Video Camera**
D-Link DCS-900
Power: 5v

**Stills Digital Camera**
Nikon Coolpix P2

**Laptops**
Sony Vaio PCG-5416
Sony Vaio PCG-6116

# Appendix Two: Connecting Guide

The following connecting guide was issued when the ERA system was sent to the SXR339 Summer School in July 2006.

# 1 Connecting the Kit

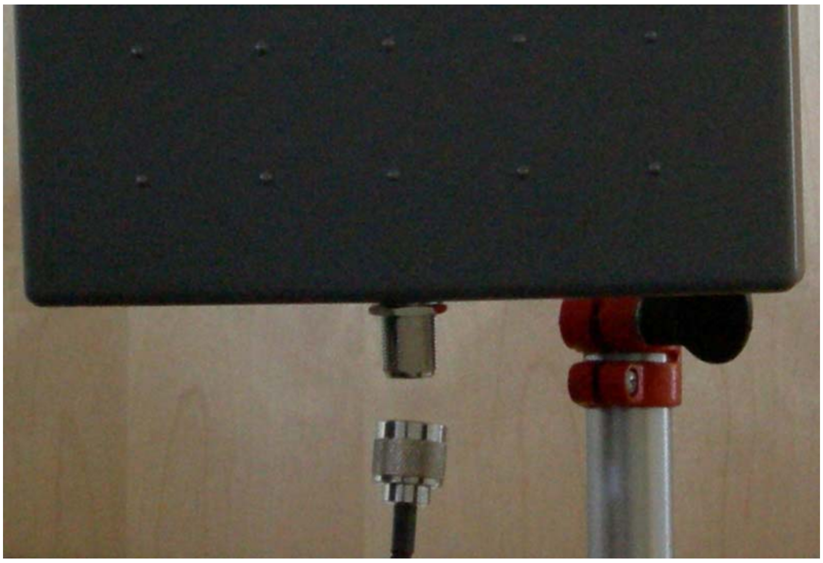
A basic guide to how all the SXR339 equipment connects together.



## *1.1 Wireless Access Point to Antenna*

The Wireless access point is connected to the antenna using the black antenna cable. At the wireless access point, the cable is connected through Socket B at the back.

On the panel antennae, the cable is connected underneath the antenna.



On the omni antenna, the cable is already attached to the antenna and only needs to be connected at the access point end.

## 1.2 Connecting the laptop to the access point

The laptops are connected to the access points at both ends using standard Ethernet cables (not wireless). These are connected into the right hand side of the laptops.

The Ethernet cable is connected from the laptop to the wireless access point. IMPORTANT: it connects to any one of the four right hand grouped sockets, but **not** the left hand single socket.

## 1.3 Connecting the power to the access points

The black or grey power cable connects to the right hand side at the back of the access points.


## 1.4 Connecting the power to the battery

The black or grey power cable connects to socket on the top of the battery. IMPORTANT: the Field battery has two connections, one for the 12v access point, and one for the 5v video camera. **Do not mix up these connections** (or you'll fry the equipment).


On the opposite side from the connectors for the camera and the WRT access point is a socket for charging the battery. Remember to charge the batteries every night!

## 1.5 Connecting the video camera

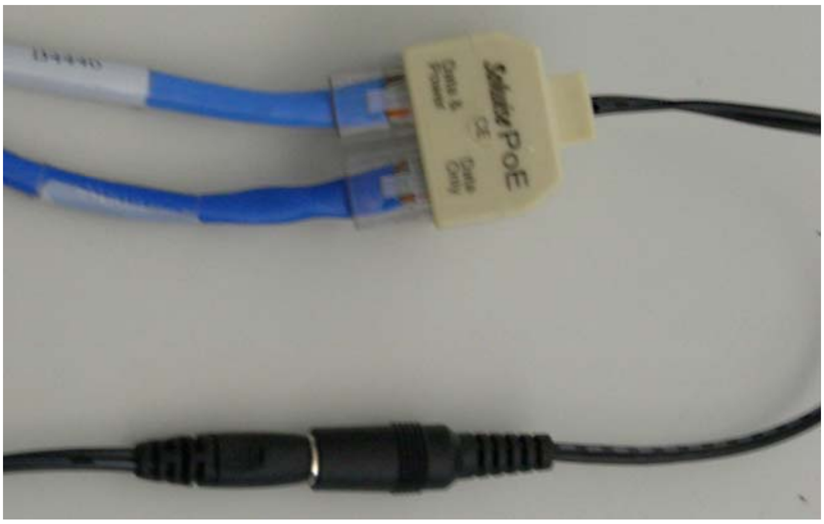
The video camera requires both power and an Ethernet connection. These are both run over "Power over Ethernet" – the power and data run down the same cable, so the set up is a little more complex. However this means there is only one cable for most of the distance which allows the video camera to be moved around on the field trip a lot easier.

### 1.5.1 The video camera data connection to the access point

The video camera transmits via a standard Ethernet cable. Plug a short Ethernet cable into the back of the access point, in the same block of ports as the laptop.

### 1.5.2 Video camera data connection the POE injector

The data cable for the video camera comes from the access point to the white POE injector (not directly to the video camera). Plug the data cable from the access point into the “Data Only” socket.

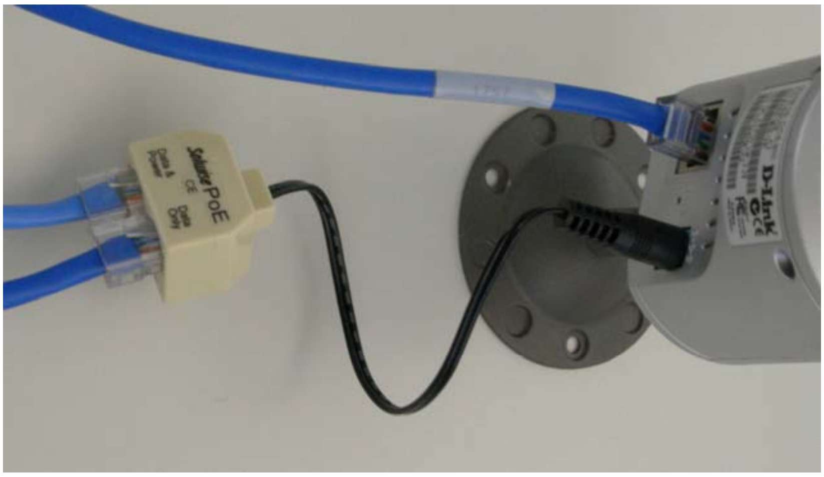



### 1.5.3 Powering the video camera

Plug the power cable from the battery into the black power connector on the white POE injector (see the diagram above).

### 1.5.4 Sending power and data to the video camera

Plug an Ethernet cable into the “Data and Power” socket on the white POE injector (see diagram above). Plug the other end into the “Data and Power” socket on the white POE splitter.




Connect the black power cable on the POW splitter to power socket on the back of the video camera.

### 1.5.5 Sending data from the POE splitter to the video camera

Connect a short Ethernet cable from the “Data Only” socket on the POE splitter to the Ethernet socket on the back of the video camera (see above diagram).

## *1.6 Connecting the Stills digital camera to the laptop*

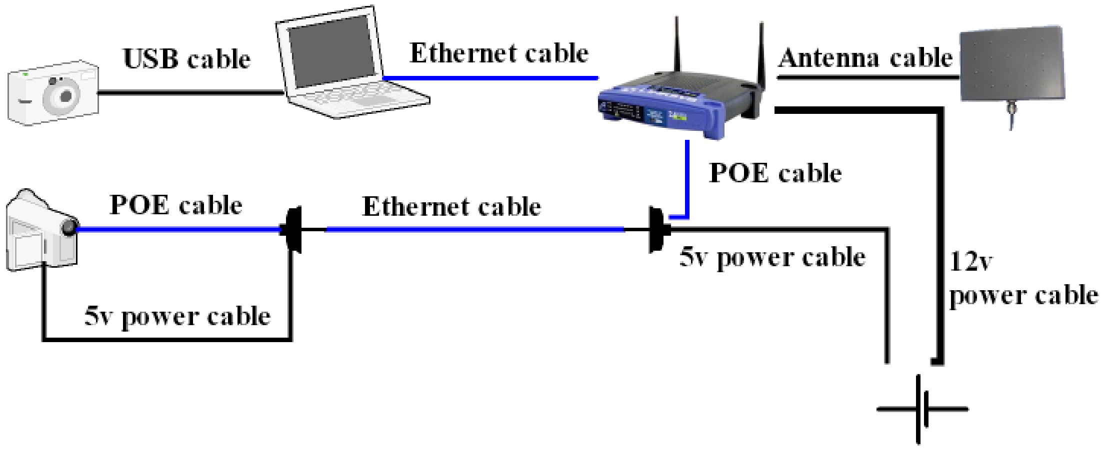
Once you have taken photos with the digital camera, download them to the laptop by using the black USB cable and connecting to the USB port on the left hand side of the laptop.


# 2 Cable connections

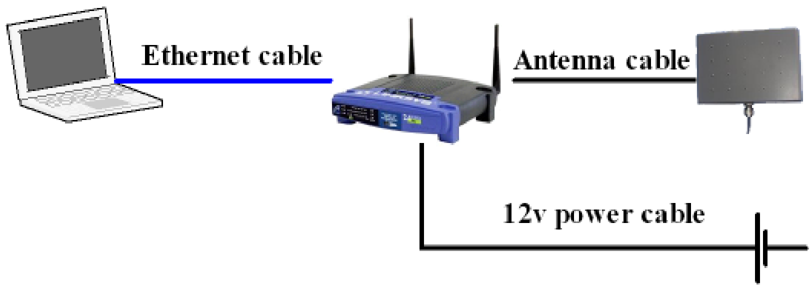
## 2.1 Introduction

This section has schematic diagrams of all the equipment and indicators which cables are used at which point.

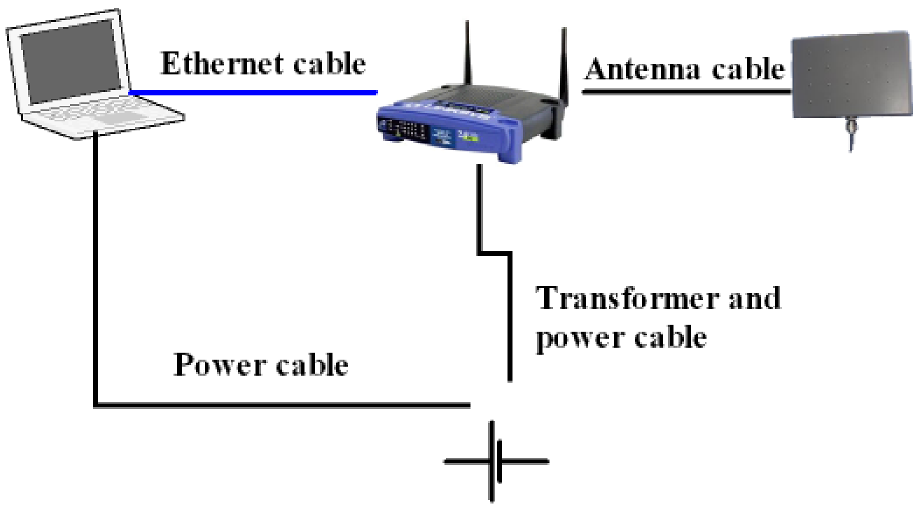
## 2.2 Field Team




## 2.3 Mid Point




## 2.4 Base Team



# Network Settings for SXR339 wireless project

***Last updated 05 July 2006 Mark Gaved m.b.gaved@open.ac.uk***

## *Introduction*

This document lays out the network settings on all the equipment used in the SXR339 wireless network project. The equipment will be given out to the project with settings committed, so no changes should be required.

## *Settings*

All the equipment is set with fixed IP addresses. None of them are set to DHCP. This means that new equipment cannot be plugged into the network without manually entering an address, nor can the laptops or video cameras be moved to another part of the network without going into the configuration settings and changing addresses. We have sought to maintain a structured approach to addresses to make it easier for additional equipment to be added if necessary.

### Access Points

All access points communicate as part of a mesh network: this means that they can be moved around as required, and the spare switched in or out as necessary. However devices are attached (in a network sense) as 'children' to their parent access point: so you will see the **Field** laptop has an address (192.168.2.11) in the same range as the **Field** access point (192.168.2.1) and the gateway for the field laptop is the address of the field access point.. Hence if the field laptop was to be moved to the **Mid** point or the **Base** it would need its settings changed to reflect that; e.g. a **Mid** point laptop would need the address (192.168.3.x) and its gateway would need to be (192.168.3.1).

**Base laptop**
IP address: 192.168.4.11
Netmask: 255.255.255.0
Gateway: 192.168.4.1

**Base access point**
Wired LAN IP: 192.168.4.1
Wireless IP: 192.168.1.4
OLSR: 192.168.4.0/24

**Mid access point**
Wired LAN IP: 192.168.3.1
Wireless IP: 192.168.1.3
OLSR: 192.168.3.0/24

**Field access point**
Wired LAN IP: 192.168.2.1
Wireless IP: 192.168.1.2
OLSR: 192.168.2.0/24

**Field laptop**
IP address: 192.168.2.11
Netmask: 255.255.255.0
Gateway: 192.168.2.1

**Field video camera**
IP address: 192.168.2.21
Netmask: 255.255.255.0
Gateway: 192.168.2.1

**Field stills digital camera**
IP address: 192.168.2.31
Netmask: 255.255.255.0
Gateway: 192.168.2.1

**Spare access point**
Wired LAN IP: 192.168.5.1
Wireless IP: 192.168.1.5
OLSR: 192.168.5.0/24

## *Rationale for the settings*

The rationale for the settings is as follows:

All equipment in the 192.168.x.x. “Class C” network.

All netmasks will be set at 255.255.255.0

Equipment communicating by wired LAN:
Field: 192.168.2.x
Mid: 192.168.3.x
Base: 192.168.4.x

Access points:
192.168.x.1

All other equipment attached by wire will therefore have their gateway as 192.168.(AP’s LAN).1

Laptops:
192.168.(follow the number of the AP’s LAN).11

Video cameras:
192.168.(follow the number of the AP’s LAN).2x

Stills cameras:
192.168.(follow the number of the AP's LAN).3x

Equipment communicating by wireless:
192.168.1.x

## *Changing settings*

Hopefully all the equipment will work and nothing will have to be added to the network to replace faulty kit! However if an access point fails, it can be replaced by the **Spare** access point (192.168.5.1). If this is put in place of another access point, the associated peripheral equipment will need their settings changed to match. Their new Gateway setting will be 192.168.5.1. Their own addresses will need to change to match the same subnet as the access point, so a laptop on 192.168.**2**.11 would need to be changed to 192.168.**5**.11.

## *Access Point Settings*

## *Introduction*

This document lays out the settings held on the wireless access points used in the wireless networking project. Settings will be held when the access points are switched off, so should not need to be changed in normal circumstances.

In the first section the key settings are described. In the second section screenshots of each section from the BASE access point are shown in order to offer an example of where to find the settings.

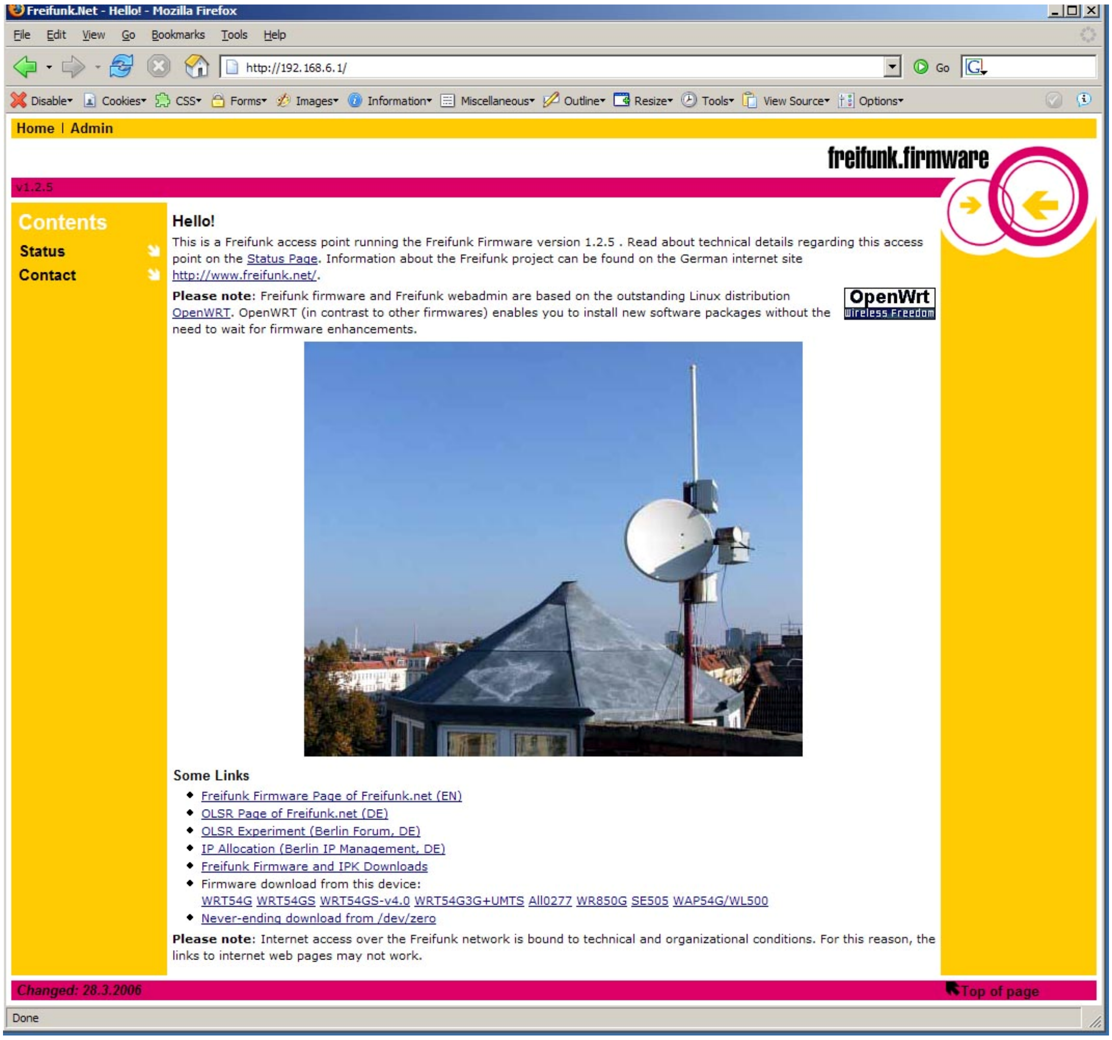
If settings need to be changed, after logging into an access point – type in the wired LAN IP address of the access point into a web browser, then login as user **root** password **admin** - make changes on each page, click **Apply** on the bottom of that page, the go to the **Restart** menu and do a **normal restart.**

## *Key Screenshots*

Here are screenshots of the key screens that you may need to check if you carry out administration work on the access points.

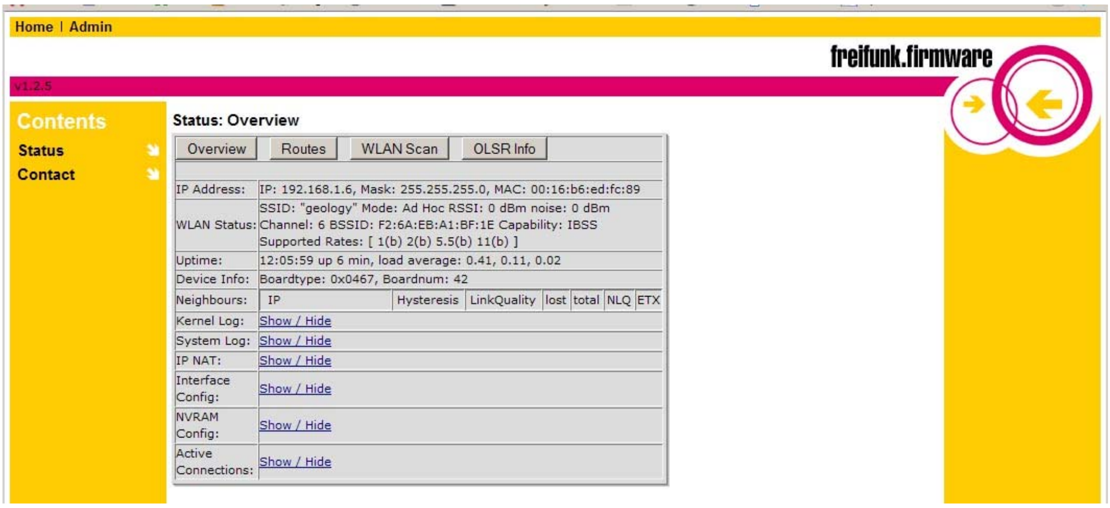
## Home Page

Checking if you can see the local home page is a good test of whether your local access point is working.



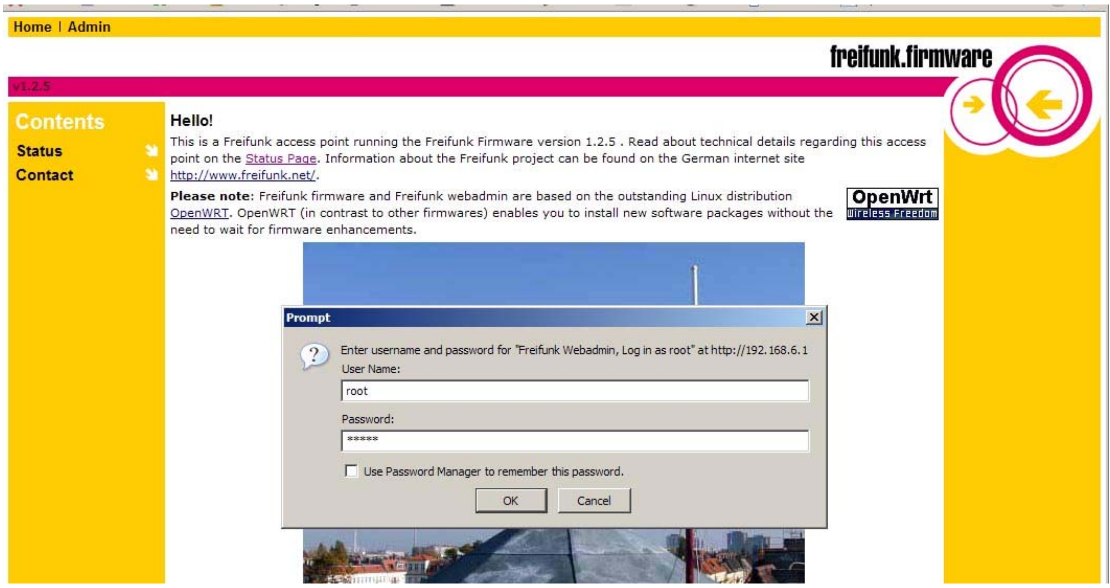
## Status Page

The status page is the front page for checking various administration aspects such as which other access points this access point can see, active connections and other wireless networks.



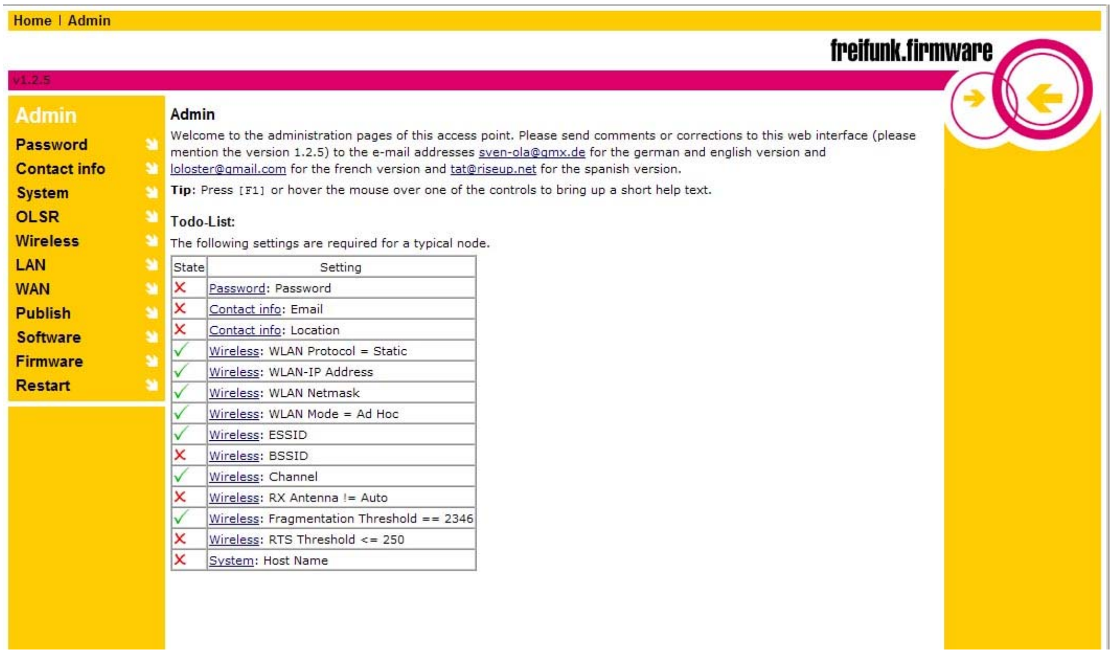

## Logging in to Administration

To make changes to the settings, log in to the administration section. However for the SXR339 project we advise you change settings on the individual laptops and peripheral equipment as the preferred method. User Name is **root** and Password is **admin**.



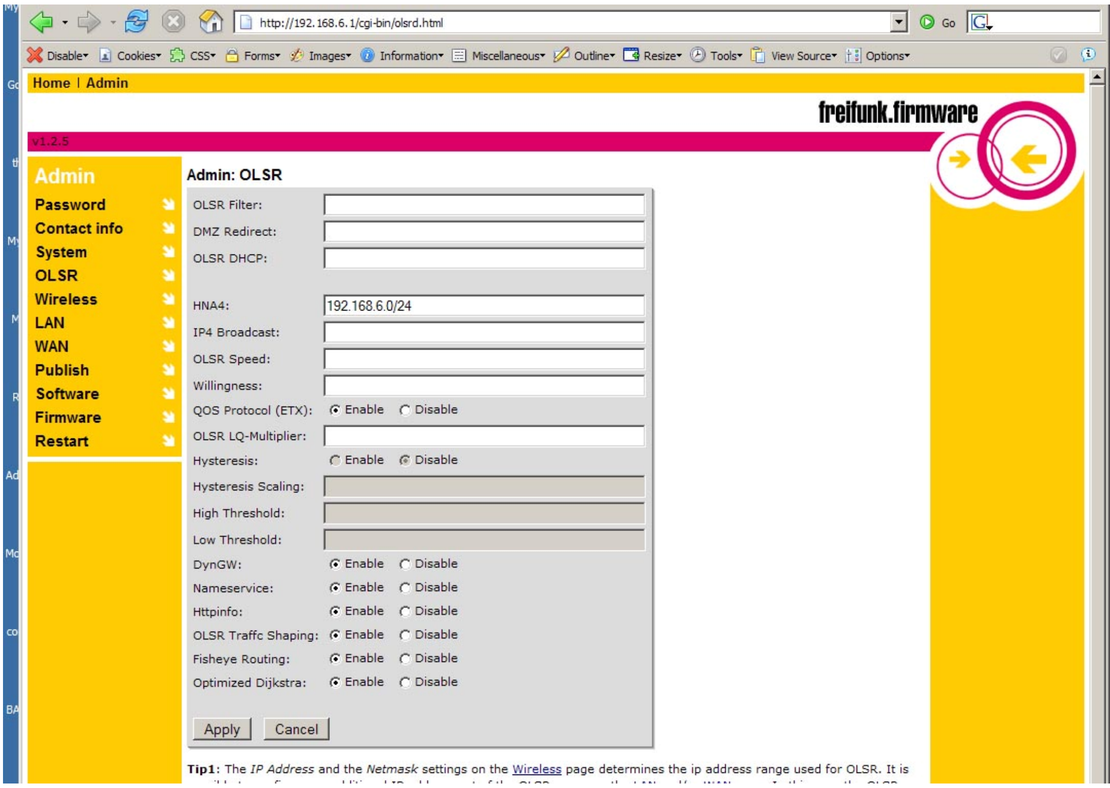
## Logged in

This is the screen you will see when you are logged in – you will notice a wider number of options in the left hand menu bar. The key pages we are concerned with are OLSR, Wireless, LAN, and WAN.



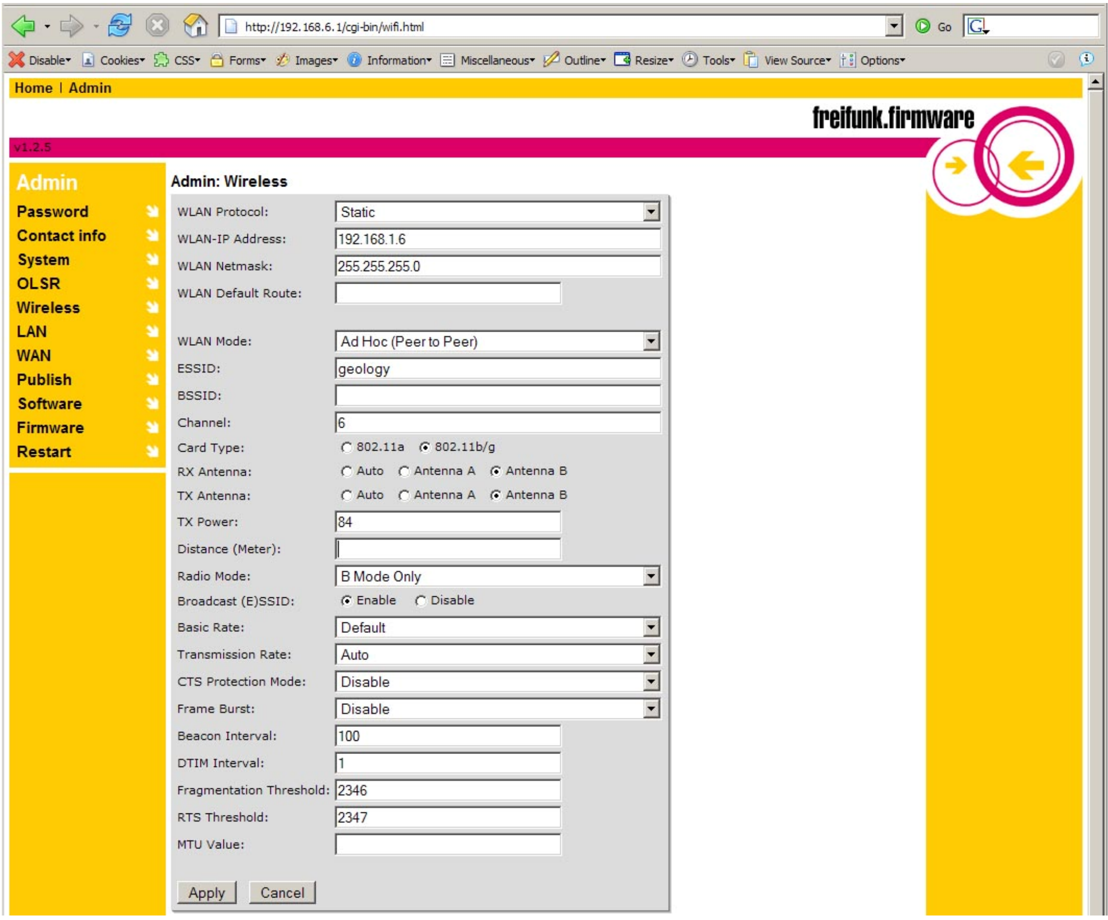
## OLSR

OLSR tells the access point which "wired" connections it should make available to the wider wireless mesh network. Here we can see 192.168.6.0/24 which means any device with address 192.168.6.0 – 192.168.6.255 and plugged into the back of the access point via Ethernet cable to one of the four LAN ports will be accessible over the network from another machine.



## Wireless

This screen defines the wireless networking settings. Here we can see the IP address of the access point is 192.168.1.6. We can also see that the only antenna which is working is Antenna B (next to the power supply at the back). The name of the network is “geology”.



## WAN

The WAN (Wide Area Network) setting tells the access point how to utilise the single WAN port (labelled “Internet”) on the back of the device. For the SXR339 project we are not connecting to the Internet so this is disabled.