A Case Study In Wireless Networking Deployment: Dublin, Ireland.

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Abstract

This document describes results obtained from a survey of WiFi networking deployment in Dublin, Ireland, conducted between May and August of 2002. Although no network operator has yet rolled out a commercial service in Dublin, over 350 distinct pieces of 802.11 equipment were found.

The following information is presented and discussed: the breakdown of equipment in use, by vendor; the density of networks not running WEP; a satellite image showing the geographical distribution of 802.11 equipment. It is found that a large number of both local area and point-to-point wireless solutions are being employed throughout Dublin and that a wide range of manufacturers' equipment is being used.

An issue in commercial roll–out of wireless equipment is investigated: given the limited number of channels available and observed localized high–density of "private" equipment, there is limited room for a ubiquitous network.

1 Introduction.

Where, and for what purpose, is wireless technology being adopted? What equipment is being deployed? When it is being adopted, are security issues of the media being considered? If it is being vigorously rolled out, is there interference caused by channel overlap problems?

Although there are surveys of American cities which tackle some of these questions, we know of no comprehensive, widely available, study of any European city. Using off–the–shelf equipment we conducted an extensive survey of Dublin. This document describes the gathered data and some of the inferences that can be drawn from it.

The rest of this document is organized as follows: Section 2 lists the equipment and the methodology used to conduct the survey; Section 3 summarizes the basic statistics acquired (Number of stations found, by vendor breakdown of equipment, etc.); Section 4 presents a satellite image of Dublin's WiFi deployment; Section 5 focuses on a particularly wireless–busy part of the city and investigates overlap issues associated with channel choice; Section 6 presents some concluding remarks.

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2 Equipment and Methodology

A range of equipment was used during the survey, as various combinations have advantages and drawbacks. For example, some of the cards can scan passively, observing beacon packets, whilst others can scan actively using a Probe Request/Response method. A lengthier description of the issues experienced with sniffing hardware/software can be found elsewhere [1]. The hardware used is readily available and the sniffing software is freely downloadable.

- **Portable computers:** Sony Vaio R600HEK running SuSE 7.3 and Windows 2000; Dell Latitude L400 running FreeBSD 4.6; Mac iceBook 2001 running MacOS X; Handspring visor deluxe.
- **Wireless cards:** Lucent Orinoco Silver card; Buffalo card; SMC EZ Connect Wireless No. SMC2632W; the standard Apple Airport card.
- **GPS:** Garmin GPS35-HSV; HI-202S; Magellan GPS companion.
- **Software:** kismet-wireless on Linux; NetStumbler on Windows; bsd-airtools 0.2 on FreeBSD; MacStumbler 0.6b on MacOS X.
- **Transport:** foot; bicycle; car.

In the course of the survey, more than a thousand kilometers was covered. The emphasis was placed on the city center and industrial areas. Residential areas were investigated less comprehensively, but, for completeness, every road and lane in one residential area, Clontarf, was searched.

3 Data Summary

The following table presents basic statistics of the gathered data. It is oft reported that a high density of networks do not use WEP; this is what we find too:

Total number of stations	378
Stations with WEP	146 (38.62%)
Stations without WEP	232 (61.38%)
Stations with changed SSID	322 (85.19%)
Stations with default SSID	56 (14.81%)

Of the 378 pieces of equipment detected, the following table gives the breakdown by vendor. The Breezenet equipment was used for directional, point-to-point links and, surprisingly, suffered from quite a lot of diffusion; the same MAC addresses could be sensed over a large region.

Manufacturer	No.
Agere-Lucent	127
Cisco-Aironet	86
Ad-hoc Network	44
3com	23
Apple, Intel	14
Smc	9
Unknown	8
Netgear	7
Breezenet, Gemtek	6
D-link	5
Nokia	4
Bromax, Compaq	3
Matsushita, Premax	2
Symbol, Z-com	2
Acer, Adv. Multimedia	1
Belkin, Cisco	1
Enterasys, Hewlett-Packard	1
Linksys, Planex	1
Tellus, No wires needed	1
Zyxel	1

It is interesting to note that there were a sizable number of ad-hoc deployments of 802.11. These deployments do not rely on an access point.

One observed phenomena of ad-hoc networks was the apparent incorrect generation of BSSIDs. For IBSS or ad-hoc networks the BSSID should be generated by taking 46 random bits r and constructing the address: rrrr rrug:rrrr rrrr:rrrr rrrr:rrrr rrrr:rrrr rrrr:rrrr rrrr, where u, the Universal/Local bit, is set to 1 to indicate a local address and g, is the Individual/Group bit, is set to 0 to indicate individual.

Some ad-hoc network equipment sets the top byte to 02 then correctly sets the rest randomly. These ad-hoc networks (while having no association) seem to generate a new BSSID every 10 seconds. Approximately 36 of the BSSIDs collected may be attributable to two devices using this scheme.

It is possible that we encountered other sniffers on our journeys; these cards, if in active sensing mode, would broadcast association requests, but not necessarily with a valid MAC address.

The following table presents the breakdown of devices by the channel on which they were operating:

Channel	Number
1	83
10	68
11	47
7	40
3	39
6	32
Undetermined	30
13	16
2	7
4	6
8	5
5	3
9, 12	1

There seems to be confusion in the use of SSIDs: in some cases, the field was interpreted as a password (for example, use the company name but swap 3 for e). 115 pieces of equipment had the manufacturer's default SSID:

[empty]	69
101	9
WaveLAN Network	8
tsunami	7
WLAN	7
Apple Network	5
any	3
3Com	3
Wireless	2
Nokia WLAN	1
Airport	1

4 Geographical

Figure 1 is a satellite map of Dublin, which is a coastal port and Ireland's capital city. A version of the map, in which WEPed and unWEPed networks are differentiated, can be found online, [1]. Dublin has a population of approximately 1.25 million. Cloud obscures the tombolo to Howth in the North-East corner. The center of the city is to the south of the main river, the Liffey, with some financial institutions on the north side of the Liffey. There is a ring-road motorway, the M50, around the outskirts of the city, at the north-most point of which runways from Dublin International Airport can be seen. Industrial estates and business parks account for much of the land adjoining the M50. The clump of networks to the south are in a Sandyford's large industrial estate, which the M50 will ultimately lead to.

802.11 has been extensively deployed throughout Dublin. The city-centre and business parks where hi-tech companies operate show high penetration, as do the universities and other third–level colleges. No

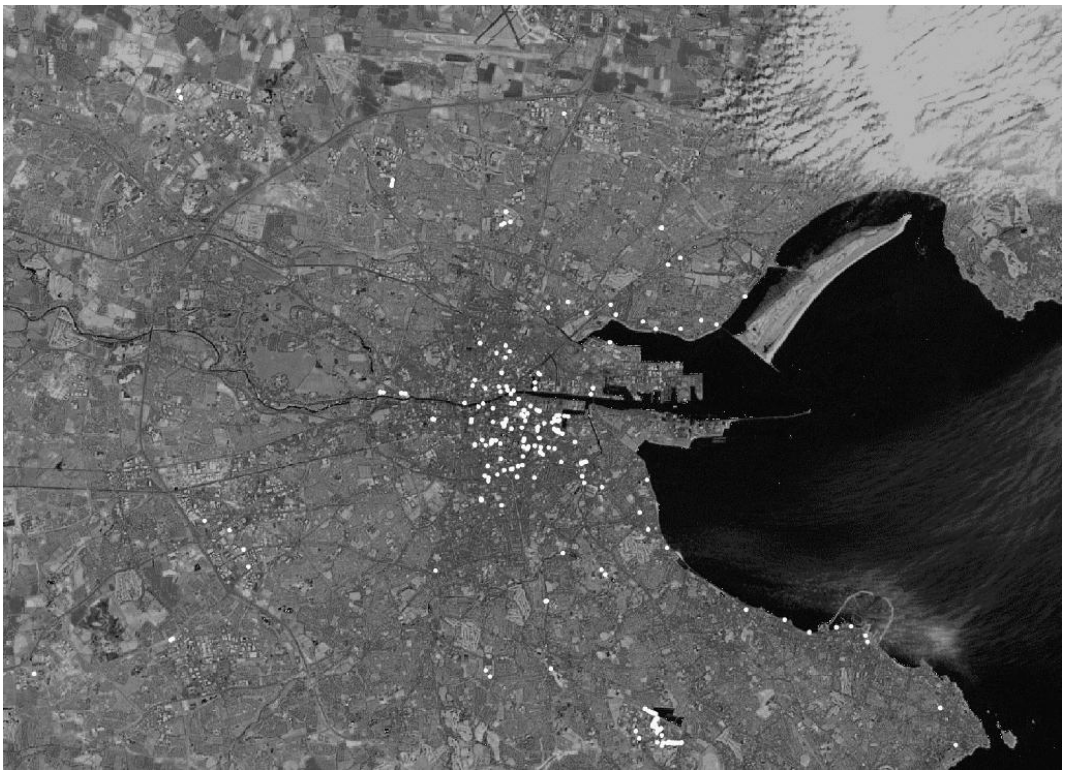

Figure 1: WiFi map of Dublin; white circles indicate 802.11 equipment.

secondary schools were identified as having 802.11 deployments, though this may be due to the time of year at which the survey was conducted.

Residential areas are, in general, RF-quiet, though there are some signs of deployment. Clontarf, on the coast to the North-East, is a residential suburb that was surveyed comprehensively by bicycle. About 10 access points were found; half seem to be residential, with the other half used by home offices or small businesses.

5 Channel overlap

TV, commercial radio, mobile phone and even amateur radio are examples of wireless networks which now enjoy wide scale deployment. The operation of all these networks is protected by licensing of the relevant pieces of spectrum. This protection is both legal (e.g., the shutting down of 'pirate' radio stations) and social (e.g., radio hams complaining about sloppy operation of equipment).

WiFi is in a different situation. The spectrum is free for general use, subject to constraints on transmission power. There are many possible sources of interference which a 802.11b network is subject to, including: portable phone handsets; wireless keyboards and mice; wireless digital cameras; bluetooth devices; microwave ovens; other 802.11b networks.

Anecdotal evidence suggests that unintentional overlap between 802.11b networks is common; in network administrator circles, there are often stories of laptops associating to neighboring companies access points.

Several companies are considering large public commercial deployments of 802.11. By the time these deployments move out of the labs and on to the streets, will there be space in the spectrum for these deployments? It remains to be seen if the mutual good nature of organizations "sharing the Ether" would be sufficient to resolve any disputes that arise; it is likely that a mutual co-operation body or a form formal regulation would be required.

In certain areas of Dublin, 802.11 equipment is already densely deployed. Sandyford Industrial Estate is one such area, the southmost WiFi-dense area in Figure 1. The breakdown of channels used in a 1km square around Sandyford is:

Channel	Number
1	35
11	11
Undetermined	10
3,6	6
13	3
7	1
2, 4, 5, 8, 9, 10, 12	0

Clearly, channel 1 is the most popular. In Figure 2, circles of 100 meter radius (the widely accepted effective range of 802.11b, [2]) are presented in black around base-stations using channel 1 within this 1km square. Gray circles are placed around base-stations using the nearby channel 3.

Although the centres of the circles are where packets were observed, not where the physical devices are, it is clear that many channels suffer overlap. Even if the managers of these networks were to co-operate, spreading the range of channels in use, it is unlikely there would be one free.

6 Concluding remarks

From the collected BSSIDs, which we will not publish – although they are easily obtained –, and the locations of observed networks, it is clear that many different types of organization have deployed 802.11 networks, including: financial; telecoms; computer; engineering; educational; graphic design; local government/public sector; residential and hobbyist. There is obvious deployment of 802.11 networks in its expected function as a computer LAN, but also as a long-distance point-to-point link.

802.11 has experienced rapid growth in deployment since its commoditisation as a consumer wireless chip-set. It is not clear that ubiquitous commercial services can be built in a stable fashion as technology evolves and unregulated deployments shall continue. For commercial service provision, careful account must to be taken of: radio propagation and interference issues; and also of security implications on a link and packet level.

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References

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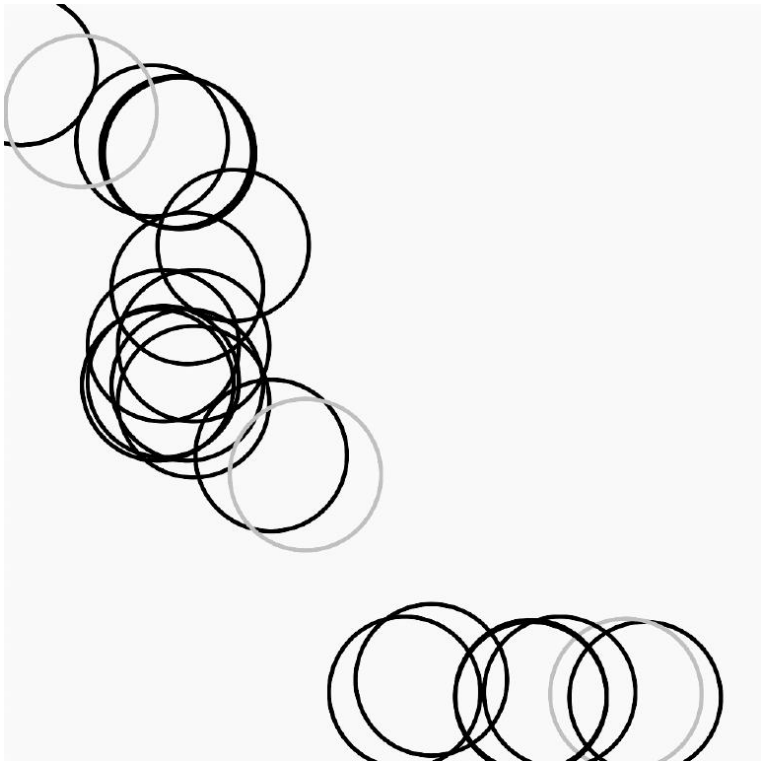

Figure 2: Channel overlap in a 1km square around Sandyford Industrial Estate. Black circles = channel 1, Grey = channel 3.