

Unlicensed Bands

Linda Doyle
 Centre for Telecommunications Value-Chain Research
 Department of Electronic & Electrical Engineering
 Trinity College, University of Dublin, Ireland

So far

- Radio broadcast with emphasis on digital radio
- Mobile communications and cellular networks (including IMS from Brian)
- We now move on to look at the unlicensed bands and the systems that operate in those bands.
- You probably know most of them already!

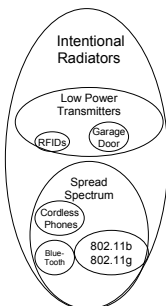
unlicensed spectrum

- Unlicensed or license-free spectrum as it is sometimes called simply means a spectrum band that has rules pre-defined for both the hardware and deployment methods of the radio in such a manner that **interference is mitigated by the technical rules** defined for the bands rather than it being restricted for use by only one entity through a spectrum licensing approach (like the mobile communications world)
- In the systems we looked at so far interference has been mitigated by assigning exclusive use of a chunk of spectrum to the some entity

what does unlicensed mean?

- basically anyone can use these bands provided they obey the technical rules – which boils down to some kinds of power restrictions [Typically, the power allotment for each license free radio is much lower than that enjoyed by licensed spectrum holders.]
- typically while there is a right to transmit (within given power limits), there is no right to receive
- in other words there is no right not to have interference from other systems like would be the case in the GSM or 3G bands
- Some of the most commonly used license free frequencies in the US are at 900 MHz, 2.4 GHz, 5.2/5.3/5.8 GHz, 24 GHz and above 60 GHz.

Part 15 Rules



All these intentional radiators must follow the Part 15 rules which limits power levels.



there are higher bands around 5MHz not marked on this picture

<http://www.electronicproducts.com/images2/facnanalognov2007.gif>

802.11g

- This works in 2.4 GHz band and surprise, surprise uses OFDM!!!
- This is the standard in our laptops
- 802.11 has overall been a very successful standard

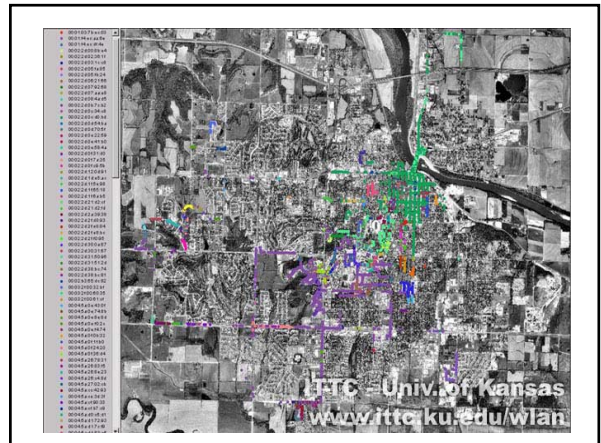
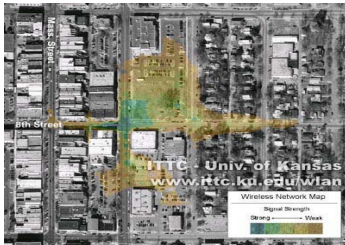
802.11n

- The newest IEEE standard in the Wi-Fi category is *802.11n*.
- It was designed to improve on 802.11g in the amount of bandwidth supported by utilizing multiple wireless signals and antennas (called *MIMO* technology) instead of one.
- You can see these products in the shops now



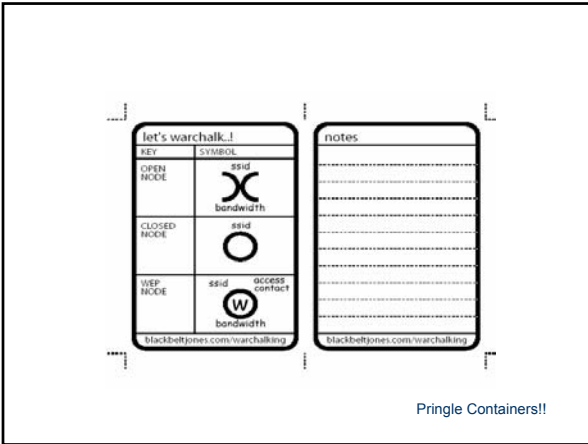
Visualisation of WLAN Coverage

- Example below shows image for 1 WLAN network – colours refer to signal strength.



Warchalking

- [play on *war-driving*: the first syllable has since been reinterpreted as an acronym for "wireless access revolution"]
- The practice of using chalk marks similar to hobo signs to indicate the nearby presence of a wireless Internet access point, a boon to strolling hackers with laptops.
- The concept was first floated in early 2002 and was instantly seized upon with cries of glee by hackers all over the portions of the world urbanized enough to have sidewalks and access points.

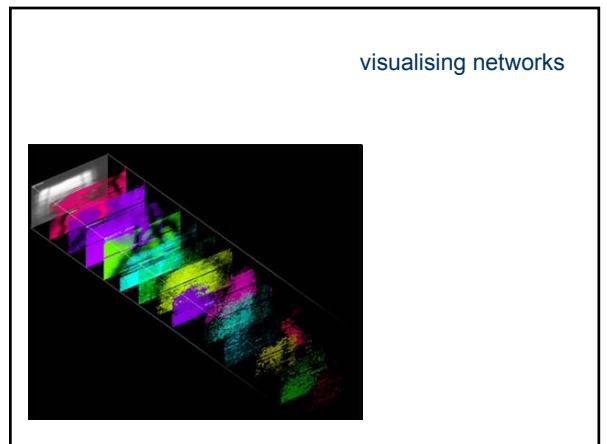
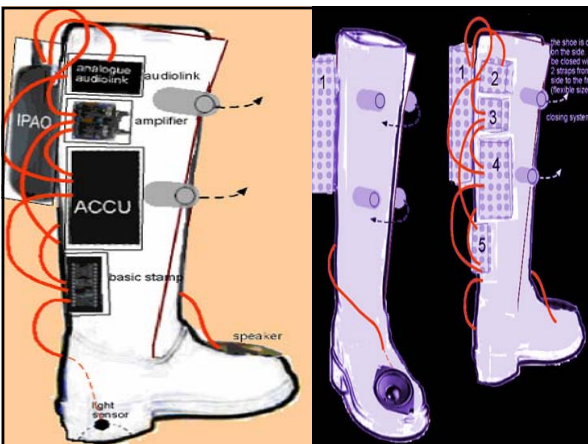


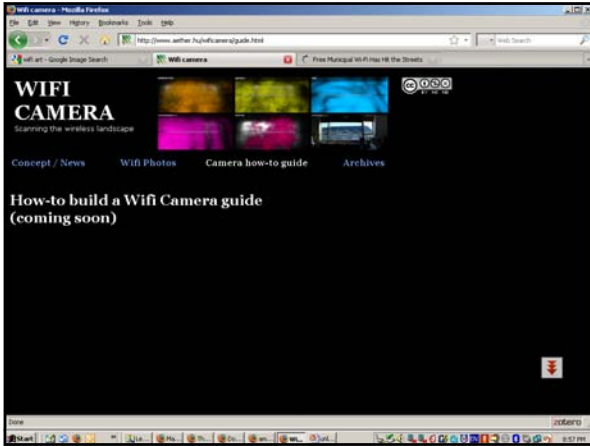
The Warbike turns this wireless network activity into sound. As you cycle the streets, you'll hear the activity of this invisible communications layer that permeates our public spaces. Who knew that so much was going on?

<http://www.mentalfloss.ca/sintheta/projects/warbike.html>

The project SEVEN MILE BOOTS is a pair of interactive shoes with audio. One can wear the boots, walk around as a flaneur simultaneously in the physical world and in the literal world of the internet. By walking in the physical world one may suddenly encounter a group of people chatting in real time in the virtual world. The chats are heard as a spoken text coming from the boots. Wherever you are with the boots, the physical and the virtual worlds will merge together.

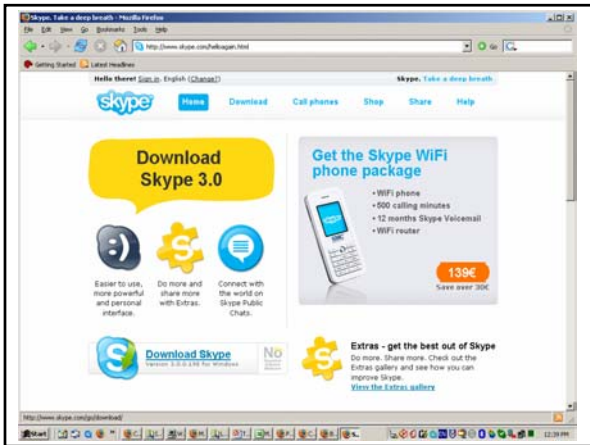
<http://randomseed.org/sevenmileboots/>





http://interactive.usc.edu/archives/cat_mobile_media.html

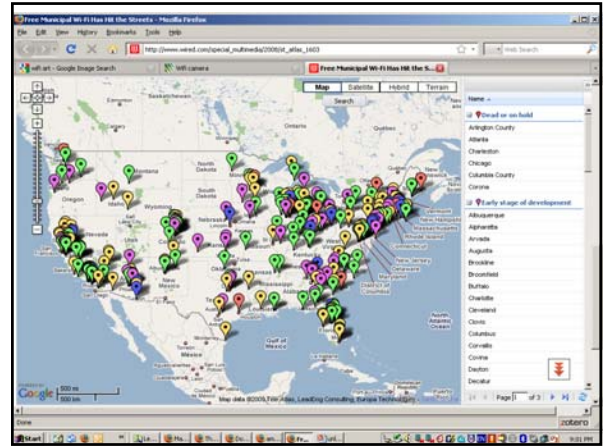
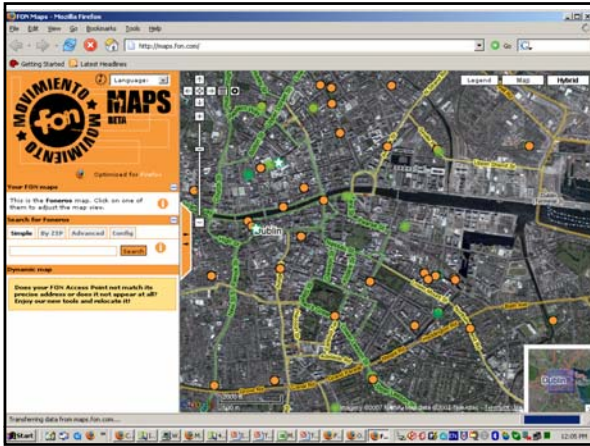
very good website



everything is connected!

The revolutionary new Eye-Fi Card looks and works just like a standard 2GB SD card except it has a tiny secret: Wi-Fi is built in. Now, docking your digital camera, connecting cables, and fumbling with card readers are a thing of the past. The Eye-Fi card will wirelessly upload your photos from your camera onto your computer and the web.





BT Fusion a brief study

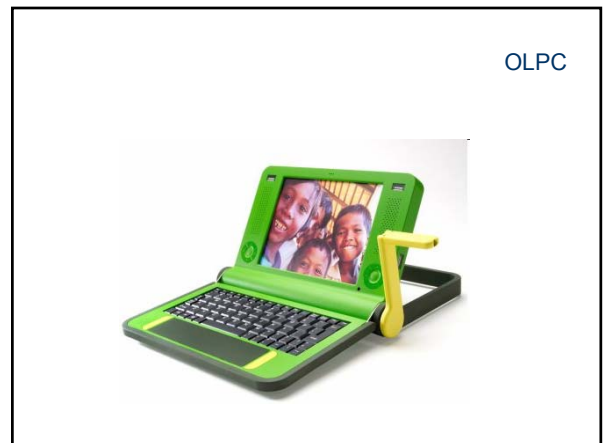
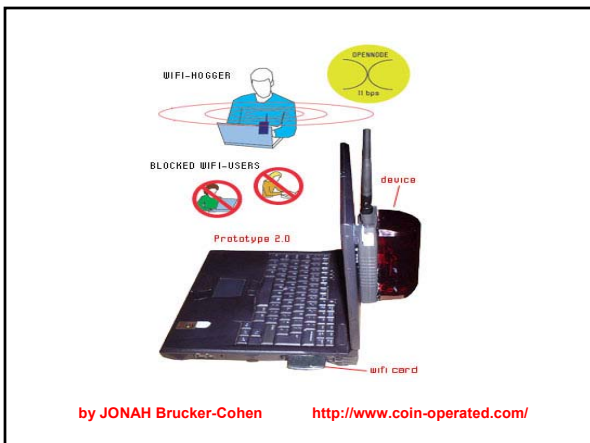
- Fusion is a convergence service that allows subscribers to make cheap or free calls via **Wi-Fi** into a **BT broadband hub at home** and then make calls via the Vodafone network or through BT's Wi-Fi hotspots when outside.
- Three dual-mode phones, including the Motorola Razr, are Fusion-compatible. It was first marketed to home users and later to businesses.
- So in other words it is a model that embraces both licensed and unlicensed use of spectrum.
- In February 2008, BT confirmed that Fusion as a consumer service is being wound down - only **45K subs** registered since 2005.

why did it fail?

- It was too complex for consumers?
- it was only available to BT broadband users.
- Only three phones could be used, and only one at launch.



- It appeared to have no retail presence.



OLPC



some OLPC details

- The rugged, low-power computers use flash memory instead of a hard drive, run a Red Hat Linux-based operating system and use the Sugar user interface (a specific kind of GUI developed with children in mind).
- **Mobile ad-hoc networking** based on the 802.11s wireless mesh network protocol allows students to collaborate on Activities and to share Internet access from one connection.
- The wireless networking has much greater range than typical consumer laptops.
- The XO-1 has also been designed to be lower cost and much longer lived than typical laptops.

aside: what is an ad hoc network?

- in a centralised system all mobile handsets connect to some kind of basestation
- 802.11 systems we encounter most of the time are set up in this manner. Rather than use the word basestation the word access point is used
- the network is **star shaped** and each computer or mobile handset connects to the destination computer or mobile handset via the basestation or access point.

ad hoc continued

- in an ad hoc network there is no central controller
- an ad hoc network is therefore a **distributed network** – messages hop from one node to the other until the destination is reached
- mobile networks just operate in centralised mode but wifi networks can be set up in a centralised fashion OR in ad hoc mode
- the key feature of an ad hoc network is the **routing protocol** that **hops packets** from one node to the other until the destination is reached.

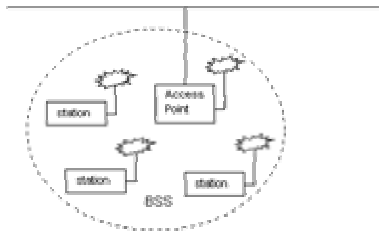
terminology

- ad hoc network
- multihop network
- mesh network
- mobile ad hoc network (MANET)

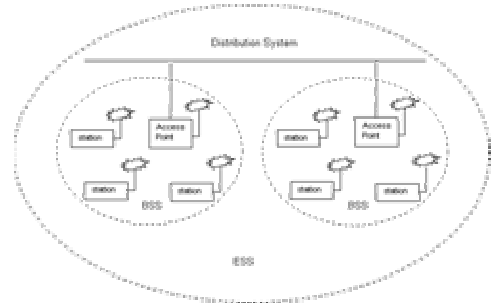
some basics

- of course any radio technology can be used in an ad hoc network.
- it does not need to be 802.11 based technology.
- however most of the research has been in the context of using 802.11 – both because of ease of availability and because the unlicensed world philosophy seems to match the ad hoc philosophy very well.

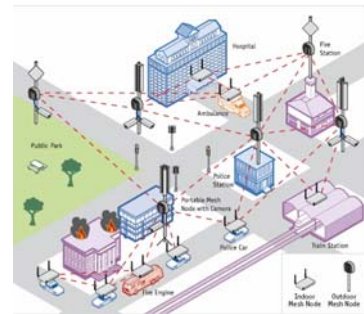
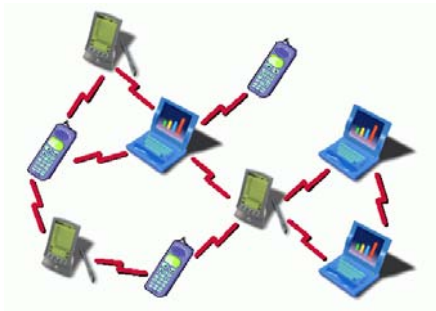
802.11 Infrastructure Mode – Basic Service Set



802.11 Infrastructure Mode – Extended Service Set



ad hoc mode



http://www.firetide.com/uploadedImages/Solutions/publicsafety_diag.jpg



car based ad hoc networkAs soon as two or more vehicles are in radio communication range, they connect automatically and establish an ad hoc network (copyright BMW group).

http://www.ercim.org/publication/Ercim_News/enw63/gerlach.html

Digital Ubiquitous Mobile Broadband OLSR (DUMBO)

3 December, 2006 (Digital Ubiquitous Mobile Broadband OLSR (DUMBO) Project, Pathumthani, Thailand & Technical Employment Campus in Phuket, Thailand)



<http://intraweb.ait.ac.th/aru/news/Jan07/art/a16.html>

'DUMBO-Project did demonstration experiment for lifesaving and weather data observation. This experimental system used MANET (Mobile Ad-hoc Network) consisted of elephants. I brought weather sensors on this network, and I made observation system, with which we can easily observe weather information about a disaster area. In AINTEC'06, we demonstrated this system. It was a great opportunity that I constructed demonstration system and discussed research topics with lots of researchers from all over the world.'



powering in different ways

- SolarMESH is an IEEE 802.11 wireless LAN mesh network developed by the McMaster University Wireless Networking Group under the supervision of Professor [Terry Todd](#).
- SolarMESH provides industry standard outdoor wireless hotspot coverage for WiFi end stations.
- This is accomplished by functioning as a WLAN mesh network and doing backhaul traffic relaying between SolarMESH nodes.

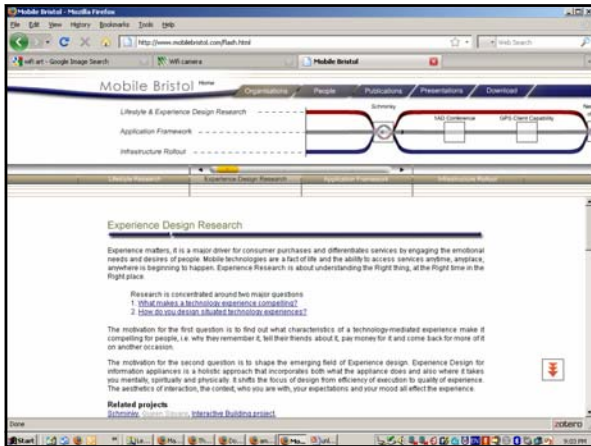
SolarMesh



jonah brucker-cohen - artist

wizy digital courier





- again the standardisation process hugely helped
- in general IEEE standardising process good
- unlicensed spectrum means great freedom
- introduced us all to wireless and made it part of our lives
- hugely creative space because of OPENness