TVWS & The Internet of Things

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Why TVWS for IoT?

- **What's TV Whitespace?**
- More Radio Spectrum
- Better Radio Spectrum
- Existing Protocols Unsuitable
- Why TVWS for IoT

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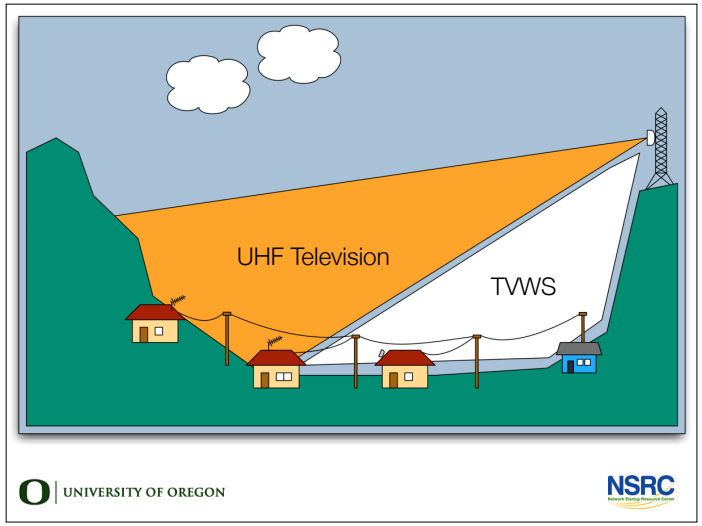
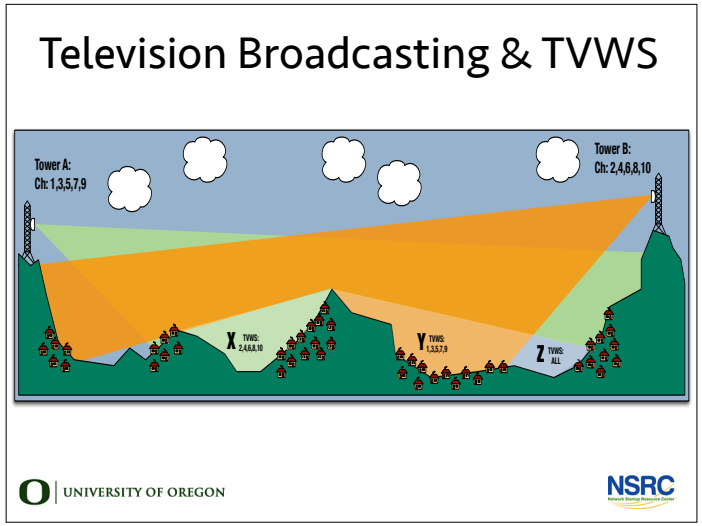


Easier to show this with a diagram.. A broadcast tv antenna concentrates its signal to provide the greatest coverage with a set amount of power. Here we have two houses receiving broadcast TV, and a third house outside the coverage area.

The next slide shows a more realistic scenario.

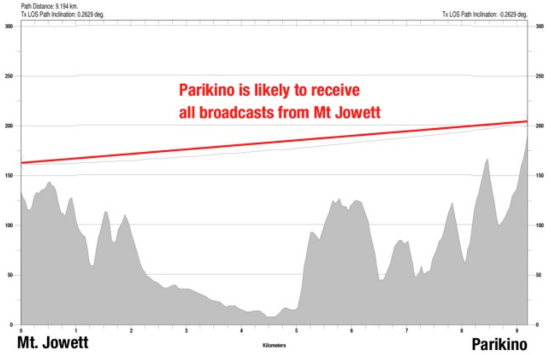


In this TV broadcast application, we have two adjacent towers using different sets of frequencies to prevent interference in areas where they overlap. A is using channels 1,3,5,7, & 9, B is using channels 2,4,6,8, & 10.

Some areas receive only waves from one of the two towers - for example X only receives signals from Tower A, and Y only receives signals from tower B.

Area Z doesn't receive any coverage at all. X, Y, and Z are all examples of Whitespace.

Primary TV Cover for Parakino



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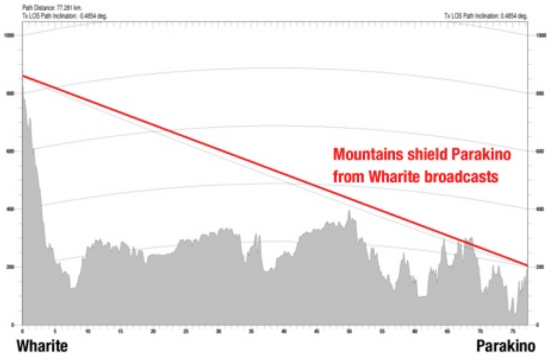
First Adjacent Broadcast Tower



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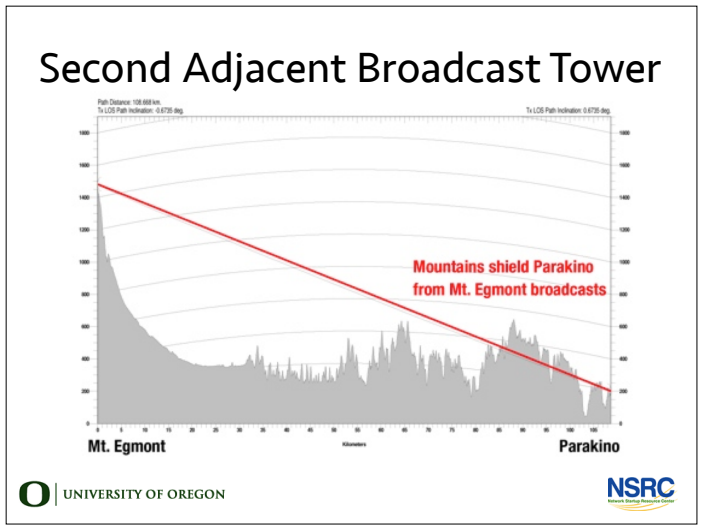

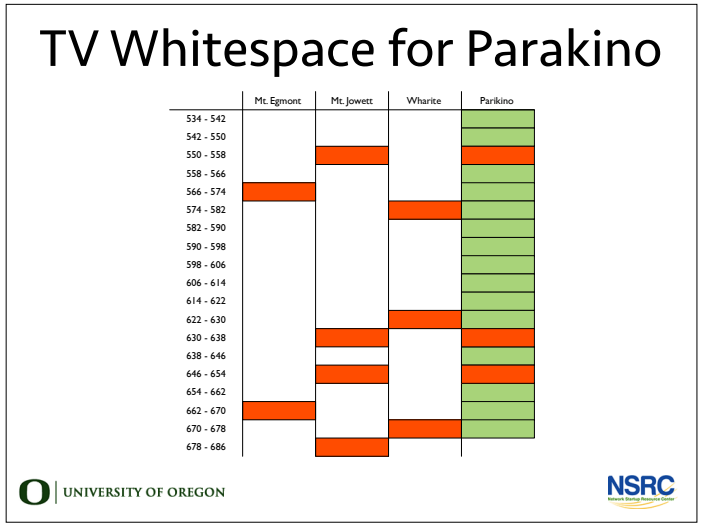

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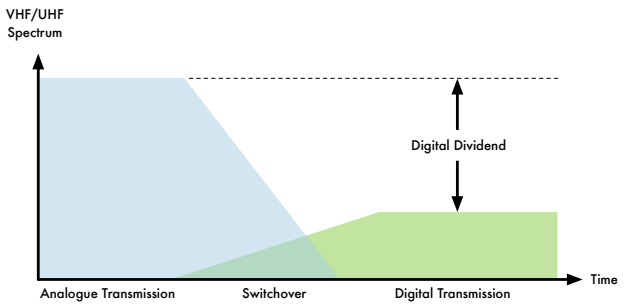
More Radio Spectrum



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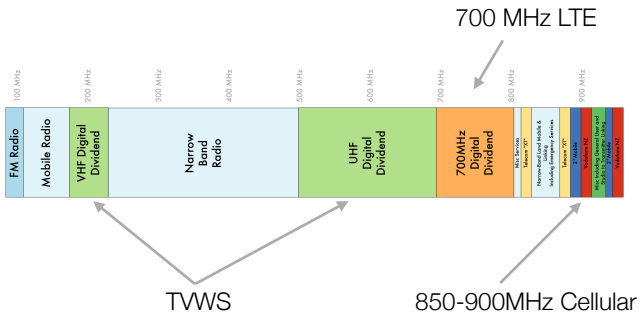
Television bands started with a lot of radio spectrum. With the shutoff of analogue television transmission and its replacement with digital tv, even more spectrum had been made available. Some of that - in particular 700MHz radio spectrums - has been moved into Cellular service.

More Radio Spectrum



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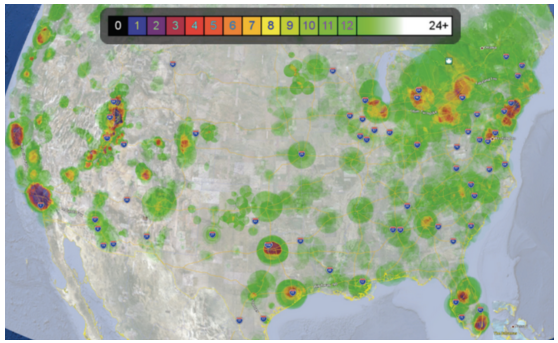
In New Zealand and most other countries, the move to digital has still left a lot of radio spectrum for terrestrial broadcast television - even though there isn't really a demand for it.

More Radio Spectrum: USA TVWS



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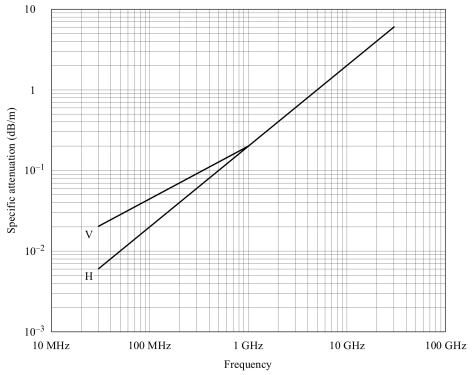
Better Radio Spectrum



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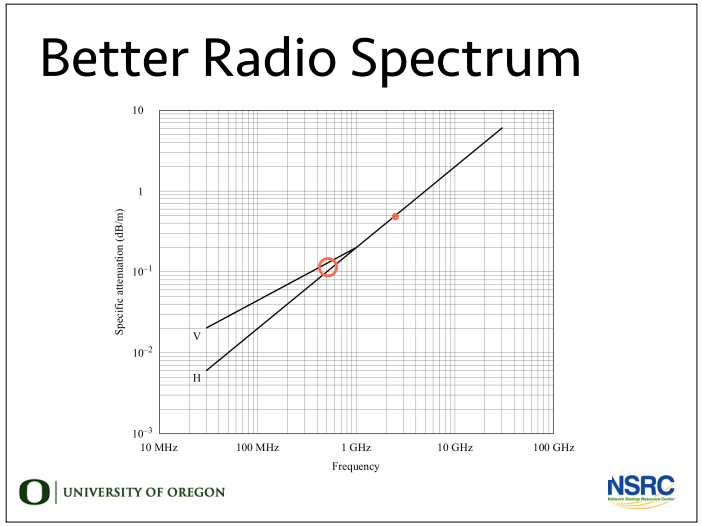
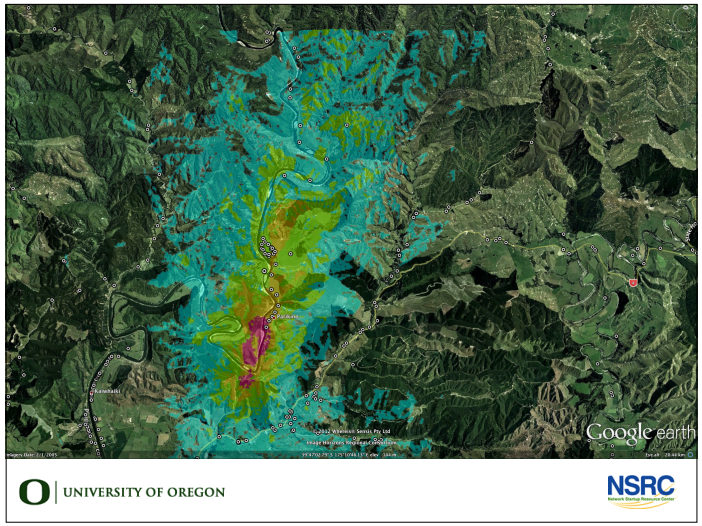
This is a graph of radio attenuation in vegetation, showing loss per meter at vertical and horizontal polarisations. Rec. ITU-R P.833-7

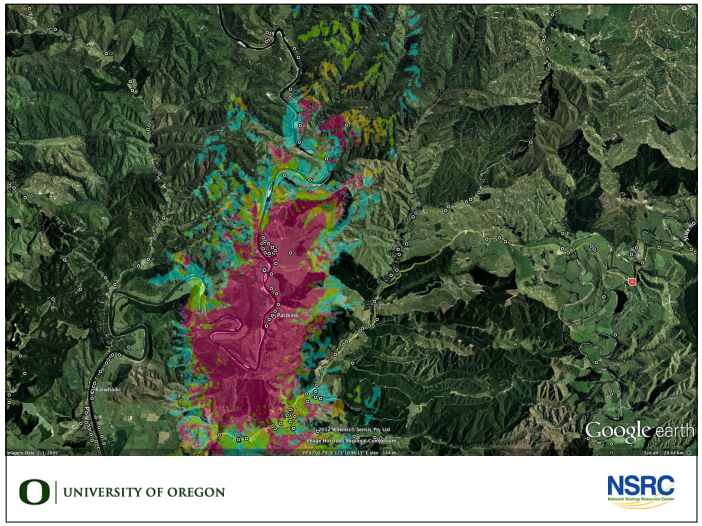


Many of the technologies we've discussed and used in the last week take advantage of the 2.4GHz radio spectrum.

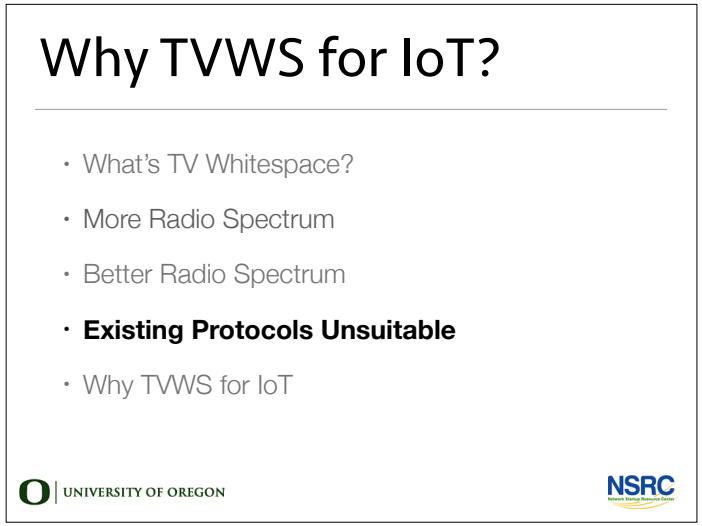
This is a graph of radio attenuation in vegetation, taken from Rec. ITU-R P. 833-7. It shows loss per meter at vertical and horizontal polarisations. At 2.4GHz, radio attenuates at around 1/2 of a decibel per meter of woodland. A single tree at twelve meters in diameter can halve the amount of signal between a terminal and a base station. At TVWS frequencies it might not even be noticed.



In this diagram, I've predicted 2.4GHz coverage into a valley with a few tens of end terminals. Two terminals fall into the best coverage area, and 18 fall into acceptable coverage areas.



Using TV Whitespace Spectrum, but no more power than Wi-Fi and similar sized antennas, the number of terminals jumps to 28, with most in the highest signal zone.



Existing Protocols Unsuitable

- 2.4 and 5.8 GHz WiFi are in the wrong spectrum
- New < 1 GHz WiFi still heavy-weight protocol
- Cellular (though popular) is high power, low resilience
- 915 MHz not universal (overlaps GSM frequencies)
- 425/433/868 MHz have very little available spectrum
- Many IoT protocols nascent or expensive

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~~Why TVWS for IoT?~~
Why TVWS for IoT Failed

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You see what I did there, right?

Dynamic Radio Spectrum

- TVWS requires dynamic use of the radio spectrum
- Small, inexpensive devices are not well suited for this
- Ad-hoc wireless networks out of the question
- Existing devices (wireless mics) don't cooperate
- TVWS devices must be two-way
- Receiving over large bandwidth = energy intensive

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Dynamic spectrum requires smarts - and most low-power devices are not smart.

Ad-hoc networks are out of the question, only a fixed, high power base station has the smarts to check Internet databases for radio spectrum allocations, then sense the local radio spectrum for other secondary users.

Existing devices allowed by most governments can interfere with TVWS devices, especially low power ones

Remember the Taggle water meter network I discussed yesterday? It's transmit only - as are many other applications in the IoT world. TVWS must be able to receive in order to know what channel to transmit on.

Devices participating in whitespace networks need the ability to listen over

TVWS is Dynamic Spectrum
Dynamic != Deterministic

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IoT Sectors: Machina Research

- Intelligent Buildings
- Smart Cities and Transportation
- Automotive
- Consumer Electronics
- Health Care
- Utilities
- Manufacturing
- Retail & Leisure
- Construction
- Agriculture & Environment
- Emergency Services & National Security

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Machina Research has divided IoT applications into 13 sectors and 60 application groups.
Imagine you're looking at a fancy info-graphic.

Which of these applications are ok for a radio network that may have varying performance depending on its ability to legally use the radio spectrum? Which are ok for opportunistic access, and which are not?

IoT Sectors: Machina Research

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I could think of reasons to not rely solely on dynamic spectrum for some sub-cases in each of the red categories.

Weightless Tried IoT in TVWS

- Architecturally it was elegant and appealing
- Practically it was very difficult to implement
  - Lower Frequencies require Bigger Antennas
  - RF Components are not broadband enough
- They punted & released a half-way solution in 2013
  - Broadband TVWS downlink from Base Station
  - Narrowband ISM 450MHz uplink from Terminal Units

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Weightless for TVWS was beautiful. I wanted it to succeed. It solved some (but not all) of the concerns I raised earlier, but it didn't fly.

Narrowband Spelled Doom

- The one silicon manufacturer (Neul) sold themselves
  - Oh hi, Huawei!
  - Senior staff departed
- Huawei IoT will now operate in cellular sidebands
- Weightless spec re-launching in 868MHz
  - Will anyone manufacture for yet another ISM thing?
  - I did not renew my membership for Weightless SIG

Is There Hope for TVWS IoT?

- New antenna configurations
- New filtering mechanisms
- Maturity of TVWS databases & markets
- See Bill Gates:

"We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don't let yourself be lulled into inaction."

Bill Gates

Thank You!

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