MELD TECHNOLOGY

Back to the Future with White Space

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One of the first commercially available TVs was a RCA TRK-9. This bulky but majestic piece of oak furniture, sported one input connector, a 9-inch black and white screen, and weighted nearly 200 lbs. Hooking this TV up was a simple matter of connecting the antenna. Much has changed since then. Now TVs are light and thin, have a dazzling array of sizes, they can the size of a wall or fit inside your smartphone.

When TVs were large, heavy wooden boxes at least aesthetics was not a problem. There was usually plenty of space to tuck wires behind the TV or somewhere behind a large A/V cabinet. However, with the popularity of thin, flat screen LCDTVs and PDPTVs (Flat TVs for short) the aesthetics, cost and practicality of running wires from source to TV is severely compromised. If your TV was portable, you were just out of luck.

Tripping over wires can be hazardous and the wire itself can be expensive with premium "Monster Cables" or digital wires costing over a hundred dollars per set. It is not unusual in a commercial environment to spend thousands of dollars on wiring for TVs.

Flat TVs do not need a lot of space and can be situated practically anywhere and may be portable. This creates a challenge, how do you connect your flat TV to your source without having to run a bunch of audio/video wires? A solution had to be found.

Cutting the Wire.

A company based in the heart of Silicon Valley California is developing systems that allow TVs to break free of their wires. The company is MELD Technology, and the breakthrough device is aptly called, the "MELD Box".

Zero, Zip, Zilch…

That's how much new spectrum has been created since the beginning of time.
As consumer demand for wireless applications and high-bit-rate streaming video continues to grow, so does spectrum congestion. WiFi networks operating in ISM bands of 2.4 and 5.8 GHz will break under the increased load, it is only a matter of time. In fact it has already started. The best defense against a total WiFi network collapse is to move high-bit-rate content such as video streaming off WiFi into a different frequency band. And that's what MELD has done... MELD's systems can reliably and wirelessly send large amounts of HD resolution video over large distances completely free of ISM band congestion.

A Channeled Effort.

The RF input on a Modern TV can range from 55.25 MHz to 997.25 MHz. This covers the combined tunable range of Terrestrial and Cable TV signal bands. MELD employs advanced frequency conversion circuits to change the signal from base-band to an appropriate low-power radiated signal that a Digital TV can directly receive.

The MELD Box automatically accesses an FCC approved database to get a list of the available frequencies (white space channels) for streaming. In theory these available channels could change from day-to-day, however in practice rarely do.

Frequency selection must be done with care as the FCC has deemed many frequencies off limit for a sustained non-spurious emitted signal (i.e. the type of signal needed to transmit DTV content.) These restrictions are outlined in FCC Section 15, Subpart H – for white space devices. The MELD box automatically selects and uses frequencies that can be legally used.

So what is White Space?

"Broadcast TV is based around huge transmitters, normally atop massive towers, which pump out enormous signals that can be picked up 40 miles away. Frequencies can be reused, but only for transmitters at least 80 miles apart or in some cases actually much further due to variability in signal propagation. In the USA there are around 1800 towers, which blanket the country with between 15 and 20 6MHz-wide channels (to carry one analogue channel or a digital multiplex) despite the fact that there are 49 slots available. This means there is spectrum available for use, provided you adhere to the rather stringent rules.

What is the Effective Range?

The effective range of the system is affected by many factors. These are the top three:
1) Frequency
2) Power and Sensitivity
3) Environment.

Frequency

As Scotty would say, "Ye canna change the laws of physics…" The general rule is the higher the transmission frequency, the lower the propagation distance and the higher the absorption. At microwave or higher frequencies, absorption by molecular resonance in the atmosphere (mostly water, H2O and oxygen, O2) is a major factor in radio propagation. Free-space path loss (FSPL) is the loss in signal strength of an electromagnetic wave that would result from a line-of-sight path through free space (usually air), with no obstacles nearby to cause reflection or diffraction. It does not include factors such as the gain of the antennas used at the transmitter and receiver, nor any loss associated with hardware imperfections.

Free-space path loss is proportional to the square of the distance between the transmitter and receiver, and also proportional to the square of the frequency of the radio signal.*

The equation for FSPL is

$$\mathrm{FSPL} = \left(\frac{4\pi d f}{c}\right)^2$$

where:

- λ is the signal wavelength (in metres),
- f is the signal frequency (in hertz),
- d is the distance from the transmitter (in metres),
- c is the speed of light in a vacuum, 2.99792458 × 10^8 metres per second.

This equation is only accurate in the far field where spherical spreading can be assumed; it does not hold close to the transmitter.

* http://en.wikipedia.org/wiki/Free_space_loss

As the frequency rises, absorption effects become more important, the weaker the signal gets. Assuming the all receivers have the same degree of sensitivity (more on that later) a weaker signal translates into worse reception. White Space frequencies are relatively low.

- 5.8 GHz transmission is 100X weaker (or has 100x more loss) than an equivalently powered transmission in whitespace TV Channel 21.
- 60 GHz transmission is 10,000X weaker than an equivalently powered transmission in whitespace TV Channel 21.

Power and Sensitivity

For those wanting more range, the first reaction is, "Hey! I'll just boost my power." Not so fast, the FCC carefully regulates the amount of power you can radiate from your transmitter. For white space frequencies there are three power classes: 40mW, 100mW, and 4W (with external amplification at the antenna). Each of these power classes have different rules for operation and generally the higher the power the fewer white space channels available. A notable restriction for operating at higher power is "adjacent channels". In this case the adjacent channel in question is usually a licensed TV broadcaster. For example channel 23 is available but there is a TV broadcaster on 24, to be able to use this channel the maximum power of your device must not exceed 40mW.

To transmit at higher power the channels on either side of the channel you want to use must be vacant, hence few high power channels available.

Inquiring minds might say, “I don’t need more power, I’ll just select a very sensitive receiver.” This is already done in every TV sold. In April 2010 the Advanced Television Systems Committee Inc. (ATSC) put in place rigorous guidelines (called A/74) for DTV sensitivity. All digital TVs sold in the US must comply with this specification.

“A DTV receiver should achieve a bit error rate the transport stream of no worse than $3x10^{-6}$ (i.e. the FCC Advisory Committee on Advanced Television Service, ACATS, Threshold of Visibility, TOV) for input RF signal levels directly to the tuner from -83dBm to -5dBm for the VHF and UHF bands…” ATSC Recommend Practice, Receiver Performance Guidelines Document A/74:2010.

Environment

This is the RF equivalent of the cars manufacturers’ claim that actual mileage/distance may vary.

There are many factors that impact radio signal propagation I will only touch on my top two.

Reflection

As mentioned earlier white space signals in the UHF band can travel through brick and stone, however no radio signal can travel through metallic objects. Hence don’t put your antenna behind a TV (with a lot of metal in it), or place your transmitter in a metal cage.

Multipath

Multipath is the propagation phenomenon results when the RF signal reaches the TV by two or more paths. In the analog TV world this would be appear as a ghost image. In the digital world the multipath signal is usually filtered out by electronics inside the TV. However, very strong multipath signals will confuse the demodulator resulting in a “loss of signal”. This error message is actually somewhat misleading; it is not a “loss of signal”, but rather to many signals. Reducing the broadcaster power and adjusting a directional antenna on the receiver could help reduce multipath signal error. As a side note this is likely the most common problem experienced when demonstrating a PicoBroadcaster. You are in a small lab or conference room with everyone crowded around the broadcaster and TV on the same small table. The picture glitches and someone will undoubtedly say, “Ha, it can’t even send a signal 3 feet, how can it do hundreds of feet?” The device is designed to send HD streams hundreds of feet not three feet. Reducing the broadcaster power and adjusting a directional antenna on the receiver could help reduce multipath signal error.

Field Test 1

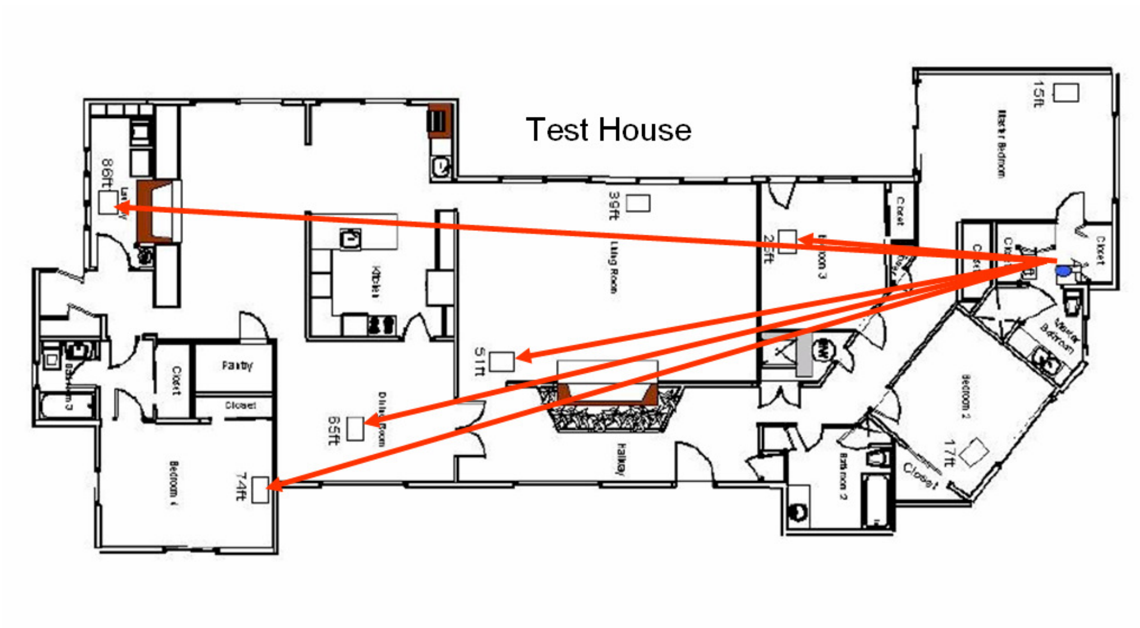
Experimental Broadcast results
Transmitter: MELD MT300 using "Magicwhip" SMA antenna
Receiver: RX Antennas Direct, ClearStream Micron R Indoor TV Antenna.
Samsung Model number 19A450C
Samsung TV, model: LN19A450C1D
Effective HD broadcast range:
A: with a partially impeded signal, distance ~234 feet
B: very impeded signal, through many walls, offices, desks, cabinets, elevator, etc… distance ~150 feet
C: with a slightly impeded signal (going through a window), distance ~1175 feet.

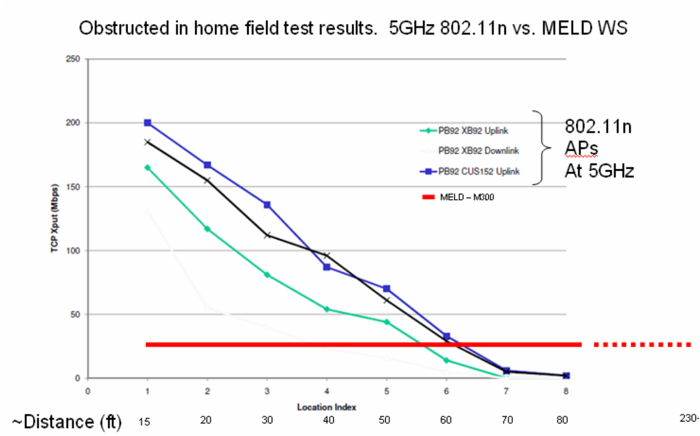
Field Test 2

Experimental Broadcast results
Transmitter: MELD MT300 transmitting 10 mW
Dipole antenna used at both Tx and Rx
Tests were done at Channel 21 (510 MHz)
Tests were conducted in a wood and stucco home in a remote area free from other Wifi traffic.

Observations:

- MELD White Space outperformed 802.11n in 5GHz band by a substantial margin (est. 300%-500+%)
- Absorption loss measured was almost insignificant.
- Dipole antenna used in the test was sensitive to antenna orientation and location.
- System performance may be hindered by multi-path energy. In the future should use a directional antenna on the receiver.





Back to the Future

History has shown that the introduction of wireless technology was indeed “Disruptive”, forever changing usage habits. The first companies to realize the benefits of new technologies gained market share at the expense of others still clinging to traditional ways. Perhaps, in the near future people will look back to the tangle of wires dangling from their TV in a similar way as to a time without cell phones. Look for more exciting news and new products from MELD for these applications in the coming months.

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