

Site Survey

Interferences, Cell Design, Best Practices

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INTERFERENCES

How to solve competitor-based Interferences?

[RE offered]

"Find an old microwave and strip out the main power conversion coils. Convert the 120 Volt AC input to 12 Volt DC. Drive into LOS of one of his antennas and give it juice: he will spend weeks replacing his valuable equipment."

[JL added]

"Termite exterminators now have a new weapon against dry wood termites. It's a 700 Watt 2.4GHz transmitter that literally cooks them in the walls, while leaving the dry wood untouched. Just contact the local termite exterminator and have them aim their disintegrator gun at the competition!"



"Mutual Assured Survival", seen on the ISP-Wireless list in April 2001

How Many Users?



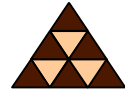
- **Depends on data rate vs. throughput**
 - ♦ Physical "11 Mbit/s" does not count, throughput is typically only 55% from it
 - ♦ Consider headers, management, and control frames, OS scheduler, bus buffers, ...
- **Expect 6 Mbit/s throughput for an AP operating at 11 Mbit/s at maximum**
 - ♦ 60 users surfing in Web (6 Mbps/100Kbps)
 - ♦ 3 users receiving video (6 Mbps/2Mbps)
- **Even worse for TCP streams!**
- **Best practice for offices:**
 - ♦ 802.11b: max 25 users per cell
 - ♦ 802.11g: max 20 users per cell
 - ♦ 802.11a: max 15 users per cell

Radio Amateurs



- **Radio Amateurs may operate with very high powers @ 2.4 Ghz**
 - ♦ Since they only use narrowband transmitters, no spread spectrum
- **Might cause interference to wireless LANs at long distances**
- **An amateur radio transmitter located several 100 kilometers away could produce the same signal level as an 802.11 remote at thirty meters away**

When FHSS and DSSS Collide



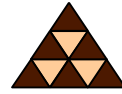
- **Massive interferences to expect**
 - ◆ Only solution: FHSS provider should also switch to DSSS
- **Manufacturers claim that around 20 different FHSS-based networks can coexist in the same area before seeing performance degradation**
- **Bluetooth, cordless phones, older 802.11 equipment**

Bluetooth



- **FHSS at 1600 hops per second over entire 2.4 GHz band**
 - ◆ No carrier sense!
 - ◆ Bluetooth simply beats 802.11b/g
- **Only an issue if proximity is below ~ 3 m**
 - ◆ AND remote station is far
- **Assure strong 802.11 signals (SNR)**
 - ◆ Use highest powers, good antenna positions
- **Other solutions:**
 - ◆ Move to 5 GHz ☺
 - ◆ Remove bluetooth ☺
 - ◆ Await IEEE 802.15.2 task group "coexistence solutions"

The Microwave Oven



- Microwave oven emits a single CW tone on a 50% duty cycle
 - ♦ For example 8.3 msec on and 8.3 msec off
- Using the CCA on WLAN devices could pause transmission during the 8.3 msec on-cycle
- It seems that microwave oven interference potential is over-rated(?)
 - ♦ The flux density of the interference is not very powerful in most cases (shielding)
 - ♦ Simply moving the wireless LAN adaptor a reasonable distance away from the microwave will allow a wireless connection that has imperceptible performance degradation
 - ♦ However, badly shielded ovens do exist

Cordless Phones



- Operate at 0.9, 2.4 (majority) and 5 GHz
- Good ones: *Might* be no problem
 - ♦ Use guard bands at either side of our 2,4 GHz spectrum
 - ♦ One side to transmit and the other to receive
- Most products do fast frequency hopping throughout the 2.4 GHz band
 - ♦ Especially cheaper products
 - ♦ Important interference source!!!
 - ♦ Try to use edge channels on WLAN equipment (1 or 11/13)
 - ♦ "Operate the cordless phone with the antenna in the lowered position if possible to dampen the RF signal" ☺
- 5 GHz: other sub-band should be used
 - ♦ Only little problems for 802.11a expected

Water



- **We send at the microwave-oven frequency: Good to heat water !!!**
 - ♦ In fact “only” a lesser efficient absorption line
 - ♦ Molecule vibrations/rotations absorb RF power (here cluster rotations(?))
- **That is:**
 - ♦ Trees and leaves cause considerable loss (better have dry walls)
 - ♦ Rain causes only (approx.) 0.5 dB/km
 - ♦ Don't transmit through aquariums

Glass

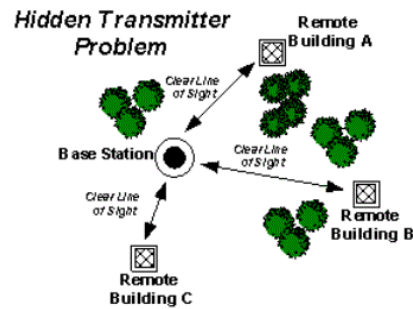


- **Most glass types are “harmless”**
 - ♦ Normal windows: ~ 3 dB
 - ♦ Fiberglass: ~ 0.5-1 dB
- **But tinted glasses**
 - ♦ **Metallic coat**
 - Often tin oxide (SnO_2) - looks reflective
 - ♦ High attenuation outside
 - ♦ High multipath dispersion inside
- **High-Energy glass**
 - ♦ Energy efficient, usually double paned, coated, and filled with gas in between
 - ♦ Good RF energy absorber ☺

Hidden Stations – Practically



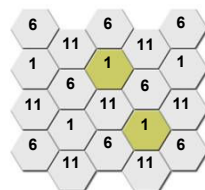
- Up to 50% degradation reported
- Similar effect as (wired) broadcast storms
 - ♦ Due to retransmission persistence
- RTS/CTS is no perfect solution
 - ♦ More than one node might send a RTS at the same time
 - ♦ Sufficient for indoor environment
 - ♦ Not suited for long-range, high-speed wireless communications between buildings



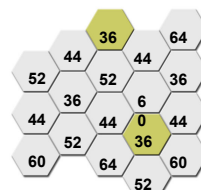
Cell Design



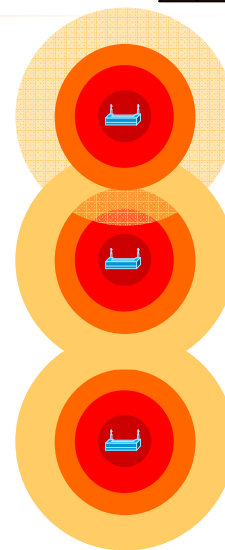
- Consider data rate adaptation during roaming
 - ♦ Which is the minimal acceptable data rate?
- Consider channel reuse
 - ♦ Depends on number of available channels
 - ♦ Depends on number of dimensions (z-axis?)



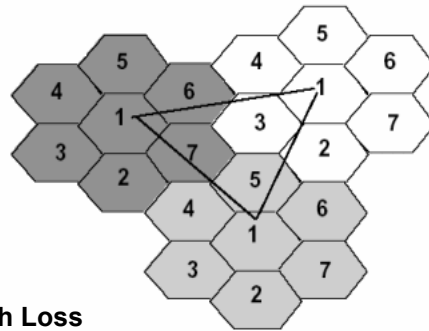
802.11b/g



802.11a



Cellular Networking



Propagation Path Loss
 $C = R^{-\alpha}$