Adjacent channel interference in a multi-radio wireless mesh node with 802.11a/g interfaces

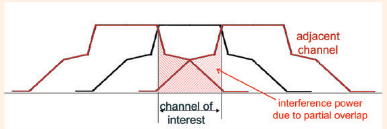
Computer Science Dept.
University of Crete

Vangelis Angelakis Apostolos Traganitis Vasilios Syris

Institute of Computer Science
FORTH

GOAL: Quantify the Adjacent Channel Interference (ACI) and its impact in wireless mesh nodes with multiple 802.11a/g radio interfaces

Use the **partially overlapping channels'** interference quantification proposed in [1] and apply it to **802.11a/g spectral mask & channel spacings**.



Our most interesting find is that although adjacent channels in 802.11a are *widely considered* to be non-overlapping using the model in [1] **we calculated and verified through testbed experiments** that, **adjacent 802.11a channels have in fact an overlap that produces significant interference** whose impact will be noticeable when the antennas are closely co-located on a node, even in the case where directional antennas are used.

	Standard	802.11a		802.11g				
	Channel distance	+/-1	+/-2	+/-1	+/-2	+/-3	+/-4	+/-5
Transmit power	100mW	n/a	n/a	79.06	52.67	26.51	0.627	0.121
	50mW	0.303	0.0050	39.53	26.34	13.25	0.303	0.061
	25mW	0.152	0.0025	19.76	13.17	6.63	0.152	0.030
	12mW	0.073	0.0012	9.49	6.32	3.18	0.073	0.015
	6mW	0.036	0.0006	4.74	3.16	1.59	0.036	0.007
	3mW	0.018	0.0003	2.37	1.58	0.80	0.018	0.004
	2mW	0.012	0.0002	1.58	1.05	0.53	0.012	0.002
	1mW	0.006	0.0001	0.79	0.53	0.27	0.006	0.001

In [2] authors perform 802.11a testbed experiments to quantify the effect of Adjacent Channel Interference (ACI) on a dual-radio multihop network. In their work they use omnidirectional antennas for their testbed and suggest increasing channel separation and antenna distance as well as using directional antennas in order to mitigate the effects of ACI.

We utilize the **SINR criterion for successful reception** and produced analytically derived results on up to four 802.11a/g interfaces on a node for:

(i) the **cell radius** of such a node with respect to the offered data rates for the uplink and the physical spacing of the antennas on the node, and
(ii) the 802.11a/g **clear channel assessment** (CCA) mechanism.

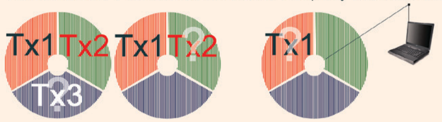
Such a theoretical analysis is important, since it can be readily extended to newer standards, such as 802.11n, and gives **initial insight on the adjacent channel interference effects** prior to any delicate, time consuming testbed experiments

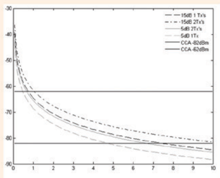
Simulated Results

CCA ERRORS DUE TO ACI

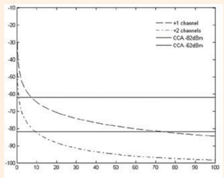
802.11a CCA repotrs Channel is Clear if:
- received power is < -82 dBm -OR-
- received power is < -62 dBm and a preamble has not been decoded

Erroneous CCA -> Tx is idle without reason -> capacity underutilization



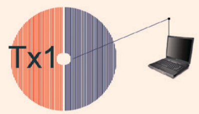


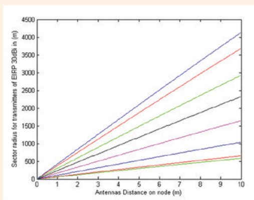
ACI power transmitted from the adjacent- channel 802.11a transmitters **on the mesh node**. Distance of transmitting interfaces is indicated on the x-axis.



ACI power **from a client** transmitting to one of the other interfaces of the node tuned to an adjacent channel. The client is assumed to be at the distance indicated on the x-axis and use EIRP of 30dBm

CELL RADIUS

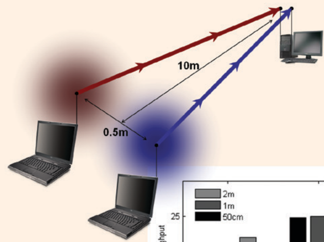


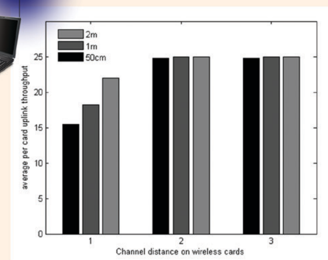


Mesh node of 2 back-to-back 802.11a interfaces, tuned to adjacent channels, with 180deg sectorial antennas with 13dBi gain and 20dB f/b, spaced apart as indicated on the x-axis. The y-axis is the **maximum distance for successful reception (cell radius)** of a 30bBm EIRP 802.11a client transmitting to one of the interfaces of the mesh node, while the other mesh interface is transmitting at 17dBm.
Bottom-up on the plot are the curves for rates of 54, 48, 36, 24, 18, 12, 9 and 6Mbps.

Testbed Verification

Two laptops with **MadWifi**-driven D-link 108AG pcmcia cards send **udp traffic for 30 sec** to 10m-away 802.11a mini-pci Atheros based cards on a linux desktop. The laptops were located in our laboratory, with their wireless cards at a distance of 0.5m. Transmission rates were **locked at 54Mbps** with **16dBm transmit power** and the udp packet size used was 1000 bytes.





FUTURE WORK

Our future work includes **uplink and downlink testing** through in-lab tesbed experimentation with **channel emulation over programmable RF attenuators** and through experiments on a **metropolitan scale mesh network.** To a more theoretical twist we intend to revisit the model proposed in [1] and refine it, taking into account the subcarriers of the OFMD scheme used in 802.11a/g. Finally, this enhanced ACI calculation can be utilized in practically any SINR modeling to provide a more accurate estimation of expected results.

REFERENCES

[1] A. Mishra, et. al. , "Partially Overlapped Channels Not Considered Harmful", SIGMetrics/Performance'06, June 26–30, 2006, Saint Malo, France
[2] Cheng, C.-M., Hsiao, P.-H., Kung, H. T., and Vlah, D.: Adjacent Channel Interference in Dual-radio 802.11 Nodes and Its Impact on Multi-hop Networking, IEEE GLOBECOM 2006, San Francisco, CA, November 2006
[3] Robinson, J., Papagiannaki, K., Diot, C., Guo, X. and Krishnamurthy, L.: Experimenting with a Multi-Radio Mesh Networking Testbed, 1st workshop on Wireless Network Measurements (WiNMee 2005), Trento, Italy, April 2005
[4] IEEE 802.11 Working Group, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications", IEEE 802.11 standard, including 802.11a,b,g and h amendments, Sep 1999-2005

TNL Telecommunications and Networks Laboratory
http://www.ics.forth.gr/netlab/

{ angelak, tragani, vsiris } @ ics.forth.gr