Local Estimators for 802.11 MAC Channel Quality

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802.11 MAC Channel Quality

802.11 Binary Exponential Backoff mechanism.

- Transmitters cannot detect collisions explicitly.
- Receivers send ACKs after successful reception.
- Missing ACK causes doubling of backoff and retransmission.

Many reasons for packet loss:

Collisions simultaneous transmission of packets by stations following MAC rules.

Insufficient signal strength resulting in failed decoding. Caused by fading, noise or low power.

Hidden nodes transmissions of other stations unable to follow MAC rules.

Aim: Understand error causes

Understanding local environment in order to adapt:

Power/Channel If noise is too great.

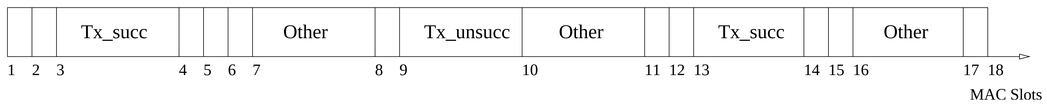
Carrier Sense If MAC protocol is failing.

Backoff If network is too busy.

Introduce two backwards-compatible estimators that give insight into local environment.

Idle/Busy Estimator

This is a passive estimator using carrier sense. Uses notion of slots.



We consider 4 slot types at sender.

Idle Slots Station has seen the medium as idle and would decrement counter if in backoff.

Other Transmissions Station has detected the medium as busy due to other nodes transmitting.

Successful Transmissions Station 1 has transmitted and received an ACK.

Unsuccessful Transmissions Station 1 has transmitted, timed-out while waiting for an ACK and is about to resume its backoff.

$$p_c = \frac{R-I}{R}; \quad p_e = 1 - \frac{1-(T-A)/T}{1-p_c} \tag{1}$$

Supposing:

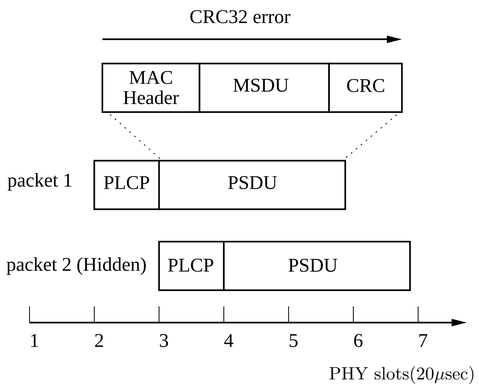
1. transmit T times and of these A are successful.
2. R other slots and that I are idle.
3. probability that others transmit is independent of station transmitting.

CRC-based Estimators

Errors seen by receiver:

PHY error an error in the PLCP preamble or header.

CRC32 error packet is decoded but CRC check fails.



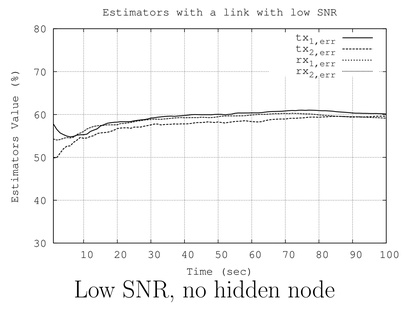
If we split collisions into PHY and CRC32: $p_c = p_{c1} + p_{c2}$.

$$\frac{CRCerr}{R-I} = p_e + p_{c2} - p_e p_{c1} - p_e p_{c2} \approx p_e + p_{c2} \tag{2}$$

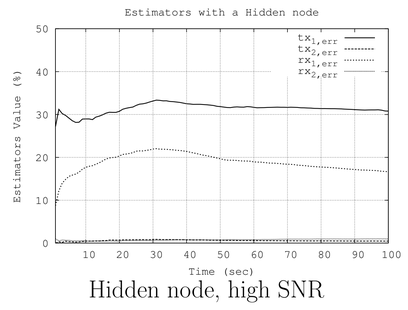
Hidden Nodes and Fragmentation

We use 802.11's fragmentation feature when we want to identify hidden node errors.

- fragmentation cuts packets into several smaller units,
- each an ordinary 802.11 frame and ACKed independently,
- first fragment contends for access,
- subsequent fragments may be bursted as single busy slot,
- 802.11 NAV (virtual carrier sense) on data reserves medium at sender,
- NAV will reserve medium at receiver after ACK is sent.
- thus subsequent fragments get significant protection from hidden nodes,
- some undesirable features of fragments might be avoided with 802.11e TXOP.



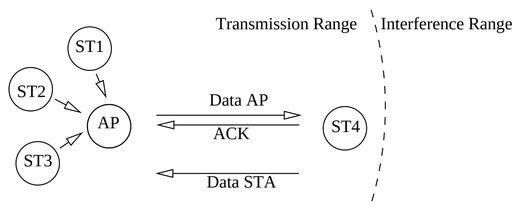
Low SNR, no hidden node



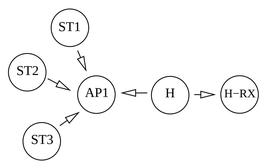
Hidden node, high SNR

Testbed Setup

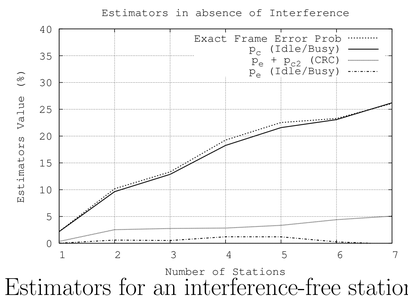
- Soekris net4801 single board computers with miniPCI slot,
- Intel 2915ABG mini PCI cards with hand-customised firmware/driver,
- Atheros AR5213 mini PCI cards with hand-customised driver.



(a) Low SNR scenario

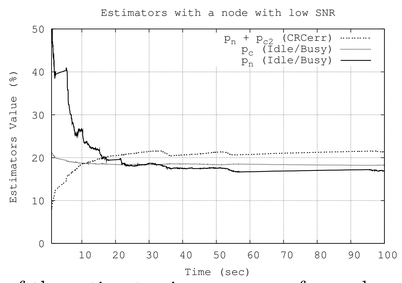


(b) Hidden node scenario.

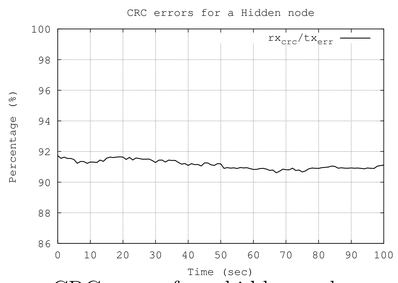


Estimators for an interference-free station

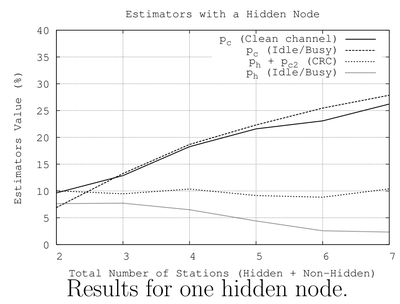
Performance of Estimator



Convergence of the estimator in presence of a node with low SNR.



CRC errors for a hidden node.



Results for one hidden node.