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# A Study of On-Off Attack Models for Wireless Ad Hoc Networks

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# Vulnerabilities in Wireless Ad Hoc Networks

It's hard to guarantee the physical integrity of the nodes and the conditions in their surrounding environment.

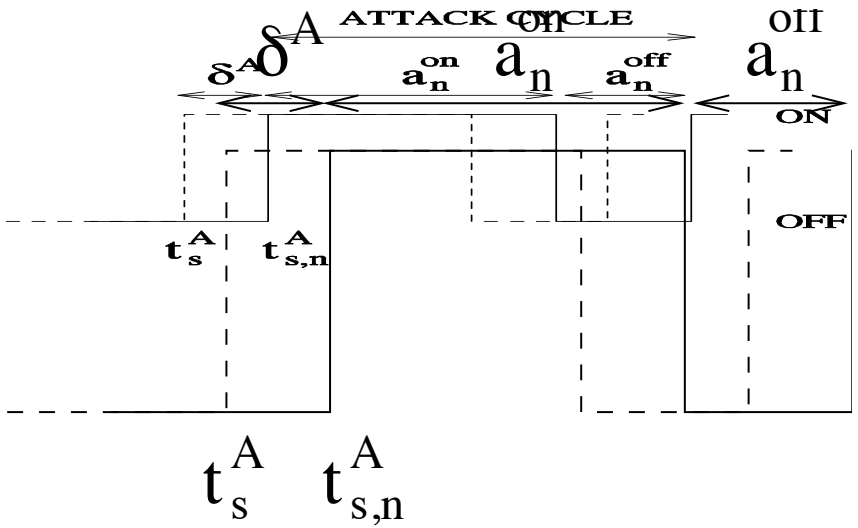
Communication protocols are subject to design and implementation faults.

# Motivation

We need to understand the risks of the technology before we can rely on it for mission-critical applications.

Risks can be quantified/estimated with computer simulation, but for that we need a model.

# On-Off Attack Model




$t_s^A$ $t_{s,n}^A$

$p$ : prob. that some node n is attacked or launches an attack

$\delta^A \sim \Delta^A$ : jitter for attack A

$t_s^A \sim T_s^A$ : start time for attack A

$T_{s,n}^A = T_s^A + \Delta^A$

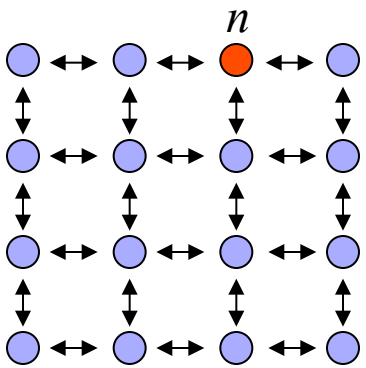
$t_{s,n}^A \sim T_{s,n}^A$ : start time for attack A on node n

$a_n^{on} \sim A_n^{on}$, $a_n^{off} \sim A_n^{off}$

$A_n^{on}$ : length of on-period

$A_n^{off}$ : length of off-period

# The *Reboot* Attack

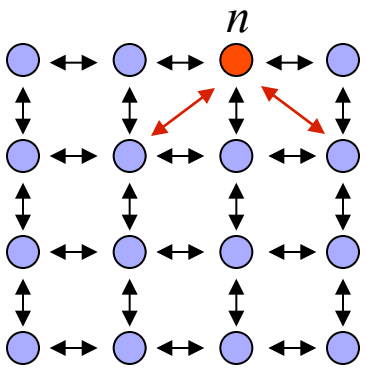



***Node n is attacked***

```
while (simulation not finished) do
  if Bernoulli(REBOOT PROBABILITY)==1 then
    t_{s,n} ← U [t_s, t_s + δ]
    at time t_{s,n} do:
    while (true) do
      power down and stay offline for a^on sec.
      bootup and stay online for a^off sec.
    end while
  end if
end while
```

The periodic rebooting of node $n$ causes the routing protocol to send out messages to re-establish routes. A physical action against the node (e.g., removing and reinstalling batteries) is able to create additional control traffic in the network.

# The *Range* Attack




***Node n is attacked***

```
while (simulation not finished) do
  if Bernoulli(REBOOT PROBABILITY)==1 then
    t_{s,n} ← U [t_s, t_s + δ]
    at time t_{s,n} do:
    while (true) do
      decrease TX range for a^on sec.
      restore original TX range for a^off sec.
    end while
  end if
end while
```

The periodic changes in the transmission power of node $n$ cause the routing protocol to send out messages to update shortest routes. A physical action against the node (e.g., obstructing the node's antenna) is able to create additional control traffic in the network.

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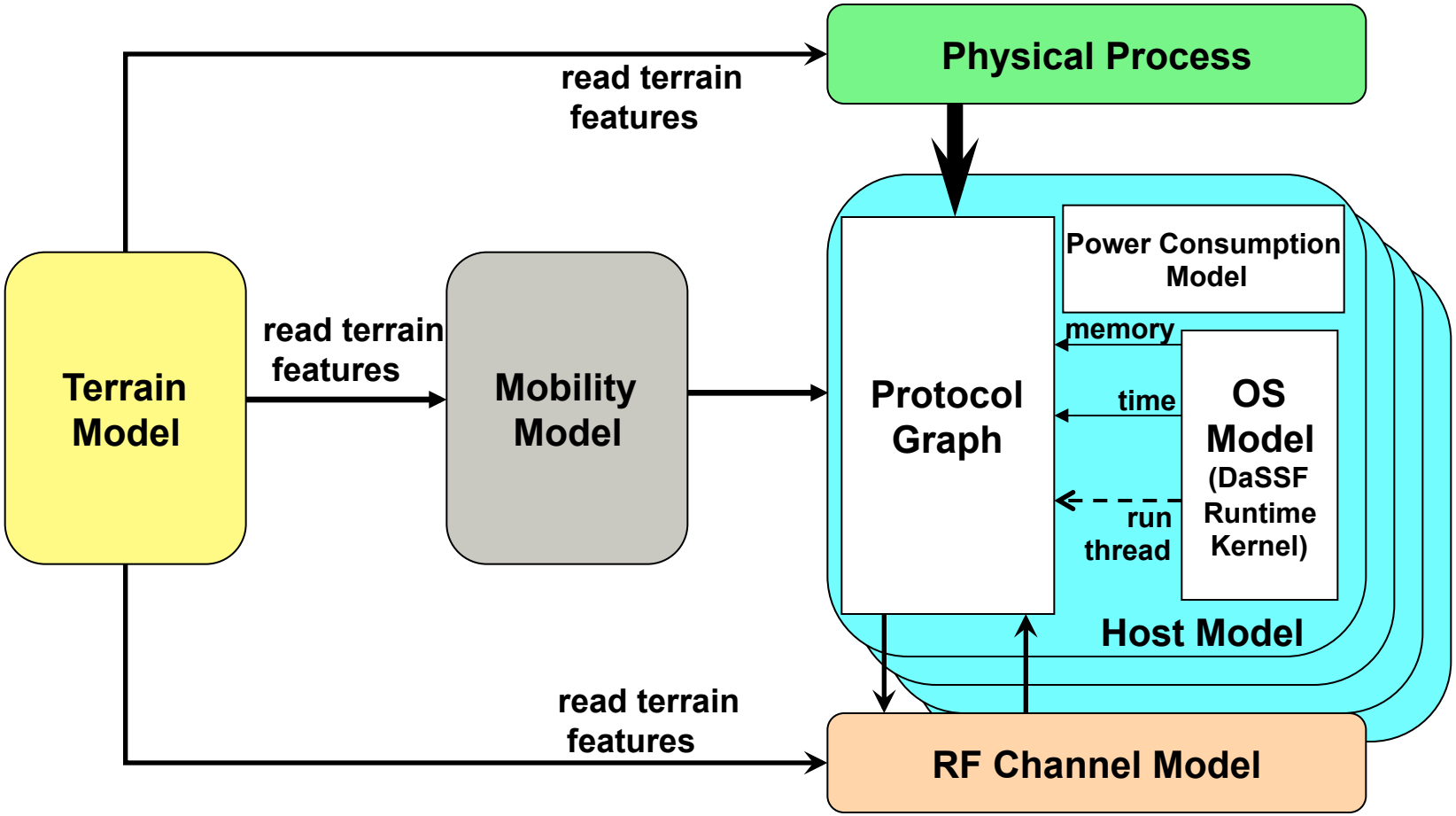
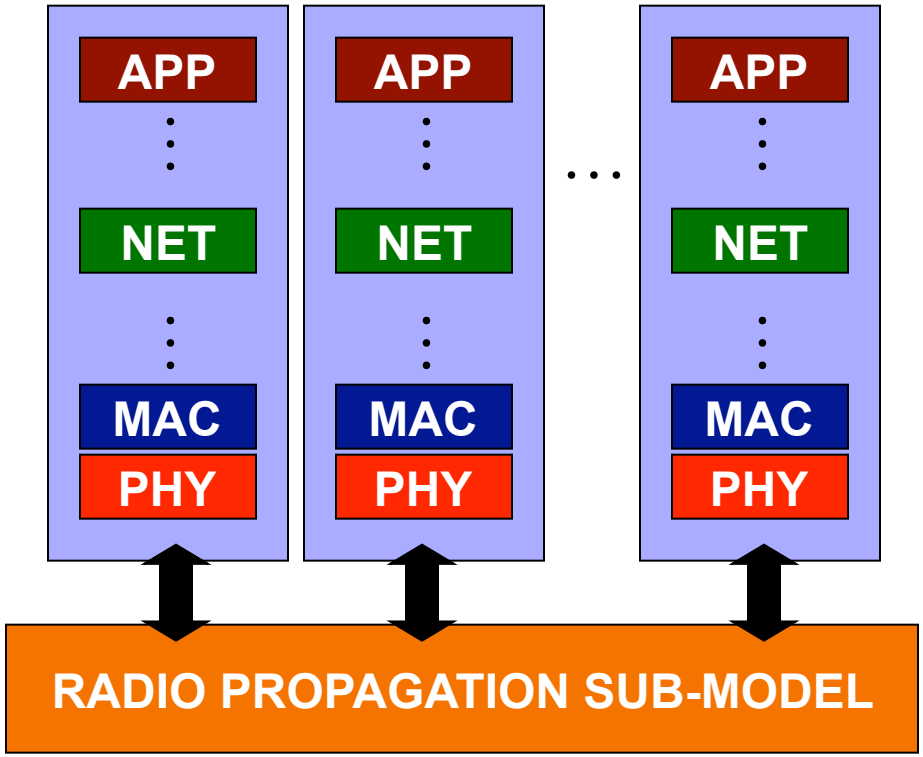
# SWAN: a Simulation Tool



# Network Model




## Sub-models

**Physical Layer:**
radio sensing, bit transmission

**MAC Layer:**
retransmissions, contention

**Network Layer:**
routing algorithms

**Application Layer:**
traffic generation or "direct" execution of real application

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# Experimental Scenario

**RF propagation:** 2-ray ground reflection, antenna height 1.5m, tx power 15dBm, SNR threshold packet reception.

**Mobility:** stationary; grid deployment.

**Traffic generation:** variation of CBR; session length=60|120, destination is random for each session, CBR 3072 bytes/s for each session.

**Network:** 36 nodes in a 6x6 regular grid (150 m spacing).

**Transient avoidance:** statistics collected after 100 sec.

**Protocol stack:** IEEE 802.11b PHY (message retraining modem capture, 11 Mbit/s), IEEE 802.11b MAC (DCF), ARP, IP, AODV routing (no local route repair, MAC acknowledgements, expanding ring search, active route time out of 10 sec., max two retries for RREQs).

**Arena size:** 900 m x 900 m.

**Replications:** 20 runs with different seeds for every random stream in the model. For all metrics estimated, we produced 95% confidence intervals.

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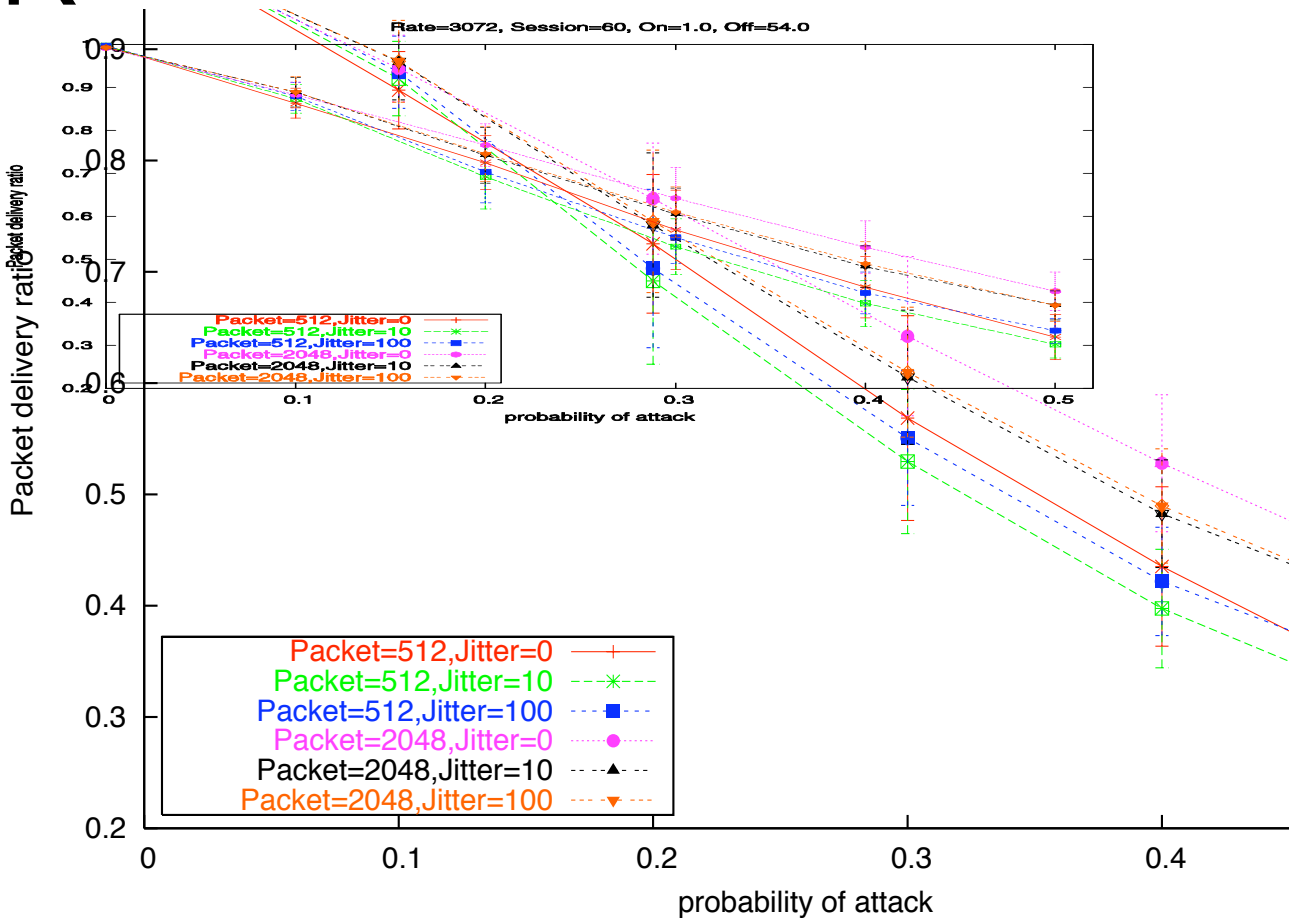
# Effect of Reboot Attack Jitter on PDR



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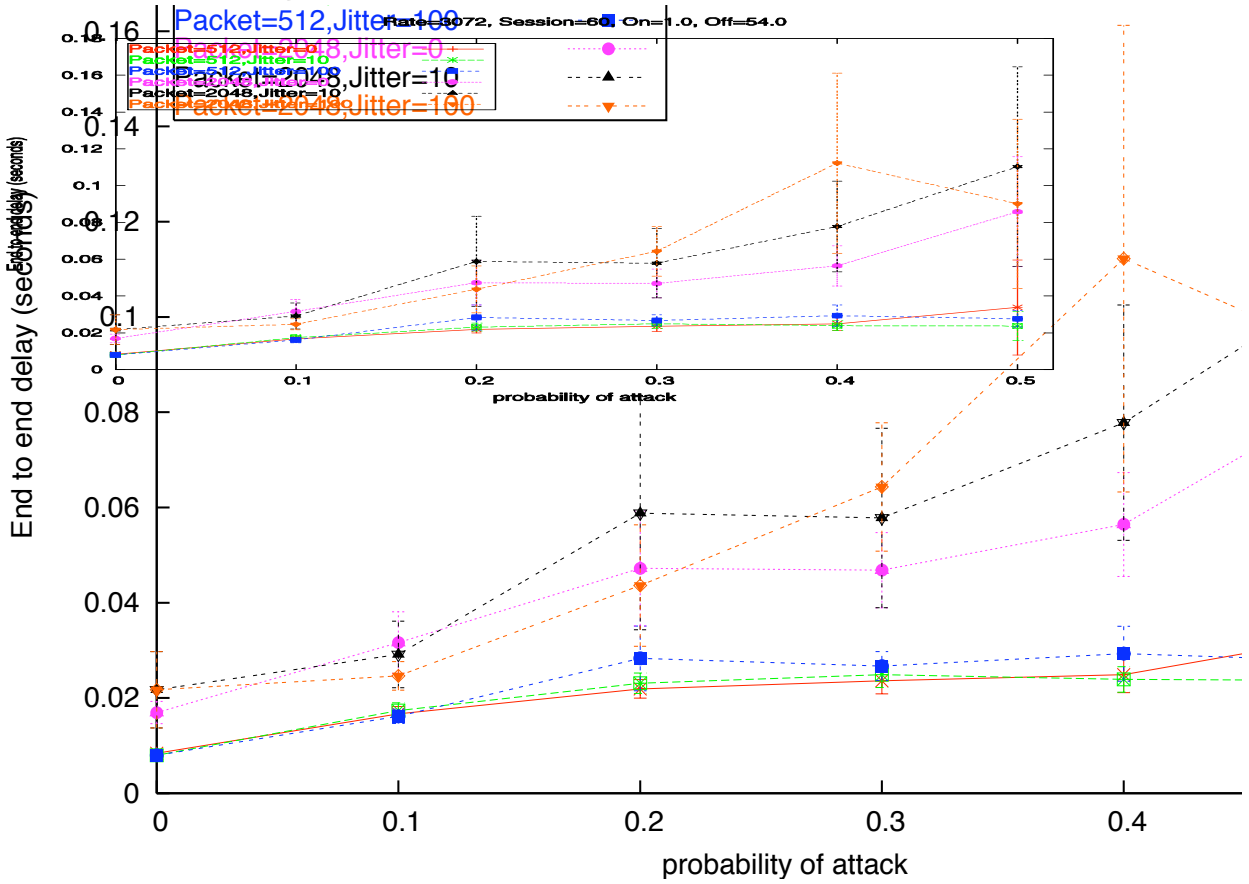
# Effect of Reboot Attack on End-to-End Delay



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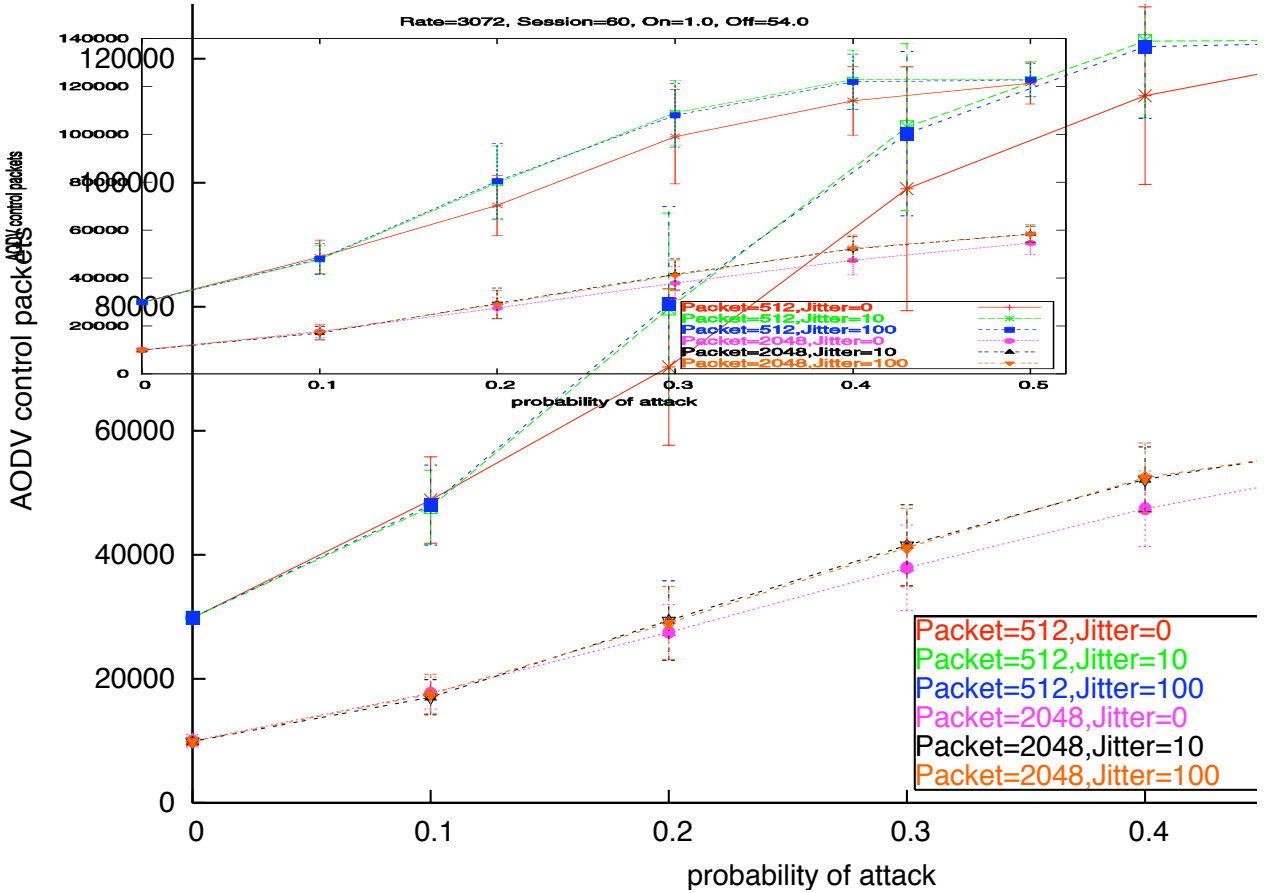
# Effect of Reboot Attack Jitter on AODV Control Packets



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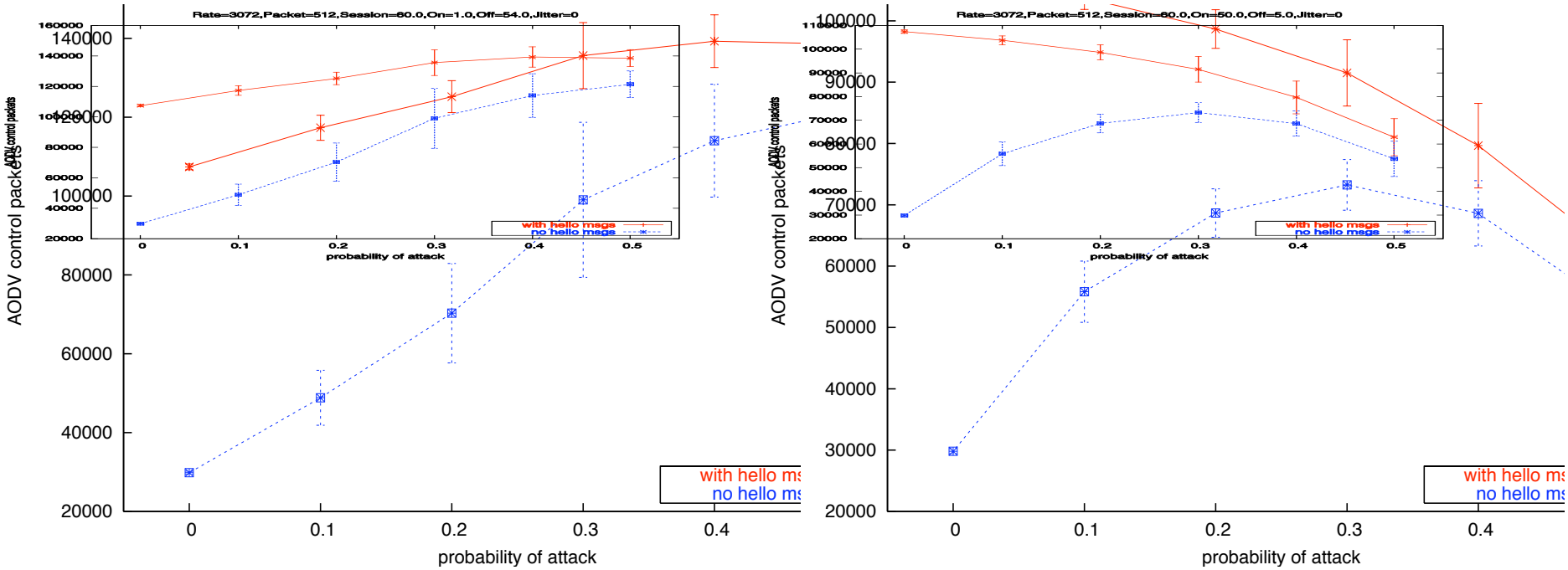
# Effect of Length of Attack Cycles on AODV Control Packets



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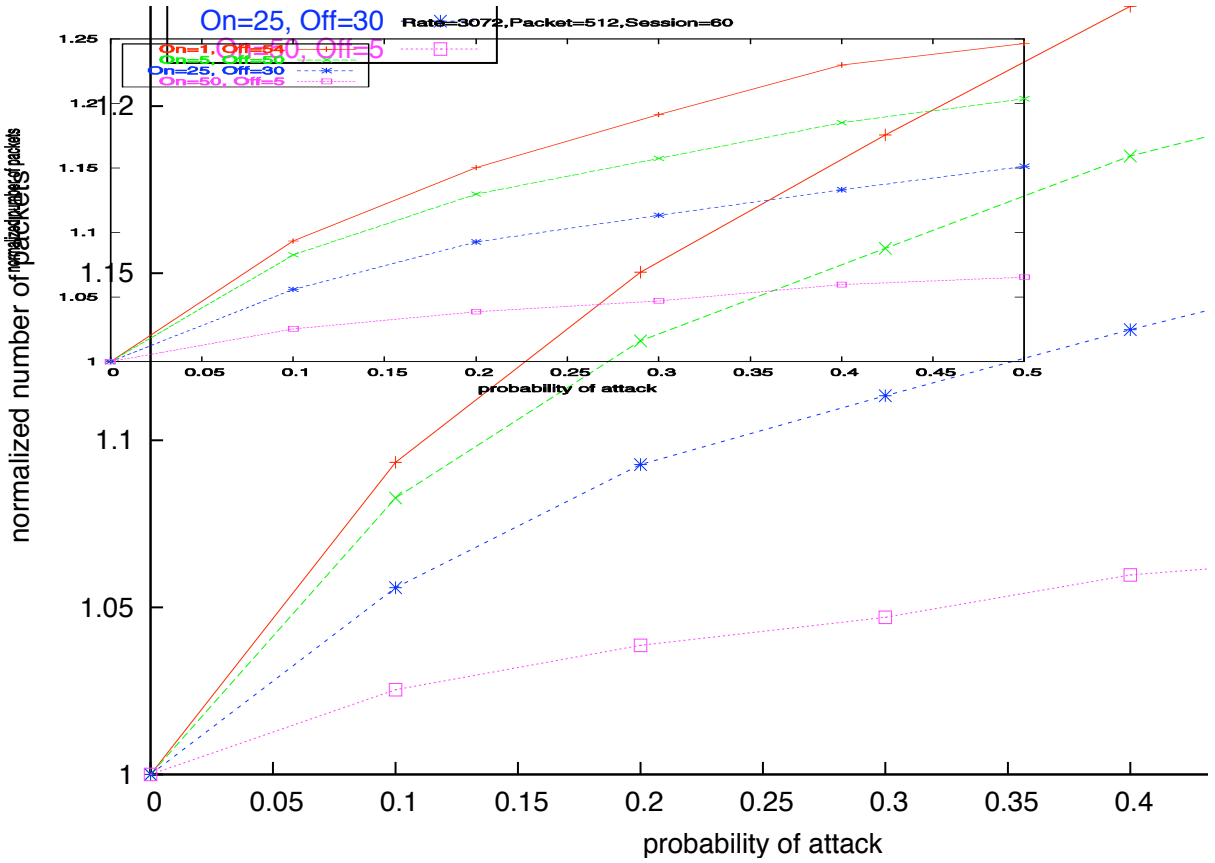
# Effect of Range Attack AODV Control Packets (Jitter=0)



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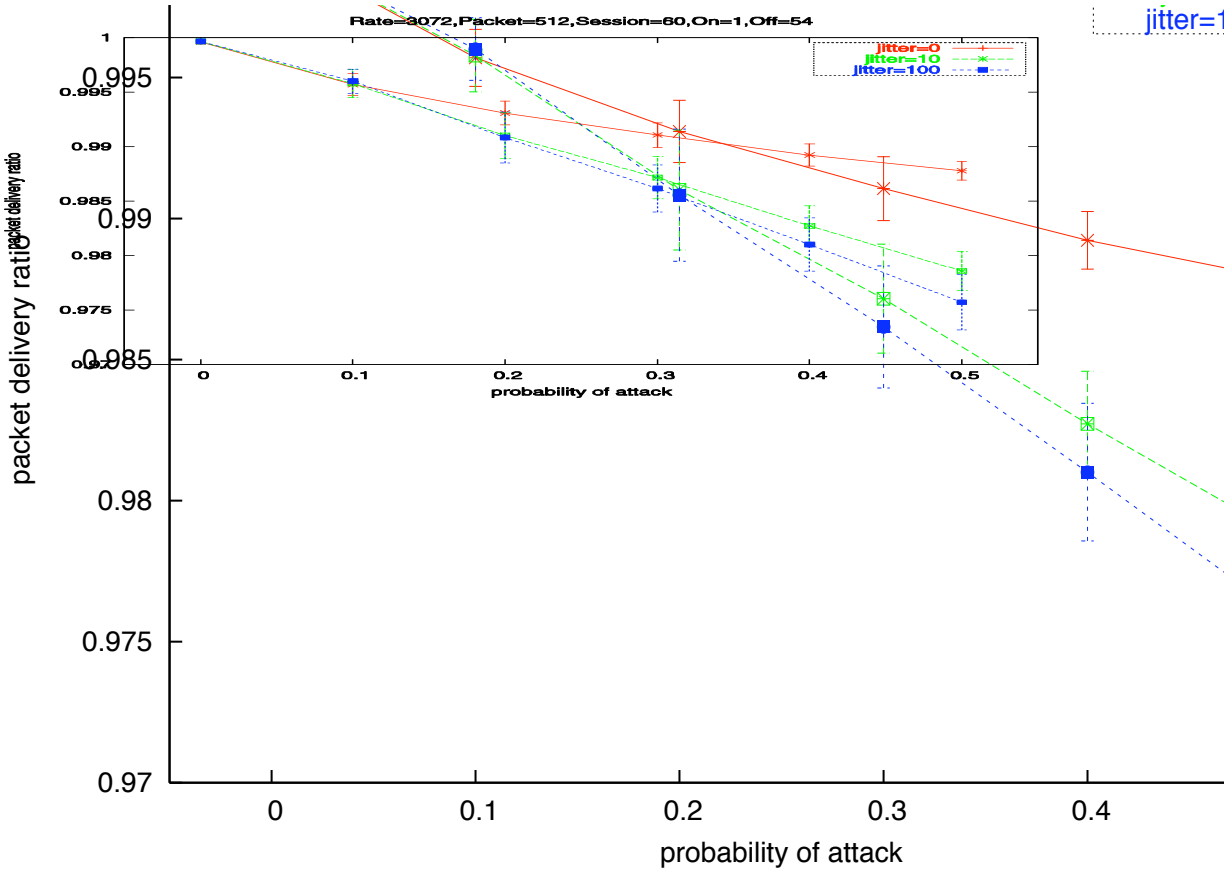
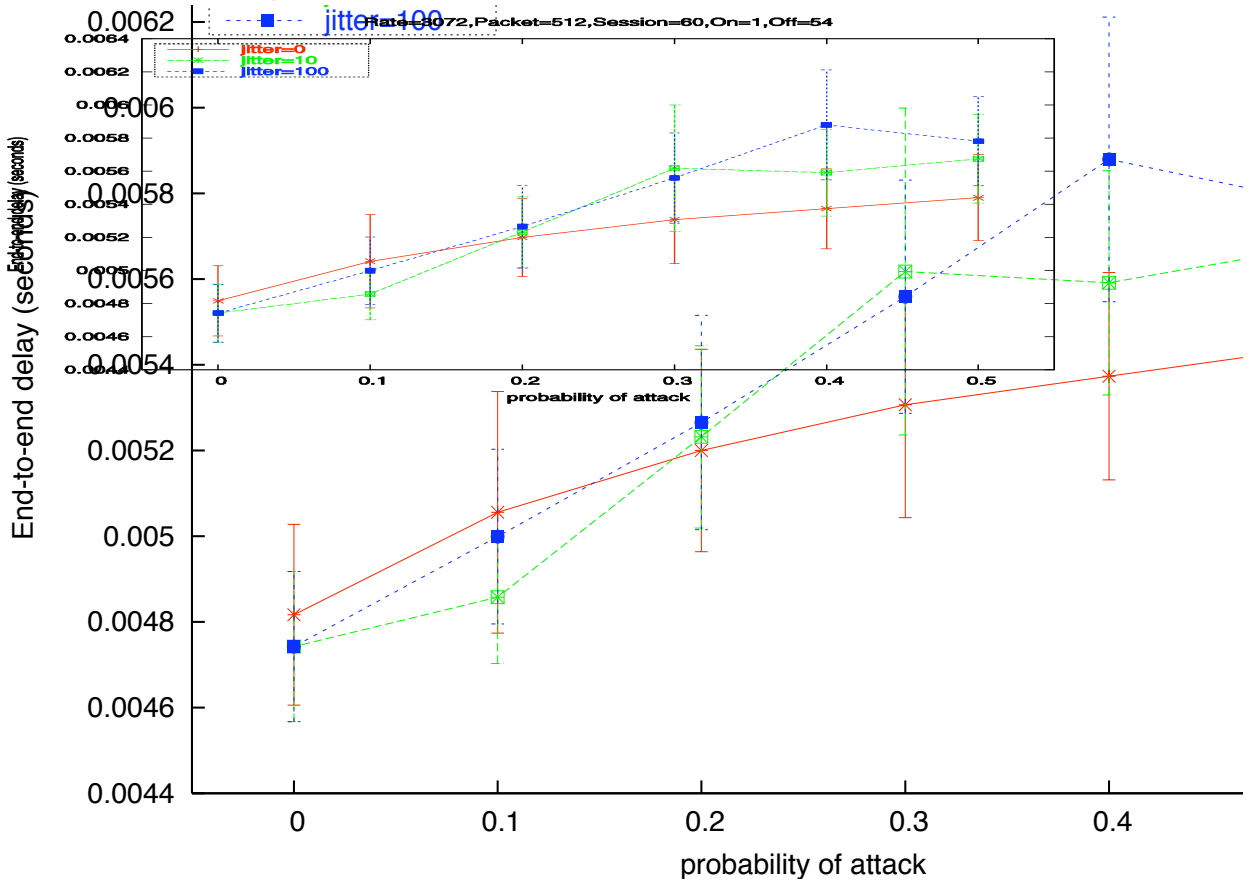
# Effect of Range Attack on PDR



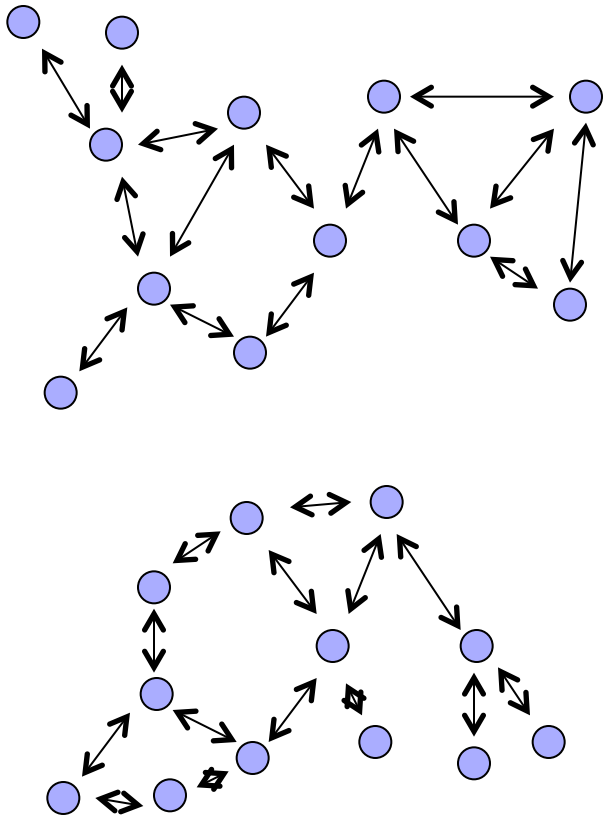
# Effect of Range Attack on End-to-End Delay



# Summary

- We presented a model that is general within the category of on-off attack processes.
- Our experimental results quantify the effects of two simple attack models on a wireless grid using ad hoc routing (AODV).

# Future Work



- Determine the impact of the attacks on other metrics of “network health”. We have investigated the effects on different metrics to quantify connectivity.
- Determine the length of the transients experienced by different metrics when there’s an attack state transition.
- Evaluate the impact of the attacks when the network topology is a random graph. The choice of analysis methodology will be important.
- Evaluate the impact of the attacks when cycle lengths are given by more complex probability distributions.